

Semantic Network Construction on Top of Museum Collection and Other Information Sources

Oksana Petrina, Dmitry Korzun

Institute of Mathematics and Information Technology,
Petrozavodsk State University (PetrSU)
Petrozavodsk, Russia
{petrina, dkorzun}@cs.petrSU.ru

Abstract—This work introduces a semantic network construction scheme on top of museum collection and other information sources. A common museum collection provides low-semantic description of exhibits. Our earlier developed ontological model defines rules for the structural information representation of exhibits as a semantic network. That structured and related representation advanced with ranking algorithms for knowledge identification and selection. The semantic network is used to construct digital services for smart museum. The key constructors of semantic network are software agents responsible for interaction with various data sources.

I. INTRODUCTION

A museum visitor has a personal mobile device accessing relevant information about surrounding exhibits and in a personalized and cognitive way [1]. It explores the processing of user preferences using various scenarios as an example. Paper [2] suggests integrative framework for supporting the pre, during and post visit phases in a personalized manner, to help the museum visitors access information concerning exhibits that are of primary interest to them during pre-visit planning, provide relevant information to the visitors during the visit, and follow up with post visit memories and reflections.

The smart museum concept developed at Petrozavodsk State University (PetrSU) [3] involves implementation information services for effective cultural and historical heritage preservation and trans-mission within a digitally enhanced museum. The information service development is based on applying the semantic network model for integrating heterogeneous cultural and historical heritage knowledge. Data mining in a semantic network is reduced to the ranking problem, which is used for constructing the services.

The review is presented [4] various ways that user preferences have been handled in Artificial Intelligence. Paper proposed [5] method of connecting museum visitors behavior and knowledge and the exhibited artifacts of interest, using the concept graph over the Wikipedia link structure. Personalization algorithms employ to choose information the most suitable for each individual user, based on the semantics and information within the user profile [6].

The mathematical task of ranking involves ordering a set of objects according to their relevance to a given parameters [7]. The local ranking model was developed to calculate the relevance estimates of exhibits [8], implemented as an algorithm in the digital services.

It is necessary to structure museum collection information to implement personalized algorithms in digital services. An ontological model was previously developed for structural description of collected museum objects [9]. Engaging the community in ontology-driven knowledge management is still challenging in many areas [10]. Traditional ontology editors as Protege are difficult for use by non-professionals. Semantic MediaWiki is a convenient tool for data structuring for collaborative maintenance of ontology by museum personnel and historians.

The rest of the paper is organized as follows. Section II defines the problem of structured information representation of cultural and historical heritage. Section III introduces our ontological model for structural description of museum artifacts using the Semantic Media Wiki. Section IV presents proposes our scheme for semantic network construction on top of museum collection and other information sources.

II. PROBLEM

The difficulty of working with small museum artifact complexes is due to the fact that photographs of the same era are stylistically, compositionally, meaningfully close to each other. When they are viewed for a long time, the researcher ceases to pay attention to essential details and inefficiently selects exhibits for future research. The possibilities of traditional method of search automation (in the database by keywords) are limited: from the field of view of the researcher fall sources that do not have a formally complete coincidence for the desired attributes. This method does not provide: a convenient solution for sorting the identified task, depending on the degree of relevance; quantitative assessment of the degree of relevance for the selection of the necessary exhibits.

Common museum collections have low-semantic description. Each individual photograph contains particular facts. Only in aggregate do these facts allow us to characterize certain aspects of the phenomenon being studied. Therefore, an additional information model is needed in which the facts are linked. This allows us to talk about the contexts of their existence and characterize social phenomena and facts. To build such a model, it is proposed to perform semantic linking of information about sources based on ontological modeling methods.

Based on the ontology that defines the conceptual model of stored information (structure), an informational description of the actual stored information about sources and their

relationships is performed - the formation of a semantic network. The semantic network describes objects, phenomena and concepts of the subject area using network structures based on graph theory. Such a structured and related presentation of information allows you to apply ranking algorithms for its identification and selection.

Database support required, which of information descriptions (semantic content) and rules (ontology) for data structuring. The relations between data allows you to organize a semantic network.

The semantic network is used to build digital services to support the museum. Digital services identify and select museum exhibits based on personality user needs. The following digital services are considered, for the construction of which ranking algorithms are used.

1) Museum fund study service is intended to improve exhibit choice for historical research task based of a ranking algorithm. The ranking algorithm consider the information in the user profile and assigns proximity rank to exhibits.

2) Exhibit service is intended to improve related exhibit choice and display their digital image on screens next to the real exhibit based of a ranking algorithm. The ranking algorithm consider the description of the given exhibit and assigns proximity rank to other exhibits.

3) Enrichment service is intended to adding new information to the museum collection and identifying new relation between exhibits based of a ranking algorithm. The ranking algorithm recounts the ranks of the exhibits relative to each other after adding new information. A significant change in rank may indicate the new relation detection.

The semantic network can be analyzed using algorithms, revealing relevant information on given parameters and thereby providing the user of services with personalized access to the museum collection.

III. ONTOLOGICAL MODEL

The sources of such information for the service are from (a) museum information system, (b) Internet sources of historical information as DBpedia, (c) exhibits themselves, and (d) individual information and historical knowledge from museum visitors and personnel.

An ontological model was developed for semantic linking of information from various sources based on the top-level ontology CIDOC CRM. Ontological classes are museum objects, and other significant entities: personalities, geographical locations, historical events. Ontology allows you to identify each individual subject and describe its relations with others. For example, you can fix the exhibit belonging to a topic, event, person, geographical object, time period.

The developed ontological model is focused on existing exhibits in the Museum Information System (MIS) of the History Museum of PetrSU. The main subject area, the exhibits of which are presented in the museum, relates to the everyday life history of the university. Museum exhibits are presented both in physical form (for example, furniture, clothes) and in digital form (digitalized photo, interview recording). The developed ontological model defines the conceptual model of

stored information (structure). The semantic network is formed on the basis of information descriptions of the actual stored information about the exhibits and their relations.

In addition to describing exhibits and related entities, the ontology provides a class for storing a user profile. The profile description determines the personalization parameters for ranking, taking into account the interests of this user.

Ranking exhibits relative to users and other exhibits involves assigning a rank to a pair of objects. An ontological class is provided for storing ranks. Ranks are divided into local and global. Local ranks represent an estimate of the proximity between a user-exhibit pair and are stored on the user's device. Global ranks represent an estimate of the proximity between two exhibits and are stored in the semantic network. Global ranks are used by the exhibit exploration service to rank the closest exhibits to a given one. Also, global ranks are recounted in the operation of the replenishment service.

The construction of the semantic network is based on the use of the Semantic Media Wiki. An expert (museum personnel) enters the data on the wiki page, marks the text of the semantic wiki with markup. The category to which the wiki page is assigned corresponds to the ontological class. And the wiki markup corresponds to the properties of ontological classes. One page contains a marked description of the exhibit, personalities, events or other ontological entities.

In SMW, objects are represented as wiki-pages. Categories play the role of ontology classes that can be assigned to the pages, thus expressing an object belonging to the class. Categories can be nested into each other, forming a class hierarchy. To describe all other relationships typed links between pages are used. The role of the subjects and objects of semantic relations in SMW always represented as wiki-pages. This model significantly limits the possibilities for information representation about the domain. That is, in SMW an expert can easily express the idea that an exhibit is addressed to a particular person Both exhibit and person are presented as pages. Nevertheless, SMW cannot describe a logical statement about individual words or other parts of the wiki-page.

The user specifies typed links with an accuracy of each symbol; otherwise it will lead to a mistake. Sometimes the user incorrectly utilizes typed links. For example, if someone's position is mentioned in the text of the interview, and then the

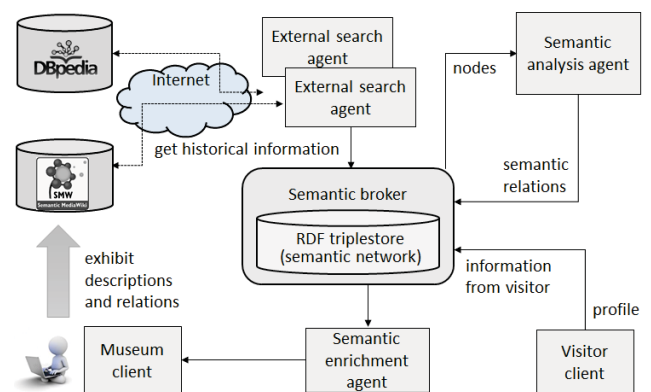


Fig. 1. Architectural agent-based design

```

SELECT DISTINCT
if (bound(?actorAuthorUri), ?actorAuthorUri, "\"") as ?actorAuthorUri
if (bound(?actorOwnerUri), ?actorOwnerUri, "\"") as ?actorOwnerUri
if (bound(?actorRepresentUri), ?actorRepresentUri, "\"") as ?actorRepresentUri
if (bound(?actorParticipantUri), ?actorParticipantUri, "\"") as ?actorParticipantUri
WHERE
{
?classUri rdf:type owl:Class. ?classUri rdfs:label \"Man-Made Thing\".
?objectUri rdf:type ?classUri. ?actorClassUri rdf:type owl:Class.
?actorClassUri rdfs:label \"Actor\".
optional {
?objectUri smartProperty:Has_former_or_current_owner ?actorOwnerUri.
?actorOwnerUri rdf:type ?actorClassUri. }
optional {
?objectUri smartProperty:Has_author ?actorAuthorUri.
?actorAuthorUri rdf:type ?actorClassUri. }
optional {
?objectUri smartProperty:Represents ?actorRepresentUri.
?actorRepresentUri rdf:type ?actorClassUri. }
optional {
?objectUri smartProperty:Had_participant ?actorParticipantUri.
?actorParticipantUri rdf:type ?actorClassUri. }
FILTER(regex(str(?objectUri), \"%1\")).
}
    
```

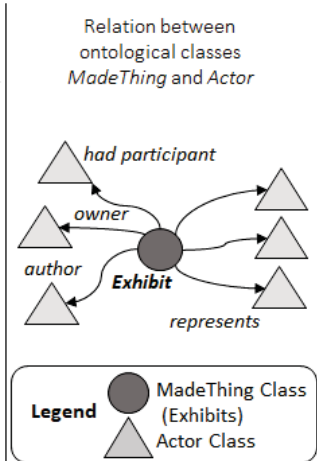


Fig. 2. SPARQL-request example

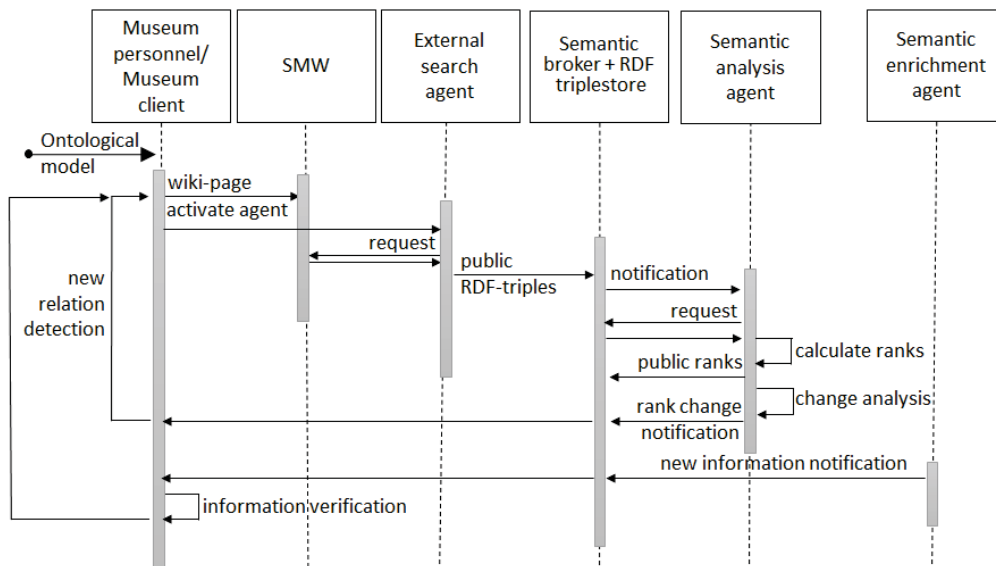


Fig. 3. Scheme of semantic network construction

Metrics	Value
<i>Semantic Network Objects</i>	
Number of Objects	729
- exhibits	297
- personality	60
<i>Ontological model</i>	
Number of classes	33
Number of properties	112
<i>RDF-triplestore</i>	
Number of triples	70226

Fig. 4. Semantic Network Metrics

therefore the typed reference can indicate only one instance of a class. Sometimes the use of typed links is insufficient, and concrete properties for a class need further specification. A software agent has been developed to extract information from a wiki. The agent executes requests to the SMW according to the specified ontological parameters and saves the extracted information to the semantic network.

Designing an ontological model has a significant role in the further structuring of information. Ontological classes determine the basic informational entities, and class properties determine their characteristics. Ontological modeling can be used for any subject area to provide access to information in terms of semantics for further analysis.

IV. SEMANTIC NETWORK CONSTRUCTION

user refers to the position as if the exhibit is a person.

In SMW one web-page represents one instance of a class,

The model of interacting agents is shown in Fig. 1. Consider the semantic network construction with the model.

Museum personnel contributes information about exhibits to the SMW <http://smartroom.cs.karelia.ru/wiki/>. SMW enables to form each cultural heritage object as a wiki page is grounded in OWL. Every page represents an ontological element (including RDF classes and properties) with appropriate URI. Based on this mapping, SMW generates RDF triples in terms of ontology for any page on request. There is a SPARQL access point based on SMW. It allows you to execute queries to extract data, see Fig. 2.

External search agents respond for interacting with external Internet resources. This agent performs as a semantic intermediary. It converts information from external sources to RDF triples and vice versa. That is publishes the extracted data to the data storage according to ontological model. In this way the External search agent forms the semantic network. External search agent retrieves data from SMW. An example request all related personalities for a particular exhibit is shown on the left in Fig. 2. A fragment of an ontology illustrating the relation between ontological classes `ManMadeThing` (exhibits) and `Actor` (personalities) on the right in Fig. 2.

Semantic agent analyzes the information provided by visitors to enrich the semantic network with more detailed descriptions and relations. Visitors can add descriptive information about museum objects and their relations with other objects. The agent implements enrichment of relations between exhibits using information received from visitors. It receives notification of the publication of new update. Semantic network update initializes the launch of the local ranking algorithm to calculate the ranks between exhibits. Global ranks are stored in the semantic network. Semantic agent checks which ranks have changed. The expert observes changes in ranks after updating information. If the expert detected new connections, then he updates the information in SMW.

Semantic enrichment agent receives notes from museum visitors. Visitors have the opportunity to be not only consumers of information, but also to supplement the information description. Visitor comments are displayed by the expert through the museum client. It is important, that updates from visitors can come at any time. The expert must verify them and, if necessary, update the data on the wiki. And the algorithm repeats again. The steps sequence is shown in Fig. 3.

Semantic network filling occurs when an external search agent publishes triples. The scheme shows an option to populate a semantic network based on a wiki. Other data sources can be used for construction. Then the agent is implemented based on the specifics of the data source, But it will publish the RDF-triples according to the ontological model in the same way. The semantic network of the History museum of PetrSU constructed based on this scheme. The semantic network metrics are presented in Fig. 4.

The proposed construction scheme can be used in other problem domains. Example are collaborative work environments and industrial monitoring systems [11]. An important aspect is development of an ontological model of the application problem domain for structuring information.

V. CONCLUSION

This work considered the semantic network construction scheme on top of a museum collection and other information

sources. The semantic network is constructed according to structural rules of the ontological model. We implemented the pilot when a semantic network is formed using the Semantic Media Wiki technology. We experimented with the semantic network construction in the History museum of PetrSU, where the pilot is used for personal assistance services.

ACKNOWLEDGMENT

This research is supported by RFBR (research project # 19-07-01027). The work is implemented within the Government Program of Flagship University Development for Petrozavodsk State University (PetrSU) in 2017-2021.

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