Hierarchy-Based Methodology for Producing Educational Contents with Maximal Reutilization

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ABSTRACT

Computer based training or distance education are facing dramatic changes with the advent of standardization efforts, some of them concentrating in maximal reuse. This is of paramount importance for a sustainable -cost affordable- production of educational materials. Reuse in itself should not be a goal, though, since many methodological aspects might be lost. In this paper we propose two content production approaches for the InterMediActor platform under a competence-based methodology: either a bottom-up approach where content is designed from scratch or a top-down methodology where existing material can be gradually adapted to fulfil requisites to be used with maximal flexibility into InterMediActor.

Keywords.-
Distance and computer-based education and learning. Content production and reuse.

1 INTRODUCTION

Content production is one of the 'hot topics' in computer-based training because it often represents a large percentage of the total amount of effort needed for the deployment of this type of educational systems. Firstly, efficient and flexible content specification methodologies are needed to maximally facilitate automatically reuse of the materials developed under certain methodology. In this sense, initial efforts are being conducted (SCORM [2], IEEE LOM [3], IMS [4]) but, from our point of view they present some serious deficiencies. But, on the other hand, tons of legacy content is already available in most organizations and interested parties are often reluctant to starting from scratch the content provision task. Unfortunately, the unstructured (i.e., non-standard) nature of this contents often prohibits its direct reuse in any new platform/tool. Our concern here focuses in the concept of reuse in a broad sense, i.e., taking into account already existing materials to be integrated into any newly deployed platform.

In this paper we revisit the problem of content production and reuse: we briefly review the competence-based methodology proposed for our distance and computer-based education platform InterMediActor [1], currently under development, and propose a hierarchy model for content production and reutilization of already existing material.

2 CONTENT DEVELOPMENT FOR DISTANCE EDUCATION IN INTERMEDIACTOR

In such hierarchy, contents are represented as nodes in a pyramid, the higher the node in the hierarchy, the more aggregated its content is, such that the base of the pyramid comprises all those 'indivisible' learning elements (ideally, full InterMediActor competences). Maximal flexibility is obtained by reusing the competences lying in the base level, but those are not always available. We propose two approaches for the deployment of such content-hierarchy:

- a bottom-up approach consisting in specifying competences from scratch under InterMediActor methodology and afterwards aggregating them into higher-level educational units, and
- a top-down method, consisting in reusing existing educational material, forcing it to conform with the minimal requirements to become a node in the hierarchy, such that it may, afterwards, be split –if possible- into more fine grain interrelated educational subunits.

In Figure 1 we observe a pictorial representation of such content-hierarchy for the particular case of a single -particular- course. We see that a course can be observed as a set of Units, these as an aggregation of Subunits, etc., at the lowest level we find a pool of atomic competences. In what follows we will describe both the top-down and bottom-up approaches, by assuming a minimal set of characteristics to be fulfilled by the "objects" under consideration. Competences being one of them, also will satisfy these constraints, but their definition is also subject to more subtle considerations, which are not the scope of this paper (see [1]): we will not take into consideration, for instance, differences between concepts and skills.

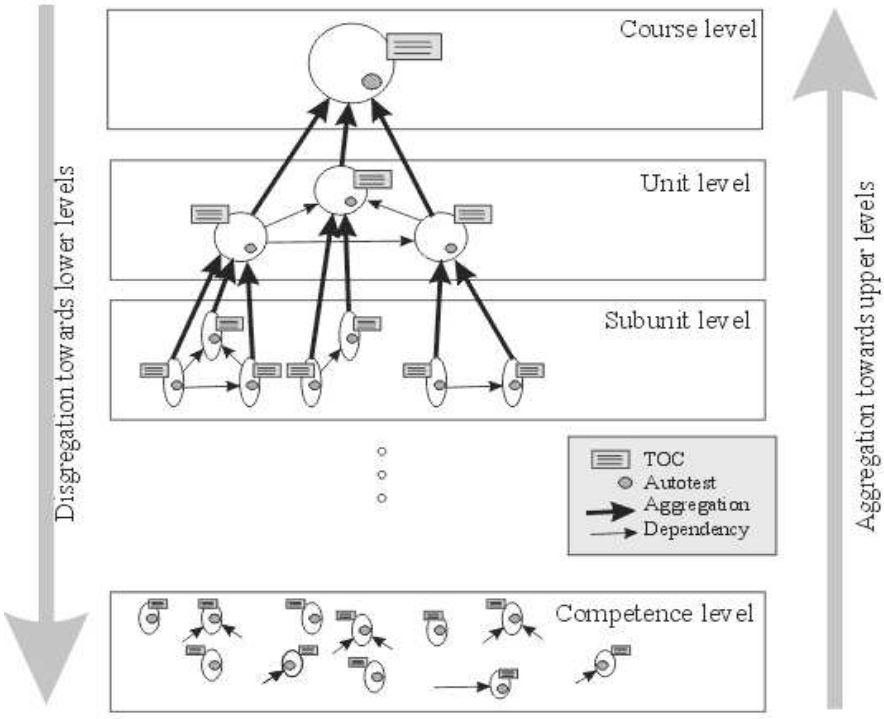

Figure 1: Aggregation-Disgregation hierarchy

2.1 BOTTOM-UP APPROACH

This is the usual approach under InterMediActor to build educational content by the intelligent (hand-crafted, edited) aggregation of atomic competences (task performed by the Course Production Client), also under development as a part of the InterMediActor project. The educational developing methodology stems directly from that of (Melton, 1997): in order to develop such content, first a grounded learning objectives analysis should be made so as to detect a hierarchy of such objectives. In a second step, all objectives should be transformed into learning competences, complete with advance organizer (an introduction), content, summary and assessment material. Finally, all such units should be joined in a synthesis process until a whole unit or course is obtained. For all such units and intermediate aggregation subunits, advance organizers, summaries and aggregated-competence assessment material should also be supplied. Note that the content of these units is in fact the aggregation of all subunits leading to each aggregated one. Also note that the methodology advocates first descending in Figure 1 (in the analysis phase), then creating "atomic" competences, and after ascending in the final synthesis phase. Because this latter process of competence integration is crucial, we have decided to call this approach "bottom-up" although it has also a top-down (analysis) flavour.

However thorough and well-rooted into educational theory such highly-structured content is, it is also very expensive to develop (as well-structured software). It is also unthinkable to recast legacy educational content into this methodology: depending on the quality and granularity of the legacy content, this process may take effort in exceed of that needed to develop it from scratch (just as it is extremely costly to recast software done in a pre-formal methodology into a more formal one: understanding its implicit structure, recovering edition materials, etc). However, rebuilding from scratch a collection of educational material may not be acceptable in some cases, and the "roundabout way" of recasting existing material might be the only way of adapting educational materials –specially if migration to new educational supports is assumed as a costless task to be conducted by teaching professionals as an extra work-.

2.2 TOP-DOWN APPROACH

In the top of Figure 1 we observe a course as a whole, its only requisites being that a main title and a Table of Contents (TOC) is given (more or less detailed, but describing what the student is expected to learn), and evaluation means such that the performance of a student following those materials can be evaluated and marked. This could be the basic structure of most educational materials already available in any organization, although their availability could be subject to a variable degree of electronic support or granularity (plain texts, slide, demos, videos, etc.). Concerning "portability", the supporting formats are irrelevant at this point, since we assume that translation to a standard readable format is possible. Therefore, our unique constraints by now are that in the structure of the educational material itself:

- a main title and a TOC is present, identifying what is to be learnt in the module
- A bulk of educational material

- evaluation means exist to mark the student's performance.

The reuse of this bulk material is certainly not "fine grain", since it can only be repeated as it is for different -but analogous- audiences, and since no metadata concerning its use and requisites, its reutilization is only possible by an experienced teacher. The next step a teacher could be interested in is to fragment this course into Units, a task already often done in practice due to time limitations for each lecture (1-2 hours Unit length is the usual case). Certainly, this division in Units could be sometimes artificial and does not always comply to "conceptual" units, but it represents a starting point which, by using the methodology proposed here, can be revised until satisfactory "conceptual" units are obtained. This fragmentation in units is represented in the second level in Figure 1 (3 units in this case), where a set of contents is identified for each unit and evaluation means are also provided. At this point, usually a graph of relationships is obtained, and a third requisite appears:

- the relationship between the newly formed modules has to be described, indicating which modules are needed as a prerequisite for accessing a particular one. Obviously, circular relationships should be forbidden.

Roughly speaking, every unit should be as much autonomous as possible, such that the maximal relationship between contents is kept inside every unit, and minimal dependence links remain among them. In this paper we do not explore the possibility of automatically finding those partitions, although schemes relying in distances computed as a function of the link-densities (cross-references, hypertext links, etc.) could be devised as a future work.. Unfortunately, in the particular case of the Top-down approach, such distance is often not available, since all content inside every Unit is usually unstructured. An exception could be a set of materials already available under some structured labeling scheme (HTML, for instance). These approaches, however, exceed by far the scope and aim of this paper. This high-level task of identifying dependences among the units is left, therefore, to the experienced teacher or content provider. At this point, unit reuse is more plausible, since units from other courses can be used to build new teaching material, possibly using semi-automatic content aggregation mechanisms, as those to be provided in InterMediActor, following a bottom-up approach starting at this level of granularity.

Ideally, at the end of the top-down approach, we could contribute with new materials to the pool of competences, extracted from an already existing material, and which could be efficiently re-used in the production of new fine-grain "ad hoc" courses for Just In Time (JIT) learning. It may also happen that some of the material presented in the course has been fragmented down to atomic competences but, in the bottom-up process, they seem not to fit anywhere in the aggregated competence: observing this is a clear evidence of the poor structure and content that the original teaching material presented. Although these "unmatching" competences lie out of the material, they could certainly be reused in other scenarios. Other potential benefit of this approach is that of identifying redundant material, situation observed specially when several teachers cooperate to alternate in teaching a certain subject. In what follows, we illustrate the application of this method to an existing teaching material on Image Processing.

3 MIGRATING A DIGITAL IMAGE PROCESSING LESSON INTO INTERMEDIACTOR

We illustrate the content reuse procedure using the material corresponding to a lesson in Digital Image Processing for Restoration, which is available at present in Powerpoint slides and cannot be directly used into InterMediActor. This type of material is hard to produce since it requires a lot of graphical work and illustration. We take this material as a starting point, and analyze its structure to break it down into smaller pieces following the top-down procedure described in previous section. In Table 1 below, we detail the contents in the original lesson, including the identified pre-requisites (those underlined are external to the present material).

Lesson: Digital Image Processing for Restoration

1 - **Visual perception** 2 - **Color formats** 3 - **Image adquisition** 4 - **Quality in Digital Images** 5 - **Pointwise processing** 6 *Requisite: Look-up-tables* 7 - **Mask processing: linear and nonlinear** 8 *Requisite: convolution* 9 *Requisite: 2D filtering* 10 - **Histogram equalization** 11 *Requisite: p.d.f.* 12 - **Transform filtering** 13 *Requisite: Fourier Transform*	14 - **Introduction to image restoration** 15 - **Contrast enhancement** 10 *Requisite:histogram equalization* 16 - **Interference cancellation** 12 *Requisite: Transform filtering* 17 - **Noise reduction** *7 Requisite:mask processing* 18 - **Geometric corrections** *19 Requisite: interpolation and 2D mapping* 20 - **PSF estimation** 21 *Requisite: Impulse response* 22 - **Model based restoration: inverse and Wiener** 23 *Requisite:Wiener filtering* 24 *Requisite:Transform filtering*

Table 1:Content description of the existing material. A requisite analysis has been performed as preliminary step towards its conversion into InterMediActor.

The result of the competence-based analysis of such material has been depicted in Figure 2, where numbering corresponds to that in Table 1, and is only used to improve readability. It may not seem clear at first sight, but a main aggregated competence has been identified: that of restoring an image, assessing the quality of the results and evaluating the associated efforts (14), at the unit level. Competences in the subunit level are those skills for restoring an image: contrast enhancement (15), interference cancellation (16), noise reduction (17), geometric corrections (18) and model-based restoration (22), the fragmentation was continued to the end, the remaining sub-competences being ancillary to them. It can be observed how some material (in shadow) has not been used, since it was not relevant for the aggregated competence at hand, but it still can be reused in the future, though. Prerequisites under the dashed line have been identified but are not present in the present material: they are expected to be found elsewhere as competences or produced here to be reused some other time or by third parties.

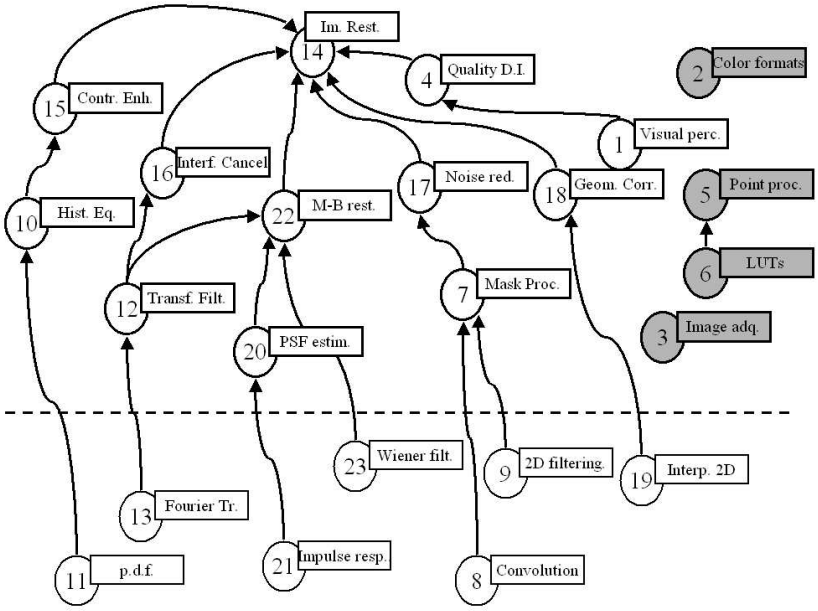

Figure 2: Graph resulting from the competence analysis of the material. Non-used competences are shown in gray, and those below the dashed line are supposed to be external

The migration process has only started: after this analysis, a new competence has to be created following the corresponding DTD, such that the original material, once converted into XML (from Powerpoint, such conversion is straightforward), becomes the "body" section. Some other fields have to be filled, the advance organizer, the evaluation part, and its pre-requisites. After this migration process has been carried out, we can conclude that most of the material has been reused, although a few slides have been discarded, as expected. Furthermore, a lot of external prerequisite competences have been identified and, a structure has been given to the material, such that navigation and self-assessment is facilitated for the student.

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