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Personalized Web Learning by joining OER

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Abstract. We argue that quality issues and didactical concerns of MOOCs may be overcome by relying on small Open Educational Resources, joining them into concise courses by gluing them together along predefined learning pathways with proper semantic annotations. This new approach to adaptive learning does not attempt to model the learner, but rather concentrates on the learning process and established models thereof. Such a new approach does not only require conceptual work and corresponding support tools, but also a new meta data format and an engine which may interpret the semantic annotations as well as measure a learner's response to these. The EU FP7 project INTUITEL[7] is introduced, which employs these technologies in a novel learning environment.

1 Introduction

For the past few years, one of the most vigorously discussed topics in technology enhanced learning (TEL) is the possibility to distribute free knowledge to large audiences via internet in Massive(ly) Open Online Courses (MOOCs). This special case of Open Educational Resources (OER) has gained ground due to increased bandwidth and the spread of mobile digital devices even in remote areas of the world. The UNESCO has given this field of TEL a tremendous push by its 2012 OER conference, and enthusiastically claims that OER could provide a solution to the world's educational problems [U12]. With many other TEL practitioners, we share a more differentiated view on this, because broadcasted video lectures have a long history and are not really considered the state of the art in TEL. Particular technical and didactical challenges that concern fundamental aspects of MOOC learning are language, cultural background of learners, as well

[7] INTUITEL = Intelligent Tutorial Interfaces for Technology Enhanced Learning, http://www.intuitel.eu, is funded in the 7th framework programme of the European Union (FP7-ICT-2011.8, Challenge 8.1) under grant no. 318496

as individual learning habits and learning discipline—to mention some of the most prominent ones.

Moreover, the anonymity of MOOC learning and its lack of individual tutoring or coaching may be responsible for the high dropout rates of 90% that are commonly observed during a MOOC [Ri13]. In this paper, we therefore investigate how MOOC learning can be made more individual, human-centered and interactive by a technologically enhanced Learning Management System (LMS).

A second aspect is concerned with the simplification of MOOC production. If one really wishes to produce a high quality video tape of a full lecture, production costs could be as high as 50.000 Euro [MWK14], making it almost impossible to keep these courses up to date by frequent updates and immensely complicating their introduction in the educational system. Fortunately, the rapid development of technology has resulted in an increased availability of OER which are *inexpensively* produced and *small* in length or learning effort: Public video platforms contain large numbers of small clips about almost any subject, also texts, pictures applets (or "apps") are available for free covering almost anything that one could think of teaching or learning. For the purpose of the present paper we label these media *Small OER*. We then elaborate on the question of how such Small OERs can be effectively collected and stitched together in order to create a MOOC-like course.

2 Technical and didactical approach of INTUITEL

The EU FP7 project INTUITEL provides a new approach to adaptive learning. Current Adaptive Learning Environments (ALE) are either test-driven or curriculum-driven, performing learner modeling or learner typization, i.e. they either follow a behaviouristic or cognitivistic learner model [KT13]. INTUITEL in contrast follows a constructivistic approach by leaving full *freedom of choice* to the learner while non-intrusively guiding him through a sequence of learning steps.

Each of these learning steps consists of learning one *knowledge object* (KO) of 3 - 10 minutes, and the concrete sequence of these objects is called a *learning pathway*. The desired personalization then consists of selecting an order for the knowledge objects based on considering all the aforementioned aspects for an individual learner—and possibly very different from one of the predefined learning pathways. While the didactical and more theoretical aspects of this approach are discussed in another paper at this conference [He14], the present contribution puts a focus on technology and its application to the MOOC problems outlined above.

INTUITEL is implemented for five different leading eLearning platforms (eXact LCMS, Clix, Crayons, ILIAS and Moodle). Each of those enhanced LMS then consists of six main components:

1. a lightweight extension of the LMS giving access to its data and user interface, in terms of user score extraction (USE), tutorial guidance (TUG) and learning object recommendation (LORE). Its specification is open and can

be applied to every type of LMS. Furthermore the concrete implementations for ILIAS and Moodle are open source and usable as blueprints for other systems, see INTUITEL web site.
2. a pedagogical ontology (PO) that is based on Meder's web didactics [Me06] and insights gained from the L3 project [L01]. It contains the vocabulary and relations necessary for enhancing the learning content with didactical and technical metadata [Sw13].
3. the Semantic Learning Object Model (SLOM) which describes how learning material needs to be annotated in order to be interpretable by the INTUITEL system.
4. the INTUITEL back-end, which aggregates the required information and uses it to create learning recommendations and feedback in a Learning Progress Model (LPM) and the INTUITEL Engine.
5. the INTUITEL communication layer (CL) interconnects the previously described components and manages message distribution.
6. a tool suite comprised of INTUITEL Editor and Merger tailored to process existing learning content most easily to transform it into the INTUITEL format.

Within the INTUITEL project, the learning process is analyzed pragmatically by considering the learning pathway of a learner through a course and by gathering additional data. The system may draw these data from four different sources: (i) *the learning content*, i.e. what has to be learned? (ii) *the learner history*, i.e. what has already been learned? (iii) *the learning environment*, i.e. what are the temporal, spatial and physical parameters? (iv) *the learner*, i.e. what are the characteristics of this person?

In the context of INTUITEL, we extract from these sources some 40 so called *didactic factors* (DF) that are symbolic statements with each of them having a distinct meaning for the learning process. Examples for these DF are:

- How does the learner compare to his peers in learning speed ?
- Which media types does the learner prefer ?

By combining them with the learning pathway information, it is possible to deduce that a certain knowledge object is better suited for the learner than others. Moreover, it is also possible to state *why* this is the case (e.g. because it is age-appropriate, has a suitable difficulty level, etc). This enables self- reflection of the learner and thus increases his metacognitive skills.

The basic definitions of the didactic factors and their value ranges are present as a separate ontology, which is interpreted by the LPM. This allows it to incorporate various soft aspects into eLearning, like e.g. motivation or other emotions [EG08]. One may also add the *actuality of a KO* to the set of didactical factors and will then receive recommendations to use more recent learning content with higher priority. At the same time, this creates an innovative learning pathway: adding new learning content while keeping the old one also allows learning about the history of a knowledge domain.

The collected data is then merged with the original SLOM data into a single ontology and forwarded to the INTUITEL Engine. This component is a combination of a set of Java modules and standard OWL-reasoners (like e.g. FaCT++ or HermiT). Its task is to analyze the provided individualized ontology in order to identify the most suitable knowledge objects with regard to the most suitable learning pathways and the current situation as expressed by the didactic factors. It therefore generates semantic queries and starts the most efficient reasoners for the specific query. INTUITEL thereby builds on the results and insights of the THESEUS project and in particular the HERAKLES Reasoning Broker [Bo09]. The output of this iterative procedure is then interpreted in order to create the final learning recommendations and also generates natural language messages for the learner, if appropriate.

3 Joining OER

Let us now outline how the INTUITEL technology is used to overcome the MOOC problems stated in the introductory text. Course authors are not restricted in their choice of what learning material they provide and in which style they do it. They just need to add further information to it in a following step - and those annotations, created with the specialized INTUITEL Editor, can be stored persistently with the learning content.

The Semantic Learning Object Model SLOM specifies a file format that contains all relevant data to exchange and store complete INTUITEL-enabled courses (i.e. courses from the LMS that have a (semi-)complete set of INTUITEL metadata). It contains eLearning course material in a form similar to IMS-CP and to the packaging of SCORM, but with additional annotations according to the pedagogical and domain-specific ontologies. The SLOM container format allows for a compact side-by-side storage of learning content and metadata, permitting the usage of INTUITEL-enhanced course material also in Non-INTUITEL systems (albeit without the functionality provided by INTUITEL). It is therefore easy to transform other semantically annotated formats for learning content into SLOM.

A particular source for this process is the extraction from a Semantic Media Wiki (SMW) which was created as an extension to the popular MediaWiki software. MediaWiki is the basis for numerous collaborative information stores, with the free encyclopaedia Wikipedia as the most prominent example. Wikis in general are well known for their capabilities to collect and share knowledge within and across communities. The SMW extends the MediaWiki software with semantic features that allow for an annotation of wiki content with machine- processable semantic information. Since other tools allow to convert a selection of HTML web pages into MediaWiki pages, a complete tool chain exists to create INTUITEL content by *importing* it from anywhere on the internet.

The important aspect for our MOOC problem is, that the INTUITEL metadata treats the concrete learning content as *resources* of the RDF/RDFS/OWL syntax, i.e., it is only linked to the content. Therefore, the resources may reside

anywhere on the global internet, they only need to be accessible by the learner's web browser. In such an extreme example, the corresponding SLOM file contains *only metadata*, annotating the distributed learning content according to the INTUITEL ontological scheme (see [He14] for details on this). To the learner, such a distributed INTUITEL course will appear as an adaptive sequence of pages and media that are not directly linked to each other - but appear as subsequent recommendations in the TUG interface component of an LMS in consideration of the predefined learning pathway(s) as intended by the teacher.

Consider, as an example, a course on Beethoven: It could start with an introductory text from Wikipedia, then offer to the learner a virtual tour through the Beethoven house in Bonn/Germany, proceeding with an audio file residing on a US server and produced by the Chicago Symphony Orchestra, etc. All of these pages and media are presented as adaptive recommendation, taking into account the learner's history as well as his current situation and behaviour in the framework of the didactical model. Every learner experiences individual tutoring, even dialogues with the INTUITEL system - and this course does not require a large monolithic production effort.

The INTUITEL approach may also affect the content production in general. Not only does it preserve the high level of freedom for course creation currently demanded by authors, but also allows novel ways of collaboration in teaching. Authors from all over the world can link their Small OER via URIs and provide their learners with a huge knowledge space. It is conceivable that such a knowledge space can attract as much learners as one of the current MOOCs—but more flexibly and with an almost unlimited individuality.

A course designer—or many of them—can contribute to this knowledge space not only by adding new learning content. They can also contribute a new Cognitive Content Map (CCM), which defines new learning pathways through this knowledge space. Easier cultural adaptation is only one of the many possibilities offered by this approach.

4 Summary and Outlook

In this paper, we outlined a way to make OER more suitable for a greater variability of learning needs, by semantically annotating Small OER and running them in a semantically enhanced LMS. INTUITEL therefore contributes to key aspects of OER, e.g. how to create online courses in a didactically meaningful way, how to add semantic interoperability, and how LMSs can assist in that. In our estimate, this could also be used for a semantic reconstruction of current MOOCs which will resolve some of their problems of maintainability and adaptability. The INTUITEL system here serves as the "glue" integrating a variety of learning content into a greater knowledge space.

By providing the information on the learning process in a suitable format, INTUITEL also opens the doors for other technologies such as learning analytics and data mining in the educational sector. With the insights that can be gained

from a data driven perspective, this could result in new didactical approaches and thus enhance education in general.

The research reported here is more than "work in progress". The USE/TUG/LORE interfaces are in working condition for the five LMSs mentioned above, and the specifications for these technical parts as well as specifications, guidelines and examples for the semantic annotation are available from the INTUITEL web site. Not only does this allow for independent testing of the concepts, it also enables integration of the USE/TUG/LORE interfaces into other LMS and therefore opens a new development line for TEL. It is also inline with the goals of INTUITEL not just to produce research results, but concrete innovation for TEL.

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