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Michal Kompan and Pavol Návrat (Eds.)

Keynote by Cristina Conati

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IIT.SRC 2018
Student Research Conference

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(Eds.)

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FACULTY OF INFORMATICS AND INFORMATION TECHNOLOGIES

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Informatics and Information Technologies

IIT.SRC 2018
Student Research Conference

Editors

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Preface

Research has been one of the main priorities of the university education since its very beginning. It is the case also for our university – the Slovak University of Technology in Bratislava and its faculty – the Faculty of Informatics and Information Technologies. Close connection of research and education leads very naturally to an active participation of students in research. This holds not only for students of the doctoral study, where research is a substantial part of their study and one of their principal activities. A participation of students in research is "going down" to students of the master's and even the bachelor study.

Universities of technology have a long tradition of students participating in a research work where they have to apply their theoretical knowledge. Outcomes of such endeavours have usually been presented at various students' competitions or exhibitions. Our university, too has a long tradition in organizing such events. However, in 2005 we decided to upgrade the framing of the event by transforming into a Student Research Conference covering topics of Informatics and Information Technologies (IIT.SRC). Participants are students of all three levels of studies, i.e. they recruit from both the undergraduate and postgraduate studies. The conference has adopted a process of reviewing as is usual at any other scientific conference. The accepted papers are available to all participants in a form of printed preprints (Proceedings). The aim of reviewing is not so much in achieving a certain acceptance rate, which is currently rather common in our community, but in assisting the student authors to amend their papers in the process of revision by providing helpful reviews. Of course, filtering out papers with a too low quality happens, too.

This is only part of our effort to support students in their (often first) steps in communicating their results to the research community at large. We also encourage students to improve their papers and attempt to publish them in international journals or conferences to make them available to their elder peers. Especially, we support the youngest generation of researchers (bachelor and master's students) by special travel grants that cover partially their travel expenses to conferences.

IIT.SRC 2018 attracted 91 student papers from which 80 were accepted as research papers (18 bachelor, 46 master, 16 doctoral) and 4 as papers to the innovative application and technologies track (4 master). The number of papers slightly varies each year. This year we have noticed a increase in bachelor and master categories comparing to IIT.SRC 2017.

The research track of the IIT.SRC 2018 conference was organized in six sections presented in course of live discussion in two poster sessions:

- Intelligent Information Processing (14 papers),
- Computer Science and Artificial Intelligence (14 papers),
- Web Science and Engineering (14 papers),
- Software Engineering (14 papers),
- Computer Networks, Computer Systems and Security (15 papers),
- Computer Graphics, Multimedia and Computer Vision (9 papers).

Papers in Innovative applications and technologies track were presented in a demo session, where student authors presented their applications online.

The conference was opened by Professor Cristina Conati's keynote titled The Eyes Are the Windows to the Mind: Implications for Intelligent User Interfaces. Cristina Conati is a professor at the Department of Computer Science at the University of British Columbia, Canada. Her research interests focus at integrating research in Artificial Intelligence, Human Computer Interaction and Cognitive Science to improve intelligent user interfaces.

Besides the 80 papers presented at the conference and included in these Proceedings several accompanying events were organized. This year we organized for the ninth time as part IIT.SRC a showcase of TP-Cup projects. TP-Cup is a competition of master students' teams aimed at excellence in development information technologies solutions within two semesters long team project module. The competition has three stages. 13 teams managed to achieve this stage and presented their projects during the TP-Cup showcase. Extended abstracts of their projects are included in these proceedings.

We continued this year with FIITApixel exhibition. FIITApixel brings together both students and staff of the Faculty as well as its potential students and alumni in an effort to create, share and judge pictures. It is organized as an ongoing event, where anyone can contribute pictures. The IIT.SRC FIITApixel exhibition presented the best pictures of this year contest.

IIT.SRC 2018 was for the sixth time organized in the new FIIT building. We all benefited from well-disposed space, which supports lively discussions. IIT.SRC 2018 is the result of considerable effort by a number of people. It is our pleasure to express our thanks to:

- members of the IIT.SRC 2018 Programme Committee who devoted their effort to reviewing papers and selecting awards,
- members of the IIT.SRC 2018 Organising Committee and accompanying events coordinators (mentioned in particular reports in these proceedings) for a smooth preparation of the event,
- the students – authors of the papers, for contributing good papers reporting their research and their supervisors for bringing the students to research community.

Special thanks go to:

- Katarína Mršková and Peter Gašpar who did an excellent job in the completion of the proceedings,
- Jana Gubová and Zuzana Marušincová and the whole organizing committee for effective support of all activities and in making the conference happen.

Finally, we highly appreciate the financial support of our sponsors which helped the organizers to provide excellent environment for presentation of the results of student research and valuable awards.

Bratislava, April 2018

Michal Kompan and Pavol Návrat, jointly with Mária Bieliková

Conference Organisation

The 14th Student Research Conference in Informatics and Information Technologies (IIT.SRC), held on April 18, 2018 in Bratislava, was organised by the Slovak University of Technology (and, in particular, its Faculty of Informatics and Information Technologies) in Bratislava.

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WeGAN – Weather Forecast with Generative Adversarial Networks

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Abstract. Generative adversarial networks represent the new architecture of neural networks, in which two models are trained simultaneously and their adversarial relationship (playing min-max game against each other) helps producing better results on set tasks. Although this framework is still pretty new, it showed its potential on many tasks. In this paper, we make use of the recent progress of utilizing generative adversarial networks for video processing and prediction, and apply them on whole new domain - weather forecast. We propose the new model for weather forecast - WeGAN, which achieved 0.15 RMSE on the task of forecasting temperature for 1 hour into the future.

1 Introduction

Weather forecast was and still is very important field of research. Not only it affects other fields such as agriculture or industry, every human has to accommodate his everyday life to the change of weather. Today, the weather forecast is done mainly thanks to powerful numerical models, which are applying laws of physics (dynamics of fluids, thermodynamics, etc.) to accurately measured actual state of weather to forecast future. This requires not only immense knowledge of the meteorological field, but also large data centers with strong enough computing power to calculate fast and precise results.

In the last years, the world of machine learning, neural networks and artificial intelligence is expanding rapidly. Main contributors are increasing strength of computing power, utilizing the modern improvements of learning neural networks on graphics cards and seemingly endless volume of data. This allows us to apply modern neural networks architectures on new domains and research more ways to improve already existing solutions.

One of the more recent additions to the researchers repertoire of tools are generative adversarial networks. This new architecture has been applied to many fields, changing the way we generate new content and push the limits of neural networks understanding. Since this architecture is fairly new, there are still many undiscovered uses of generative adversarial networks.

In this paper, we focus on one of them – weather forecast – where we apply model of generative adversarial networks for task of forecasting the weather state. We utilize large amount of weather data, which describes multiple weather variables (temperature, cloud coverage, humidity, etc.) over selected area in last few years. This data represented as grid, which we interpret as pseudo-pictures. We also draw parallels between RGB channels of images and weather variables and sequences of frames - video and sequences of weather states. Thanks to this we can use the latest advancements in frame prediction in videos. Two main contributions of our paper are as follows:

1. We propose WeGAN – Weather Forecasting framework (derivated from iVGAN [6]). To the best of our knowledge, there has been no literature on applying the GAN model to task of forecasting weather.
2. We demonstrate the improvements in weather forecast with WeGAN thanks to taking advantage of using multiple weather variables. Considering weather is a fluid, dependencies between multiple weather factors are good way to improve the forecast.

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IIT.SRC 2018, Bratislava, April 18, 2018 .

2 Related work

2.1 Generative adversarial networks

Generative adversarial networks [3] are generative model containing two neural networks: a generator network is trained to generate a sample data and a discriminator network trained to differentiate between fake sample data created by generator and real sample data chosen from the data distribution. Both networks are trained in an adversarial relation, competing in min-max game.

Main model has been proved on multiple visual datasets (MNIST, CIFAR, Faces of Toronto) and created objectively real looking images. They also showed success in tasks as image generations [2, 4, 5, 10], generation of super-resolution images [12], transformation of style [12] and many others.

However, GANs have some issues with being potentially unstable during training. There are multiple solutions to this problem. One of them is to change regular MultiLayer Perceptrons (default neural networks of generator and discriminator) for Deep Convolutional Neural Networks (DCNN) and set some constrains on training generator, creating a new class of GANs - Deep Convolutional GANs (DCGANs) [10]. Another way is to minimize the Wasserstein-1 or Earth-Mover distance between generator and real data distribution [1]. In a follow-up paper, they propose use of a *critic* – a discriminator with an improved training method, which behaves more stable [4].

2.2 VGAN and improved VGAN models

Vodrick, Pirsiavash, Torralba [11] capitalized on large amount of unlabeled video data and created a special model for learning video dynamics. Learning video dynamics can be then directly used for multiple video processing and generating tasks. Their VideoGAN (VGAN) model used spatio-temporal convolutions to recognize objects and their dynamic movement over time. They also opted to use two stream architecture for generator, trying to create foreground and background of the video separately. Although they successfully generated videos in the domain of static backgrounds, main disadvantage of this model is necessity of having stabilized videos as source, which can be rare or non-trivial to stabilize shaking, for example.

Building on the core points of VGAN model, Kratzwald et al. propose improved VGAN (iVGAN) model [6]. Their focus is to process and generate videos in the wild, without any prior assumptions. This leads to simplifying the generator back to one-stream version, opposed to VGAN. Task of training image generation with GAN models is non-trivial, as for video, even more challenging, because of addition temporal aspects. To help with this issue, they applied generalized state-of-the-art Wasserstein GAN model to context of video generation for more stable convergence.

For tasks of video generation and frame prediction, they need to use an input to the generator network. For this, they defined an encoder network, which processes an input frame into latent vector representations, which is then used as input with noise for generator network. In their experiments, this has been proved to be state-of-the-art solution for generating videos. They acknowledge the difficulty of the task, but their model learns to recognize most like to move objects and generative plausible motions.

2.3 Weather forecast

As of today, the weather forecast is made mainly by Numerical Weather Prediction, which uses mathematical models of the atmosphere and oceans to predict the weather based on current weather conditions [8]. This method requires an initial state of weather – the most possibly precise observations of the actual weather, measured by multiple sources (weather balloons, meteorological stations, satelite pictures, etc.), assimilated into single weather state and computationally-hungry mathematical model to compute forecast of the weather. Even in impossible scenario of perfect definition of weather state and unlimited computational power, the chaotic nature of the fluid dynamics equations involved in weather forecasting makes 'the perfect forecast' impossible [7]. Because of this, weather forecasts today are supported by creating ensembles of forecasting models and actual predictions are then further evaluated with statistical models.

We take a deep inspiration from these methods, finding similarities between forecasting weather from single weather state and creating videos from initial video frame, as well as reinforcing the model with statistical data, which can be interpreted as neural network learning from historical data of weather states.

3 WeGAN model

For weather prediction, we propose the WeGAN model. We derived it from iVGAN model, since it has been proved to have state-of-the-art results on tasks of generating videos and frame predictions. We propose a novel way to process numerical weather data - grid of weather state variables (temperature, cloud coverage, humidity, etc.), in this context, as images. Thanks to this, we are able to use large amount of numerical weather data, as well as take advantage of image and video models.

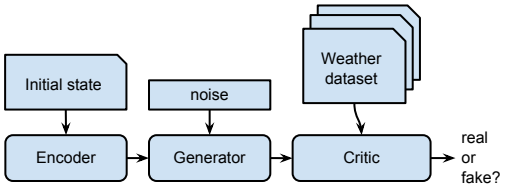

Figure 1. Basic visualization of the WeGAN model.

Model is separated into 3 main parts: Encoder, Generator, Critic. We describe them in more details in following sections.

3.1 Encoder network

For processing the initial state of the weather - grid or map of several weather variables - into *generator* friendly format, we need to encode it into latent feature vector, which can be then used as an input with noise to generate forecast. As of now, we are using Deep Convolutional Neural Networks (DCNN) for encoder network, but in future work we are planning to apply recurrent neural network. This can improve encoding of some latent temporal information into the feature vector and thanks to that improve quality of the forecast.

3.2 Generator network

The generator is defined as DCNN, taking k-dimensional normal distribution vector and produces a sequence of future weather states - forecast. Model is using spatio-temporal convolutions, to mantain spacial and temporal information.

3.3 Critic network

The critic is also defined as DCNN, mapping an input of generated or real sequence of weather states to output of real value. It is, similarly as generator, created with spatio-temporal convolutions. Despite general use of soft-max layer or any activation in final layer, we choose to swap training of the critic to classify between real and generated samples, for training to return a good gradient information for generator updates.

4 Experiments

We evaluate our Weather Forecast model on our weather dataset. To our knowledge, there is no other weather forecast model, which works with numerical data and is openly available for public. Most weather forecast systems use numerical computing models, based on mathematical and physical calculations of actual weather state, which require large amount of computing power. This prevents us from making a real comparison with other models. However considering computational power required to process and create weather forecast by numerical methods, one of the marginal contributions is reduction of mandatory capacity to create weather forecast.

4.1 Dataset

In our experiments, we use one core dataset of weather data, which we further preprocessed for each experiment. The dataset that we are using is data reanalysis dataset ERA-5 by The European Centre for Medium-Range Weather Forecasts (ECMWF), which owns and operates one of, if not the world's largest archive of numerical weather prediction data.

Dataset ERA-5, the newest version of reanalysis datasets by ECMWF, contains collection of weather data of the whole world. It only contains years from 2010 to 2017, since it is the most recent dataset released. For future work, we may be able to obtain more data, the release of the years 1960-2010 is set to be later in 2018. Step size of the dataset is 1 hour and contains multiple weather variables, from which we had primarily chosen temperature, humidity and cloud coverage.

We created special processing of weather data into image and video models - is to use regular RGB channels of image as channels for weather parameters. We believe that, as physics models define dependencies through numerical formulas, we envision our model to learn same thanks to observation of data samples.

Another advantage of using this dataset is the possibility of expanding observed data, not only by area, but volume, as this dataset contains multiple (137) levels of height. This allows us to further expand complexity of the model and possibility of increasing quality of the results.

Considering the area of the whole world would require too big of a model to execute experiments in usable time-frame, we decided to create 2 sets of maps – 32x32 and 64x64. This not only reduces the size of the model, but allows us to study different results based on the size of the map. For now we set the middle point of maps around Slovakia, but in the future, we may try to work on more diverse area – to see how, for example, sea affects the predictions. Weather data is usually stored in GRIB2 data format, mapping projections of latitude and longitude, with each point separated by 0.3 degree (around 30km). Next, we transform data into regular multidimensional data grid and normalized set data around 0 [-0.5, 0.5], to ease training for our neural network.

4.2 Results

For evaluation of the forecast, the most significant value is error of the forecast. Mean error value may

be good for general evaluation, but since we are working with multidimensional space of sequential data, we want to see the error on the grid. This helps us to analyze and better evaluate our model, see if the errors are concentrated around particular area.

First experiment works with the smallest area dataset (32x32 points). Our focus is to prove the power of our model to create relevant forecast. We exchange number of weather variables, starting with only temperature and forecasting based on 1 hour sized step.

This experiment proved the initial expectations of our model. We calculated Root Mean Squared Error between real weather and generated one and achieved error of 0.15. Although this number may seem high, we have to consider the fast, that we are working with large grid of variables and we are not using supervised learning. Furthermore, we are observing check-board patterns in forecasts visualizations, which are cause by deconvolution layers in generator network [9]. Removing this unwanted pattern may reduce the error.

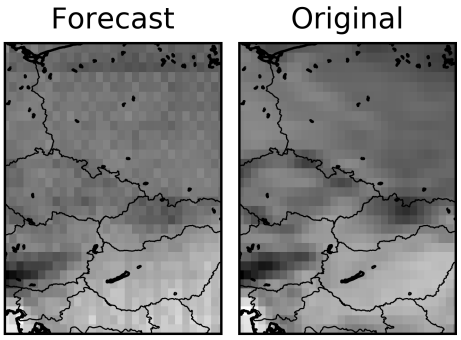

Figure 2. Visualization of generated forecast and real weather state.

After this experiment, we can enlarge testing by means of enlarging surveyed area to grid of 64x64, surveyed volume by addition of height layers and increasing number of weather variables.

5 Conclusion and future work

In this paper we focused on the weather forecast using generative adversarial networks. We modified existing model for generating predictions of video and created new model WeGAN for generating numerical weather data forecasts. We evaluated model in an experiment with error of 0.15 on forecasting weather of map 32x32 points for 1 hour into the future. We then observed the results and visualizations of results to plan progress for future work.

We plan to expand observed area of model, which could improve forecast as well, since it will be able to see more potential factors for the change of weather. Adding height levels may improve model further, considering the weather as fluid is very dynamic and could be different in separate levels, but this could also bring unnecessary complexity to the model, since it will have to consider moving not only in 2-dimensional area, but in 3-dimensional space. Enlarging number of weather variables can be beneficial, considering dependencies between weather factors – such as temperature drop in area under the cloud, with rain, and many more. Adding temporal factor (hour in day, day in year) could also help network to create forecast, considering weather is affected by not only cyclical dependency of day, but also seasonal and long-term dependencies.

References

[1] Arjovsky, M., Chintala, S., Bottou, L.: Wasserstein GAN, 2017.

[2] Denton, E.L., Chintala, S., Szlam, A., Fergus, R.: Deep Generative Image Models using a Laplacian Pyramid of Adversarial Networks. *CoRR*, 2015, vol. abs/1506.05751.

[3] Goodfellow, I.J., Pouget-Abadie, J., Mirza, M., Xu, B., Warde-Farley, D., Ozair, S., Courville, A., Bengio, Y.: Generative Adversarial Networks. *arXiv preprint arXiv*, 2014, pp. 1–9.

[4] Gulrajani, I., Ahmed, F., Arjovsky, M., Dumoulin, V., Courville, A.C.: Improved Training of Wasserstein GANs. *CoRR*, 2017, vol. abs/1704.00028.

[5] Im, D.J., Kim, C.D., Jiang, H., Memisevic, R.: Generating images with recurrent adversarial networks. *CoRR*, 2016, vol. abs/1602.05110.

[6] Kratzwald, B., Huang, Z., Paudel, D.P., Gool, L.V.: Towards an Understanding of Our World by GANing Videos in the Wild. *CoRR*, 2017, vol. abs/1711.11453.

[7] Lorenz, E.N.: Deterministic Nonperiodic Flow. *Journal of the Atmospheric Sciences*, 1963, vol. 20, no. 2, pp. 130–141.

[8] Lynch, P.: The Origins of Computer Weather Prediction and Climate Modeling. *J. Comput. Phys.*, 2008, vol. 227, no. 7, pp. 3431–3444.

[9] Odena, A., Dumoulin, V., Olah, C.: Deconvolution and Checkerboard Artifacts. *Distill*, 2016.

[10] Radford, A., Metz, L., Chintala, S.: Unsupervised Representation Learning with Deep Convolutional Generative Adversarial Networks. *CoRR*, 2015, vol. abs/1511.06434.

[11] Vondrick, C., Pirsiavash, H., Torralba, A.: Generating Videos with Scene Dynamics. *CoRR*, 2016, vol. abs/1609.02612.

[12] Zhu, J., Park, T., Isola, P., Efros, A.A.: Unpaired Image-to-Image Translation using Cycle-Consistent Adversarial Networks. *CoRR*, 2017, vol. abs/1703.10593.

Generating Subgraphs of Finite Grids

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Abstract. In this paper we explain the generation of finite grid subgraphs. Specfically, it will generate self-avoiding paths on the square grid, enabling us to better understand the dissemination of information across different communications networks. If we can find all the self-avoiding paths in the finite grid, we can determine the probability of delivering a message from one node to another at a certain line error rate in that network. So far, we have been able to optimize this problem so much, that we can find all the paths that have a length of 0-24 edges in about 21 hours and the number of different 24-edge paths is 1,246,172,974,048. At 25-edge paths, the expected time is about 3 days and the number of paths will be proportionately increased to this time increase.

1 Introduction

This work deals with self-avoiding paths in the graph. Our task is to find out, how to make the most effective algorithm to count all these paths, and we will be able to tell something more about the graph that represents the network. Nowadays, there are many different networks in the world, especially those, where information flows and without which we could not exist anymore. In addition to studying these different networks, we have also encountered such a problem. These networks often have the form of a graph, and in our case it will be a grid graph. We will specifically deal with a square 2D grid according to [3]. In this paper, we describe how we have gradually created this algorithm, how it works, and what paths we actually managed to count. From a time perspective, this is a very challenging problem, and so we have been looking for different simplifications, that would make it easier for us to do it. We used mathematics to reveal hidden symmetry and recursion, thanks to which we have been able to speed it up.

2 Self-avoiding paths

First of all, we want to explain, what we mean by the self-avoiding paths in our case. On the basis of [4], we have found that similar problems, that count self-avoiding paths are many, but ours are unique. We will create them on a grid that has only a positive direction and that means it starts at the bottom left vertex and we move, so we add edges up or right, otherwise not. It follows, that our horizontal edges are oriented to the right and vertical edges upward. This means, that they will not be totally self-avoiding, because they can touch, but still can not intersect. On the basis of [1], the path is a non-null sequence of vertices in the graph, but as we will see, our path can be twisted, because from the vertex we can move in two directions at once.

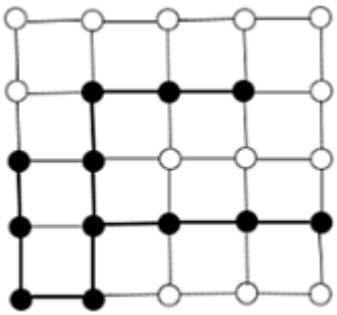

Figure 1. Self-avoiding path on the square grid.

We will create such paths, as in Figure 1, in a way that we start at the bottom left vertex, which we call the active vertex. From this active vertex we have up to 4 possibilities what can happen. It is actually a simulation of the spreading message in network, in this case from vertices along the edges, so the line can be broken, as well as in a network. Even both can be broken, both up and down, and then the message does not even begin to spread, which is the first option.

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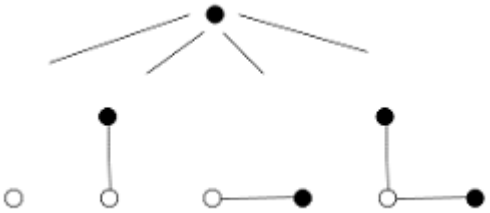

Figure 2. Four options from one-active vertex.

The other two options are when only one of two possible lines is broken, and we can then send the message to the other, undamaged. With these two possibilities, we have a new active vertex that has received the message, and the old one is extinguished. Best is, of course, when none of them are broken, so we can send a message along both lines. Black vertices in Figure 2 are active. More complicated is that in this last option, we get up to two new active vertices, exactly those who have received the message. At the same time, we will create a subgraph of length 2, because it has 2 edges.

We can, of course, develop these subgraphs as long as we have at least one active vertex. At two active vertices, our number of possibilities from this subgraph will expand to 16. This is because we have 4 options from each active vertex and their combinations give us $4 \cdot 4$ and thus 16 different options, which is quite a lot. We can see how the number grew by adding only one active vertex. From this we assume that this problem is computationally expensive and counting these paths, or otherwise subgraphs, already for small lengths will take long time. In the work [2], which deals with a similar problem, it is written that it is an exponential problem of size k^n, where the k constant is about 2.638 and n is the length of the path. We assume it will be little more in our case.

3 Symmetry and recursion

In our algorithm we also used symmetry. If we look at the grid so we can notice its symmetry, namely the axial symmetry, according to the y = x axis. At the beginning we begin to develop one active vertex essentially at the coordinates [0, 0]. We will basically create 3 other configurations because we did not consider what the two lines were wrong, or we considered it as 0-edge length configuration. Two of them have one active vertex and one edge length. If we think about it, these two configurations will develop the same, because they are symmetric and so we can count one and weigh it as two. The third configuration with two active vertices can not be simplified in this way.

In addition to this observation, we also came to another interesting idea, namely the recursion. We start from one active vertex, and also the two branches that have been adjusted to just one by symmetry, start from one active vertex. It follows, that the number of paths from one active vertex should always be the same, but they will be moved one place in sequence, because the initial configuration has zero edges and our two have already one edge. When we release the program, we get the output in 1, 2, 5, 14, 42, 130, etc. It is a sequence created from the number of subgraphs of certain lengths. Specifically, we have now told the program to count all self-avoiding paths of length 5 or less. The program found that the number of 5-edge length paths is 130, 4-edge length 42, and so on. If we do not start the same program from the initial vertex [0, 0], but from the configuration that has the active vertex at the coordinates [0, 1], then we return the sequence 0, 1, 2, 5, 14, 42. The same sequence, but is shifted. The same can be done if we execute the algorithm from the vertex [1, 0]. If we add these two sequences, we do not yet get the initial sequence, which we want. Of course, we need to calculate and assign the sequence that occurs when we start from a configuration that has two active vertices at the coordinates [0, 1] and [1, 0]. In this sequence, we also enclose the initial configuration, with zero edges, and the program calculates the sequence of 1, 0, 1, 4, 14, 46. If all we count together, we get the sequence 1, 2, 5, 14, 42, 130. It is good for us.

However, due to this recursion, we do not have to think of the two configurations with one active vertex, but it is enough to calculate the sequence that the configuration will give us with two active vertices and then we will make an interesting calculation, that we will add two times previous member to each member. We add previous member, because it differs only one edge and two times because we have two identical branches.

$$X_{n+1} = 2X_n + S_{n+1} \tag{1}$$

Where X_n is number of n-edge paths from configuration with one active vertex and S_n is the same number from configuration with two acive vertices. Try it: 1, 0, 1, 4, 14, 46. Start from the second member because the first one does not have a predecessor. We create 1, $0 + 2 \cdot 1$, $1 + 2 \cdot 2$, $4 + 2 \cdot 5$, ..., what is our known sequence. Everything works because, if we have a previous one, it is actually current in the sequences we did not take, those one-edged with one active vertex. In other words, for example zero-edge, in the sequence of the double-active configuration, it is 1. This is the number of 1-edged ones in the sequence we do not count, and since there are also two, we add $2 \cdot 1$ to the sequence which is already done, to the number of 1-edged ones. So there will be number 2 here, because there was zero. This number tells us the number of 2-edged ones in the sequence we do

not count, and since there are two of them again we have to add $2 \cdot 2$ to the number of 3-edged ones in the resulting sequence. This way we go through the whole sequence and we have the result.

3.1 Deeper recursion and pthreads

Previous paragraph shows, that it is enough to calculate the sequence, that is based on our 2-edge configuration with two active vertices. Now we need to look at this configuration. This configuration gives us 15 new options. We can divide these options into 4 subgroups. The first group are configurations with one active vertex. The second group are configurations that have two active vertices, and these active vertices are spaced apart by only one diagonal. There is also a configuration that has two active vertices, but there is a bigger distance between them, specifically two diagonals. This configuration creates the third group itself. The last fourth group includes configurations that have three active vertices. Group number 2 we can do the same way we initially removed 1-edge configurations with one active vertex, because that group has the same two active vertices as the configuration we are based on.

We have created the groups to get independent tasks that can be done independently, which means it's best to use parallelization. In particular, we used POSIX Threads in our program. However, these groups do not divide the total work evenly, and therefore the running time of the program will depend on the thread, that will do it the longest. Each thread takes up one group. In group number 3 is only one configuration. In the other two, where there are configurations with one active vertex and three active vertices, we can simplify it again only for one configuration of the type, and reckon the same way we do it anywhere. This configuration will, of course, have the smallest number of edges from group, so we can do it in this way. Testing has shown us, that most work needs to be done with the two active vertices that make up group number 3 alone.

4 Algorithm

```
N − length of the biggest path
 struct  configuration
          number of edges(NOE)
          number of active  vertices (NOV)
          active  vertices
          struct  configuration  pointer

 int  result [N+1]
 init  first  configuration
 init  stack  S
push(S,  first )
WHILE S is not empty DO
        init  current  configuration  = pop(S)
         possibilities  = 4^ current .NOV
        FOR p from 1 to  possibilities  −1
                 init  new configuration  by  current
                 FOR v from 1 to  new.NOV
                          x = 2∗v − 1
                          y = 2∗v
                          IF y−th bit  in  p == 1
                          THEN  addEdgeUp(new, v)
                          ENDIF
                          IF x−th bit  in  p == 1
                          THEN  addEdgeRight(new, v)
                          ENDIF
                 ENDFOR
                 IF  new.NOE > N THEN
                          free  new
                 ELSEIF new.NOE == N THEN
                          result [new.NOE]++
                          free  new
                 ELSE
                          result [new.NOE]++
                          push(S,  new)
                 ENDIF
        ENDFOR
        free  current
ENDWHILE
```

In this algorithm, we describe how main part of our program works. We have to go through all different paths and for each one increment the result array. After that, we still need to do the calculations that we mentioned above. If we use pthreads, every thread is doing similar work, but this main skeleton of program is everywhere same.

The first configuration we are based on has 1 or more active vertices and some number of edges. This structure is located at the top of the stack. Then we go through while, then through for cycle.

When we look at the iterator p, it's a number of options. This number has bitwise representation, and the number of bits is exactly 2 times the number of active vertices. For example, for one active vertex, two bits are enough. For one active vertex, our iterator passes numbers 1, 2 and 3. These bits are now used to know what to do from the active vertex. For example, if the configuration has 3 active vertices and we would be on the 39th option of the total 63, the bitwise representation of the number 39 is 100111b. If these bits are cut on the pair, the first active vertex will have 11b, the second 01b and the third 10b. On the grid we move in two directions up and right. The ones indicate that we add an edge and zero that we do not add. If the first active vertex has 11b, it means that we add the edge up and to the right.

5 Testing

Testing is to the paths of length 24. You can see this sequence in the Table 1 as well as time. Interesting

in this sequence is the quotient of the member and the previous member, which we can see in the third column of the table. The fourth column of the table shows the differences of these quotients. As we can see, these differences are approaching zero. If we could calculate the number where sequence of quotients would stop, we could determine the next member so that we could multiply the actual number by that and we are done. Since we are only at number 24, it is questionable, whether or not there is an endless limit. It would be best if we were able to find a relationship in our sequence, avoiding any time expensive calculations, and using this formula to earn the next member.

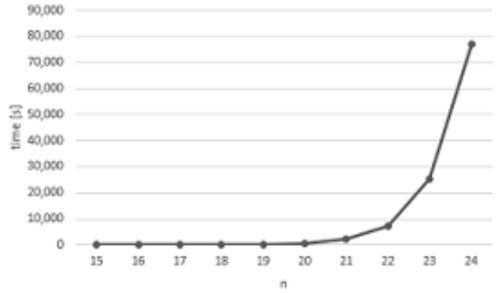

Figure 3. The rise of time.

In Figure 3 we can see diagram, which shows the rise of time. It is from last column of Table 1. X axes start from number 15 because smaller numbers have less than 1 second.

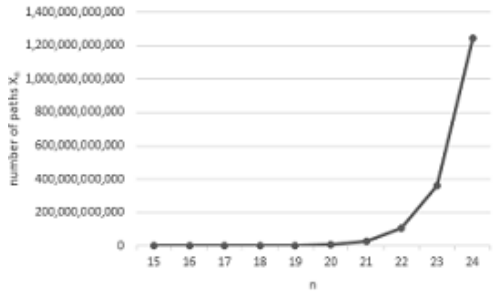

Figure 4. The rise of number of paths.

In Figure 4 we can see again a diagram, but now about number of paths. As we can see, these diagrams are same, just y axes is otherwise marked. Time is in thousands of seconds and number of paths is in billions. Number of 24-edge paths is even bigger than one trillion. This implies that increase of time is directly proportional to increase in number of paths. When we look at the Table 1, on column where is X_n/X_{n-1}, we can see that is about 3.4. When we mark this number as q, then complexicity or number of paths equals $\prod_{i=1}^{n} q_i$ and this product is somewhere between 3^n and 4^n.

Table 1. Number of paths and the other dependencies.

n	X_n	X_n/X_{n-1}	diff	time[s]
0	1			0.000
1	2	2.0000		0.000
2	5	2.5000	0.5000	0.000
3	14	2.8000	0.3000	0.000
4	42	3.0000	0.2000	0.000
5	130	3.0952	0.0952	0.000
6	412	3.1692	0.0740	0.000
7	1,326	3.2184	0.0492	0.000
8	4,318	3.2564	0.0380	0.000
9	14,188	3.2858	0.0294	0.000
10	46,950	3.3091	0.0234	0.000
11	156,258	3.3282	0.0190	0.015
12	522,523	3.3440	0.0158	0.031
13	1,754,254	3.3573	0.0133	0.109
14	5,909,419	3.3686	0.0113	0.390
15	19,964,450	3.3784	0.0098	1.280
16	67,618,388	3.3869	0.0085	4.462
17	229,526,054	3.3944	0.0075	15.256
18	780,633,253	3.4011	0.0066	53.395
19	2,659,600,616	3.4070	0.0059	184.859
20	9,075,301,990	3.4123	0.0053	632.047
21	31,010,850,632	3.4171	0.0048	2108.957
22	106,100,239,080	3.4214	0.0043	7383.248
23	363,428,599,306	3.4253	0.0039	25409.308
24	1,246,172,974,048	3.4289	0.0036	76911.023

6 Conclusion

The most important thing is that X_n/X_{n-1} grows but still slower and slower, so it may has a limit in infinity and we will be able to count next number. So our next task is to make this algorithm more and more efficient to see next numbers of paths. The most beautiful will be, if we find the perhaps hidden formula. So far, this program is abstract, but we believe it will find use in communications or other networks in the future.

References

[1] BONDY, J., MURTY, U.: *Graph theory with applications*. Elsevier Science Publishing Co., Inc, New York, 1982.

[2] van den Dool, W.: Counting Self-Avoiding Walks on the 2D Square Lattice. Bachelor's thesis, UTRECHT UNIVERSITY, 2016.

[3] Weisstein, E.W.: "Grid Graph." From MathWorld–A Wolfram Web Resource. *http://mathworld.wolfram.com/GridGraph.html*, [Online; accessed february 24th, 2018].

[4] Weisstein, E.W.: "Self-Avoiding Walk." From MathWorld–A Wolfram Web Resource. *http://mathworld.wolfram.com/Self-AvoidingWalk.html*, [Online; accessed february 24th, 2018].

Is Electronic Identity Needful?

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Abstract. This paper points to importance of electronic identity that people often need to utilize common e-services. However, sometimes for people it is not the best practice to have their personal identity shared with third parties, they may prefer anonymity, in order to avoid theft of their personal or sensitive data. Therefore, an interesting part of this topic is an approximation of borders between anonymity and identity need. Moreover, the common issue is identity copying, compromise or identity retrieval after theft. This paper contains case study around using aspect oriented programming in Java to obtain eIDs of LinkedIn users.

1 Introduction

Electronic identity or digital identity is simply defined as *"set of attributes related to an entity"* as ISO defines [9]. Furthermore, we know eID as entity model based on various types of identifiers linked to attributes that are part of some entity/entities introduced inside of some context [6].

Or more precisely there exist another definition [1] explaining digital identity as *"an online or networked identity adopted or claimed in cyberspace by an individual, organization or electronic device. These users may also project more than one digital identity through multiple communities. In terms of digital identity management, key areas of concern are security and privacy"*.

Nowadays one of the most interesting topics around identity is looking for a right border between anonymity and digital identity. Do we need electronic identity at all? There are situations when people wish both, identity and anonymity. For example, if we would like to make an inquiry to obtain feedback, it is maybe better to let authors more freedom and keep it as anonymous. From the opposed point of view, someone could want to be identified for the purpose of submitting a direct complaint.

2 Incidence of eID

Every human have own personal identity de facto from his or her birth. Eye iris, DNA, fingerprints and much more biometric information are related to only one specific person forming its identity. In a moment when this data is transferred to digital form, we can claim, eID was born. Nowadays lot of companies or systems offering authorization methods are based on biometric digital identity [14]. But on the other hand there exist another enterprise, national or governmental solutions as identification of people in systems with IC cards [2] or so called smart cards [17].

Well, as we can see every piece of information that points to one specific person describes its identity. In a digital world it is really effortless to procure your eID on your own for example just via creating an e-mail account. This common behavior results to a problem [15] of identity duplication as multiple eID identify one person what can outcome to inconsistency.

In addition, plenty of digital systems or organizations providing their electronic services require its users to authenticate in order to use their services what is a crucial condition to make these systems working. An example can be bank systems, e-shops, e-commerce, e-health, e-education, social networks as LinkedIn, Facebook, Twitter, Pinterest and much more[3].

Imagine that you would not hold any account in the bank, but you need to receive money from second

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[1] Digital Identity - Definition - What does Digital Identity mean?: https://www.techopedia.com/definition/23915/digital-identity

[2] ICC - integrated circuit cards

[3] Egovernment: https://www.egovernment.ch/en/umsetzung/schwerpunktplan/elektronische-identitat/, indrastra

parties. How the bank would know that this money belongs exactly to you? How would you like to receive products from e-shop if you will not provide the system with your sensitive data? It is obvious that in order to use digital services we need to send out to network our private data. Even in LinkedIn you wish to own your eID and have it published as public for the local system with a purpose of selling yourself for the labor market. Furthermore, the reliable digital identity is a base structure for credibility, trades, business and party's collaboration [5].

Beside the advantages that electronic identity brought [8], eID management and systems supporting digital identities can be very expensive for realization [3]. Additionally, it is required to develop systems that help protect eIDs before theft [12]. It is possible that your stolen identity can be restored, but it can depend on various factors as time (when you find it out), reporting theft, faults of attacker and so on [11].

There exist people who worry about using eID because they could become manageable by others and as a result become non-free [1]. Furthermore, what if someone would like to gather data about users from social networks for example as LinkedIn for advertising or other malicious purposes? There exist software to use like LinkedIn Lead Extractor, but it has its own restrictions with amount of downloading data per specific time unit.

3 Shades of anonymity

We can simply define anonymity as absence of identity, in our mean, digital identity. There is a question, if anonymity is real at all. For example, in the case, I want to leave someone feedback, there still exist methods how to detect my identity. If I will leave feedback on a paper, they have my manuscript, if I will do it on a web, it is still possible to identify person with another software or hardware techniques like browser fingerprinting. To support anonymity and avoid my disclosure there exist secure net tunnels as proxy or upgraded VPN security networks [16] that changes location data of the device as well as its IP address [4].

But as it was mentioned before, browser fingerprinting techniques like saved browser settings, size of window (equals to size of screen that can be used to detect type of your hardware you use) or other browsing habits can make website fingerprinting attacks possible. After all, these days it is still possible to make yourself anonymous for example with good known Tor browser that often warn you to not use fullscreen mode in order to avoid detection, but not offer perfect security, just approximately 63% [10, 19].

Therefore, we can claim that anonymity is possible and real concept. Even there exist Crypto-Book [13] explaining a cryptography danger of anonymity misusage. Considering anonymity as a problematic conception, there exist various cases of cyber attacks, thefts, abuse, blackmailing, money laundering and other criminal activities [2]. But on the other hand anonymity is demonstration concept for freedom in the cases you need to have the rights to privacy. It means, people should have the privacy rights to keep personal information (list of friends, what you like, who you are, what you have or know) private if they want to, what is morally correct. Consequently, it is known [7] that this data can be misused and there is a need to classify users information according to privacy levels. One of examples can be threat of selling databases containing users data to third parties.

4 Case study - AOP with java in LinkedIn

Main purpose of this study was to develop java project application based on aspect oriented programming within an aim of programmatically receiving indirectly public digital identities of LinkedIn users. AOP techniques were used for easier work with changing browsing patterns. This dynamic programming access saved a lot of time during development. Case study shows a possibility of creation home made program in a short time to gather user identities data to prove their easy accessibility even on professional social networks. It implies that user accounts on LinkedIn are not definitely public for everyone, just for logged in users and therefore not visible for public world in a full form. This can be known as privacy loss where it is even possible to search for hidden connections between users [18].

One of the main part of this project was the need to develop program or so called web bot, that was able to use one account for logging into LinkedIn in order to obtain some number of eIDs from system. This project was realized with Java in IntelliJ IDEA environment on a Windows platform with web automation framework Selenium and PhantomJS web browser. Web bot used asymmetric aspects for logging all results and its behavior to ".txt" files. Various program aspects measured speed of bot activity.

Definite instructions or steps to behave for the web bot were as follows:

1. Open Java Application window - user interface and wait for input[4]

[4] Input consists of field for LinkedIn URL login page.

2. Log into LinkedIn system
3. Browse to list of friends
4. Save links to user accounts
5. Loop through accounts and per every item save all data about
6. If I have not enough eIDs then jump to step 3. for selected user
7. Save all eIDs data to txt file

Primary utilization of AOP in practice as a result was ability to enrich program source code with other new functions without the need of reprogramming existing code. Therefore, it was much easier during development to affect behavior of web bot to test various use cases. One main use case consisted of running web bot as a bare java program based on selenium framework, when web bot make run "PhantomJS.exe" file. PhantomJS browser run at the background and web bot use it with various log functions to download users data in text form and even with screenshots. This was one of the key steps in order to see behavior of bot on a web. Thanks to screenshot functions it was possible even to capture profile pictures of LinkedIn users as a part of their digital identities.

There were exactly six not elementary issues around implementation of this web bot, that finally were resolved. To sum up, we reached some practical results from this project assuming how easy or quick can common people with this Java application receive foreign (partially private) digital identities from LinkedIn.

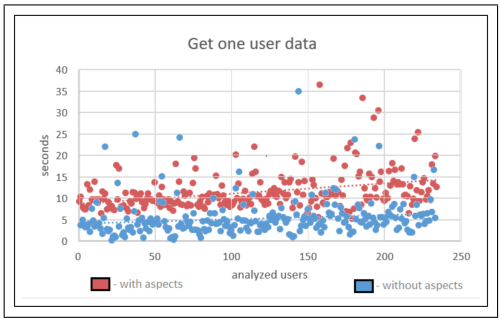

Figure 1. Speed of receiving eIDs.

As it is shown in Figure 1, aspects can partially slow down the application performance/speed, but provide specific advantages. We can approximate results in a number of 5 seconds that are need to download one eID data from LinkedIn user. One of the speed problems lays in internet download speed (4.27Mbps) as a lab condition in which this app was tested.

Moreover, there is a great chance to improve performance of app by using multithreading and more memory. In the calculation, with 8GB memory in a device with multithreading and creation of multiple web bots we can improve performance by number of 10 times. With better download speed and some code optimization we are able to receive in a legal manner eIDs of three users per second. The main problem for web bot is LinkedIn security system that make users available to see connections of other users maximally up to level one. If web bot detect inaccessibility, then it is possible for every previously searched account to view overview panel called "People Also Viewed" which will enlarge web bot possibilities.

5 Summary

Electronic identity is really important concept in this digital world in order to use various services. It makes trade, business and government processes more reliable, but the eID should remain protected and anonymous or private for public. The case study showed us an example that not every digital identity is unreachable. Therefore, it is needful to care about development of strong eIDs. Additionally, people should have an opportunity to act anonymously when they are legally approved to do so. What is more, mentioned case study points to possibility of developing own program at home that is able in legal way obtain a huge number of linkedin users data in an established portion of time. Secret of this possibility lays in correct work with HTML elements, patterns and HTML structure with connection of Javascript website testing frameworks made for automation purpose. By using our web bot it is possible to gather approximately every 5 seconds all LinkedIn user not hidden data, even pictures as binary form. LinkedIn system is well secured system, but in a manner of creating own account that is misused to search LinkedIn users profiles, it can be classified as a possible approach to foreign, but indirectly not public data. Related works like LinkedIn Lead Extractor system have its own restriction for downloading data, our case study web bot seems could not have. After all, people in these social networks do not face cyber attacks every day, but they should remember, that they are creators of its own identity that should be conscious with information that they can afford to leak in this risky sector of digital world.

6 Future work

There is a need to create another case study to test how large network of web bot searching results can be reached. What's more, one of the most interesting areas for future work may be research of credibility between two-parties. Moreover, an important role in trust between two sides play their digital identity. There is need to find or invent some method or algorithm that will help with strengthen assurance of

trust between two eIDs. In addition, it can be essential to make new or to update existing mathematical model of digital identity. It is possible that techniques like crowdsourcing, decentralization or clustering are a way to go.

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References

[1] Big data and government: China's digital dictatorship. (2016, December). The Economist. Retrieved from http://www.economist.com.

[2] Aseef, N., Davis, P., Mittal, M., Sedky, K., Tolba, A.: Cyber-Criminal Activity and Analysis. Technical report, Paul G. Allen School of Computer Science & Engineering, University of Washington, 2005, Group 2.

[3] Birch, D.G.: Digital Identity is complicated. Technical report, Dutch Payments Association (Amsterdam), 2017.

[4] Carpenter, B.E.: IP Addresses Considered Harmful. *SIGCOMM Comput. Commun. Rev.*, 2014, vol. 44, no. 2, pp. 65–69.

[5] Castro, D.: Explaining International Leadership: Electronic Identification Systems. In: *Electronic Identification*. The information technology & Innovatioon foundation, 2011, p. 71.

[6] Ferdous, M.S., Norman, G., Poet, R.: Mathematical Modelling of Identity, Identity Management and Other Related Topics. In: *Proceedings of the 7th International Conference on Security of Information and Networks*. SIN '14, New York, NY, USA, ACM, 2014, pp. 9:9–9:16.

[7] Fung, B.C.M., Wang, K., Chen, R., Yu, P.S.: Privacy-preserving Data Publishing: A Survey of Recent Developments. *ACM Comput. Surv.*, 2010, vol. 42, no. 4, pp. 14:1–14:53.

[8] Group, B.T.B.C.: The value of our digital identity. In: *Liberty Global Policy Series*. Liberty Global, 2012, p. 65.

[9] ISO: Information technology – Security techniques – A framework for identity management – Part 1: Terminology and concepts. In: *ISO/IEC JTC 1/SC 27 IT Security techniques*. ICS : 35.030 IT Security, 2011, p. 20.

[10] Juarez, M., Afroz, S., Acar, G., Diaz, C., Greenstadt, R.: A Critical Evaluation of Website Fingerprinting Attacks. In: *Proceedings of the 2014 ACM SIGSAC Conference on Computer and Communications Security*. CCS '14, New York, NY, USA, ACM, 2014, pp. 263–274.

[11] Ledford, J.: How to Recover Your Identity After Identity Theft Identity theft is scary but there are resources to help. Technical report, The Balance, 2017.

[12] Madsen, P., Koga, Y., Takahashi, K.: Federated Identity Management for Protecting Users from ID Theft. In: *Proceedings of the 2005 Workshop on Digital Identity Management*. DIM '05, New York, NY, USA, ACM, 2005, pp. 77–83.

[13] Maheswaran, J., Wolinsky, D.I., Ford, B.: CryptoBook: An Architecture for Privacy Preserving Online Identities. In: *Proceedings of the Twelfth ACM Workshop on Hot Topics in Networks*. HotNets-XII, New York, NY, USA, ACM, 2013, pp. 14:1–14:7.

[14] PYMNTS: Biometric Bank Buffers, For All. Technical report, Socure collaboration, 2017.

[15] Satchell, C., Shanks, G., Howard, S., Murphy, J.: Beyond Security: Implications for the Future of Federated Digital Identity Management Systems. In: *Proceedings of the 18th Australia Conference on Computer-Human Interaction: Design: Activities, Artefacts and Environments*. OZCHI '06, New York, NY, USA, ACM, 2006, pp. 313–316.

[16] Singh, K.K.V.V., Gupta, H.: A New Approach for the Security of VPN. In: *Proceedings of the Second International Conference on Information and Communication Technology for Competitive Strategies*. ICTCS '16, New York, NY, USA, ACM, 2016, pp. 13:1–13:5.

[17] Slamanig, D., Stranacher, K., Zwattendorfer, B.: User-centric Identity As a Service-architecture for eIDs with Selective Attribute Disclosure. In: *Proceedings of the 19th ACM Symposium on Access Control Models and Technologies*. SACMAT '14, New York, NY, USA, ACM, 2014, pp. 153–164.

[18] Staddon, J.: Finding "Hidden" Connections on linkedIn an Argument for More Pragmatic Social Network Privacy. In: *Proceedings of the 2Nd ACM Workshop on Security and Artificial Intelligence*. AISec '09, New York, NY, USA, ACM, 2009, pp. 11–14.

[19] Wang, T., Goldberg, I.: Improved Website Fingerprinting on Tor. In: *Proceedings of the 12th ACM Workshop on Workshop on Privacy in the Electronic Society*. WPES '13, New York, NY, USA, ACM, 2013, pp. 201–212.

Generating More Coherent and Informative Responses with Neural Chatbot

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Abstract. Ever since the emergence of artificial intelligence (AI), conversation was one of its greatest goals. It is because conversation is the closest to what we think of as "intelligence". It combines understanding natural language with its content and basic logic operations. Nowadays, the most perspective sector in AI are neural networks. However, solutions based on them still face large problems. Our aim is to solve some of these problems in the field of chatbots. The way neural networks operate causes repetitiveness and low informative value of utterances since the model creating responses tends to rely on safe, general, but barely informative responses like "I don't know". Our method consists of identifying utterances of this type and avoiding it. It also introduces more diversity into response generation as well as additional robustness into question processing.

1 Introduction

Neural networks "learn" new information during the process of training. The typical objective function that is maximized in tasks involving sequence to sequence learning is likelihood of output sequence given input sequence.

In the field of conversational systems, this is not a very good objective, because it tends to favor general responses that are applicable to almost any question. The frequency of this type of responses in human conversations (and available corpora) is relatively much higher to more specific responses. Furthermore, they appear as responses to wide range of semantically different questions, which makes it even easier for model to pick them up. Experiments with traditional models confirm it [5, 7].

For the task of sequence to sequence learning, the most widely used architecture is the *encoder-decoder* [2]. The input question is processed by the encoder which creates its representation, and then it is used by the decoder to generate response. The decoder does that incrementally. So, while first word is generated solely based on representation by encoder, following words are generated based also on previous ones. Consequently, the further from beginning of sentence the decoder is, the less guiding original representation is.

It makes the encoder-decoder model rather error-prone. In other words, a minor error in the question representation or starting words significantly affects generated answer.

In this paper we propose method dealing with aforementioned problems by increasing robustness and redundancy of response generation while increasing diversity and informative value of responses.

The paper is organized as follows. In section 2 we briefly present representative papers related to the proposed approach. In section 3 we define our method and in section 4 we present our early experiments and further planned tests. Section 5 concludes this paper.

2 Related work

Our paper builds on top of several previous works in the field. These are presented in this section, and are divided into two subsections. The first subsection presents neural conversational agents generally, the second aims specifically at the problem of repetitiveness.

2.1 Conversational Agents

Basis for the most of recent works in the field of natural language processing (NLP) or sequence to sequence problems is the paper establishing the encoder-decoder based model SEQ2SEQ [6]. Its main advan-

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tage is the end to end nature, and therefore applicability to wide range of different tasks (machine translation [6], conversation [7], paraphrase generation [1] etc.). This precise model was further used for the task of response generation [7] and is also basis for implementation we used for our early experiments.

2.2 Tackling repetitiveness

General, vague and repetitive responses have been studied already [2]. In our approach we directly use principle of Maximum Mutual Information (MMI), first introduced in this field in [4].

Given question Q and target response R, point of usual objective function is to maximize log-likelihood of response given question $\log p(R|Q)$. MMI as an objective function maximizes pairwise mutual information between response and question, and it can be written as $\log p(R|Q) - \log p(R)$.

It works very well, because it forces responses to be more specific. It expects mutual information between the question and response. In a sense, it is reversed with respect to the response generating model. While in normal model many specific questions may lead to one general response, in MMI only specific, more informative responses lead back to correct question.

3 Method

When you are having a conversation with someone, the other side may misunderstand what you say. What often helps is rephrasing the same thing and saying it again, in different words.

This is also basis of our method. The model may have problem understanding the question (the encoder part of it) and create wrong representation. The decoder then generates incoherent response, or settles for safe, vague one. We propose using paraphrases to prevent it. Our method has three steps.

Step 1: Paraphrase generation After receiving the question, the model generates semantically equivalent paraphrases. The most basic and naive approach is to replace original words with their synonyms according to the dictionary. This process does not involve AI, it is just about the algorithmic permutations generation. Another, more advanced way is to use an existing neural network specialized in paraphrase generation [1].

Then, the original question is, along with its paraphrases, used as an input for traditional SEQ2SEQ, encoder-decoder based response generator. It outputs a set of candidate responses.

In theory, the encoder is supposed to notice semantical similarity of paraphrases and output roughly the same representations, from which in turn the decoder generates roughly the same responses. In reality, this is not the case. The encoder is not perfect, so is not the decoder, and their however minor imperfections result in wide range of different responses. That is obviously what we desired.

Step 2: Response generation When having the paraphrases, another question is how to use them in response generation. One of the approaches is to use them separately, i.e. to generate a separate set of possible responses for every paraphrase and then to join all these sets to one big set of candidate responses.

Another, more efficient approach, is to generate representation for each of paraphrases, and then average them and create single resulting representation, from which the decoder generates set of candidate responses.

The first approach has the advantage of more diverse resulting candidate set. In the second approach, we introduce strong redundancy into the input, which in the field of neural networks is very desirable. It makes it easier for the network to notice what is important or recurring.

The usual model accomplishing the response generation itself is aforementioned encoder-decoder. Typically, it is implemented with Recurrent Neural Networks (RNN) for both encoder and decoder. In our case, words of question are one by one input into the encoder. Encoders output after the last word is the representation of question, and it serves as an input for decoder. The decoder then predicts words of response one by one, using inputs of question representation and previously generated word in each step.

During training, pairs of questions and responses are used. Question serves as the input, and model predicts the output. After each word is predicted the loss is calculated (i.e. how far the predicted word was from real word of the original response). This loss is back-propagated through the model and used to tweak its parameters (weights and biases). It is done through both decoder and encoder at once, as they created the loss together.

Step 3: Final response choice In the last step of our architecture, we have the set of multiple candidate responses and we need to chose one final. We expect this set to include variety of diverse responses, some more suitable, some less suitable. Some of responses may be completely off, since paraphrase generation may have introduced nonsense sentences, and some responses may be general and vague as we mentioned earlier.

Each candidate response was generated along with

its "score" - the number estimating relative probability of this response being the correct one according to the model. In our setting however, responses may come from different estimations (if we generated paraphrase questions separately) which renders the relative score useless. Furthermore, as we have discussed earlier, the score itself cannot be entirely trusted since it tends to promote responses with low informative value.

Nice and elegant solution for this task happens to be MMI. It is based on a separately trained network, that instead of predicting the best response for question, predicts the best question for response. Its beauty comes from its simplicity - exactly the same model that is used for response generation may be used for this, and it may be trained on exactly the same dataset with only the slight change of swapping questions and responses.

So, in the last step we score each of candidate responses with the reversed model that is most likely again encoder-decoder based, and implemented with RNNs. For each candidate response, we input it word by word into the encoder and final output representation is input for decoder. Now however, we do not let decoder predict question word by word, in each step using previous word as input. Instead, in each step we input word of original question, and let the decoder estimate probability of next word of "generated" question being same as the next word of original question.

The highest ranking candidate response (response that as input results it the highest probability for original question) is the response we finally output.

Summary Our method thus consists of three separate modules responsible for three different tasks (see schematic diagram in the Figure 1). The important aspect is independence of these modules. They are trained separately, just as they would be if they were used for their primary task (e.g. paraphrase generation) - regardless of the fact that they form a pipeline which aims to improve certain aspects of a chatbot. This approach has its advantages and disadvantages.

Models are not sharing information, they are not utilizing what other models "found out". If all models would be connected during training, final loss could theoretically be propagated more accurately to all models. However, creating this "connected" architecture would be very hard. Loss propagation is a delicate issue, and managing it across three models with different goals and architectures would likely fail.

Training each model separately is much simpler task, furthermore, one we already have relatively solid existing solutions for. Having three standalone components, any of them can be anytime swapped for other with same functionality. Or, to take the advantage of end to end nature of SEQ2SEQ model, we could have all components built on the identical model with only difference in training data.

4 Experiments proposal

General tests of our complete proposal need yet to be done. However, we have already tested some of its aspects using existing implementation [1]of "google chatbot" [7] with pretrained data.

To test paraphrase effectiveness, we have asked the same bot same question but rephrased in different words.

Q: what is your favorite color?
A: Dickless.
Q: what is your favorite colour?
A: Blue.
Q: what color do you prefer?
A: Sons to the district register.
Q: what colour do you prefer?
A: Second district ... .ummm ...

All questions are semantically identical, but as we expected, we received completely different responses. The main problem appears to be basic coherence, but in one phrasing we received correct response. Our method aims to improve probability of choosing correct response also in cases when actual model did not

Q: How old are you?
A: Twenty-five.
Q: What is your age?
A: I'm sorry. i'm sorry.
Q: How vintage are you?
A: Uh, i'm a traditional party.

In this case, the first question yields correct answer, whilst the second one results in barely informative response. The third question is intentionally wrong paraphrase which may occur with the naive approach to paraphrase generation. Its response is off-topic as expected, but it is not a problem, since MMI will safely filtrate it out and chose the only response that may be

[1] Used implementation is available at https://github.com/Conchylicultor/DeepQA

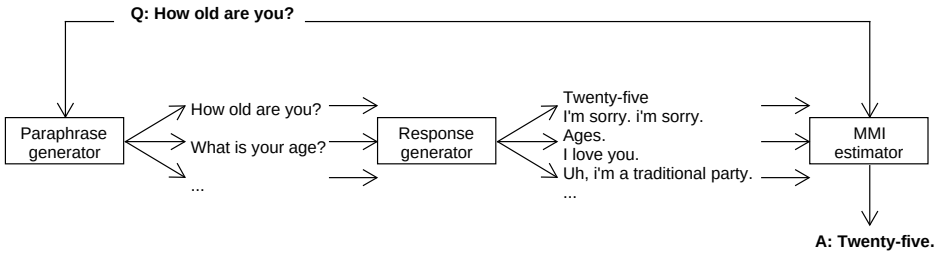

Figure 1. Schematic diagram of our method.

tracked back to the original question.

With the final implementation we plan to compare the effect of different paraphrase generation methods (no paraphrases vs. word-level dictionary based vs. sentence-level neural network based). Interesting is also comparison of different paraphrase uses for response generation (separate response generation vs. generation from one common representation). Lastly, we will compare results with and without MMI.

We will test general quality and informativeness of responses on human volunteers. Automatic evaluation of these attributes is still an open problem with no satisfying solution.

A very important part of learning in the field of neural networks is dataset used for training. Widely used standard for conversational agents is Cornell Movie Dialogues Corpus [3], consisting of more than 200000 conversational exchanges from movie scripts. For our experiments we are going to use primarily this dataset.

5 Conclusion

No conversational system is perfect (not even the most advanced one - humans). During the conversation, errors may occur in understanding of utterances. Our method aims to compensate and fix these errors by adding redundant information - paraphrases. We are not directly improving the response generation model itself, rather we are giving it more information and chances to get it right.

As a byproduct, we expect our method to improve repetitiveness and informative value of responses. In one variation, more information allows the model to create more specific answers. In the other variation, paraphrases of original question introduce further diversity into candidate responses and final response in turn.

Our method is simple to build and train using existing implementations of respective modules. It utilizes certain aspects of encoder-decoder model, but may be used on top of virtually any conversational system.

References

[1] Cao, Z., Luo, C., Li, W., Li, S.: Joint Copying and Restricted Generation for Paraphrase. In: *Proc. of the Thirty-First AAAI Conf. on Artificial Intelligence, February 4-9, 2017, San Francisco, California, USA.*, 2017, pp. 3152–3158.

[2] Chen, H., Liu, X., Yin, D., Tang, J.: A Survey on Dialogue Systems: Recent Advances and New Frontiers. *SIGKDD Explorations*, 2017, vol. 19, no. 2, pp. 25–35.

[3] Danescu-Niculescu-Mizil, C., Lee, L.: Chameleons in Imagined Conversations: A New Approach to Understanding Coordination of Linguistic Style in Dialogs. In: *Proc. of the 2nd Workshop on Cognitive Modeling and Computational Linguistics*. CMCL '11, Stroudsburg, PA, USA, ACL, 2011, pp. 76–87.

[4] Li, J., Galley, M., Brockett, C., Gao, J., Dolan, B.: A Diversity-Promoting Objective Function for Neural Conversation Models. In: *NAACL HLT 2016, The 2016 Conf. of the North American Chapter of the ACL: Human Language Technologies, San Diego California, USA, June 12-17, 2016*, 2016, pp. 110–119.

[5] Sordoni, A., Galley, M., Auli, M., Brockett, C., Ji, Y., Mitchell, M., Nie, J., Gao, J., Dolan, B.: A Neural Network Approach to Context-Sensitive Generation of Conversational Responses. In: *NAACL HLT 2015, The 2015 Conf. of the North American Chapter of the ACL: Human Language Technologies, Denver, Colorado, USA, May 31 - June 5, 2015*, 2015, pp. 196–205.

[6] Sutskever, I., Vinyals, O., Le, Q.V.: Sequence to Sequence Learning with Neural Networks. In: *Proc. of the 27th Int. Conf. on Neural Information Processing Systems - Volume 2*. NIPS'14, Cambridge, MA, USA, MIT Press, 2014, pp. 3104–3112.

[7] Vinyals, O., Le, Q.V.: A Neural Conversational Model. *CoRR*, 2015, vol. abs/1506.05869.

Diagnosis of Alzheimer's Disease by the Analysis of Data Obtained from Cognitive Tests Using Machine Learning Algorithms

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Abstract. In today's world neurodegenerative diseases, such as Alzheimer's disease, which is a type of dementia, are one of the leading medical challenges faced by humankind. Alzheimer's disease imposes a great financial and social burden to society, and its early diagnosis is crucial for treatments to be effective. Machine learning algorithms are often utilised as diagnostic tools. With the aid of machine learning algorithms, the analysis of patients' physical state can be performed in much shorter time. This paper describe the use of two approaches, a simpler one, logistic regression, and a more complex one, artificial neural network, which are used to evaluate the results of patients' cognitive tests to determine whether they have Alzheimer's disease or not. This paper also encompasses data pre-processing, the way the algorithms work in the context of predicting dementia in patients, and how suitable these algorithms are for the early diagnosis of Alzheimer's disease. In the end, we conclude that fusion of multiple examinations is necessary to achieve higher prediction accuracy.

1 Introduction

Alzheimer's disease (AD) is a progressive neurodegenerative disorder, which is the most common type of dementia. AD is a disease of the elderly, with over 10% of the population over 65 being affected [2]. The disease leads to the loss of nerves and tissues in certain areas of the brain, dramatically reduces their volume and affects most of their function [4]. AD alters the cognitive functions of the patients, which can be assessed using cognitive tests. AD also leads to structural changes of the brain, which can be detected using imaging studies (MRI, CT, etc.) [7]. Cognitive tests are standardized tests that are used to assess the cognitive status of patients. Such tests include inductive reasoning, situational judgement, intelligence and memory tests [9]. The above mentioned approaches allowed us to classify three stages of the disease: healthy brain (HC), brain with mild cognitive impairment (MCI) and the fully developed Alzheimer' disease (AD) [10].

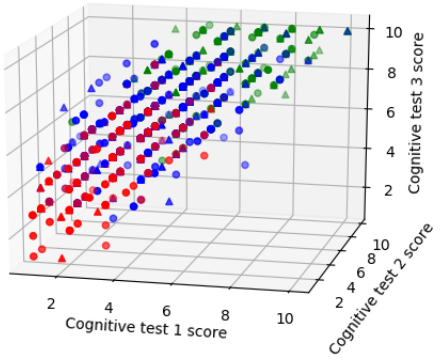

Figure 1. 3D display of the scores from 3 cognitive tests by patients.

Figure 1. shows the score of three cognitive tests of patients, where the axes represent three different tests and the colors denote the stage of the disease (green – HC, blue – MCI, red –AD).

There is an urging need to find a solution for the early diagnosis, as there is only a short time window where symptomatic treatment is effective. Furthermore, a study carried out by the Alzheimer's association in 2012 revealed that the number of people affected by the disease increases every year and it is predicted to double in the next two decades [2]. The affected individuals can find everyday activities difficult, and are often incapable of

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performing the simplest tasks. Therefore, they require social care. It is clear that the early diagnosis could reduce the cost of treatment and care, as well as to provide the patients with a better quality of life.

In the last 10 years many researchers have focused on developing computer-aided systems for the diagnosis and prediction of AD in patients and/or people at risk of developing the disorder. The systems use the data obtained from both imaging modalities and cognitive tests. Cognitive tests constitute an essential part of the diagnostic process. The aim of our work is to create a method for analyzing the data obtained from cognitive tests for the diagnosis of AD.

2 Related work

In the past the results of diagnostic tests of AD patients were analyzed manually. Since computer science developed rapidly, machine learning algorithms have been applied in the medical field. These algorithms are able to analyze data obtained from imaging modalities (such as MRI, PET, CT and DTI scans), gene maps and cognitive tests. The combination of results from different types of diagnostic methods can lead to a more accurate diagnosis/prognosis of the disease. These algorithms also offer a huge advantage over manually performed analyses, as they are much faster and do not require trained staff.

Stonnington et al. [11] performed a study in 2010 in which they analyzed data from MRI scans using a machine learning algorithm, relevance vector machine (RVR), to predict the clinical scores of the patients. They reported that RVR could be used to assess the relation between structural changes of the brain and cognitive tests, and therefore in practice could be utilized as a tool for diagnosis and prediction of the disease.

Another group, Reyes-coronel et al. [8] used support vector machine (SVM) algorithm to examine the results gathered from electroencephalogram (EEG) and neuropsychological assessments to predict whether an individual is at risk of developing AD or not. The combination of the data resulted in 80% accuracy of the prediction, and therefore was concluded that both EEG and cognitive test results are employable as AD predictors.

Lins et al. [6] proposed in 2017 the idea of using artificial neural networks to evaluate the data from neuropsychological tests. This report also took into account several other parameters, such as age, gender and level of education. They demonstrated that the level of accuracy of using only cognitive tests was above 90%, and therefore it was suggested that their approach could be very beneficial in using it either alone or as a support tool in diagnosing patients with dementia.

One of the most recent studies by Fasano et al [5] from 2018 also combined data from imaging modalities and cognitive tests, and analyzed them by SVM. They found that some cognitive patterns might be more important than others, and especially emphasized the usefulness of data from visuospatial memory tests. They also reported that the accuracy was 100%, however, the limitation of the study was that the sample size was only 22.

3 Proposed approach – AD prediction using Logistic regression (LR) and ANN

In this work we utilized two types of machine learning algorithms, and tested them on ADNI[1] datasets. LR, which is one of the simplest algorithms, was used as it is easy to understand but still serves are a valuable classification tool. Artificial neural network (ANN) is a more complex algorithm which plays a very prominent role in research. It offers several advantages, including providing a greater insight into the relationship between variables [13]. The algorithms employed in this project were subjected to several iterations to obtain the most accurate version for the diagnosis of Alzheimer's disease based on cognitive tests. Age, gender, level of education, score and which of the tasks were carried out correctly were used as features describing observations.

3.1 Logistic regression

Logistic regression was run both with a smaller and larger set of features. We also investigated how the algorithm behaved when the training set was modified to yield an equal sample size in each group, which is referred to as balanced training set throughout this whole paper. Two metrics were measured, accuracy and balanced classification accuracy. Accuracy (ACC) reflects the number of correct predictions out of all predictions:

$$ACC = \frac{(TP+TN)}{(P+N)} \qquad (1)^2$$

Balanced classification accuracy (BCA) calculates how accurate the predictions would be if the sample size in each group was equal:

$$BCA = (\frac{TP}{P} + \frac{TN}{N})/2 \qquad (2)$$

Table 1. shows that LR achieved the highest accuracy (Logistic regression 2) when multiple attributes and an unbalanced training set were used. The use of balanced training set resulted in a decrease in accuracy. On the other hand, balanced training set lead to increase in BCA.

[1] Alzheimer's Disease Neuroimaging Initiative.[1]

[2] TP – true positive, TN – true negative, P – positive, N - negative

Table 1. Results of various uses of Logistic regression in terms of Accuracy and Balanced Classification Accuracy. The table shows the 4 versions of Logistic regression-based experiments, which varied in used attributes and sample sizes of the groups. It also shows the breakdown of the confusion matrix, where 0 means healthy brain (HC), 1 means mild cognitive impairment (MCI) and 2 means Alzheimer's disease (AD). The highlighted green rows represent where the algorithm made the correct prediction, while both brighter and darker red ones were incorrect. The values of the confusion matrix are represented under each other in separate rows.

	Logistic regression 1	Logistic regression 2	Logistic regression 3	Logistic regression 4
Balanced training set	FALSE	FALSE	TRUE	TRUE
Including tasks	FALSE	TRUE	FALSE	TRUE
Accuracy	0.6627	0.7015	0.5904	0.5864
Balanced Classification Accuracy	0.5801	0.6147	0.6680	0.6918
Classified 0 correct 0	40	35	107	81
Classified 0 correct 1	7	2	13	3
Classified 0 correct 2	91	63	18	16
Classified 1 correct 0	3	2	16	11
Classified 1 correct 1	151	151	193	180
Classified 1 correct 2	75	56	20	18
Classified 2 correct 0	27	29	138	140
Classified 2 correct 1	58	71	112	121
Classified 2 correct 2	322	338	157	177

3.2 ANN

ANN algorithm has also undergone several iterations, where different attributes, architectures and distinct training strategies were applied and evaluated.

The final architecture which was employed in this paper can be seen in Figure 2. The neural network consists of two hidden layers (100 neurons in every layer) and classifies subjects into 3 classes (HC, MCI, AD).

In addition, different training techniques were utilized, such as evaluation, network tuning, dropout and early stopping. Dropout and early stopping were used to avoid overfitting. The results in terms of accuracy and BCA by different iterations of ANN are summarized in Table 2.

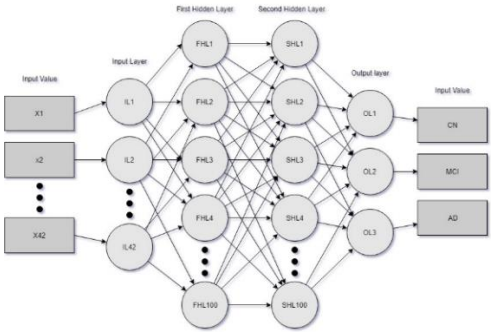

Figure 2. ANN architecture.

Table 2. Accuracy and Balanced Classification Accuracy achieved using artificial neural network (ANN). The table shows the 4 variations of the algorithm, which varied between their attributes and sample sizes of groups. It also shows the breakdown of the confusion matrix, where 0 means healthy brain (HC), 1 means mild cognitive impairment (MCI), 2 means Alzheimer's disease (AD). The highlighted green rows represent where the algorithm made the correct prediction, while both brighter and darker red ones were incorrect. The values of the confusion matrix are represented under each other in separate rows.

	ANN 1	ANN 2	ANN 3	ANN 4	ANN 5
Balanced training set	FALSE	FALSE	TRUE	TRUE	TRUE
Including tasks	FALSE	FALSE	TRUE	TRUE	TRUE
Evaulating and tuning	FALSE	TRUE	TRUE	TRUE	TRUE
Dropout	0	0	0.1	0.5	0.5
Early Stop	FALSE	FALSE	FALSE	FALSE	TRUE
Accuracy	0.6563	0.6589	0.6627	0.6801	0.6613
Balanced Classification Accuracy	0.5725	0.5716	0.6142	0.5974	0.6372
Classified 0 correct 0	33	31	44	33	51
Classified 0 correct 1	4	7	2	0	1
Classified 0 correct 2	101	100	54	67	48
Classified 1 correct 0	2	1	7	3	5
Classified 1 correct 1	163	164	149	151	156
Classified 1 correct 2	64	64	53	55	48
Classified 2 correct 0	26	28	61	40	66
Classified 2 correct 1	69	64	75	74	85
Classified 2 correct 2	312	315	302	324	287

Table 2 shows that ANN worked the best with multiple attributes, balanced training sets and 50% dropout rate (ANN 4). BCA values improved when early stop was also applied. ANN4 achieved the best results in terms of accuracy, while ANN5 resulted in the highest BCA result.

3.3 Comparison of our two algorithms

The two algorithms, LR and ANN, used in this work produced approximately the same level of accuracy. The best version of LR (LR 2 from Table 1.) resulted in 70% accuracy, while the highest accuracy of the ANN algorithms was achieved by ANN 4 (from Table 2.) at 68%. Similarly, the highest BCA score by LR (Logistic regression 4 - Table 1.) was 69%, while by ANN (ANN 5 - Table 2.) was 64%.

4 Comparison with other works

Among the current grand challenges there exists a so-called Tadpole challenge where researchers compare their algorithms which work on ADNI datasets for the diagnosis and prediction of Alzheimer's disease. Most of the research groups use a combination of different types of data contained in ADNI, such as MRI, PET, CSF, DTI, gene maps and cognitive tests. The top ten algorithms work with an accuracy of over 85%, which are 20% more accurate than approaches described in this paper [12]. In our opinion the difference is caused by the fact that most other methods utilize not only cognitive tests, but also additional information.

5 Conclusion and future work

In our work, we experimented with two machine learning algorithms to accurately diagnose Alzheimer's disease from the results of cognitive tests. The cognitive tests are vital in diagnosing Alzheimer's disease, as they assess the memory, language, visual spatial abilities of patients [3]. Imaging studies only reveal the structural or functional changes in the brain. There was no significant difference between Logistic regression and ANN. In comparison to other algorithms, which also analyze data from neuroimaging, we achieved lower accuracy. In the future, we are going to combine various tests and examinations (not only cognitive) to achieve higher accuracy of the diagnosis and prediction of Alzheimer's disease.

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References

[1] Adni.loni.usc.edu. (2018). ADNI | Alzheimer's Disease Neuroimaging Initiative. [online] Available at: http://adni.loni.usc.edu/ [Accessed 25 Feb. 2018].

[2] Alzheimer's association, et al. 2012 Alzheimer's disease facts and figures. Alzheimer's & Dementia, 2012, 8.2: 131-168.

[3] Baldwin, Sharelle; Farias, Sarah Tomaszewski. Unit 10.3: Assessment of Cognitive Impairments in the Diagnosis of Alzheimer's Disease". Current protocols in neuroscience, 2009, Unit10. 3.

[4] Bishop, Nicholas A.; LU, Tao; Yankner, Bruce A. Neural mechanisms of ageing and cognitive decline. Nature, 2010, 464.7288: 529.

[5] Fasano, F., et al. Combining structural magnetic resonance imaging and Visuospatial tests to classify Mild Cognitive Impairment. Current Alzheimer research, 2017.

[6] Lins, A. J. C. C., et al. Using artificial neural networks to select the parameters for the prognostic of mild cognitive impairment and dementia in elderly individuals. Computer methods and programs in biomedicine, 2017.

[7] Neugroshl, Judith; Wang, Sophia. Alzheimer's disease: diagnosis and treatment across the spectrum of disease severity. Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine, 2011, 78.4: 596-612.

[8] Reyes-Coronel, Carmina, et al. Predicting rapid cognitive decline in Alzheimer's disease patients using quantitative EEG markers and neuropsychological test scores. In: Engineering in Medicine and Biology Society (EMBC), 2016 IEEE 38th Annual Int. Conference of the. IEEE, 2016. p. 6078-6081./

[9] Sims, Regina C., et al. An examination of dedifferentiation in cognition among African–American older adults. Journal of cross-cultural gerontology, 2009, 24.2: 193-208.

[10] Steiner, Ana Beatriz Quintes, et al. Mild cognitive impairment and progression to dementia of Alzheimer's disease. Revista da Associação Médica Brasileira, 2017, 63.7: 651-655.

[11] Stonnington, Cynthia M., et al. Predicting clinical scores from magnetic resonance scans in Alzheimer's disease. Neuroimage, 2010, 51.4: 1405-1413

[12] Tadpole.grand-challenge.org. (2018). TADPOLE - Leaderboard. [online] Available at: https://tadpole.grand-challenge.org/leaderboard/ [Accessed 24 Feb. 2018].

[13] Tu, Jack V. Advantages and disadvantages of using artificial neural networks versus logistic regression for predicting medical outcomes. Journal of clinical epidemiology, 1996, 49.11: 1225-1231.

Automated Segmentation of Brain Gliomas using Convolutional Neural Networks

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Abstract. Deep neural networks are currently very successful in many areas of research but medical image processing still lacks the required precision. In this paper, we compare two approaches to automatic brain tumor segmentation based on deep neural networks. In particular, we focus on segmentation of brain gliomas characterized by their different shape, size and position. The first approach is the classification model using convolutional neural networks, where we classify the larger regions of the image. The second approach is simplified and modified U-Net [8] model. For training, testing and evaluation of proposed approaches, we use the data of the International Multimodal Brain Tumor Segmentation (BraTS) Challenge 2017 [2, 5].

1 Introduction and motivation

Semi-automatic and automatic segmentation of medical volumetric data and their analysis is currently a problem that is difficult to solve. In our work, we focus on on segmenting the most commonly occurring tumor form, i.e. glioma [4], which is characterized by its heterogeneity. It is a type of tumor that occurs in different sizes, shapes and has different properties depending on the stage of development, which makes identification difficult.

One of the other causes of the complexity of the problem is the use of various MRI standards. Each MRI has a specific setting that differentiates the voxel display of the same objects in the real world. In the case of manual annotation of experts, this can lead to the problem of incorrect segmentation [4]. Another factor contributing to inaccuracies is the length of the manual annotation from the expert. Manual annotations are performed on images of the whole brain, often using data from various magnetic resonance imaging (MRI) modalities (T1, Tc1, T2 and FLAIR). This makes the processing complexity to grow, which is a negative factor in professional judgment.

2 Related works

Many approaches of tumor segmentation are currently known to address the issue to a certain extent. Current state-of-the-art methods still do not achieve optimal results so the problem of brain tumor segmentation is still considered to be current by the research community. From multiple approaches used to automatically segment brain tumors, we consider atlas-based segmentation [6] and artificial neural [1, 3, 7, 8] to be dominant these days.

3 Dataset

In our work we are using dataset from BraTS, which consists of two categories of tumors, Low-Grade (LGG, 75 volumes) and High-Grad (HGG, 210 volumes) Gliomas. Each volume in training set is composed of four modalities and segmentation mask, which consists of 4 labels. For training and evaluation of our model we used LGG data. We modified the segmentation's masks to regions of size 5x5x5, where final label of region is is equal to the most occurring label contained in this region. Finally, we transform all segmentation's masks to binary segmentation with labels 0 (non-tumor, original label 0) and 1 (tumor, original label 1,2 and 4).

4 Methods

Our approach is based on state-of-the-art methods (the best and the most recent method) of automatic brain tumor segmentation using convolutional neural networks (CNN). In our approach we classify small volume's regions with the same size. The final segmen-

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tation mask of volume consist of all labels made by regions classification(RegionCNN-classify).

4.1 RegionCNN-classify

The architecture of our CNN network contains five convolutional (2D CNN) and three fully-connected (FC) layers. Convolutional layers preserved resolution of the input signal. This was achieved by padding .The activation function of every layer was ReLu. Softmax was used as the activation function of the last layer. The architecture of RegionCNN can be seen in Table 1.

Table 1. Architecture of the RegionCNN-classify neural network.

Layer	Size
Input	*(5,5,5*4)*
2D CNN	*(3,3,20,40)*
2D CNN	*(3,3,40,60)*
2D CNN	*(3,3,60,80)*
2D CNN	*(3,3,80,100)*
2D CNN	*(3,3,100,120)*
FC 1	*(5*5*20*6, 2048)*
FC 2	*(2048, 1024)*
OUT	*(1024, 2)*

4.1.1 Pre-processing

In each modality of all brains we use normalization to zero mean with unit variance. Then we randomly chose from LGG data 54 volumes for training set and 20 volumes for test set. Each volumes we divide to independent samples of size 5x5x5x4 (depth, height, width, number of channels). To address the problem of very imbalanced classes contained in the data, we adjust training samples. We use for training 80% of samples with label 0 and all training samples with label 1 we repeated 2 times. Final size of training and validation set in in the Table 2.

Table 2. Approximate number of samples in training and test sets.

Label	0		1	
Set	*Training*	*Valid*	*Training*	*Valid*
Size	400 000	200 000	80 000	20 000

4.1.2 Experiments and Results

In our experiment we focused on input parameters to our method. We test our model with two different input size. Input of the first experiment is a 3D region with size 5x5x5x4, where 4 is the number of channels representing different MRI modalities contained in a particular examination. In the second experiment, we add to each sample their neighbourhood of size 4 on each side, resulting in a region with size 13x13x13x4. The label is in the second experiment still based on the 3D region with resolution 5x5x5x4.

Table 3. Average of Dice score on test set.

Input	(13,13,13,4)	(5,5,5,4)
Dice score	*73%*	*62%*
TPR	*79%*	*73%*
TNR	*97%*	*94%*

Table 4. Confusion matrix of all four evaluation tests on test LGG data with input shape 5x5x5x4.

		True condition	
		Condition positive	*Condition negative*
Predicted condition	*Predicted condition positive*	*54 850*	*45 857*
	Predicted condition negative	*19 916*	*810 452*

Table 5. Confusion matrix of all four evaluation tests on test LGG data with input shape 13x13x13x4.

		True condition	
		Condition positive	*Condition negative*
Predicted condition	*Predicted condition positive*	*53 720*	*24 546*
	Predicted condition negative	*14 605*	*837 987*

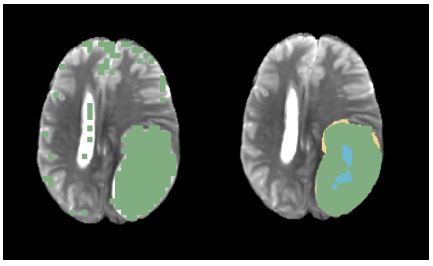

Figure 1. Compare of segmentation by RegionCNN-classify (size of input 5x5x5x4, left) with true segmentation (right).

We test our method on four same experiments with randomly selection of training ant testing set, where we measure average of Dice score, True positive rate

(TPR) and True negative rate (TNR), Table 3. Also we construct confusion matrix of testing data, tables 4 and 5.

5 Conclusion

We presented our approach of fully automated technique for segmentation of gliomas. We use deep CNN, which is core of the state-of-the-art methods. As the results show, the addition of the neighborhood to each sample has positive impact to final segmentation. The improvement of the results is 11% of Dice score. Next step in our research will be compare our method with U-net model [8]. The approach of U-net, where is whole segmentation mask of each brains is generated at once. They can achieve better results because our experiments have also shown that exploration based on wider contextual consciousness leads to better results.

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References

[1] Andermatt, S., Pezold, S., Cattin, P.: Multi-dimensional gated recurrent units for the segmentation of biomedical 3D-data. In: *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. Volume 10008 LNCS., 2016, pp. 142–151.

[2] Bakas, S., et al.: Advancing The Cancer Genome Atlas glioma MRI collections with expert segmentation labels and radiomic features. *Scientific Data*, 2017, vol. 4, no. July, pp. 1–13.

[3] de Brebisson, A., Montana, G.: Deep Neural Networks for Anatomical Brain Segmentation, 2015.

[4] Havaei, M., et al.: Brain tumor segmentation with Deep Neural Networks. *Medical Image Analysis*, 2017, vol. 35, pp. 18–31.

[5] Menze, B.H., et al.: The Multimodal Brain Tumor Image Segmentation Benchmark (BRATS). *IEEE Transactions on Medical Imaging*, 2015, vol. 34, no. 10, pp. 1993–2024.

[6] Nayak, D., Roth, T.L., Mcgavern, D.B.: HHS Public Access, 2014, vol. 24, no. 2, pp. 367–402.

[7] Pinto, A., Alves, V., Silva, C.A.: Brain Tumor Segmentation using Convolutional Neural Networks in MRI Images. *IEEE Transactions on Medical Imaging*, 2016, vol. 35, no. 5, pp. 1240–1251.

[8] Ronneberger, O., et al.: U-Net: Convolutional Networks for Biomedical Image Segmentation. In: *Medical Image Computing and Computer-Assisted Intervention – MICCAI 2015*, Cham, Springer International Publishing, 2015, pp. 234–241.

New Testing Scenarios for MANET Routing Protocols

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Abstract. In this paper we propose new efficient attacks and testing scenarios for evaluation of security in MANET routing protocols. Created scenarios were implemented in the network simulator and impacts on the network properties were evaluated.

1 Introduction

MANET (Mobile Ad Hoc Networks) are nowadays one of the most evolving networks. Basic characteristic of MANETs is dynamic forming with independent mobile nodes, connected by various wireless technologies without previous network infrastructure and centralized administration. Their main disadvantages are limited bandwidth, dependency on energy sources and greater vulnerabilities to attacks [1].

Existing routing protocols must be quickly adaptable to frequent topology changes, while saving up limited computing resources. In general, they use link state (proactive) or distance vector algorithms (reactive) [2]. In our paper, we focus on reactive protocols which nodes request path information only when it is necessary. There is no need for periodical flooding of topology requests. Examples of reactive routing protocols are AODV (Ad hoc On-Demand Vector routing) and DSR (Dynamic Source Routing).

Several methods were proposed to secure these routing protocols. Their prevention mechanisms can be based on asymmetric cryptography (ARAN [3]), symmetric cryptography (SRP [4]), one-way hash chains (SAODV [5]) or hybrid principles (Ariadne [2]). Solutions of SRP and SAODV proposed extended secure header which can be used by other non-secure routing protocols, while ARAN and Ariadne are standalone protocols.

Security proposals are not standardized tested, so their comparison based on their papers can be difficult. Therefore, we proposed new attacks which can thoroughly verify proposed solutions. These attacks are part of the created testing scenarios which includes various modes of attack types that are focusing to influence the same network properties.

2 Related work

No other papers dealing with security evaluation of MANET protocols have been found. Scenarios used in individual evaluations are often simplified and not very detailed. Proposals of SAODV [5] and SRP [4] contain only security assumptions without any evaluations. Authors in [6] were evaluating proposed mechanism on AODV protocol with only specific scenario for detection of blackhole. Other types of attacks focusing route discovery processes were not tested. Solution was verified with packet delivery, packet loss and throughput metrics.

Detailed analysis was done by authors of ARAN [3]. Protocol proposal was tested on attack types as modifications of protocols fields, tunnelling, spoofing and fabrication. Simulations were performed with 20 and 50 nodes with random initial positions. Results were evaluated using several metrics, such as average path length, routing load, average delay etc.

In common, evaluations are mainly focused only on few specific use cases that are often suited for the created methods. Created vulnerabilities to other attack types could not be therefore detected. Further information about nodes speed, transmission delays and ranges are also rare.

3 Basic principles of reactive routing protocols

In general, reactive routing protocols are using three types of messages. Route request (RREQ), route reply (RREP) and route error (RERR).

RREQs and RREPs are used in the route discovery process. If node A wants to send data to node B and routing table of node A does not contain created route, then node A initializes route discovery process with broadcasting RREQ message. Every node, except destination node B, that receives this message rebroadcasts it to the network and saves the backward route to node A. Special field called

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broadcast id in RREQ message is often used for loop prevention, when node drops this type of message with already seen value of broadcast id.

Node B after receiving first RREQ sends unicast RREP via already created backward route. Other received RREQs are dropped. This ensures that created route is the fastest and not the shortest one. When node A receives RREP, route is established and communication between these two nodes can begin.

RERR messages serves as notifications of topology changes. They can be generated in multiple situations to cause reinitialization of the route discovery process.

4 Created attacks and testing scenarios

Created attacks are based on the use of communication between multiple cooperating malicious nodes.

Each testing scenario consists of multiple attacks called modes. Modes in scenario share common goal, such as prevention of regular message delivery.

4.1 Juggler attack

The goal of the juggler attack is to cause delays in communication between nodes, consumption of the available bandwidth and increase load on nodes in the network. Messages will be delivered to the destination but added delay can cause problems for different applications. Amount of added delay can be controlled. The assumptions for successful attack are:

- Existence of route from source to destination node through malicious node
- Existence of at least two malicious nodes

Attack consists of three following steps:

1. Perform an attack to ensure routing to destinations via malicious node. (Optional)
2. Add delay by creating temporary loop between cooperating malicious nodes.
3. Deliver a message with a defined delay.

First optional step can influence routing discovery process using modified RREQs. These modified messages can contain very low hop count value and therefore will malicious node be chosen as a next hop for the destination node. More routes via malicious node will cause greater impact on the network.

Second step adds defined delay to the communication between source and destination node. Our solution exploits the existence of other malicious nodes in the network. Incoming messages are wrapped to another message and send to randomly selected cooperating malicious node. Malicious node that received this message will send it again to another malicious node in the network. This process creates loop that adds delay to the original message and also consumes part of limited network resources.

The initial malicious node that created delay loop checks if the defined delay has been achieved. Once this condition is met, original message can be sent without any modification via defined next hop and a stable addition of the delay will be achieved. It is advisable to periodically initiate route discovery process between malicious nodes to ensure stable connection.

Example of this attack can be seen in the Figure 1 where node A wants to send data message to node F.

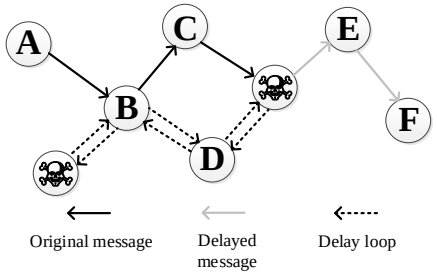

Figure 1. Juggler attack with two malicious nodes.

4.1.1 Testing scenario of juggler attack

In the case of a juggler attack, scenario consists of the three modes whose influence on the selected network parameters will be compared with other modes.

First mode adds static delay without creating delay loop. Malicious node, after receiving data message from the basic nodes will hold this message for defined time interval and then send it to the next hop.

Second mode uses described juggler attack without the first optional step. Malicious nodes do not create any modified messages to exploit route discovery processes.

Third mode consists of juggler attack with first optional step. Malicious nodes will try to exploit route discovery processes to influence path selection.

4.1.2 Monitored network parameters of juggler testing scenario

Modes will be evaluated within the following monitored network parameters:

- Average ping delay
- Total size of data transmitted in network
- Number of messages, that were delayed
- Number of messages, that were not delayed
- Number of messages, exchanged between malicious nodes

4.2 Black-wormhole attack

By combining the blackhole and wormhole attack we can create a very strong attack that can offset the imperfections of single blackhole mechanism. Attack consists of two following rules:

1. If received message is used in the route discovery process, then act as wormhole.
2. If received message is data message, then act as blackhole.

Blackhole uses modified fake messages with low hop count values to pretend that the shortest path to destination node leads via this malicious node. All received data messages are then dropped. This mechanism is inefficient in cases where the modification of hop count values is not possible for reasons of secure routing protocols or when protocol does not use this field at all.

To overcome limitations of single blackhole attack, we propose to use wormholes to create seemingly shortest and fastest path between ordinary nodes in network. Wormholes are using high speed connection between malicious nodes to speed up the delivery of messages in the network. Ordinary nodes will than appear closer than they really are. RREQs will be then faster delivered via this created tunnel, which will result in creating routes via malicious nodes. After creation of these routes we can switch nodes to blackhole or greyhole (random drop) mode. For the most difficult detection of the attack we can use wormholes in hidden modes, so they will be invisible to other nodes in the network.

Example of black-wormhole attack with three collaborating malicious nodes can be seen in the Figure 2. Node A wants to send data to node E but the route is not established yet, so route discovery process is initiated. RREQ will be tunnelled via wormhole, so the first message that node E will receive will be through our malicious nodes. Node E sends RREP back via our wormhole. Route is successfully created, and all received data can be dropped.

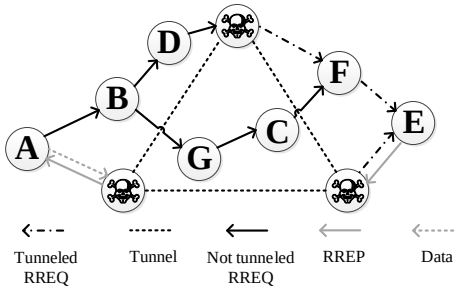

Figure 2. Black-wormhole attack.

4.2.1 Testing scenario of black-wormhole attack

Created testing scenario consists of the five modes. First mode uses nodes only in wormhole mode which will create shortest paths without the need of message modification. Anonymous mode in which these nodes are not visible to ordinary nodes is recommended.

Nodes in second mode are working only as regular blackholes which are generating fake messages to exploit route discovery processes. All messages routed via these nodes will be dropped.

Third mode uses only grey holes instead of black holes. All messages routed via these nodes are randomly dropped. Some of them will therefore be delivered and some not.

Fourth mode is based on our proposed black-wormhole attack which was described above.

The last fifth mode adjusts the fourth mode to use a greyholes instead of blackholes.

4.2.2 Monitored network parameters of black-wormhole testing scenario

Modes will be evaluated within the following monitored network parameters:

- Average percentage of successful pings
- Average hop count
- Number of exploited route discovery processes
- Number of dropped messages
- Total size of data transmitted in network

5 Evaluation

Selected routing protocols and proposed scenarios were implemented in OMNeT++ network simulator. All scenarios were tested on the network with 5 - 15 nodes which could move randomly. Every simulation was repeated five times to achieve average results. Values of network and routing protocol parameters can be seen in the Table 1.

Table 1. Parameters of network simulations.

Parameter	Value
Number of ping retransmits after failure	*5*
Transmission range	*300 m*
Ping retransmit wait	*500 ms*
Transmit delay	*10 ms*
Speed of nodes	*10 m/s*

This paper presents evaluation results of AODV protocol with parameters in the Table 2.

Table 2 Parameters of AODV protocol.

Parameter	Value
Routing table lifetime	*3 s*
Routing table lifetime update interval	*1 s*

5.1 Juggler scenario evaluation

Results of the scenario simulation can be seen in the Figure 3. Each attack was successful and added certain delay to ping messages.

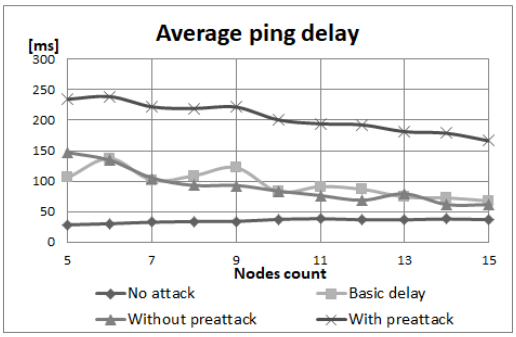

Figure 3. Simulation of Juggler attack.

Best results were achieved with our proposed attack which used first optional step. Other modes achieved significantly lower results in this metric.

Difference between basic delay and without pre-attack modes were noticed in total data transmitted metric, where mode without optional step generated 1 266 % more data than basic delay mode which was not creating any additional data compared to simulation without attack. Attack with optional step achieved best results with 13 653 % more data generated then basic delay attack.

5.2 Black-wormhole scenario evaluation

Ping success rate of the scenario can be seen in the Figure 4.

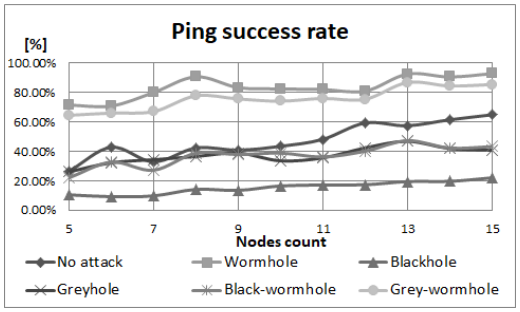

Figure 4. Simulation of Black-wormhole attack.

Basic blackhole achieved lowest ping successful rate of all modes. Our proposed black-wormhole attack achieved same results as greyhole. This is very interesting because we did not generate any fake messages to exploit route discovery mechanism and therefore is our proposed attack much harder to detect. Modes based on wormholes achieved higher successful rate due to increased availability of the nodes in the network. These routes can be used to eavesdrop communication between nodes.

Lowest hop count values were achieved in modes based on wormholes with values from 1-2 hops (5-15 nodes) followed by mode without attack (1-3 hops), blackhole (2-3 hops) and greyhole (3-5 hops).

6 Conclusion

In this paper we proposed testing scenarios for MANET routing protocols with two new attacks based on collaboration between multiple malicious nodes.

New proposed attacks are described in detail with assumptions for successful execution, individual steps and example figures. Scenarios are defined by multiple modes with specified monitored network parameters.

MANET routing protocols can therefore be compared with each other using our testing scenarios which were not created with focus on specific attacks that should be detected by proposed solutions. Scenarios contain also standard and non-standard attacks for thorough protocol evaluation and comparison.

References

[1] LIU, J., CHLAMTAC, I.: Mobile Ad-hoc networking with a view of 4G Wireless: Imperatives and Challenges. In: *Mobile ad hoc networking*, (2004), pp. 13-64.

[2] ALSLAIM, M., ALAQEL, H.: A comparative study of MANET routing protocols. In: *e-Technologies and Networks for Development (ICeND)*, (2014), pp 178-182.

[3] SANZGIRI, K., DAHILL, B.: A secure routing protocol for ad hoc networks. In: *Network Protocols 10th IEEE International Conference*, (2002), pp 78-87.

[4] PAPADIMITRATOS, P., HAAS, Z.: The Secure Routing Protocol (SRP) for Ad Hoc Networks. INTERNET-DRAFT, (2002).

[5] ZAPATA, M.: Secure ad hoc on-demand distance vector routing. In: *ACM SIGMOBILE Mobile Computing and Communications Review*, vol. 6, (2002), no.3, pp. 106-107.

[6] TANK, V., LATHIGARA, A.: To Detect and Overcome Sinkhole Attack in Mobile Ad hoc Network. In: *Communications on Applied Electronics (CAE)*, vol. 2, (2015), no.6, pp. 1-5.

Mathematical Optimization of Design Parameters of Photovoltaic Module

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Abstract. We propose a method for finding the most appropriate photovoltaic (hereafter PV) module, the direction of PV module and the return on investment for specific household needs, leveraging mathematical optimization. Based on electricity consumption and location of the household, the algorithm finds PV module design parameters. According to these computed design parameters, the algorithm finds the most similar PV module from the dataset of PV modules and calculates savings and the return on investment. When calculating the return on investment, the algorithm takes into account the price of electricity, government subsidies, initial investment and maintenance costs.

1 Introduction

PV modules represent one of the possible alternatives to current sources of electricity. The advantage of PV modules is that they do not need a distribution network. They become an interesting choice in areas that are not connected to the distribution network yet and also for small systems whose connection to the distribution network would be economically disadvantageous, e.g. electronic information boards alongside motorways.

But we will deal with the use of PV systems in households, especially in terms of return on investment. The economy of the PV system, for ordinary users, is highly dependent on their consumer habits and lifestyle, as it affects the electricity consumption curve throughout the day. The ideal case would be if consumers spent their energy just in time when the PV module generates the most electricity. However, this ideal scenario is out of the question in practice because people are usually at work at a given time unless it is a weekend or a day off. This problem can be solved to a considerable extent by installing batteries that are charged at the peak of electricity generation, and then this energy can be used to cover increased consumption at a time when the PV module cannot fully cover household demand.

2 Related work

In recent years, interest in renewable energy has grown and it is natural that a number of projects have been created to help calculate and decide whether the investment in the PV system will return and if so, when. The most well-known projects are Project Sunroof developed by Google [3] and System Model Advisor [6] developed by the National Renewable Energy Laboratory.

The aim of the Project Sunroof [3] is to provide the user with information about the solar potential of his roof. The user can enter his / her address, or select the building that interests him / her directly from the map. Google Maps is used for this purpose. The user still has to set the monthly electricity bill. Subsequently, the Project Sunroof calculates how much sunlight falls on the roof of the selected building for one year. These calculations work with Google image and map databases, 3D models of roofs. They also calculate different shadows that cast the surrounding buildings and trees, all possible sun positions over the year, and historical cloud and temperature data that can affect the power generation from PV modules. Output is the number of solar hours over a period of one year, the size of the roof area that is suitably illuminated for the installation of PV modules, estimated savings over twenty years, and potential positive environmental impacts. The biggest drawback of the Project Sunroof is that it only takes into account some areas of the United States and no other country. Also,

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a user cannot choose a more detailed consumption curve or at least some model household, he can only enter an electricity bill. Even the selections of the PV module or the size of the battery capacity are not available.

System Advisor Model [6] is software that provides a performance and finance model for renewable energy. In the field of renewable energy, this software covers photovoltaics, wind turbines and even biomass. They use a large database of PV modules, voltage transducers, parabolic trough receivers and collectors, wind turbines and biogas combustion systems. They take into account the location of the system, the type of device in the system, the cost of installing and operating the system, the financial and incentive assumptions. Unlike the Project Sunroof, they allow the user to choose the individual elements of the system from their component database. They also allow the user to select the weather for a particular area from the list, download weather data from the internet or create their own weather data. On the other hand, the software is very extensive and therefore the orientation in it is not easy at all. With the huge amount of functionality the software provides, the user can quickly lose himself.

Due to aforementioned drawbacks, we decided to implement our own application, which would have a clear and simple interface and would only cover the area of photovoltaics.

3 Proposed algorithm

Our goal is to maximize the financial savings and return on investment for PV modules by means of optimization function defined by equation 1. Based on annual data on electricity consumption, electricity prices and location, the algorithm decides whether the investment will pay off. If a user has no data of his / her consumption, he / she can generate data using various tools (e.g., Load Profile Generator [7]). The user will also be able to choose:

- the amount of government subsidies (if any),
- expected power of the PV system,
- battery capacity (if installed),
- the azimuth of the PV module manually or choose to optimize it.

The algorithm then calculates the design parameters of the ideal PV module based on the power consumption and household location.

Objective function is defined to maximize total savings. We can express it as:

$$\text{maximize } S_t(X) = 20 * S_a(X) + G – C_t \qquad (1)$$

where S_t represents total savings, $S_a(X)$ represents average annual savings saved by the PV system with or without battery, X represents PV module design parameters to be optimized (and azimuth if chosen), average annual savings are multiplied by 20 because we assume the system lifetime to be 20 years without the need for a complete component replacement, G represents government subsidies, C_t represents total installation costs of the PV system and is defined by the following formula:

$$C_t = 2 * I_b + I_c + I_i + C_i + I_p \qquad (2)$$

where I_b represents the amount of investment in batteries, I_c represents the price of charge controller, I_i represents the price of solar inverter, C_i represents the cost of installing the PV system, I_p represents the amount of investment in PV modules. The amount of investment in batteries is multiplied by 2 because we expect the battery lifetime to be 10 years, but the lifetime of the PV system to be 20 years.

Due to the fact that the battery voltage affects the type of charge controller, we have decided to choose the appropriate battery type and the charge controller that work together. We have given the user the ability to enter the number of batteries. We chose the battery [9] with a price of €425 after the price was converted from the dollars. The appropriate charge controller [8] has a price €257.

The price of the inverter depends on the power of the PV system. After consulting the prices with the company ESolar [2], we chose the following prices shown in table 1.

Table 1. Inverter prices based on PV system power.

Power (W)	Price (€)
1501 - 2000	590
2001 - 2500	650
2501 - 4000	1090
4001 - 10000	2560

We have also consulted the installation costs with the company ESolar [2] and came up with the following prices:

- metal construction for mounting PV modules:
  - pitched roof: €53 per PV module,
  - facade: €86 per PV module,
- the price of installation of the PV system, including the material is calculated as €0.29 per 1 Wp of PV system performance,
- estimated cost of battery installation is €15 per battery,
- estimated cost of charge controller installation is €10.

Since databases of PV modules do not include their average prices, the prices of PV modules are estimated

as follows:

$$I_p = n * M_{pp} * P_{wp} \quad (3)$$

where I_p represents the amount of investment in PV modules, n represents the number of PV modules, M_{pp} represents PV module peak performance, P_{wp} represents price for Wp (watt peak). Due to the huge variety of PV modules and the prices, the price for Wp can be changed by the user. The default value is arbitrarily set to €0.35.

The choice of a particular PV module from the database is calculated as the least different PV module from the PV module design parameters obtained by the optimization. Since each design parameter affects the performance of the PV module to a different extent, weights of influence have been introduced for each design parameter. Finding the least different PV module is done by computing the weighted Euclidean distance between PV module design parameters and computed design parameters for each PV module from the database. The weights that affect the weighted Euclidean distance are just the above-mentioned weights of influence. Since testing has shown that weights of influence can not be generalized for all locations and household consumption, the user has the option to choose a not weighted Euclidean distance. As the least different PV module, we consider the one whose Euclidean distance is the smallest.

4 Battery model

If the initial costs of purchasing batteries are not too high, PV battery systems become more economical choice [4], [10]. To minimize battery replacement costs, it is necessary to keep the battery life as long as possible. We consider using a 12V (volt) lithium-based battery system with 10 years lifetime warranty because they are industry standard [1]. In the paper [10], the batteries are modelled with a simplified approach, considering a mean watt-hour efficiency of 95%. For that reason, we have introduced a constant L that expresses the loss of energy caused by battery storage. By doing so, the battery will drain faster than its output to the appliance network (1.0526 Wh of battery capacity is consumed for each Wh covered consumption, it is in fact a reversed value of mean watt-hour efficiency and we got it from the ratio of 100% / 95%). They also restricted the state of charge of the battery to a range between 20% and 80% of the nominal battery capacity to extend the battery life to the maximum. Therefore, the battery capacity with which the algorithm will work will be 0.6 * total battery capacity.

The battery will be charged exclusively from the PV module and will only be charged when there is excess of amount of generated electricity. The battery will be discharged at a time when the PV module will not cover all consumption. The battery will be discharged until there will be a need to cover consumption or until the state of charge reaches zero. With the state of charge being equal to 0, the battery still holds the amount of energy equal to 20% of its total capacity.

Basically, the ageing of the battery leads to a decrease in battery capacity. Therefore, it is assumed that 90% of the usable battery capacity is indeed utilised within the lifetime on average. It is assumed that the lifetime of the PV modules will be 20 years and the loss of performance factor due to ageing is considered to be 2%.

Battery capacity is defined by the following formula:

$$C_{Wh} = 0.9 * C_{Ah} * V \quad (4)$$

where C_{Wh} represents battery capacity in Wh (watt hour), C_{Ah} represents battery capacity in Ah (ampere hour) and V represents voltage of a battery in volts. We multiply this equation by 0.9 because of the ageing of the battery as discussed above.

Battery capacity with a restriction of charge and discharge to a defined level is calculated as follows:

$$C_{rWh} = C_{Wh} * (1–(R_L + (1 - R_H)) \quad (5)$$

where C_{rWh} represents restricted battery capacity in Wh, R_L represents the battery charge level below which the battery must not be discharged and R_H represents the battery charge level above which the battery must not be charged.

Charging the battery is defined by the following formula:

$$SOC = SOC + ((W_c * h_c)/C_{rWh}) \quad (6)$$

where SOC represents state of charge of the battery, W_c represents charging the battery in watts and it is multiplied by h_c which represents the number of hours the battery is charged. It is divided by C_{rWh} so that when the SOC is equal to 0, the battery still holds the amount of energy equal to 20% of its total capacity. Similarly, when SOC is equal to 1, the battery holds the amount of energy equal to 80% of its total capacity.

Discharging the battery is defined by the following formula:

$$SOC = SOC–((W_d * h_d * L)/C_{rWh}) \quad (7)$$

where W_d represents discharging the battery in watts, h_d represents the number of hours the battery is discharged and L is our introduced constant that expresses the loss of energy caused by battery storage and is equal to 1.0526 as mentioned above.

5 Implemented prototype

The algorithm is implemented in the Python programming language and we used the pvlib [5] library to calculate the PV module performance based on the location of the household. The prototype calculates the PV module design parameters based on the power consumption data in the form of .csv (comma separated values) file and the location of the household. The user can specify the azimuth of the rotation of the PV module or let the algorithm to optimize it. The user can enter the number of panels and the battery capacity either in ampere hours and volts or directly in kilowatt hours. The algorithm itself runs as follows:

- load power consumption data from .csv file,
- find the lower and upper bounds of the design parameters from the PV module database,
- find the PV module design parameters by maximizing objective function 1, government subsidies and total installation costs of the PV system are not implemented yet,
- find the least different PV module from the PV module database based either on the weighted or not weighted Euclidean distance as mentioned in section 3,
- calculate the annual savings for the chosen number of PV modules and battery capacity and display the power consumption and generation graph along with more detailed information. Example of such output is shown in the table 2.

Table 2. Recommended PV module for houshold located in Nairobi (Kenya).

Recommended PV module: SolFocus SF-1100S-CPV-28
Generated electricity from a PV module (kWh): 4050.521
Household demand (kWh): 11727.183
Electricity consumption covered by a PV system (kWh): 3512.673
Electricity consumption covered from a battery (kWh): 1201.778
Electricity consumption covered by a PV module (kWh): 2310.896
Savings (€): 436.32
Maximum output power from a PV module (kW): 1.593
Maximum household demand (kW): 7.984

Annual savings are calculated as the amount of energy that was used to cover household demand and is multiplied by the price for electricity.

6 Conclusion and future work

Both consumer habits and household location significantly influence the choice of the appropriate PV module. The economy of investment in the PV system is influenced by the price for electricity, government subsidies and initial investment costs. The proposed algorithm takes all of this into account. As a key feature of the algorithm we consider that it is faster to find a suitable PV module when a large database of PV modules is available than if we were to compute the return on investments of each PV module separately.

In order for application to decides whether the investment will pay off, it is necessary to implement the price model of PV system components, therefore we consider it to be part of our future work. Given that some countries offer government subsidies for investing in photovoltaics, we want to add this option too. Finally, we want a backend implemented in Python to put on the server and make an Android client to interact with this server.

References

[1] 21, I.S.C.C.: IEEE Guide for Selecting, Charging, Testing, and Evaluating Lead-Acid Batteries Used in Stand-Alone Photovoltaic (PV) Systems. *IEEE Std 1361-2014 (Revision of IEEE Std 1361-2003)*, 2014, pp. 1–39.

[2] ESolar: ESolar. https://www.esolar.sk/, [Online; accessed March 24th, 2018].

[3] Google: Project Sunroof. https://www.google.com/get/sunroof, [Online; accessed April 2nd, 2018].

[4] Khalilpour, K.R., Vassallo, A.: Technoeconomic parametric analysis of PV-battery systems. *Renewable Energy*, 2016, vol. 97, no. Supplement C, pp. 757 – 768.

[5] Laboratories, S.N.: Python pvlib. https://github.com/pvlib/pvlib-python, [Online; accessed February 22nd, 2018].

[6] Laboratory, N.R.E.: System Advisor Mode. https://sam.nrel.gov/, [Online; accessed February 22nd, 2018].

[7] Pflugradt, N.: Load Profile Generator. http://www.loadprofilegenerator.de/, [Online; accessed February 22nd, 2018].

[8] Solar, E.: FLEXmax MPPT80 Charge Controller. https://www.enfsolar.com/pv/charge-controller-datasheet/2238?utm_source=ENF&utm_medium=charge_controller_list&utm_campaign=enquiry_product_directory&utm_content=21404, [Online; accessed March 24th, 2018].

[9] solar, W.: Fullriver DC210-12 AGM Sealed 12V 210Ah Battery. https://www.wholesalesolar.com/9949469/fullriver/batteries/fullriver-dc210-12-agm-sealed-12v-210ah-battery, [Online; accessed March 24th, 2018].

[10] Weniger, J., Tjaden, T., Quaschning, V.: Sizing of Residential PV Battery Systems. *Energy Procedia*, 2014, vol. 46, no. Supplement C, pp. 78 – 87, 8th International Renewable Energy Storage Conference and Exhibition (IRES 2013).

OntoSEC: Cloud Service Recognition

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Nowadays, the use of cloud services is increasing. They allow small businesses, but not only them, to save money and effort by providing software infrastructure or even the entire software cheaper and better. However, the choice of appropriate service is subject to many requirements for data security, safety, guaranteed availability and reliability. These requirements come from businesses' own needs, as well as laws in countries they operate in.

In addition to the fact that different countries have different laws on how they are allowed to manipulate with data, the laws tend to change. This, in combination with various certificates, which individual cloud service providers can meet, causes a lot of unnecessary work and ambiguity, which can prevent the use of these services. For a small business, it is often difficult to judge whether a cloud service is good for them or even appropriate. Public administration cannot use a service at all until strict requirements are met. And a cloud service provider, who wants to capture new customers, would have to be certified according to every possible certificate and study the laws of each country.

Cloud services prove their qualities to the customers by being certified according to different standards. These standards are captured in the form of certification schemes requirements. The current approach is to take all the relevant documents, where the necessary requirements are specified, start comparing each with every other and after any change in either one of them start the comparison all over again. This creates lots of combinations and manually checking every single one of them is significantly inefficient. Therefore, we are proposing an ontology-based approach, where the cloud service characteristics requirements are described using a common dictionary – ontology [2, 3]. A person processes each change only once, formalizes it and our application is able to work algorithmically with these formalized records. The user is able to display, compare, create, review, modify, publish, export and import formalized data. This optimizes monotonous human work by ultimately automating the recognition of appropriate cloud services based on the evaluation of matching and overlapping of cloud service characteristics with demand [1].

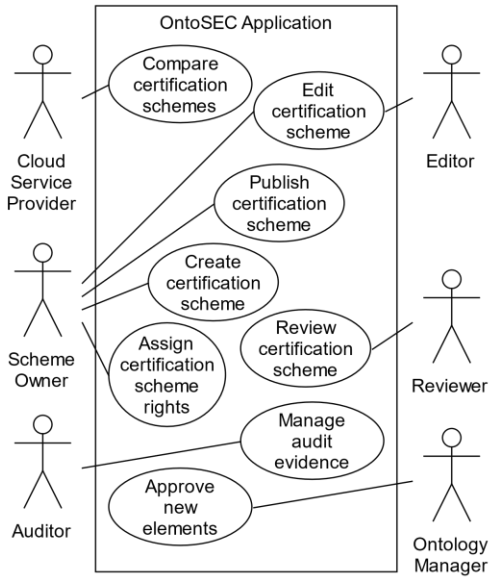

Figure 1. Roles in our application.

Consider the following example. Peter is a cloud service provider. His cloud service has a certificate X according to the respective scheme. There has appeared a new big company on the market that needs exactly the service Peter provides. But this company requires the service to have a certificate Y

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according to the respective scheme. In order to satisfy the new company's requirements, Peter wants to know if there are some things he lacks in providing his cloud service.

As shown in Figure 1, our application offers exactly what Peter is looking for. He can compare schemes X and Y and find out if by fulfilling the requirements of scheme X he fulfils scheme Y as well. Additionally, when two certification schemes are compared, the application also provides information on the number of requirements which the first certification scheme fulfils from the second one and vice versa. It is possible Peter discovers he does not need to meet any new requirements. This means the whole Y scheme is contained in the X scheme he is already certified by. Either way, after comparing schemes X and Y in our application, Peter determines the differences between them. He now knows if and which new requirements he has to fulfil in order to get certified by scheme Y and can request for an audit, based on which the required certificate can be granted.

Certification schemes are the core of our application. They consist of controls, which are complex sentences written in natural language, used for checking whether the requirements imposed on a cloud service are met. In order for our application to be able to compare and evaluate certification schemes, we need them to be present in our application in certain format – ontology. This way every newly added certification scheme is automatically compared to every other scheme already in the application. However, manually rewriting hundreds of complex sentences into a common format is very time consuming. This is why we provide a functionality that speeds up and simplifies the process of rewriting certification schemes by automating the transcription into ontology. Our application divides every certification scheme's control's complex sentence into separate simple sentences using natural language processing (NLP), suggesting the wording of control objectives to which are searched and assigned security attributes and metrics that already exist in the application. Our application also provides support for performing audits by allowing auditors to collect and store audit evidence and to monitor the parts of schemes that have already been checked.

Every certification scheme has an owner who has the right to edit and publish it, and a list of reviewers, editors and auditors. The rights to a scheme are specified by the owner of the scheme. Editors can make changes to the entities which have not been approved yet. Whoever has a right to edit cannot be a reviewer and vice versa.

After adding a new certification scheme and its entities, every entity that was newly created needs to be approved by the scheme's reviewer in order for the scheme to be published. This is done to ensure uniqueness of every entity. The hierarchy from the bottom to the top of the approval process is as follows:

- at the lowest level a newly added metric needs to be approved,
- when the security attribute's metric is approved, the security attribute can be approved,
- the control objective to which a security attribute belongs can be approved after approval of that security attribute,
- in order for a control to be approved, all of its control objectives need to be approved,
- the scheme can be published only when all of its controls have been approved.

Every entity, which has been already approved, is blocked for editing.

In conclusion, the vision of our application is to formalize the description of cloud services using ontology, which not only allows comparison but also automates it. As a result, cloud services will be easier to use by customers from different countries.

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References

[1] García, J.M., Fernandez, P., Pedrinaci, C., Resinas, M., Cardoso, J., Ruiz-Cortés, A.: Modeling service level agreements with linked USDL agreement. IEEE Transactions on Services Computing, (2017), vol. 10, no. 1, pp. 52–65.

[2] Takahashi, T., Kadobayashi, Y., Fujiwara, H.: Ontological approach toward cybersecurity in cloud computing. In: *Proceedings of the 3rd international conference on Security of information and networks*. ACM Press, (2010), pp. 100-109.

[3] Veloudis, S., Paraskakis, I.: Ontological Templates for Modelling Security Policies in Cloud Environments. In: *Proceedings of the 20th Pan-Hellenic Conference on Informatics*. ACM Press, (2016), pp. 1–6.

Votter: A Web Tool for Managing Decisions

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1 Introduction

Making right decisions is an essential part of our everyday life. For an individual it is easy to make a suitable one, but making group decisions is a great burden for people, and often, despite the time and energy invested, the result is not satisfactory. Traditionally, group decision-making includes the following steps: option collection, group voting and result evaluation. Before the voting begins, group members suggest items that are aggregated into a list of options. After that the voting process occurs, during which options are rated by each member of the group. There are many possible ways to rate the options as well as to evaluate the results of the voting. The combination of rating and result evaluation approaches is called a voting strategy [1].

The last few years saw the appearance of services that attempt to facilitate this process (e.g. Doodle[1], NeedToMeet[2], Rally[3]). However, most of them focus on collaborative scheduling rather than voting. They do not provide users with a great deal of flexibility in choosing a strategy to evaluate their votes. This can significantly reduce efficiency, as different approaches to evaluation are appropriate for different occasions.

Therefore, we are in need to create a solution that gives a user the freedom to choose the voting strategies exactly for his needs. What makes achieving a definitive decision in group voting much more difficult is the need to somehow compare votes and preferences of its individual members. It is clearly because a group as the whole tries to settle on the best option, but individual members' private preferences make it impossible to globally define, which one is really the best. This is the reason why we decided to create our own solution that will provide more ways on how to achieve an ultimate decision within a group.

The main goal of our application, called Votter, is to give users an ability to try and figure out, which ways of evaluation are the most suitable for their problems. Under problems we understand decisions about which film we want to watch, what restaurant we want to eat, or which game we will play, etc. Some of the provided voting strategies are integrated into electoral systems of several democratic states and used during different types of elections, but there are also voting strategies, which are more closely related to a particular problem or a particular group of people.

2 Voting strategies

Generally known voting strategies provided by our solution (we chose so far twelve of them) are basically divided into four categories: basic, rate, points and surprise.

Basic category contains most simple strategies well known to majority of people. An example of basic strategy is cumulative voting, in which group members give each option a positive or negative vote.

Rate category consists of voting strategies, where users rate options by their mutual ordering. Usage of this category of strategies allows users to express their priorities. For instance one of such strategies, least misery, involves calculation of average of users weighted votes, as well as elimination of worst rated option for every user.

Points category also allows users to express their priorities, but in a different way. Every user is given

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[1] http://doodle.com

[2] http://www.needtomeet.com/

[3] http://rallly.co

a certain amount of points or tokens, and then every user has to divide them between desired options. Option with the most points could be considered as the best one.

The last category called surprise is a little bit different than the previous categories. This category contains a few extraordinary evaluating strategies, which are not suitable for serious decision-making, but their main purpose is to have fun. Even if the decision is not very important, somebody has to make it, and that is a goal of this category.

3 Architecture

Our application utilizes Docker and consists of three main containers:

- Django REST backend container for business logic and communication with PostgreSQL database,
- Angular frontend container, which is responsible for user interface generation,
- NGINX server, which serves as a proxy HTTP server and allows communication between containers via API calls.

Figure 1 illustrates the architecture of our system.

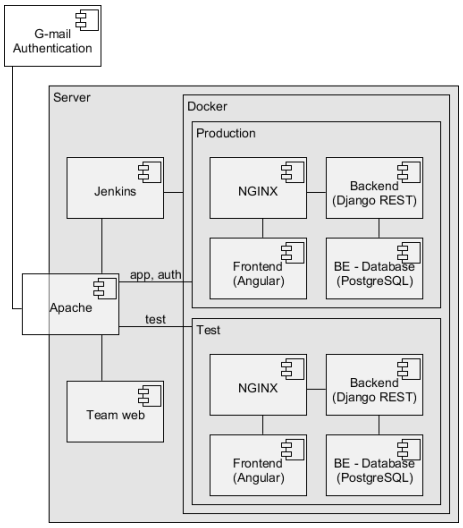

Figure 1. Architecture of the server.

Our server employs two types of Docker-compose environments: production environment for our application and test environment for automatic and manual testing. Both environments are managed by Jenkins, which also provides continuous deployment and integration.

Our backend consists of Django REST Python framework and PostgreSQL database. Django REST framework provides simple way of communication with frontend through serialization of objects and easy database model creation with migrations. The main tasks of our backend are to monitor correctness of all requests, to create and evaluate user votes using various voting strategies, as well as to ensure their persistence.

As for frontend, we have decided to use a JavaScript Angular frontend framework to be able conveniently implement all voting strategies. The application is made of multiple reusable components in order to avoid duplication of code.

Testing is provided by Dockerized Protractor which runs Selenium tests in a Google Chrome browser. Tests can be run both manually in local development environment as well as automatically by Jenkins before deployment (using headless mode).

4 Conclusion

Currently, Votter allows users to create votings based on four basic voting strategies. The creator of the voting can stop it, which will prompt application to calculate and visualize results. In the future iterations we plan to add more strategies and support for user profiles that will allow users to easily create and manage recurrent votings. Innovation we bring to the market lies in those strategies.

At the moment, one of our major objectives is UX testing. The biggest challenge for future users is to be able to understand the idea of a particular voting strategy from a brief description or picture. This may prove to be difficult, when dealing with more complex strategies. Therefore we need to test different solutions to this problem, evaluate the results and choose the best one. The second objective is a marketing campaign. The main goal here is to present the product as a flexible solution for voting in groups of young people. Our target audiences for this are students at two universities (one is in Slovakia, another is in Norway).

We would like Votter to be an application that would be used by groups of young people who want to solve their problems in the most suitable and intuitive way. In order to achieve this goal, we would continue to implement the mentioned functionality and test it in an appropriate way.

References

[1] Kompan, M., Bieliková, M.: Voting Based Group Recommendation: How Users Vote. In: *HT (Doctoral Consortium/Late-breaking Results/Workshops)*. Volume 1210., 2014.

Open Contracts: Linking Open Public Data

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The government and public institutions publish a large amount of open data about contracts, companies, entrepreneurs and many others. Since the year 2011, the government is obliged to disclose these data about contracts otherwise they would be automatically invalid. For this reason, the state began to publish contracts using its interface[1]. However, the interface was not easy to work with. In order to allow easy access to this data, the project otvorenezmluvy[2] (Open Contracts) was created. The project started as a collaboration of Aliancia Fair-play[3] and Transparency International[4] with the main goal of analyzing this data via public crowdsourcing and to find suspicious contracts. This can increase the level of state management of its budget and reduce corruption.

However, after the project started, any work on the project was inactive for several years, until we started working on it within the Team Project. During this inactive time, the technologies the project was using became outdated and the state also changed its publication methods of contracts and the existing method was not functional anymore. Since the downloading of contracts is a key part of the project, it had to be repaired.

Nowadays the state is publishing even more data. None of this data is linked. Therefore, all the necessary information is not available when analyzing it. Linking this data would greatly improve its analysis and the detection of fraudulent contracts. Also, providing the people channel of a communication about contracts can be helpful for connecting people and also increase public awareness. Our main goal in this project is updating outdated technologies, adding new data sources and to provide a convenient and simple way to work with this information.

One of the datasets that can greatly increase the amount of information that the project offers is the Register of Legal Subjects. It is one of the key registers in public administration. It allows us to obtain specific information about the companies that are part of a contract. All contracts contain the identification number of the organization. We can therefore connect that company from the contract with the data from the register. This way, we can get valuable information about the company, for example its official company name, since the names on contracts can vary. Another information we can gain is the residence or economic activity of company. Although the state provides its own API, it is preferable to use API from slovensko.digital[5], which integrates multiple registers and provides a way to synchronize data.

Another dataset is the Register of Public Sector Partners[6]. This dataset contains information about business end owners. With this information, the contract can be associated with a particular person standing behind the company and gaining profit.

The Registry of Financial Statements[7] contains data about the economic activities of subjects such as its turnover, profit, liabilities or assets. It could also increase the chance of detecting fraudulent contracts. For example, if a company signs a contract with a high value, it is expected that it has an adequate turnover and assets.

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1 https://www.crz.gov.sk
2 http://otvorenezmluvy.sk
3 http://fair-play.sk/
4 http://transparency.sk
5 https://ekosystem.slovensko.digital/otvoreneapi
6 https://rpvs.gov.sk/rpvs
7 http://www.registeruz.sk

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We already managed to add the Register of Legal Subjects during the winter semester and are currently working on adding another new data source and connecting them with existing ones. All these newly added data sources will not just increase the amount of information provided but will also allow for more accurate and easier searching of contracts or companies. So, the next step after adding new data sources is making sure to properly integrate them into the project and linking them with the original data to enhance transparency. For example, by enabling a new and more specific search method or adding new user screens.

Not all public data is of equal quality. Anomalies when the contract value is zero, but it is worth millions in reality, are very common. The detection of these anomalies is another challenge which can increase data transparency. Another problem is the quality of the contracts that are published by the government. Some contracts have incorrect or missing metadata. One of our goals is to give administrators of the site more options in editing this metadata and also the option to directly edit the scanned contract. Because of changing laws, the option to hide certain contracts is also a useful feature for administrators that we want to add to the project.

Since the project started in the year 2012 and was not updated since then, the technologies it uses are outdated. The project is using Ruby on Rails, Elasticsearch and PostgreSQL as a database. Sustainability is one of the important properties of software projects. It is therefore important to update these technologies for easier future maintenance and extensions. The technologies that the project is using evolved during the inactive period of the project and newer versions are not completely compatible with older versions. It is one of our main goals to update them. There is a great possibility that other teams within the Team Project might continue working on this project and updated technologies will allow them to focus on delivering new functionality and improving already existing ones.

The project otvorenezmluvy.sk allows citizens to conveniently and comfortably read, search and evaluate contracts concluded by the state and state institutions. This will improve the state's state management of its budget, increase transparency and reduce corruption.

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Bee-hives Monitoring using Internet of Things

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1 Introduction

In our project, we focus on bee-hives, perform their monitoring, hive control and thereafter notice the beekeepers about important changes that affect the quality and quantity of the honey production. The goal of the project is to simplify the beekeeper's work. Our solution is suitable for a professional and a hobby beekeeper. We use innovative technologies such as the Internet of Things, the Sigfox network, and various sensors to identify the amount of honey, bee swarming or to detect hive movement. We create an easy-to-use system for young and old people who are not familiar with modern technologies.

In comparison to our life, the bee´s life is just a minute, but it´s importance is enormous. According to this, we have decided to use modern technologies to help beekeepers perform the regular actions necessary for keeping the colony of bees. A professional beekeeper or one who takes bees as a hobby, needs to have an overview of the conditions of their hives. In most cases, the colony of bees is not located near the home, their place is in the nature, outside of the everyday civilization. Therefore, the great advantage would be to have this information without the need of the personal check. Those, who do not have regular access to their hives, will appreciate the possibility of remote control and early notifications of the unusual situations, that have would occurred.

One of the basic elements of our solution is to provide information about temperature inside the hive and outside. By monitoring the temperature, the beekeeper is able to detect a situation, when there is a lack of eggs, when is the right time to treat bees against pests or to detect the presence of mother. The most important moment in the life of the colony of bees is the presence of a healthy and fertile mother. Another element which we bear in mind is the weight of the hive. For laic it is just a number signing the presence of honey. For the beekeepers it is much more complicated. Last but not least, it is important to provide information about overturning of the hive or nowadays also about stealing the entire hive.

We proposed our system with usage of Sigfox technology, which cover much larger area than GSM base stations. Comparing to others, using Sigfox is very cheap and has lower consumption of the energy. On the other side, we use knowledge of existed works thus we use Arduino Mega 2560. We designed the system for web application and for android application. The main benefit is an early warning when something unexpected happens in the bee hive.

2 Related Works

Authors of *Honey Bee Colonies Remote Monitoring System* [1] designed a low-cost, reliable bee-hive-monitoring system based on wireless-sensor networks to measure the temperature, relative humidity, and weight of beehives in real time and non-intrusively. WBee as it is called, saves the data in each part of the network if there are failures in the communication.

The purpose of the device in the work *Telemetric measurement system of beehive environment conditions* [2] is to perform measurements of parameters such as ambient or internal temperature, atmospheric pressure, humidity and sound level. To accomplish the study, they decided to use the base module Arduino Mega 2560. The measured values were transferred to the MySQL database, which is located on an external server, with the use of GPRS protocol.

3 Solution Design and Technologies

Our proposed architecture consists of multiple components. Complete flow of data is shown in the Figure 1. The first part is Hive Monitor. It is composed of microcontroller - Arduino Mega 2560 with Sigfox antenna and sensors. Sensors perform

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measurements of the ambient and internal temperature, humidity, hive position and weight

DHT22 is accurate digital temperature and humidity sensor. To filter the noise from the environment, the producer recommends connecting the pull-up resistor to the DATA pin. The accelerometer includes a 3-axis gyroscope along with a 3-axis accelerometer. The sensor is based on a chip MPU-6050. For weight measurement we use TMOEC 200kg electronic load weight sensor.

Sigfox Transmitter communicate with devices connected to Sigfox network. It sends data from devices to the Sigfox Cloud Server. This server collects data from devices and by using HTTP Callbacks send data to our Bee Web Server.

On one side it hosts our website and on the other hand it is place, where the database is stored with all measured data. After receiving twelve bytes, the server parses these data and stores them. Despite this, the functionality of user login and registration is also implemented on the server. For providing measured data to beekeepers REST API is implemented on Bee Web server. It also provides authentication and registration of new users.

On our web page, we can find all information about project and about related technologies. Next, there is a simple form in section order, where the customer can order one or multiple devices. After registration, the beekeeper is able to follow up all new collected data or historical data. Web and mobile applications get data in JSON format using API calls. For better visualisation we have decided to use charts. Once the threshold limit is reached, the page displays a notification describing the problem. Whole this functionality is also implemented in Android application.

In Sigfox technology there is implemented protocol that allows you to transmit a small amount of data and has low power consumption, which is ideal for IoT. Each message is sent three times due to unreliable connection, each time at another randomly selected frequency. Maximum length of message is 12 bytes and each Sigfox end device sends up to 140 messages a day. This represents one message in about 10 minutes, so total daily capacity is 1680 bytes. IoT devices can communicate through Sigfox network. It uses Ultra-Narrow Band for communication and cells of this network allow to cover a much larger area than GSM base stations. Therefore, this technology is built on a cellular system similar to GSM and uses the star topology. The network operates in the 868 MHz band in Europe and 902 MHz in the USA. The maximum allowed transmit power is 25mW. The main advantage of this approach is that network can support large number of IoT devices. In Slovakia, Sigfox is provided only by one mobile operator – SimpleCell Networks Slovakia.

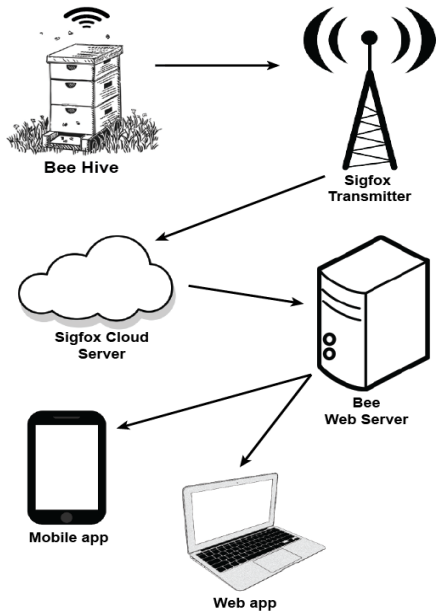

Figure 1. Suggested Solution Architecture.

4 Conclusion

Our solution provides real-time bee-hive monitoring through Sigfox network. Communication is realized using Ultra-Narrow Band and cells of this network allow to cover a much larger area. Sigfox technology limits us to use only small messages which could be sent 140 times a day. Despite this limitation, the beekeeper regularly receives all actual information which are displayed on a web or Android application. With this in mind, our mobile application implements a notification feature, which triggers when an unexpected situation happens. For instance, when inside temperature is too high, or hive's position has changed. Above all, our future work could be focused on audio and video analysis for better prediction of the bee´s colony needs. Furthermore, it can be focused also on sending SMS message in case of exceeding the defined values.

Acknowledgement: This project was partially supported by SimpleCell Networks Slovakia.

References

[1] Kviesis, A.; Zacepins, A. System architectures for real-time bee colony temperature monitoring. Procedia Computer Science, 2015, 43: 86-94.

[2] Walendziuk, W.; Sawicki, A. Telemetric measurement system of beehive environment conditions. In: Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments 2014. International Society for Optics and Photonics, 2014. p. 92901G.

Smart Parking

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Since the first car was invented hundreds of years ago, there has been a dramatic increase in cars number on the roads in the past 40 years. Our social lives became more dynamic than ever before and we have started to use cars on daily basis. One of main problems the increasing number of cars brought to our lives is that we are running out of possibilities to extend parking places in urban areas.

According to Global Innovation Series[1], up to 74% of all traffic jams in downtown areas are caused by cars cruising in order to find a free parking space. It means that a lack of free parking spaces does not mean only unsatisfied citizens but also high wastes of fuel and higher emissions. With a development of information technologies we are not able to provide cities with more land to build parking infrastructure, but smart parking systems and IoT (Internet of Things) can provide a critical component to a smart cities' infrastructure and help highly populated areas to make parking more effective.

Main goals. We think that the smart parking system proposed in this paper could improve traffic situation in urban areas, help drivers to reduce time spent by searching for a parking space and even municipalities in adapting parking infrastructure to real needs. According to this, the main goals of developing smart parking system is to make information about the usage of parking spaces with a division into streets and urban areas available to ordinary people and municipals in order to:

- quickly and efficiently park, reduce traffic jams and air pollution,
- help cities and city police to optimize parking through visualizations, statistics and predictive parking models, and subsequently, on the basis of the data obtained, propose a change in the parking prices in favour of the municipality and the drivers,
- maximize cities revenue from provided parking in order to better critical infrastructure funding.

Achieving these goals requires rational data gathering process and big data analysis along with data visualization.

Features. Created parking system supports visualization of municipals registered parking spaces along with real-time occupancy, history occupancy preservation and parking lot statistics. The occupancy data is collected in real time using physical devices located in the area of each parking space (drilled into the parking surface). Based on the stored historical parking lot occupancy we summarize parking lot statistics that can help people to plan when and where to park but also municipals to optimize parking infrastructure according to actual needs of city residents (reduction of areas with long-term parking unavailability due to high parking lots occupancy).

System architecture. The smart parking system is implemented as a web application optimized for both desktop and mobile devices based on React framework (JavaScript library for building responsive user interfaces). In development process we use UU5 and Plus4U5 React libraries provided by Unicorn Systems Slovakia in both front-end and back-end part of the application to ensure unified development process so the application can be easily maintained and developed in the future.

Gathering data about occupancy of a parking lot is accomplished by special parking sensors created by The Faculty of Electrical Engineering and Information Technology STU in Bratislava especially for the pur-

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[1] https://www.mashable.com/2011/04/13/smart-parking-tech

pose of an intelligent parking system. These sensors are mounted in the pavement of every parking box and are based on LoRa network which offers a very compelling mix of long range, low power consumption and secure data transmission to send information about the parking box when a car parks in or it leaves it. Through LoRa network all the data are sent to Orange Live Objects platform from which all the parking data is transfered through MQTT connection and stored in our central MongoDB database (Figure 1). This data is then processed and available to users of our application. Users are allowed to see general parking lot information, current parking lot occupancy, historical occupancy and parking lot statistics.

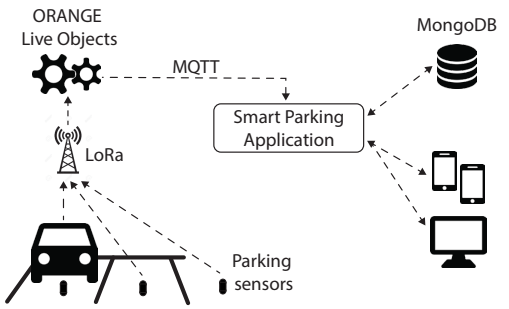

Figure 1. System overview.

For displaying maps to provide city and parking lot navigation we have integrated Google Maps API, which allows us to use all the benefits of advanced Google's maps technology (Figure 2).

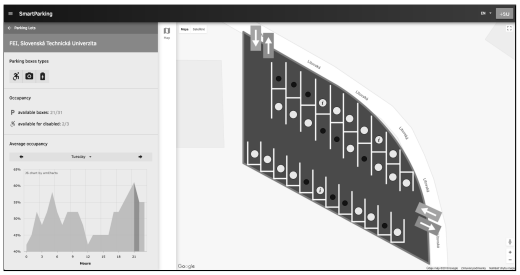

Figure 2. Application preview - parking lot.

Deployment & real usage. It turns out that there is a high demand for this type of parking system. In cooperation with Orange Slovakia and Unicorn Systems Slovakia we are now achieving the first possible co-operations and system deployments in two Slovak cities, which would like to use our system to monitor their toll-free parking limits in the city.

This type of system is becoming popular also to cities all around the world as according to few companies providing similar parking systems, cities have gained 30-60% increase in parking lot revenue by using it[2], so returns can be achieved easily.

Future work. Our system provides functionality which can be used in real life, but as we are still in development there are some features we plan to be implemented next.

For ease of use and its faster expansion to the public, it is necessary to cover as many parking spaces as possible. We aim to create the possibility of simply adding new parking spaces and managing them directly by municipalities or administrators of these areas.

As all parking spaces are not free of charge, created system should also allow making reservations and support payments for parking spaces where this is necessary. Also, real-time data collection can be useful for city police in toll parking service tracking to reduce illegal parking activity.

We also plan to enhance data statistics and big data analysis to support decision-making process in municipalities and to help people decide and organize parking in the cities.

Another feature we would like to support is advanced system personalization to fit needs of each user. In addition to occupancy monitoring and parking statistics, users will also be able to manage cars linked to their account, making them considerably easier to process a parking reservation or to access other system options that they will be able to freely use (e.g. built-in navigation system).

Conclusion. We have proposed a smart parking solution that could help cities to reduce enlarging traffic problems using IoT. By using our smart parking system we can now achieve improvement in quality of provided parking services, improve traffic situation in many cities as it helps drivers to find a free parking lot more quickly and support municipalities decision-making process by providing advanced data statistics to build a better parking infrastructure. We believe this system can help many cities to deal with parking problems more effectively and provide their citizens with a better life.

Acknowledgement: This work is the result of the project DA-SPACE as a part of Danube Transnational Programme and was conducted in collaboration with partners Unicorn Systems Slovakia and Orange Slovakia.

[2] https://www.ipsgroupinc.com/smart-parking

DeepSearch: Building Ontologies from Unstructured Biographies

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Great amount of information is stored in historical books. However, majority of this knowledge is hidden within long texts. At this moment, the extracted information only describes main concepts, for example date of birth or death. Lots of data describing connections between people or communities remain undiscovered. Nowadays, with accessibility of digitalized texts, many opportunities for automating discovery of these connections arise.

In this paper, we focus on building ontologies from unstructured biographies using named entity recognition. Result is visualized as a graph of entities and connections between them. Using our tool for building ontologies, one can easily search through processed biographies and review potential interesting information.

Text data mining on unstructured data was always challenging topic. Nevertheless, methods for entity recognition within English language are constantly being improved. Unfortunately, these methods cannot be applied on other languages without tweaking. Even though there are languages, which are fairly similar, grammar differences tend to require major adjustments for successful entity recognition.

In the context of Czech language, there are only few papers published on this matter. Strakova et al. published Czech Named Entity Recognizer [3] in 2013. In the paper, the authors present a new named entity recognizer which outperforms previously published Czech entity recognizers. Other notable recognizers were published in [1] and [2].

Mining of relevant information from biographies is usually done by manual processing. Results are then represented into various digital formats. This process takes a lot of resources, including multiple revisions by many authorities for possible mistakes. Even after successful processing of unstructured data is finished, other problems arise. Not all formats are mutually compatible, therefore some kind of bridge or translator must be utilized. All of these points prove, that manual text processing is highly inefficient.

Even though, textual digitalization is a way to go, some obstacles still need to be overcome. Existing ontology representations, for example MARC21, are not always user friendly. Because of that, institutions like museums, galleries, libraries and authorities representing cultural heritage have problem sharing this information.

In addition to that, user interfaces of data search systems have limited capabilities of searching for connections between students, professors, communities and dates. At this moment, a user can search through digitalized documents by browsing, or by executing queries, which include only limited amount of data. This data usually consist of persons name, work or information about birth or death. Besides museums and cultural institutions, there are many personal authorities like historians, anthropologists or ethnologists, which have data on their own. This prevents recognition of lesser known personalities like writers or artists representing cultural heritage. Furthermore, it complicates sharing any information on local, national or international level.

Our goal is to build simple, easily extensible ontology on relationship between named entities and authorities. Discovered ontologies are presented in comprehensible graph structure showing relations within recognized entities (shown in Fig. 1). Digitalizing this data makes it easier for users to get familiar with their area of interest. Furthermore, users will be able

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to filter the data and limit the scope to chosen people or authorities. Final product aims to be a web portal for cultural heritage authorities to build and try to complete knowledge database. Together with graph visualization luring people to view discovered connections.

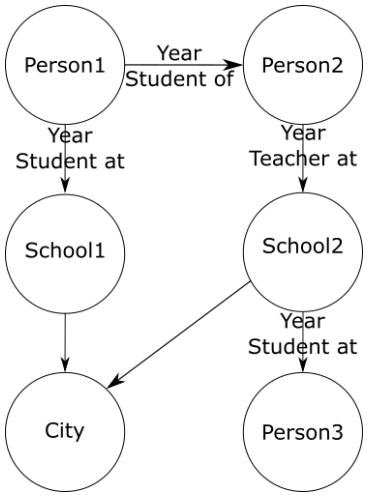

Figure 1. Graph illustration of entities and connections

At the very core of our method lies pipeline processing of unstructured biographies. Steps of the entity identification process follow:

1. Parse biography from input
2. Tokenize sentences
3. Tag words (using MorphoDiTa [1])
4. Extract sentences by rules
5. Recognize named entities (using NameTag [2])

Thenceforth, recognized entities, formatted as triplets, are stored within Neo4j graph database. These triplets can be easily visualized. Persons, institutes are presented as graph nodes, while years and employment status form connections between them. Users can efficiently search for entities, which are afterwards displayed in the graph alongside related entities. Communities and associations can be discovered more easily.

This paper presents a way of discovering various artists or further increasing user's knowledge by revealing connections between them. Our tool can be used for educational purposes as well as specialized research projects. Data mining within digitalized texts can furthermore enhance databases which specialize on historical figures, artists, authors.

Processing biographies still bears many obstacles. They are usually written by different authors, which causes differences in sentence structures. This ultimately complicates extracting information from the documents. To process input from various sources, we had to utilize filtering based on chosen identifiers to improve information extraction. This enhancement allowed us to reduce unstructured text to few sentences with entities. With help of MorphoDiTa and NameTag services, we successfully extracted approximately 70% of entities and stored them into graph database which is connected to web interface.

References

[1] Konkol, M., Konopík, M.: Maximum Entropy Named Entity Recognition for Czech Language. In Habernal, I., Matoušek, V., eds.: *Text, Speech and Dialogue*, Berlin, Heidelberg, Springer Berlin Heidelberg, 2011, pp. 203–210.

[2] Kravalová, J., Žabokrtský, Z.: Czech Named Entity Corpus and SVM-based Recognizer. In: *Proceedings of the 2009 Named Entities Workshop: Shared Task on Transliteration*. NEWS '09, Stroudsburg, PA, USA, Association for Computational Linguistics, 2009, pp. 194–201.

[3] Straková, J., Straka, M., Hajič, J.: A New State-of-The-Art Czech Named Entity Recognizer. In Habernal, I., Matoušek, V., eds.: *Text, Speech, and Dialogue*, Berlin, Heidelberg, Springer Berlin Heidelberg, 2013, pp. 68–75.

[1] Link to MorphoDiTa web pages: http://ufal.mff.cuni.cz/morphodita

[2] Link to NameTag web page: http://lindat.mff.cuni.cz/services/nametag/

reCommers - Recommendation for E-commerce

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In modern society, usage of information and communication technologies has spread to almost every part of everyday life. Number of electronic transactions is growing every year. It is comfortable buying products of different kinds online with just few clicks. With growing numbers of customers, new e-shops come to markets every year. To attract more customers, provide better user experience and increase customer satisfaction, they often use recommendations [3].

Recommendation. Recommendation can make online shopping for customers easier and faster. It can find top rated books according to our past preferences on genres or authors, help discover new music albums and musicians or suggest perfect vacation on exotic island. On the seller's side, it increases profit and provides information and opportunities for improvement. Many large companies, such as Amazon [2] or Netflix [1], develop their own recommendation systems, which helps them to improve their positions on markets and provide better quality service for their existing and new customers.

There is, however, large number of smaller companies for which is development of their own recommendation services not affordable. Therefore, they need to focus on external solutions, generally referred to as Recommendation as a Service (RaaS). In addition to recommendation algorithms, they provide support, monitoring and visualizations of various metrics.

In our project, we develop our own RaaS platform for e-commerce. Whole recommendation process is a complex sequence of various steps. At first, data about users of e-commerce service (customers of e-shop, music service listeners, etc.) must be collected. This involves capturing of user behaviour online, i.e. events such as searching, listing categories or viewing product details. These events are substantial for consequent recommendation process.

Next step is processing and modification of customer data in form suitable for the recommender system. They are stored and used by recommendation algorithm for generating recommendation personalized for a specific customer. When this customer is using service (for example, he is viewing site of e-shop or looking for movie on video streaming site), he is provided with generated recommendations.

reCommers platform. Our solution is based on an existing platform, which has been used in real production environment for e-shop in Slovakia. Our tasks is not to create a new recommender system, we are focusing on development of complex RaaS platform that provides following additions and improvements to the existing infrastructure:

- Multiple business customers. Service can be easily used by more than one e-shop. Definition of data modification rules for specific e-shops is achieved through configuration files without unnecessary effort.
- Visualization and evaluation of recommendation results through key metrics. Web application is provided to customers of our service (e-shops), where they can inspect values in tables or graphs. They can choose metrics and times, for which visualization and statistical evaluation is provided. Configurable dashboards present quick overview of current state.
- Integration and selection of multiple recommender systems. New recommender system can be integrated with the platform in any time. E-shops are able to select most suitable recommender, even change it whenever they want.
- Error monitoring and debugging. This can be done easily using web interface, where history for recommendations is provided.

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- User management. Safe access to the web interface through logging for e-shop and maintainers is provided, too
- Technologies. Platform is built on a dozen of modern and perspective technologies, which are secure, reliable and used by many other well-known products in area of personal recommendation and data analysis.

Key factor of the recommendation service is speed. Recommendations for specific user is delivered in less than 150ms. It is consequence of well-designed architecture, scalable and fast technologies and advanced programming approaches.

Technologies. As mentioned before, we are developing our platform using current technologies. They are mainly open-source technologies, with large communities of developers and maintainers. System architecture is presented on *Figure 1. System architecture*.

RaaS platform is developed in Python programming language. Substantial part of whole project is web application, for which Django web framework is used. Django is free, secure, fast and scalable open-source web framework. In addition, we use a variety of open-source libraries for database migrations, asynchronous processing and other tasks.

There are two ways in which data from a customer can be send to the recommender through our middleware platform. In addition to http endpoints, on which data can be send from customer side, we are able to extract data from Apache Kafka topic. It is more secure, reliable and errorproof solution.

For visualizations of metrics and statistics, we use Metabase. It is a web-based platform, which provides means for better and more effective way of exploration, visualisation and manipulation with data stored in database. As a main database storage, PostgreSQL was chosen as the best alternative.

Monit is used for monitoring, maintenance and repair in runtime. Monit conducts automatic maintenance and repair and can execute various actions in case of error situation, such as sending email to maintenance team. To ensure better performance and quick response of recommendation requests, we are using Celery (asynchronous task queue based on distributed message passing) in combination with Redis. Finally, Sentry is used for error reporting.

As a result, platform is developed as easily maintainable, so next generations of students can improve our solution, add new ideas and provide better results for satisfied customers.

Educational benefits. In addition to commercial value, our platform brings new benefits in education and research. There are many students and employees on our faculty which are developing their own recommender systems in various projects or master theses. Many of them have already shown interest for this type of platform. From perspective of research tool, the platform is able to provide options for comparison of results with other recommender systems, monitor performance and evaluate metrics during longer time periods.

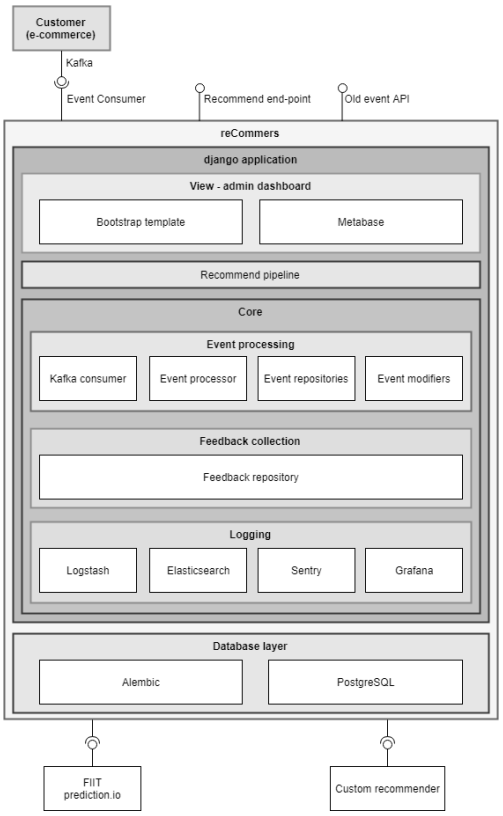

Figure 1. System architecture.

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References

[1] Bennett, James, and Stan Lanning. "The netflix prize." In *Proceedings of KDD cup and workshop*, vol. 2007, p. 35. 2007.

[2] Ekstrand, Michael D., John T. Riedl, and Joseph A. Konstan. "Collaborative filtering recommender systems." Foundations and Trends® in Human–Computer Interaction 4.2 (2011): 81-173.

[3] Sivapalan, Sanjeevan, Alireza Sadeghian, Hossein Rahnama, and Asad M. Madni. "Recommender systems in e-commerce." In *World Automation Congress (WAC), 2014*, pp. 179-184. IEEE, 2014.

Invest: Investment Portal for Laics

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Investing in financial products has gradually become widely spread among ordinary people. Gaining profit from investments requires domain knowledge and evaluation of large amount of available data.

Investment Portal provides a simple solution for potential stock traders, who desire to keep track of their portfolios and get systematic help with their trading strategies. Our goal is to provide simple and easy to understand application for tracking investments, compensating the lack of knowledge of laic users.

This paper provides an overview of the application, describing the architecture model and common usages of our system. It shows how users can manage their own portfolios with automatic investment tracking or use one of our model portfolios for virtual experimenting with their investments.

Investing in financial market is becoming more and more accessible to everyone. People lacking domain knowledge are in disadvantage and are potentially vulnerable to great losses. This knowledge gap can be significantly closed by available technologies.

Investment Portal is an application for people who desire to start investing and who lack required knowledge. The application provides an easy way to track your investments, profits and losses, all through an easy to understand user interface made to suit laics. Investment portal is the application designed to close the knowledge gap of these potential investors and to ease their first steps.

Using automated daily calculations, the system keeps track of changes in stock markets and provides up-to-date information to their users, who are not required to execute any additional actions.

Several other applications provide similar, though not the same, functionality as Investment portal. One of the most popular investment tracking applications, Google Finance, stopped providing their services by November 2017. Other apps such as Yahoo Finance[1] or Personal Capital[2] provide an option to track your investments. The main difference between them and our application is in the laic oriented design and investing assistance.

Architecture of Investment portal is divided in two distinguished part – client and server applications, as pictured in Fig. 2. The client application is user interface implemented as web application, based on Angular 5 technology. It provides easy to use interface, where even investor-beginner can learn to track their portfolios and make educated decisions about their next step.

Secondly server side is Spring Boot based application, which handles all required communication with client application, PostgreSQL and InfluxDB databases, and a calculation module. The server side serves the information through REST API and provides the service of notifying user about changing market trends by Web sockets.

As a part of the server module, the calculation module is the main base for calculating different metrics of the stock markets and for predicting statistical changes. It is implemented as Spark application which gathers data from several market exchanges and manages calculations over these data by R and Python scripts.

The most important part for understanding the financial and investment potential of user's portfolios, is the visualization of the past, present and possible future states of their assets. To achieve these objectives we created Dashboard page, as pictured in Fig. 1, for users to see all their portfolios' activity in one place. A

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[1] https://finance.yahoo.com/

[2] https://www.personalcapital.com/

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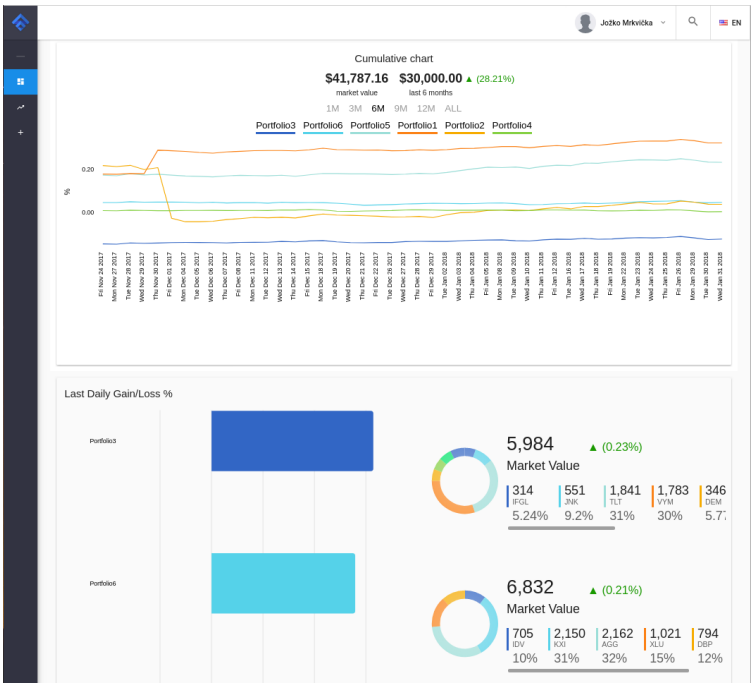

Figure 1. Dashboard screen user interface.

specially for novices we provide Help tools, that guide users' experience through the client application.

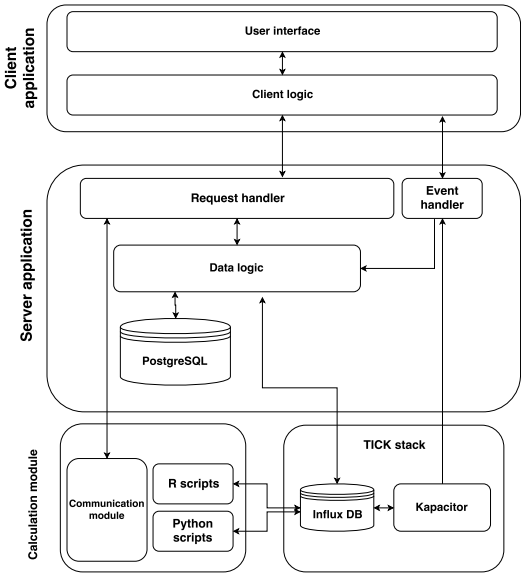

Figure 2. Architecture model of the Investment Portal.

Investors have different objectives and for example, they accept different degree of risk. Their skills make different tactics and strategies appropriate as well. Users can therefore customize a set of rules, behaviours or procedures that the investment system will use to guide selection of the user's investment portfolio.

Investment Portal gathers data and calculates metrics above them. These are then used for recommendation of best possible strategies, that users can choose from or can edit as see fit in a portfolio management.

In the future there is potential to incorporate customizable levels of the visibility of user's portfolios and therefore provide similar services to professional investment agents, who could work with their clients more efficiently.

The Investment Portal is an online application for tracking your investments in stock market. The application is oriented to assist laic investors and help them to keep track of their investments despite their potential lack of knowledge. The application can also be used to simulate your potential investments and to see how the stock market evolves in easy to understand charts and visualizations. Our system also provides investment recommendations based on everyday financial calculations.

Behavioral Biometrics on Mobile Devices

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There are a large number of different applications of various types, which collect raw data from sensors of mobile devices. However, the integration of such applications and data collection methods with other applications for the purpose of research is problematic. There are a few implementations of a logger for collection of sensor data from mobile devices, such as the one in [1], our implementation offers an easy to use library, integrable into various kind of mobile applications, allowing the logging of any kind of mobile sensor data, including touch events, all configurable by the user.

The three main goals of the project are:

1. Making the work of any researcher working in the field of biometrics, or needs user data for other type of research easier, by the integration of our library into their own application. Individual implementations of similar logging solutions is a significant waste of time, so by using our library, they can utilize their time more effectively.
2. Creation of a simple to use framework for machine learning, containing predefined methods for preprocessing, feature extraction and model creation, to be used by researchers.
3. Finally, by combining these two solutions, the creation of a new layer of security and a new method of protection of mobile devices against misuses by unauthorized user, using behavioral biometrics for the identification of the user. Developers can integrate our solution with their applications to improve the security of these applications.

We propose a project called Behametrics, consisting of two main parts: *Logger* - the module intended for the collection of data from the sensors of mobile devices such as accelerometer, gyroscope or events from touch screen.

User authentication - creates the overall solution of our project using machine learning, along with the logger.

For proving the validity of our project and ensuring credibility both by the professional community and by the general public, we aim to:

- publish the proposed solution as an open source project, so anyone would be able to see how does it work, without hiding any part of the implementation,
- provide a simple method for integration, making the testing of and working with the project easier and more accessible,
- provide base use cases and suggest further possible scenarios for the usage of the library.

At the current stage of the project implementation, we are able to collect and send data to a storage device from individual sensors and the touch screen of a mobile device, using the logging library. This functionality was tested by the product owner, using an independent application integrating our library. The stored data is further processed and separated into bunks applicable for machine learning. Currently data from the accelerometer, gyroscope and the touchscreen events are collected. The data then undergo feature extraction and feature explosion, to obtain usable information from the raw data. These features are the ones consumed by the models, providing us the results of the authorization, which is sent back to the client (Figure 1). The security response depends on the application implementation, the simplest being locking of the application and possibly asking for a specific se-

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curity question. With the completion of the project a demo application will be created, which demonstrates the functionality of the solution as data collection and user authentication library. The demo application also shows how simple and fast is to integrate the Behametrics library into a mobile application. The data collected is measurements at different time intervals, consisting of numeric attributes. The individual attributes depend on the sensor collecting it. Most sensors send data in the form of x, y, z coordinates at a timestamp, but the touch events send a larger number of attributes, so this data has to be handled differently from the other sensor data. Different sensor hardware can also send different data for the same type of sensor, so these data have to be handled accordingly.

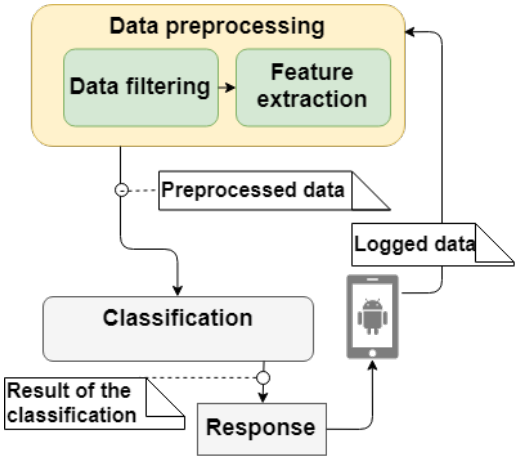

Figure 1. The dataflow of Behametrics.

The final project will provide the following features:

- an open source publication and license of the library, for making future development possible and providing easy access to our library,
- easy usage and a simple way of integration of the library into applications,
- a separate logging library, containing the data collection aspects of the project,
- a new security measure, using biometric user authentication.

The area of using machine learning models in biometrics for identification is difficult and still under intense research, so we cannot ensure at the current time that our solution will work as proposed and that it will provide satisfactory results.

However, the main goal of the project is research, so the knowledge gained during it is more important than the practicality of the final solution.

Acknowledgement: This work was partially supported by the Slovak Research and Development Agency under the contract No. APVV-15-0508 Human Information Behavior in the Digital Space.

References

[1] Lee, W.H., Lee, R.B.: Implicit Smartphone User Authentication with Sensors and Contextual Machine Learning. In: *Dependable Systems and Networks (DSN), 2017 47th Annual IEEE/IFIP International Conference on*, IEEE, 2017, pp. 297–308.

MedPix: Simplifying the Analysis of Complex Medical Image Data

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Health is a precious thing and a key attribute in leading a prosperous and quality life. The health is always threatened by a substantial number of factors including diseases that are hard to diagnose. A correct early diagnosis is essential in providing the right treatment and thus ensuring the health and satisfaction of the patient.

Medical image data analysis is one of the vital processes in providing a patient with a diagnosis. Doctors, radiologists and medical specialists have to analyze several different scans (e.g. MRI, CT, X-Ray scans) that help them to map the health condition of scanned body parts, find potentially harmful masses and evaluate the possibility of treatment.

A doctor usually has to go through several types of scans and analyze them under different conditions (e.g. lighting, contrast, filters) that help him to spot differences between healthy tissue and potentially harmful tumors or other signs of diseases. Collaboration between medical specialists is also necessary, because different body parts may be influenced in different ways and a diagnosing doctor may have to consult a specialist to ensure that the diagnosis and treatment he proposes is correct.

Such effort requires very specific tools, skills and training. The software tools have to provide a variety of instruments and views to work with the medical images. Current software choices are therefore either very robust, rigid applications that offer exhausting number of settings, require large computational power and specific working conditions at the cost of portability and flexibility, or, in the other case, provide only a very limited view and tools and are too slow in image processing and viewing for real life usage during diagnosis.

We propose a solution – MedPix – to solve some of the described limitations and to merge benefits from both approaches.

MedPix aims to create a simple, flexible and portable tool to simplify the collaborative aspects of medical image data analysis by providing a joinable work-in-session environment with a cloud-based storage system. MedPix application allows displaying the complex medical scans and provides standard tools for analysis, such as notation, all while working on a portable device - tablet.

We challenge the current solutions in several ways, merging the fast image processing with portability and viewing on devices with less computational power, by moving the processing almost entirely to the server. This also allows us to create an interactive environment supporting easier collaborative analysis and interdisciplinary consults for specific health conditions.

MedPix allows a doctor to sign in and upload new patient scans or to search for patients and medical trials in database. The application can handle all types of medical scans (e.g. CT, MRI, X-Ray) as long as they are in a valid DICOM[1] format. After patient lookup, a doctor can select patient's trial to start a new analytic session or to re-open an older session already performed on the image data.

Figure 1. Loaded brain scan prepared for analysis.

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[1] DICOM is a standardized format commonly used for medical image data

After the trial selection, a doctor can start its analysis by using fast scrolling through the images and annotation tools from the provided toolbox. Metadata for the patient's trial are displayed on demand (See Figure 1).

Each segmentation, note, drawing or other tool used creates a bookmark in the session for the scan for a quick and easy finding if and when needed. The doctor can invite specific colleagues into his working session and give them the opportunity to support him in the analysis by providing their own notations, drawings and other insights into the process. A doctor can always see, who is joined to his session and all the bookmarks that were created by the collaborating experts.

In summary, MedPix provides tools for the diagnosing doctor to:

- Annotate data and share annotations with other medical experts.
- Load and examine any medical image data.
- Collaborate with other experts in real time.

The server side provides all the communication, image data processing, storage and session persistence for all the clients joined to a session. We chose to use a modular python server with a database, indexing and search engine, and an email module when registering a new user. For the communication between client and server, REST APIs and websockets are used. APIs are to provide metadata and other information, while websockets are used to transmit image data, commands and image processing objects to provide speed and fluent undisrupted image views while scrolling through the images. Once a session is created or activated, the requested image data are loaded from the database and cached in-memory in Redis to allow collaborative work and fast processing.

The search through patients and trials is powered by Elasticsearch which allows full-text search in patient data, trial data and also metadata of the medical scans.

Mongodb was chosen as a database to store the image data for performance reasons, outperforming other possible database options when storing large image data.

The MedPix solution is implemented using smart architecture allowing it to scale and be flexible in both development and deployment:

- Docker for Elasticsearch, Mongodb, Redis and python environment (See Figure 2).
- Model-view-presenter on the frontend side.
- Modular architecture of the server.

MedPix application opens the door to fast and portable medical image data analysis. It provides the means for a specialist to perform his or her analysis of medical scans, consult and collaborate with a colleague, propose a diagnosis and have it confirmed by another specialist with less effort thus ensuring greater accuracy and ultimately better healthcare. We created a tool to deal with some of the limitations of current software and it is not only usable for the specialists, but also, possibly, for education. With MedPix, we provide the opportunity for a teacher to perform an analysis of a medical scan in medical class and each student can see the teacher's process and notes on his or her own device in real-time.

Acknowledgement: This work was partially supported by the company Siemens Healthineers.

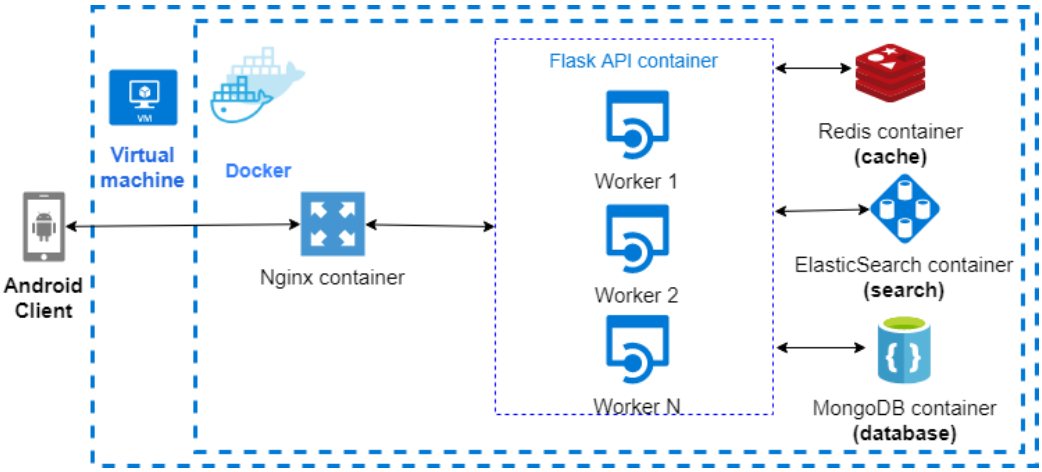

Figure 2. MedPix backend architecture.

Distributional System of Questionnaires

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There is a lot of competition in public transport sector, every company tries to be the best. To maintain a high level of their services, they need a feedback from their clients in order to limit existing problems and attract new customers. At this moment there is no such option for passengers to send their feedback via enquiry to carriers using the Funtoro-MOD [1] directly via the display in the bus seat. Here, space has been created to get feedback directly when traveling, when the feelings of the passengers are the most recent.

However, creating the questionnaires is not a sufficient solution. Tedious and lengthy questionnaires can often distract people, so we try to include the best possible gaming elements that will revive the questionnaires and motivate people to fill them up. Questionnaires should come in several types like for example, educational, fun or informative. The aim of the questionnaires is to make the journey enjoyable for passengers and also to provide feedback to bus companies that will use this system.
Gaming elements that can be included in the questionnaire system are:

- Keys and/or Rarities. This is a gamification element taken straight from video and PC games. Passengers must complete a questionnaire to earn a key. With this key they can either unlock the next level or they are required to save up a certain number of keys to unlock a reward. If we want to take it a step further we can even create keys that will give them access to "hidden" content, like treasure chests, or doors that lead to resources, like fun games or puzzles.

  For more adventurous passenger, or the ones who become easily distracted we created the idea of unlocking rarities. For example, let the passengers know that there is a few of very rare objects hidden throughout the questionnaires (e.g., bonus points or special badges). Passengers can unlock these items only by completing special tasks or outperforming their peers
- Give passengers the opportunity to earn free tickets during the questionnaire and then hold a raffle at the end where they can win prizes. This game mechanic can be tricky, since passengers aren't participating simply for the questionnaire, they are in it to win and earn reward. This is why it's always a good idea to pair it with another game mechanic.
- Points are earned by completing simple tasks or participating in questionnaires. Once passengers they have a certain amount of points they can trade them in for a reward or unlock new levels.
- Leaderboards are one of the most competitive gamification elements, as they encourage passengers to surpass the others in order to be the first. It's the ideal game mechanic for those who want to be recognized or praised.

  To get the most out of leaderboards, don't force passengers to compete if they aren't comfortable competing with their colleagues. This ensures that your introverted passengers won't feel alienated, but still gives others the chance to work their way to the top.

The project is divided into two parts. The first part is a web application that will allows a service provider to register their customers, which are carriers. The entire web part is under the authority of provider and hence can provide or withdraw access rights to functionality. With the help of the web application, bus companies can manage their buses and create questionnaires. The web part allows carriers to distribute questionnaires to individual buses, create roles for their employees, and process the results received from buses. Thanks to this solution, the companies can create questionnaires with any content and character that suit them the best. Within the web application, language variability has also been introduced, allowing you to change the language

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based on client requirements. Language variation was a necessary condition because provider has customers across Europe.

The second part of the project is to develop functionality for bus servers that works together with the web part. The questionnaires are sent to the servers on the buses from the web section and are processed on screens where they will be provided to customers. By virtue of its unique identification, the bus server connects through an Internet connection to a web server from where it can retrieve data and send data from previously completed questionnaires. Within the functionality of the bus server, gaming elements will also be incorporated. Each questionnaire on the bus server have its own time limit to evaluate its results at regular intervals and thus provide room for improvement of service.

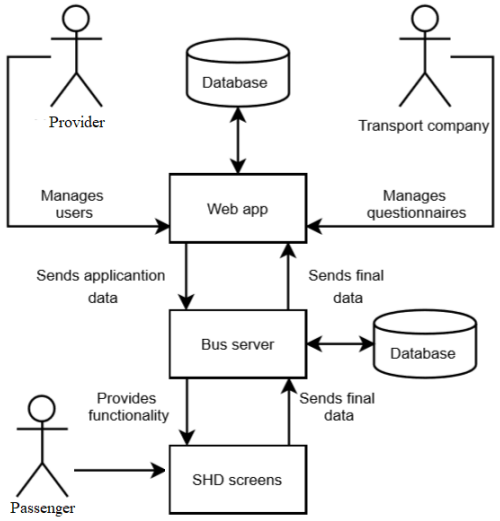

Figure1. Architecture of creating questionnaire.

Figure 1 shows an overview of the system. The product owner and the customer are accessing the web app [2]. The provider of the service manages users and the fleet of buses manages data for their fleet. The web application is linked to the database. This database stores data sent by fleet owners to their buses while at the same time providing feedback from passengers. The web app is linked to the server on the bus. From the web application, fleet owners send application data for their particular buses, and these data are further processed directly on the server on the bus. The bus server contains all the functionality. There is a database on the bus server that contains the data sent from the web application and information from the passenger's feedback. The server contains a functionality that pulls data from the database and transforms them into a form of questionnaire that is subsequently provided to the customer in the form of a knowledge game. The results of this game are saved in the database after it is completed and sent to a database linked to the web application where the bus owner can access it. The server runs a program that scans the database at specified times, adds new data to it, and sends it to a database linked to a web application if there are new items in the database. SHD screens are the screens in the bus that the passengers come in contact with. Passengers use the functionality of these screens, and if they decide to fill out the questionnaire, the data from the screen is stored in the database on the bus server.

The questionnaires for achieving feedbacks from passengers are current used in planes, trains and buses too. The solution for feedbacks is provided by Opinion Plus from the Wavetec company. However, our solution differs in several innovations. To our clients is afforded opportunity to create their own questionnaires via the web interface and easily distribute them into entire bus network. Unlike the solution by other providers we introduce into questionnaires also gamification elements which aim is to hold passengers interest and make them to fill the questionnaire in.

The architectural is sophisticated and suitable for every conveyor. The great advantage of our system is the ability to send questionnaires generated through the web application to the buses the carrier wants. This makes it possible to locate questionnaires because different types of questions can be provided in different areas. This is why we differ from all of the current attempts to distribute questionnaires on buses, as transporters attempting to generate questionnaires were solutions nationwide and thus little variegated.

References

[1] Molpir s.r.o.: MEDIA ON DEMAND SYSTEM. In: User Manual, (2013). [Online; accessed February 20, 2018]. Available at: http://shop.molpir.sk/Priyzlohy/254130002110_0.pdf

[2] C. Pappas, „7 eLearning Gamification Elements to Get the Most Out of Serious Games" Learning Technology Trends, 17 January 2017. [Online; accessed February 20, 2018]. Available at: https://www.docebo.com/2017/01/17/7-gamification-elements-for-elearning-serious-games/.

Immersive Web

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1 Introduction

The result of the project is an easy-to-present, innovative solution for presentation of websites' content. The goal of the project is to design and create a prototype of a website that allows a user to browse the information space in an immersive virtual reality environment. Specifically, this site should serve to present the 3D Lab[1].

Information as such takes on a "tangible" form, allowing users to explore, navigate and interact within the information space in a more natural and effective way.

The main goal of the project is to design and create a new kind of website that allows a user to browse the information space in a virtual reality in 3D space. The site serves to present the 3D Lab, its equipment and projects emerging in it. In this 3D space, we provide complex information, which immerse the user and give him ability to move and to interact with few specific objects.

In the analysis of our problem area, we have found that the best way to create the necessary 3D models is the photogrammetry method.

During the development of our project we are using various technical devices and software to make photos of space that we present in virtual reality.

As Priolo remarked in his paper [1], technology of 3D virtual tours started to be popular for museums or big companies. Our project should not only support these tours but also transform whole web space to one big virtual tour.

2 Immersive Web Prototype

Our web application is converting ordinary websites into virtual reality. As the first prototype, we chose a website where we present a virtual tour of the lab in which we work.

Virtual space provides wide range of presenting information to users. The main functionality is to inform users about the space they are in, what they see and allow them to interact with surrounding objects. The way to interact in this particular space is to move around the room in a virtual tour, grab the objects in their vicinity, change the size of the objects and learn the details about them by clicking on them. Details can be displayed by text in pop-up window or video presentation captured by 360°camera to enhance the stimulation of the human senses. This gives the user the best experience of watching a recorded experiment.

The biggest problem so far has occurred when the user moves through the space. It is very difficult for a human brain to quickly realize the change of space that he sees when he actually did not move. This has often caused a dizziness or even nausea with some testers. We finally solved this problem by adding a few hundredths of a second between shifting the scene.

The other interesting part of the project is the ability for site administrators to modify content while being in the virtual space. By grabbing an existing object, it is easy to move to another location or change its size. Also, if the administrator needs to add a new object, it is not necessary to interfere with the source code of the website but simply fill in the object's parameters into a JSON file. In the same way (by editing a JSON file) objects can be easily deleted.

The current version of our web application is available on our team website[2], where HTC Vive owners can try out all the features.

In *Figure 1* and *Figure 2* can be seen a sample of our current prototype. As can be seen in these images, the application is tested on the 3D Lab website with virtual tour in which we are working on this project. It can be also seen our feature of presenting details

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[1] http://3dlab.fiit.stuba.sk/

[2] http://team13-17.studenti.fiit.stuba.sk/

about objects in 3D space. After clicking on object in *Figure 1*, text representing details about it pops up above the controller (arrow), displayed in *Figure 2*.

During testing, several geometric shapes and also parts of furniture have been added into the space. These objects have been moved and their size have been changed.

Figure 1: Clicking with controller on 3D model of camera Samsung Gear 360 in virtual space.

3 Technologies Used

To achieve all of this, we use several technologies and methods.

Photogrammetry is the process which allow us to create the 3D models from a lot of photos of the object. To create 3D models by photogrammetry, process the special software is required. Photogrammetry process is very tedious and these steps need to be abide: all photos must be sharp, photos cannot be edited, stand has to be used, zoom cannot be used, photos have to be saved in JPEG format, flash has to be disabled.

Web Graphics Library (WebGL) is a JavaScript API for rendering interactive 3D computer graphics and 2D graphics within any compatible web browser without the use of plug-ins.

It is integrated completely into all the web standards of the browser allowing Graphics Processing Unit (GPU) accelerated usage of physics and image processing and effects as part of the web page canvas. Its elements can be mixed with other HTML elements and put together with other parts of the page or page background.

Three.js is an open-source JavaScript library used to create 3D graphics in a web browser. Three.js uses WebGL described above.

It allows create and render complex 3D objects display in the browser without the effort required for a traditional standalone application or a plugin.

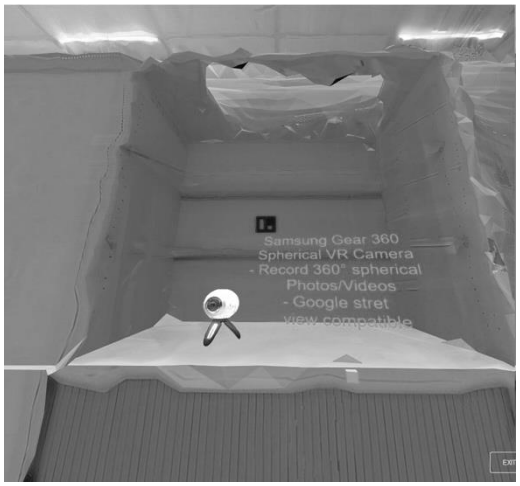

Figure 2: Displaying pop-up text representing details of model of camera Samsung Gear 360 after clicking on it.

4 Conclusion

The specific content of the website with our prototype serves the presentation of the 3D Lab at FIIT STU and its main goal is to provide information on the projects and equipment of this laboratory. However, the web application has many other uses for the future. The plan is to modify other 2D websites into this form, for example museum or sightseeing tours, e-shops into virtual market place or teaching purposes.

Acknowledgement: This work was partially supported by the projects UVP and VEGA.

References

[1] Priolo, F. R., Mediavillo, R. J. B., Austria, A. N. D., Angeles, A. G. S., Fernando, M. C. G., & Cheng, R. S.: Virtual heritage tour: a 3D interactive virtual tour musealisation application. In *Proceedings of the 3rd International Conference on Communication and Information Processing*, ACM Press, (2017), pp. 190-195.

Collab-UI: A Collaborative User Interface Prototyping Tool

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Nowadays, prototyping has become an integral part of the software development cycle. Functional prototypes can provide a valuable insight on the products characteristics and they are highly utilized in various agile development methods [2]. However, the process of designing a prototype from scratch and discussing its properties with the development team is often lengthy and overly complicated. Participants in this process have to rely on external communication tools and sequential workflow. The effectiveness of the prototyping team would be greatly improved by a collaboration-oriented prototyping tool that will let everyone contribute in real time.

Since no such solution of sufficient quality is currently publicly available, in this paper we present a new user interface prototyping tool named Collab-UI. It is designed to help user interface designers develop prototypes of applications utilizing HTML and CSS in their presentation layer.

Our goal is to provide a solution that is accessible from any device, regardless of its operating system. Therefore, we designed Collab-UI as a dynamic web application that integrates real time collaboration with browser-enabled communication channels and online management system of existing prototypes. We aim to develop an all-round solution that encapsulates all activities related to user interface prototyping in a single online platform.

Because functional prototypes are often kept and steered towards the final product quality instead of being discarded [1], we have designed Collab-UI to be able to export the prototypes as a fully functional source code.

To achieve this, we utilized an already existing browser-based prototyping solution based on JavaScript and gradually added more and more collaborative and communication oriented aspects to it. Currently, the core Collab-UI feature structure includes:

- User management
  - E-mail based user registration and verification
  - Project activity notification system
- Project management
  - Basic & detailed prototype overview
  - Prototype collaborators management
  - Collaborator privileges support
- Real-time prototyping
  - Interactive and customizable prototype editor (see *Figure 1*)
  - Immediate prototype change propagation and synchronization
  - Connected collaborators overview
- Source code export & versioning
- Means of real-time communication
  - Voice chat
  - Text messaging

In order to provide these features, our application relies on a number of specialized technologies and external libraries. The backend part of the application consists of a pair of databases (a relational and a non-relational one) and two dedicated application servers – each taking care of different tasks. These servers expose their REST APIs for clients to call upon.

The presentation layer is built on various specialized JavaScript libraries, all of which cooperate together in order to provide the desired functionality. Even though the technological stack is quite diverse, all the end user needs in order to start prototyping is a common web browser with JavaScript support.

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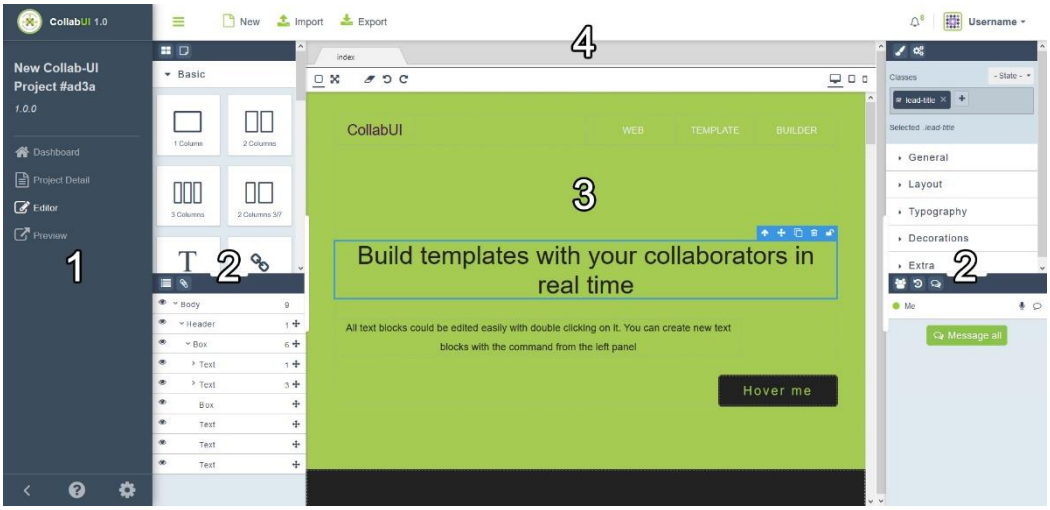

Figure 1. A screenshot of the Collab-UI interactive prototype editor. It consists of four main sections: (1) selected project overview and navigation, (2) editor panels containing the main editing tools, (3) prototype canvas, and (4) additional prototype actions toolbar.

Collab-UI is primarly aimed at UI/UX designers and frontend developers working together in development teams. However, it can be also used by any other person included in the user interface prototyping process – even by the product owner himself (e. g. to check on the progress of the team).

We designed a very straightforward prototyping process consisting of just two basic steps. First, every user needs to go through the registration process. Fortunately, this process is rather simple and it is no different from registering on other websites. The user will be registered under his e-mail address and after activating his account, he can immediately create a new project. A default Collab-UI project contains one predefined prototype and is characterized by its project name, owner and a set of user-defined tags.

After creating a new project, the user can start working on prototypes right away or he can invite some collaborators first. Each project collaborator is identified by his e-mail address and a privilege (edit or watch), which has been assigned to him by the project owner during the invitation process.

From this point on, any project member with sufficient privileges can work on the existing prototypes or create a new one. Since the application is not publicly available yet, there is currently no limit for the maximum number of user interface prototypes per project.

Every prototype change is synchronized across all connected clients by a dedicated NodeJS server in real time. This collaborative way of work can be considered the key feature of our application and we are constantly working on improving it even further.

The idea behind Collab-UI is to provide a universal tool which overcomes the notorious issues associated with user interface prototyping in teams. We have managed to address these issues by providing a way for individuals to communicate and collaborate in real time without the use of any external applications.

It is important to note that Collab-UI is accessible from any operating system via standard internet browser and it can be used to design user interfaces for both mobile and desktop devices.

As for the future work, there are numerous new features that could be added into the application in order to make it even more helpful and enjoyable to use. Moreover, it is built on technologies which are constantly evolving and therefore it offers a lot of possibilities for future work in this regard.

References

[1] Abrahamsson, P., et al.: Agile software development methods: Review and analysis. *arXiv preprint arXiv:1709.08439*, 2017.

[2] Paetsch, F., Eberlein, A., Maurer, F.: Requirements engineering and agile software development. In: *Enabling Technologies: Infrastructure for Collaborative Enterprises, 2003. WET ICE 2003. Proceedings. Twelfth IEEE International Workshops on*. IEEE, 2003. p. 308-313.