SpotTheLink: A Game for Ontology Alignment

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Abstract: The interoperability of data depends on the availability of alignments among different ontologies. Various approaches to match, merge and integrate ontologies and, more recently, to interlink RDF data sets were developed over. Even though the research area has matured, the full automation of the ontology alignment process is not feasible and the human user is indispensable. Such tasks involve mainly bootstrapping the underlying methods and for validating and enhancing their results. The question of acquiring such input still remains to be solved, in particular when it comes to the motivators and incentives that are likely to make people dedicate labor to ontology alignment tasks. In this paper we build on previous work of ours on using casual games to tackle this problem. We present SpotTheLink, the latest release of the OntoGame framework, which allows for the definition of mappings between Semantic Web ontologies as part of a collaborative game experience. We illustrate the idea of SpotTheLink in an instance of the game aiming to align DBpedia and PROTON, and explain the game background mechanics by which players' inputs are translated into SKOS-based ontology mappings. A summary of findings of SpotTheLink user evaluation and the experiences we gained throughout the entire life span of OntoGame allow us to derive a number of best practices and guidelines for the design of incentives-minded semantic-content-authoring technology, in which human and computational intelligence are smoothly interwoven.

1 Introduction

A large share of tasks in semantic-content authoring crucially rely on human intelligence [SS10]. This holds for many aspects of ontology engineering, but also for ontology-based annotation, be that for data-oriented resources, such as images, audio and video content, or for functionality, such as Web services and APIs. In previous work of ours we have extensively discussed the importance of motivators and incentive mechanisms to encourage a critical mass of Internet users - in particular, users beyond the boundaries of the semantic-technologies community - to contribute to such inherently human-driven tasks. Through OntoGame[1] we have

[1] http://ontogame.org

provided a framework for casual games which capitalizes on fun and competition as two key motivators for people to willingly invest their valuable time and effort in semantic-technologies-related tasks, whose technical details hide behind an entertaining collaborative game experience [SH08a]. This paper presents the newest release of the OntoGame series, called SpotTheLink, which addresses this challenge in the area of ontology alignment.

Ontology alignment is undoubtedly one of the most active and mature area of research and development in semantic technologies [ES07]. A multitude of approaches that aim at automatizing the matching, merging and integration of ontologies, both at the schema and the instance levels, have been proposed and successfully applied to resolve heterogeneity issues; more recently, the topic has received attention in the context of interlinking RDF-encoded data sets exposed over the Web as part of the Linked Open Data Cloud. Human input remains a key ingredient of ontology alignment, as a valuable source of domain knowledge used either to train matching algorithms and to develop the underlying knowledge base, or to validate and augment automatically computed results. SpotTheLink provides a means to systematically harvest such human input as a side-product of an entertaining collaborative online game. The particular instance discussed in this paper is based on DBpedia and the upper-level ontology PROTON, which was also at the core of one of our previous games, OntoPronto.[2] The mappings are encoded in SKOS (Simple Knowledge Organization System),[3] but other alignment languages could be easily supported.

A first evaluation of the approach was carried out in a controlled fashion in order to study the feasibility of the approach - that is, to show whether the data generated through the game is useful - and to receive early feedback on the game experience, which is very valuable for the future implementation of SpotTheLink and its official release.

2 SpotTheLink: a game for ontology alignment

SpotTheLink is designed according to the generic principles proposed in [SH08b]. It is developed on top of the OntoGame platform and is available online for free use by semantic-technology enthusiasts or casual-game addicts.[4] Its goal is to relate concepts of two ontologies to each other. In the particular instance discussed in this paper, we match DBpedia concepts to concepts from the PROTON upper-level ontology, but the game can be easily configured for other scenarios, as well as for different ontology alignment problems, such as the generation of training data sets in order to enable automatic algorithms to autonomously run matching tasks, and the validation of matching results which have been previously computed

[2] DBpedia ontology available at `http://wiki.DBpedia.org/Ontology`; PROTON ontology available at `http://proton.semanticweb.org/2005/04/protont`

[3] `http://www.w3.org/2004/02/skos/`

[4] `http://ontogame.sti2.at:8080/OntoGameServer`

automatically.

2.1 How the game works

When the player starts a game a random partner is negotiated and assigned.[5] This team-of-two has to collaborative solve a series of challenges, in other words, each player will only get points if the team gives consensual replies to each challenge. Every game round consists of two challenges: (i) first, the players are presented with a random concept from DBpedia, along with a description and an image (if available), and have to choose and agree on a related concept from the PROTON ontology (see Figure 1); (ii) then the players have to agree on the type of correspondence between these concepts.

Figure 1: Step 1 - Match the related concept

In the example shown in Figure 1, the players have to choose whether the *Film Festival* concept (on the left-hand side) is a *Happening*, an *Abstract* or an *Object* (shown as tree on the right-hand side). If their answers are identical, they earn points. In the next step, they further specify the nature of this match, that is,

[5]The game is available online, but has not yet been officially released. For this reason, if the interested reader is willing to try it, it is very likely that she will not find a fellow semantic-technology enthusiast playing the game simultaneously. For such situations, in OntoPronto and OntoTube we have also implemented a single-player mode using pre-defined questions with answers from previous rounds of the game. As SpotThelink is still under development, the single-player mode is not yet available; for testing purposes, the game can be played by opening two browser windows.

whether the concept they just selected in PROTON is *more specific* or *the same* as the given DBpedia concept. For the relationships we have chosen SKOS mapping relations (*skos:exactMatch*, *skos:narrowMatch* and *skos:broadMatch*), however, we renamed them for a clearer understanding for a broad audience of players. If both players choose to skip or if they do not agree on any of the two challenges, they can continue playing on a new concept. Otherwise, if a broader match has been identified on the PROTON side, the game is resumed for sub-concepts of this particular PROTON concept. For instance as *Film Festival* is a more specific concept than *Film Happening*, players may try and match the former to sub-concepts of the latter: *Event*, *Situation* and *TimeInterval*.

Each game has a time limit of 3 minutes and can include an arbitrary number of challenges.[6] A game round ends in the following cases: players disagree on one of the challenges, players agree to skip, or the deepest level of the inheritance hierarchy has been reached. The latter is indicated in the hierarchy by a *black-dot* symbol, whereas the *folder*-symbol indicates that there is another level in the hierarchy. Pairs of players are computed randomly and anonymously for each new game round. This provides a simple mechanism to prevent cheating, as players cannot communicate to each other by other channels outside the game. The game ends when a player closes the game application, disconnects from the game server, or when the game time is up.

2.2 Deriving semantic content

In SpotTheLink players agree on pairs of similar concepts from two source ontologies and on the type of relationship between these concepts, expressed as exact or narrower matches. The data collected across multiple game rounds is analyzed offline and the results are encoded is SKOS. The analysis targets only alignments which have been confirmed throughout multiple game rounds by different pairs of players.

3 Evaluation

To evaluate SpotTheLink we analyzed the results of the individual challenges and the associated alignments, and conducted structured interviews with some of the players to assess their game experience. The trial involved a randomly chosen group of 16 players, who all had some expertise in semantic technology. They played the game in the same time - in order to simulate the gaming experience where several users can be paired randomly - for around 20 minutes, without having received any additional information on the purpose or goal of the game. This accounts for a

[6] The time limit, just as the number of points and the challenges per game round can be configured through the OntoGame framework.

total of 5 hours of labor, across 190 game rounds involving 246 DBpedia concepts. After completion of the game playing session, we analyzed the collected data with the help of two ontology-engineering experts from outside the SpotTheLink team and interviewed the players.

The evaluation was conducted with a focused user group in order to catch design flaws at a relatively early stage in the development process. We will certainly have to carry out a second evaluation, with a different, and larger user group following the release of the game. For the analysis of the data we investigated the level of consensus, i.e., how often was a pair of players able to reach consensus, and the correctness of the alignments. The evaluation revealed that the approach is feasible, and that the game produces useful data which can be used, for instance, for testing purposes by automatic alignment tools. For the user experience analysis we were primarily interested in the fun factor of the design, the level of understanding of the rules of the game, and the role of the human partner in motivating users to engage with the game. The feedback indicated a number of issues in the design of the game, particularly at the level of the user interface, which we are currently addressing with the help of a professional game development company.

The 16 participants matched 32 of 246 DBpedia concepts to the PROTON ontology. The total number of inputs recorded throughout the evaluation session was 882. On average, each player produced 23.5 matches during the playing session. 146 of the total 190 game rounds were logged as consensual, which means that in more three of four cases players were able to find consensus about matching concepts and associated correspondence. This confirms findings from previous OntoGame evaluations [SH08a].

After playing the game the participants filled out an online questionnaire.

Challenge and understanding. A high majority of the users stated that playing SpotTheLink is some intellectual challenge (52, 9%) or has just the right intellectual challenge (23.5%), whereas about 24, 6% of the players stated that the game was too difficult. None of the respondents considered the game to be no challenge at all. Almost two third of the participants found it easy to grasp the game's goal and to find a corresponding concept (58.8%), but less than the half found it easy to select an appropriate relationship between the two concepts (47.1%). This could be surprising given the small number of choices they had, but can be traced back to the difficulty of deciding whether two concepts are exact matches of each other given the limited context in which this decision is supposed to be taken. Players could not browse through the two source ontologies, or see any of the other concepts close-by in the inheritance graph.

The game interface. More than half of the interviewees (57.1%) considered the interface generally comprehensible, but less than half of them (42.9%) found it appealing. Only slightly more than one third (35.7%) thought of the interface as responsive, and less than one third experienced it as self-explanatory (28.6%). These issues will be addressed in a second release of the game, which will result in a major re-design of the graphical layout of the game by a game development

company to improve the user experience.

Game fun. Almost all participants would rather not (64.7%) or not (29.4%) play SpotTheLink again in its current form. Accordingly, most of the players considered the game boring (11.8%) or fairly boring (52, 9%) and about a third of the people found the game fun (35, 3%).

From the results of the user experience analysis, we can conclude that that the two types of challenges the game is built upon - concept selection and relationship selection - must be even further simplified and better explained through examples and a self-contained interface. Fast-paced casual games require repetitive and extremely simple tasks, and the latter is still to be achieved. Furthermore, the way in which concepts and inheritance hierarchies are represented should be improved to foster immediate understanding of the purpose of the first challenge. The results on the correctness of ontology matches confirms previous findings: the output of the games for general knowledge problems is of high-quality. A greater challenge is to make the game interesting and fun to play.

3.1 Designing games for semantic-content authoring: lessons learned

In this section, we summarize some of the most important lessons learned over the last three years of continuously developing the OntoGame framework. The ultimate aim of this line of research is to provide comprehensive decision support in matters related to the execution of human-aided semantic content authoring tasks. This can be achieved by identifying those tasks that can be effectively addressed through games, crowdsourcing platforms such as Amazon Mechanical Turk,[7] or social platforms.

Task selection. The identification of those semantic content authoring tasks that are suitable for the casual-game paradigm is of paramount importance for the overall success of the approach. Hiding tasks behind games is not trivial, and cannot work for every aspect of semantic-content-authoring, no matter how highly human-driven it might be. Candidate tasks cannot be too difficult, or too easy; they have to be divisible or combinable, so that they can be broken down into smaller chunks that can be independently solved across a potentially large group of contributors [Ste72]. They have to be suitable for a broad audience of players and, in the context of games, be mappable to a series of consensual-decision-making challenges. The number of challenges in a game round is equally important.

Game fun: user interface and social factor. The challenge here is to reach a balance between an appealing design and the purposefulness of the game with respect to the task to be solved. Games for semantic content authoring are in many cases on the edge of being too difficult for a non-expert audience. The positive side of this is that such games provide an intellectual challenge, which is important

[7] http://www.mturk.com/

to keep the games sufficiently interesting. The negative side is that creating an attractive and easy-to-grasp interface for such technical tasks is not trivial; user interfaces studies for semantic technologies are still in their infancy even when it comes to expert-oriented environments such as ontology editors. Massive user participation and generation of output is crucial for the games and the methods they incorporate: they require a critical mass of contributions. Even when the task is intellectually challenging, and the interface is perceived as usable and pleasant, we cannot expect a massive user involvement per se. Additional incentives schemes and motivations are needed to make users start and continue playing. Keeping scores is an important feature of every game. Players want to improve their ranking and standing within the player community. With respect to sociability, knowing that they are playing against a real partner is motivating for many players. As the games are cooperative by design, players might want to know more about their partner. Allowing communication after the gaming session - if they achieve a certain amount of points - could be such a measure. Moreover, players should be able to indicate preferences for the choice of their partners, be able to invite people from their social network to play the game, and report extensively on their achievements, for instance, through frequent status updates.

Knowledge corpora. Games with a purpose usually need a corpus of knowledge to start with, which is an integral part of the game challenges. Challenges cannot be shown too often to the same players without damaging the game experience. This requires a large repository of knowledge in the background that can be used as input, whereas online collections of resources such as YouTube, Flickr, Wikipedia or WordNet are surely useful. Ontologies suitable for an ontology-alignment game should be of manageable size (several hundreds of concepts), and in a domain that a broad audience of users can relate to (e.g., media, entertainment, sports, but also ontologies capturing general knowledge such as DBpedia and PROTON, as in our game instance).

4 Related work

The concept of 'games with a purpose' and 'human-aided computation' was proposed by Luis von Ahn and colleagues. The first 'game with a purpose' was the ESP game for annotating images [vA06] (more games on the GWAP website[8]).The game Phrase Detectives tackles the challenging problem of anaphor resolution,[9], Sentiment Quiz gathers information about words' sentiment scores,[10], while Page Hunt[11] investigates human search behavior. Yahoo's Videotaggame[12] and TAG [13]

[8] http://www.gwap.com
[9] http://anawiki.essex.ac.uk/phrasedetectives/
[10] http://www.facebook.com/apps/application.php?id=28282268272
[11] http://pagehunt.msrlivelabs.com/PlayPageHunt.aspx
[12] http://videotaggame.sandbox.yahoo.com/
[13] http://www.few.vu.nl/~aes200/taggame.html

encourage players to annotate videos. Waisda [14] works like von Ahn's PopVideo as well, but is used to annotate live shows. Wordhunger [15] incentivizes players to map Wordnet concepts to Free base concepts.

5 Conclusion and outlook

In this paper we presented the latest release of the OntoGame framework, called SpotTheLink, which allows for the definition of mappings between Semantic Web ontologies as part of an collaborative game experience. The contributions of the paper are twofold: first, we investigate whether and how the alignment of ontologies can be addressed through casual games, showing that the human input gathered through SpotTheLink is valid and can be used to augment automatic ontology alignment methods and techniques; second, based on the findings of the evaluation, and on the experience gained throughout the entire life time of OntoGame, we see the major challenges in the level of difficulty of the task, the attractiveness of the game design, the emphasis on the social component, the availability of suitable knowledge corpora and simplicity of game play.

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[14] `http://www.waisda.nl/`

[15] `http://wordhunger.freebaseapps.com/`