Metadata representation of Real-World Objects for Architectural Education

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Abstract

Within the MACE project, we support simple access to and retrieval of digital learning resources in exploratory architectural education. In order to facilitate the improved access, we introduce a digital representation of real world objects through an extension of the LOM based MACE application profile, named entity recognition and the combination of various databases. Automatically grouping learning resources, we add additional metadata otherwise not available and thus improve retrieval of suitable learning resources. Our first results clearly indicate the suitability of our approach.

1. Introduction

Digital architectural learning resources are scattered over a large number of repositories. The diversity of repositories hinders easy retrieval and access to appropriate learning resources that meet the needs of students and teachers in this fragmented landscape. They have to access each repository, search through them and retrieve possibly useful resources.

Education in architecture, especially at the university level, specifically relies on the paradigm of “learning by example”, meaning that students use existing objects like buildings and projects, but also other objects as sources of inspiration [1][2]. As such, access to and navigation of learning resources in the architectural domain cannot only rely on simple keyword search and result link presentation, but needs more advanced forms of access, e.g. image and location based search, classification browsing, and generally speaking discovery oriented mechanisms for access to the provided learning material.

Within the European project MACE (Metadata for Architectural Contents in Europe) [10], we enable unified and simple access to the architectural learning resources scattered over repositories world-wide. Users of the MACE portal [10] are able to search through and find learning resources that are appropriate for their context in a more discovery oriented way [13]. The learning resources relate to each other across repository boundaries thus enabling learners to discover new learning resources that can serve as additional sources of inspiration.

The MACE system bases on the representation of the learning resources through the MACE application profile. Each learning resource is described through an instance of the application profile that combines information about the domain of the learning resource with information about its context, educational descriptions and competence data, that builds on the ideas outlined in [5] and [11]. The application profile bases on the Learning Object Metadata standard [4].

The MACE application profile is extensible so that we are able to describe real world objects like buildings as learning resources, thus following the IEEE definition of learning objects. This is necessary because architects use buildings in the real world as learning objects in their curricula. The instances are stored in the MACE store [12].

In this paper, we describe our approach for enabling the description of real world objects within the MACE system. Chapter 2 briefly outlines the characteristic of real-world objects while chapter 3 describes the generation of real word object representations (RWO). First results are presented in chapter 4 and chapter 5 concludes.

2. Real-World Object characteristics

We distinguish three kinds of entities in MACE, 1) real world objects and subjects introduced above, 2) users of MACE (e.g. an architecture student, a teacher or an architect), and 3) digital learning resources describing either real world objects/subjects or users [12]. Hence, MACE entities – including RWOs and digital contents – are not constrained to either the physical or the virtual realm (or world), as MACE entities may have their origins in both realms.
Real world objects (and subjects) are “things” of the real world with a relation to architecture, for example architects, buildings and places. RWOs were originally described as a prerequisite for storing contextual information in a relational data representation similar to the context model of Zimmermann and Lorenz [13]. In this approach, each object of the physical world (as perceived by the human mind) has exactly one virtual placeholder, which serves as a bridge between both realms: information technology relies on the simple (but essential) fact that digital content can be linked to another specific digital content through a unique reference. Such references, for example, can be a memory address or an URI. However, objects of the real world do not take up virtual computer memory and do not inherently gain an address through this. Virtual placeholders for the real world objects that take up virtual space and therefore become addressable are needed – these are the RWOs in the MACE store.

RWOs, per definition, reach out of the computer realm and into the realm of the real world structure. They are the nexus between a computer address and a human abstraction of physical matter. RWOs must fulfill two postulates:

Completeness: The set of RWOs must be exhaustive. There must be one RWO for each real-world object.

Uniqueness: There may not be two RWOs for the same real-world object.

A number of problems is associated with each of the two postulates. For example, the postulate of Completeness requires that the list of RWOs may not leave out any physical object about which even the smallest piece of digital information exists, and that this list must be kept up to date to reflect changes in the real world or in the data that is available.

We tie RWOs to learning resource metadata sets with a unidirectional link, so that an RWO functions as a bag collecting related learning resources. This approach allows us to simply share existing metadata of the related learning resources.

We deal with completeness by adding a new RWO for each new digital learning resource in the MACE store for which no RWO exists. Uniqueness on the other hand requires ensuring that not two RWOs for the same learning resource exist. This is quite problematic, because different languages and ambiguities in one human language result in different names for the same physical object. If RWOs are entered manually there is no easy way to check if an entry already exists as the new entry might be just a new name for an already existing RWO. Also we have not defined relations between RWOs like inheritance as the architects did not consider this necessary for their exploratory learning process. By checking exhaustively the MACE store for plausibility, we ensure that no duplicate RWOs are generated. The next section will outline the generation of RWOs in more detail.

3. Generating RWOs

We aim to automate the generation of RWOs and their relation to learning resources but nevertheless also foresee a manual creation process. As for the metadata representation of LOs we also use the LOM standard for describing RWOs. In a first approach, we generated RWOs by matching a full text index of learning resource texts from MACE with the GEONAMES geographic location database [8]. The results were used to automatically generate RWOs and add their geographical locations. With an error rate of about 90%, this approach was not feasible for us.

Our second and more successful approach relies on named entity recognition. We automatically extract names of persons, locations and buildings from the texts of learning objects and their metadata. The person and building names are used to create new RWOs if they do not exist in the MACE store, and to connect learning objects to already existing RWOs. The location names are used to automatically assign geographical locations to learning objects using the above mentioned GEONAMES database.

To extract the named entities we use GATE (General Architecture for Text Engineering) [6]. The system uses a set of modules adapted from the ANNIE information extraction system, which consists of a set of IE components included in GATE.

Names of locations and persons are identified through the GATE gazetteers and the rules used by the semantic tagger which annotates the text with new information such as entity types. Occurrences of buildings in learning resources and respective metadata are identified using a list of building names which is automatically generated using the DBpedia API [6]. The DBpedia data set is a large multi-domain ontology which consists of RDF triples that have been derived from Wikipedia. Thus, DBpedia makes it possible to ask sophisticated queries against Wikipedia using SPARQL, a query language for RDF. Currently the DBpedia knowledge base describes more than 2.6 million things, including at least 213000 persons and 328000 places.

All identified persons and buildings are looked up in DBpedia for validation purposes. Thereby, we ensure that we have one RWO per person or building in our database, even if different names are used to refer to
the same person, resp. building. Furthermore, this approach also filters out results for persons for which no further data is known. All titles and descriptions extracted from DBpedia are stored with a language tag. For buildings, also the belonging geographical coordinates are stored using the OGC KML standard [15]. Links to LOs which reference the RWO are stored using the “isReferencedBy” relation, the link to the belonging DBpedia entity is stored using the “isRepresentedBy” relation. Additionally, the RWOs are related, so that a RWO representing an architect is related with the RWOs representing buildings created by this architect.

4. First results

We aim for a high precision of the RWOs because faulty RWOs lower the acceptance of the MACE system. In our first evaluation, we considered the title and description fields of the metadata for 50 learning objects in which 78 locations, 22 persons and 30 buildings were mentioned. The content of the title and description fields were given in English. We did not address multilingual issues here as we wanted to validate our approach first. Results were quite encouraging: For the recognition of location names we reached a precision of 96.61% and a recall of 73.08%. Frequently we did not find the mentioned districts of a town but only the town itself. The recall rises up to 79.17% if we consider only the name of the town. We query DBpedia to filter the results and to retrieve the respective geographic coordinates. If the geographic location is not present in DBpedia, we retrieve it from the GEONAMES database.

For the recognition of person names we achieved a precision of 85.71% and a recall of 54.55%. Unfortunately, we did not identify names of buildings. This is caused by the fact that most buildings in the selected learning object metadata were not known buildings in the architectural world, but e.g. apartment houses in a special architectural style. Additionally many buildings are referred to using imprecise descriptions like “Schlikker’sche villa” instead of the official name “Villa Schlikker” or imprecise names, e.g. “Church of Our Lady” instead “Church of Our Lady of Lourdes”.

5. Conclusion and further work

RWOs are required for the university education in architecture. Their automatic generation poses a number of problems, of which the most urgent ones are completeness and uniqueness. Through the usage of named entity recognition in combination with existing databases for locations of RWOs as well as ontologies of existing buildings and lists of architect names, we are able to address and satisfactorily solve the problems. Further work includes the improvement of the recognition of named entities, e.g. the recognition of names of architects and buildings by using additional highly specialized databases like ICONDA which covers worldwide technical literature relating to all aspects of planning and construction [9].

6. References