Games with a Purpose: User Generated Valid Metadata for Personal Archives

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***Abstract*—With the proliferation of mobile devices, management of the growing user personal generated multimedia content is more demanding. Proper organization of this content requires manual metadata authoring, since automated or crowdsourcing approaches are inapplicable in case of personal content or content of a small social group (e.g. family). Recently, games with a purpose gained popularity in solving many human intelligence tasks, with main focus drawn onto resource metadata and semantics acquisition. Games with a purpose seem to have large potential for solving further problems, but they also face several design issues involving mainly the validation of human-created artifacts they provide. In this paper we analyze these issues and propose directions for overcoming them for the semantics acquisition domain. Furthermore, we propose a method for annotating and presenting personal multimedia content based on our previously developed game with a purpose, which also exploits the alternative artifact evaluation.**

***Keywords*-human computing; games with a purpose; semantic web; user collaboration;**

I. Introduction

For effective search, browsing and authoring, proper metadata for multimedia content and assets are required. Not only resources on the Web and public repositories but also private content of small, closed social groups like families or friends have to be properly annotated and categorized. Only afterward they can be effectively accessed, organized or even used for automated composition of personal narratives [1].

However, acquisition of quality metadata for multimedia content is still hard to be done by automatic means. Despite some approaches based on the resource context, existing semantics, visual or aural features exist [1]–[3], they are not sufficiently accurate. As an alternative, crowdsourcing and social collaboration approaches (e.g., Facebook tagging, YouTube comments and ratings)or manual approaches like online image galleries (e.g., Flickr) are used. However, existing human oriented approaches often suffer from sentiments expressed in the comments or provide too general annotations as result. Moreover users differ in the style of annotations they provide and sometimes deliver annotations (tags) that although descriptive, cannot be used in the classification [4].

In case of personal multimedia content like family photos or videos, the annotation is usually left solely on the manual labor of the resource author. Here, automated approaches based on context cannot be used and visual feature analysis cannot cover the specific and personal semantic properties of the content. Also, although temporal and spatial data are sometimes available, they do not reflect the semantics of the resources sufficiently. Social and crowdsourcing approaches can neither be used here due to lack of motivation, lack of the participants with enough knowledge about the captured situations and also due to privacy issues. Therefore, the authors usually annotate resources manually or not at all. Some approaches stress annotation directly upon creation, for example using voice commentaries transliterated to texts [5], however, they still demand user concentration and effort.

As an alternative approach for (multimedia) metadata authoring, the games with a purpose (GWAP) emerged in recent years. These games represent human computation approaches but unlike crowdsourcing, they provide more controlled environment to manage allocation of the human effort (so the resource does not receive unnecessary, redundant annotations) and also to provide entertainment to their players, who are therefore more motivated to do the job. The games with a purpose align the solution of the task they solve (e.g., image annotation) with rules of the game so the score of the player is directly or indirectly dependent on the quality and quantity of task instance solutions he provides.

In this paper we show, how the GWAP principles can also be used for personal multimedia content metadata acquisition to make this task more appealing and entertaining. We base our solution on our existing image annotation GWAP – *Pex-Ace* [6], which is a modification of the popular board game *Concentration*, where players collect pairs of identical cards facing down the board. The game, which can be seen also as a multimedia presentation tool, collects annotations for images. Annotations are entered by players, who are this way allowed to remember content of facing-down cards. We show that the game, although played with relatively small number of players (e.g., family or friend group), can deliver relevant annotations for personal multimedia.

The design of games with a purpose is, however, a non-trivial task which has to deal with several issues: it has to be appealing, keep the attention of the players, prevent players from cheating but most importantly, it has to have an artifact validation strategy, which means it has to be able to evaluate the usefulness of the player's game effort and the problem solution he produces, to give the player immediate and relevant feedback and reward. Most games solve this issue by multiplayer schemes [7], [8], however, this introduces the problem with cold-start, when there may not be enough players to play the game at the same time.

In our method, we overcame this issue by introducing a game scheme which motivates players to create useful artifacts, but with score computation scheme independent on the artifact creation. This allowed us to provide the player immediate feedback after the game and validate the eventually created artifacts (image annotations) later on by comparing outputs of multiple players offline.

II. Human Computing and Metadata Creation

The concept of games with a purpose emerged in recent years after it was coined by Luis von Ahn and his *ESP Game*, which has the purpose of acquisition of image annotations in form of tags [7]. Since then, many GWAPs were devised to employ human brain potential to solve *human intelligence tasks* – problems that are hard or impossible to be solved by machine but relatively easy for humans (e.g., labeling images with relevant tags) [8]. Although some outliers exists (e.g., game for FPGA layout optimization [9] or protein molecule folding [10]), GWAPs are being utilized mainly for solving problems related to the Semantic Web domain:

- *Multimedia resource annotation,* especially image tagging are often performed by GWAPs [7], [8], [11]. Following Ahn's ESP Game for image annotation, originally devised for two collaborating players [7], modifications of this approach were created to increase game appeal by introducing new player roles (*KissKissBan*) [8] and to annotate other types of multimedia content like audio or video streams [7]. Some games build upon already existing image tags to locate the exact position of objects in the images (*Peekaboom*) [7]. Another example of game exploiting human ability to process images is *Villain Ville* [12] which deals with human shape perception.
- *Annotation of textual resources.* Despite text is processed for metadata by automated methods with relative success (e.g. NLP techniques), some specific issues like noun-pronoun co-references identification are being addressed also by games with a purpose [13], [14].
- *Domain modeling.* Here, the games are utilized for collecting common sense facts to form the ontology triplets (as seen in Ahn's *Verbosity* word guessing game) [7], populating ontology with concept instances [15], [16] or aligning and linking existing ontologies [17].

Although there are no known limits for problem types that can be solved by them, the drawback of GWAPs lie in their non-trivial design process. There is yet no methodology for transforming a problem to game with a purpose and therefore, GWAPs are created rather ad-hoc. However, several design issues recur for every game:

- *Attractiveness of the game* – the ability to appeal and keep the attention of the players. In his work [7] Luis von Ahn postulated two coefficient metrics for evaluating the quantitative effectiveness of GWAPs. One of them was identified as the *average lifetime play* – a total number of hours that average player spends on playing the game (the other was *throughput* – a number of task instances solved in one hour of playing). In fact, this metric represents the capability of the game to keep player's attention by motivating him to play by social interaction [7], [8], self-challenge (reaching over one's own limits) [9], [15] or competition [13], [14], [18]. As third important aspect of a GWAP, not mentioned by Ahn, we also consider the number of players that had or will ever play the game, which depend mostly on spreading ability of the game, i.e. how the game initially appeals to the potential players.
- *Decomposition of the problem* to enable parallel task instance solving. This is usually done trivially in tasks like resource annotation, where the problem (e.g., annotation of images) is split into independent instances (e.g., images). The decomposition is also important to keep the tasks simple, so they are not overwhelming for players (especially beginners).
- *Task instance allocation.* As we discovered in our own game, GWAP Players show different expertise for solving different subsets of all task instances (they may be experts in a particular subdomain – a car expert would provide much more elaborate annotations to images with cars, rather than to images with natural sceneries). Therefore, the quality of artifacts produced by a GWAP can be increased if the game supports task allocation considering user expertises.
- *Vulnerability to cheats.* Dishonest player behavior can hamper not only the fairness of the game itself, but may also damage the problem solving capabilities of the game.
- *Validation of the player-generated problem solutions*. The design of the GWAP must deal with a paradox: to be useful, the player has to be motivated to provide problem solutions (at least indirectly). Therefore, the game scoring mechanism must be based on solution quality or at least enforce it. But how can be the correctness of an artifact evaluated other way, than by other human? The solution is to let the same task to be played two or more times by different players. However, this would suggest waiting with the feedback for the first player to the time when other player plays the game. Unfortunately, this would cause distraction of the first player from playing the game due to the waiting for feedback.

More or less, these design aspects also influence each other and are often contradictory (e.g., the cheating prevention may restrict the attractiveness). In our further work, we focus on the last aspect, which we consider most critical in the GWAP design.

III. Artifact validation strategies in GWAP

The player task solution (or artifact) validation paradox must be addressed by every GWAP. The goal of GWAPs is to provide accurate results while relying solely on the human mind labor. Therefore, *all* known games use the crowdsourcing approach of mutual validation of the players' outputs – a single task instance is solved by multiple players and their solutions are afterward compared and only matching ones are passed as valid (the actual number of agreeing votes needed for valid solution vary, depending on how wide is the possible solution space and what level of solution correctness is expected from the gameplay) [7]. The question that needs to be answered here (in relationship to the paradox above) is *when* to perform this voting procedure, i.e. whether the game is dependent on this procedure also for score computation. We have identified several models used by GWAPs so far:

- Multiplayer game mode.
- Bootstrapping.
- A motivation to create helper artifacts.
- Exact evaluation algorithm.
- Approximative evaluation algorithm.

In the ESP Game and other GWAPs [7], [8], [14], [16], the *multiplayer game mode* is used to ensure that players receive feedback on their gameplay immediately after the game ends. In this scenario, at least two players (partners or opponents) play the game at the same time with the same task (e.g., they have to match on term characterizing an image). They generate the task instance solutions simultaneously and blindly (they cannot communicate). If they agree on a solution, they receive positive feedback because they reached the same one independently and it is therefore true with high probability. This approach has however, one major disadvantage: it needs sufficient number of players willing to play at the same time, which means serious cold start problem for the game. This problem is even greater, when the game requires the players to be anonymous to each other [7], [8].

Sometimes, this issue is solved by the *bootstrapping* model. Here, the game sessions of real players are recorded for being "replayed" against another player in case there is no living player wiling to play at the same time. In fact, an originally multiplayer game can run solely using such bot players [7], [16]. Bootstrapping approach is also a primary solution validation technique in games like the image annotation framework of Seneviratne and Izquierdo [11]. In this game-like annotation framework, the user is asked to annotate a set of images, from which some (randomly mixed with others) are already annotated in the framework. User's score is computed based on answering these images. However, as he does not know which are the test images, the best option for him is to annotate all images with relevant tags [11]. By using bootstrapping approach the game's cold start problem becomes significantly lower: no large living player pool is required at the start, only sufficient number of prerecorded game sessions or initial set of solved task instances is needed.

One option for an artifact validation model, although case-specific for each problem or GWAP, is what we call *motivation to create helper artifacts* and what we also introduced in our own GWAP – the *PexAce* [6]. The idea of this model is to create a computer game with transparent scoring mechanism in which player is allowed to (but do not have to) create "helpers" that will make it easier for him to achieve winning conditions. However, the design of the game must imply that these helpers are the desired artifacts or problem solutions. For illustration, in PexAce we allow players, who seek pairs of image cards, to make helper textual annotations on the card backs so which make the process easier [6]. This allows the game to provide immediate feedback to player since scoring is independent on the created artifacts, which can be cross-validated with other players later on.

The case of *exact evaluation algorithm* is, naturally, the best strategy a GWAP can have. Here, the problem instance solution is algorithmically testable for correctness so no further human validation is needed to provide feedback to the player (no cold-start problem). However, it is a rare case when a problem-solving algorithm does *not exist* or has unacceptable complexity (and is therefore suitable to be solved by GWAP) and meanwhile the solution-testing algorithm *exists* in acceptable complexity (a typical case are NP-complete problems) [19]. In reality, only few games *outside* Semantic Web domain are implementing this model [9], [10].

However, a more likely scenario for a GWAP than previous one is to have an *approximative evaluation algorithm* for task instances, which means we can compute an approximation of a real solution value based on some characteristics. We can therefore automatically generate (although not completely fair) player feedback. The idea here is that player does not need to know the exact algorithm of score computation, he only has to know how the task instance solution should look like to earn him more points. As an example of this approach, we present our own game with a purpose called *Little Search Game* [18].

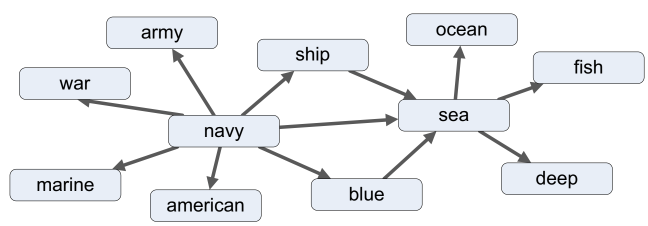

Fig. 1. Subset of the term network created by Little Search Game [18].

We designed the Little Search Game with a purpose of creating lightweight semantic structures of terms and relationships among them (for illustration see part of the generated term network in the Figure 1). In the game, the player's task is to formulate web search queries to minimize the number of results yielded by the search engine. Part of the query is given as a task instance (e.g. "sea", yielding 2 billion results). Player's task is to append some negative search terms to it, to decrease the number of results (the search engine exclude results containing these negative search terms, e.g., "sea –fish –deep –blue", yielding only 400 million results). The lesser is the number of results the greater is the score for the player.

Players quickly realize that successful terms (they may use only limited number of them, but may do as many attempts as they want) are those with high co-occurrence on the Web with the given task term. Players interpret the co-occurrence of terms as their relatedness and therefore, by collecting their game attempts we collect their opinion o term relatedness, which can be afterward transformed to a term network after the voting procedure (the offline cross-validation of player outputs – only relationships "suggested" multiple times make it to the network). Using this game we were able to retrieve relevant term relationships including those, which are not really supported by a frequent term co-occurrence on the web, but are still relevant (e.g., words "roentgen" and "bone"). In fact, these "hidden" relationships of terms are the most valuable artifacts produced by the game [18].

We see that this GWAP computes the game score not by evaluating the relatedness of terms themselves, but by measuring their co-occurrence on the web, which does not always correlate with the true relatedness [18]. However, these two values are at least partially correlating, so we can exploit the computable one (the co-occurrence) to run the game (without a cold-start problem) and seek for the second during offline cross-validation.

IV. Game Approach for Personal Multimedia Management

Games with a purpose seem to work well for annotation of multimedia content. Therefore, it might be a good idea to use it also for annotation of the personal (or small, closed group) multimedia resources. However, we now have to consider the GWAPs as part of the crowdsourcing techniques and that means (almost by a definition) that they are inapplicable for annotation of the personal content, mainly for privacy issues and also because of lacking expertise [20] of the crowd in one's personal life. Fortunately, this is not completely true, as the GWAPs are something more than a crowdsourcing technique.

Currently, GWAPs are not yet oriented to seek "expert" knowledge, they consider their players equally skilled for solving an arbitrary task instance. However, we can argue that if we let an ESP Game [7] player to play over his own personal photos, we will achieve not only greater joy of the player playing over the content he likes, but also the annotation of this content. The player would turn the boring annotation and categorization task to a more appealing one. However, a critical problem arises upon trying to run the game in such conditions: there will be no suitable game partner available, because ESP Game requires anonymity among playing partners – if the players know each other, they tend to provide invalid task solutions (e.g. irrelevant tags) and if they agree to "play fair", the gameplay would pretty much be like regular manual tagging. Moreover, most of the attractiveness of the ESP Game sources from the anonymity and from social experience of exploring the other person through means of the game [7].

If we turn back to *artifact validation models* from the previous section, we can see that the problem lies in this particular aspect of GWAP design: potential multiplayer model games (for annotation of personal multimedia content) are hampered by the need for anonymity that cannot be achieved in a small group of players. Bootstrapping and bot models will not work either, because of the need for preparatory sets of already solved tasks, which in addition must not to be known to the players. Personal multimedia content annotations can hardly be evaluated algorithmically (exactly or approximately) because they are too specific to any existing classifier. The only option here is to create game that motivate players to use helper artifacts, which can be transformed to multimedia annotations. Basing on our previous research with GWAP PexAce [6], we propose such method.

A. *PexAce – annotation of multimedia*

PexAce is a game with a purpose for acquisition of textual tags describing images that the game uses as its input [6], [21]. The game is a modification of the popular memory-based board game for multiple players – the Concentration (known as Pexeso). In Concentration, the player's task is to collect highest number of identical card pairs. All cards in the game (usually, there are 32 card pairs in the board of 8x8) are mixed and laid facing down the board. Players play in turns and in a single turn, player may flip two cards on the board. If they are identical, he may keep the pair and have an extra turn, otherwise the turn is passed to the next player. Memorizing the content and positions of the cards turned in unsuccessful attempts is the means for the player to retrieve them (not by accident) before their opponents do.

Fig. 2. Screenshot of the PexAce GWAP. On the left side is the panel with cards (some already disclosed), on the right are larger image thumbnails and in the middle text fields to enter annotations to currently flipped cards [6].

The PexAce is a single-player modification and computer adaptation of this concept (see screenshot in the Figure 2). Here, player has to retrieve all card pairs, but has to achieve it in lowest possible time with lowest possible number of turns. In addition, he is allowed to write annotations on the cards he turns and retrieve these annotations "for free" in a tooltip frame, by moving the cursor over a card facing down. If player uses this option, it drastically reduces the number of redundant card flips, and therefore, the player receives more points (which are then used in game's ladder). The player may not use annotations, they are optional and the score is computed based on number of flips. But players use them because they are motivated to do so.

After the game, the textual annotations are processed for tags. As we allow players to use free text, players sometimes use different languages, so the annotations are firstly automatically translated, then tokenized and lemmatized so each image-player combination receives a set of “suggested” tags (a single image is used in the game multiple times, always with a different player). Then, a voting procedure is run and tags suggested by two or more players are declared correct.

We implemented the game as a web application[1] and collected over 24000 of raw image annotations over 4000 images. Each image was annotated by 15 players and received 5 approximately tags. We conducted an expert evaluation over 400 images tagged by the game and shown that 94% of these tags is truly relevant as annotations for the images [6].

B. A game for personal content annotation proposal

Based on our previous experience and experiments, we propose a modification of the PexAce game concept to create more entertaining alternative to manual personal multimedia content annotation. The new approach keeps the advantages of the original game:

- The tags acquired through game are relevant.
- It is single player and requires relatively small group of players to annotate individual images (the number of players can even be further decreased as we show below).
- It requires no other inputs (starting set of annotated resources) apart from images that need to be annotated.
- It serves also as a multimedia presentation tool – the players enjoy the images while they play (several players reported they were sometimes observing images for their pleasure).

The main difference from the original game is that we allow players to load their own image set to the game to play with (in the original game, we used general images, provided by Corel 5K image dataset), also with his friends or family (together forming a *social group*). Such approach has following advantages:

- The image set gets annotated also with tags specific for the social group, such as names, places, events etc. which cannot be provided by crowd.
- The social group is highly motivated to view the images, because it perceives the game also as presentation tool for its own images. As we have observed in case of one of our players, this greatly increases the motivation of players to play the game: during the early testing stages of the PexAce, we used an image set provided by this player, which we eventually changed to Corel dataset. After that, this player reported to us that the game became much less appealing to her and that she prefer playing with her own images.
- The game generates a friendly competition among social group members.
- The players are still able to participate in global competition (the global ladder of all game players), despite they use completely different image set because changing the image set to anything cannot effectively reduce the complexity of the gaming challenge (it can only worsen it). The game simply computes the score from number of flips, size of the board, etc. which can be used also in the global ladder.

Even if the size of the group is very small (for instance, a family with four members), the voting procedure yield some relevant tags (one to three) as we have observed in experiments with PexAce [6]. However, the number of tags can be increased by:

- *Repeated use of a single image in the game for a single player* to increase his “suggestion” pool. We originally designed the PexAce task assignment policy in a way which prefers players encountering an image only once. However some players exceeded the image pool and annotated some images for a second time. In these cases we have observed that players use more or less different annotations, which expanded the number of suggestions for a single image up to 1.5 times.
- *Named entity extraction*. Named entities such as names or places specific for the social group can be mined throughout all raw annotations of the social group. If they recur often across multiple images, they might be considered correct for each image even if they were used only once on that image, because it is not probable they have been used by accident.
- *Introduction of weighted tags*. In this model, every tag suggestion, although unconfirmed by the other players is used in the metadata with a low weight. Then, during the eventual resource retrieval, the weights can be considered in resource ranking.

V. Conclusion and Future Work

In this paper, we introduced our method for playful annotation of the personal multimedia content (namely image collections) which is based on our existing game with a purpose, the PexAce. PexAce is a modification of the popular board memory game: the Concentration, where players seek for the pairs of identical cards (images) concealed on the board. In the game, the player is allowed to write textual annotations on the cards to avoid the need of memorization. Experiments with PexAce demonstrated that apart from acquisition of metadata for images it also serves as an image presentation tool.

Games with a purpose have been a research field for some years, however, we now present this principle tailored for the first time for acquisition of highly specific personal metadata. Our novel approach is enabled by unconventional player output validation scheme, where the game’s score computation is independent on the quality of artifacts that player provided (in this case image annotations). The player is only motivated to create annotations to help him to achieve his game goals. The game can therefore be used among much smaller groups of players and suffer no cold-start problem, common for most of the existing GWAPs. Using our approach, players annotate their own resources while participating on the global

[1] http://mirai.fiit.stuba.sk/pexace

competition and also competition and socialization with their friends and relatives.

A major part of the future work, although the preliminary results are promising, is the validation of our method in the environment of small social groups and their multimedia resources. We say multimedia to include video resources (also typical for personal archives), which can be transformed to single images (as screenshots) or short image sequences, to be used and annotated in our game as well. The resulting annotations can be then used not only for video categorization and search (for example, in faceted browsers [22]), but also as input for automated composition tools for personalized narratives [1].

Other interesting idea that needs exploration is the increased difficulty of the game, which can be achieved by including semantically similar images into one game session. This would force players to use more specific tags for the given images, which is in favor of our approach [6]. In the domain of personal multimedia resources this can be easily done by including images from a single album – they have a high probability of being similar, related for instance to some event. Inclusion of the images belonging to one story would also increase the attractiveness of the game itself. There is also option of designing the whole game concept optionally multiplayer, as we can easily imagine a group of friends playing the game together at the same time.

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