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An approach for pedagogical hypermedia design

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ABSTRACT

This paper deals with management of multimedia and numeric information in an instructional context. We submit a model in order to represent explicitly the pedagogical information structure. This model is based on a graph of information-units. An information-unit is an autonomous node of the graph, composed with an internal structure, an external structure and a set of associated actions. The model allows managing multimedia interaction, conceptual interaction and pedagogical interaction. We then submit a four-step design method: 1-Pedagogical survey, 2-Modeling, 3-Drafting, 4-Editing. To end with we submit further elements to deal with multimedia interaction in a pedagogical context.

Keywords: Multimedia, Hypertext, Instructional context, Design method, Information structure

1. INTRODUCTION

Multimedia software represent one of the new answers offered in order to fulfill the new needs engendered in the field of education. In the other hand one has to admit that this kind of solution is not so much used in real situation. One of the reasons may be the lack of experiment in an emerging and quickly evolving domain. In order to submit solutions for the design of multimedia learning software, we adopt an approach based on the study of the specificity that the support carries. Whereas textual documents introduce spatial representation (Goody, 1979) “numeric information are computable, and only computable” translated from (Bachimont, 2000). The internal representation of information in a computer is not linear, and this delinearization determines the design of numeric documents. Therefore a new way of representing information has to be adopted.

After having studied basic concepts (information-unit, internal structure, external structure, associated actions) to deal with non-linearity, we describe a design approach based on the integration of four surveys (pedagogy, information modeling, drafting and edition). Finally we propose a set of tools in order to help managing multimedia interaction in a pedagogical context.

2. PEDAGOGICAL HYPERMEDIA MODEL

Because of the non-linearity of the information inscribed in a numeric support, we propose to model an hypermedia as a graph, i.e. a set of nodes and links between them. The first implication of such a representation is that the reading depends on the way the nodes are accessed (i.e. computed). Indeed, a node is a computation-unit. Since books or videotapes impose the reading process (one page or sequence after the other), numeric supports do not: the reader is expected to build by his own a proper linearity. Therefore, there is no guaranty on what the user has accessed before, and what he will access then, while reading a computation-unit. We submit the following hypothesis in order to deal with this problem: the information representation in hypermedia should be based on information-units (IU) corresponding to computation-units.

We define an information-unit as an autonomous node of the graph, which reading is necessary and sufficient in order to understand a concept. This implies that information-units are indivisible and independent from other units. IU are used in pedagogical hypermedia, which implies that:

- an IU can be composed with a set of media of different kinds (multimedia)
- an IU is linked to other units (hypermedia)
- an IU is associated to a set of pedagogical actions necessary to understand it (pedagogical)

Three questions emerge from this representation:

- How to manage the multimedia interaction between the set of media that compose an IU?
- How to manage the conceptual interaction between the set of IU that compose an hypermedia?
- How to manage the pedagogical interaction, between the actions associated to an IU?

In order answer these questions, we define a model for a pedagogical hypermedia as a set of IU organized with an internal structure, an external structure and a set of associated actions (Figure 1).

The internal structure is the explicit logical structure of the set media that compose an IU and the relationships between these media. In the example (see Figure 2) an Exposition/UI (Exposition is the type of UI) is defined by a title and some contents. The contents are defined by a main media, a set of redundant media, a set of complementary media and an a set of illustration media.

The external structure is the explicit conceptual links between an IU and the other IU that compose the hypermedia. In the example (see Figure 3) an Exposition/UI can be linked to other Exposition/UI (refer to or is followed by), to Exercise/UI (is applied by) or to Question/UI (is evaluated by).

The associated actions are the pedagogical actions to perform when accessing an IU. In the example (see Figure 4), a learner can read, annotate, mark and comment an Exposition/UI, and a teacher can emphasize it.
3. A FOUR-LEVELS DESIGN METHOD

Having adopted the previous concepts for the modeling of a pedagogical hypermedia, we identified four distinct functions in the design process:

- **Pedagogical survey level**: The first level involves the identification of the role the hypermedia can play within the pedagogical process. This is achieved by defining a methodological tool that helps experts describe the process in terms of discrete pedagogical acts. This explicit representation serves as a reference for the subsequent design levels.

- **Modeling level**: This level translates the pedagogical acts into the corresponding hypermedia models by defining the set of IU models. All the necessary information to define these models is derived from the pedagogical survey.

- **Drafting level**: Here, the drafts of the hypermedia are created, with a focus on producing multimedia contents that follow the internal structure and are linked to the IU models based on the external structure. This level also addresses the challenge of managing interactive and pedagogical interactions through appropriate content models.

- **Editing level**: The final level involves the design of the human-machine interface. It focuses on choosing a physical representation of the UI and applying the models and their instances to enable the execution of pedagogical actions on the contents.

The pedagogical survey level comes first, with the purpose of defining the role the hypermedia can play. The modeling level follows, translating pedagogical acts into IU models. The drafting level then creates multimedia drafts, and finally, the editing level designs the human-machine interface. Each level builds upon the previous one, ensuring a comprehensive design process.

The design process is illustrated in Figure 5 and further explained in detail throughout the text.
1. Pedagogical Survey

The teacher defines a concept
The teacher reformulates a concept
The students annotate the contents
The teacher illustrates with examples
The teacher gives an exercise

2. Modelling

```xml
<MODEL Name="Exposition">
  <INTERNAL_STRUCTURE>
    <!ELEMENT exposition (title, contents)>
    <!ATTLIST exposition Id [#PCDATA]>
    <!ELEMENT title (#PCDATA)>
    <!ELEMENT contents (main, reformulation?)>
    <!ELEMENT main (written_text | didactical_image)>
    <!ELEMENT reformulation (speech | video)>
  </INTERNAL_STRUCTURE>
  <rdf:PropertyType ID="IsFollowedBy">
    <rdfs:domain resource="#Exposition"/>
    <rdfs:range rdf:Resource="#Exposition2"/>
  </rdf:PropertyType>
  <rdf:PropertyType ID="IsIllustratedBy">
    <rdfs:domain resource="#Exposition"/>
    <rdfs:range rdf:Resource="#Example"/>
  </rdf:PropertyType>
  <rdf:PropertyType ID="IsAppliedBy">
    <rdfs:domain resource="#Exposition"/>
    <rdfs:range rdf:Resource="#Exercise"/>
  </rdf:PropertyType>
  <EXTERNAL_STRUCTURE>
    <ASSOCIATED_ACTIONS>
      <ACTION Name="Read" Actor="Learner" />
      <ACTION Name="Annotate" Actor="Learner" />
      <ACTION Name="Exercise" />
      <ACTION Name="Example" />
    </ASSOCIATED_ACTIONS>
  </EXTERNAL_STRUCTURE>
</MODEL>
```

3. Drafting

```
<EXPOSITION Id="Exposition1">
  <INTERNAL_STRUCTURE>
    <TITLE>Definition of an algorithm</TITLE>
    <CONTENTS>
      <MAIN>An algorithm is...</MAIN>
      <REFORMULATION>In other words...</REFORMULATION>
    </CONTENTS>
  </EXTERNAL_STRUCTURE>
  <IsFollowedBy rdf:Resource="#Exposition2"/>
  <IsIllustratedBy rdf:Resource="#Example1"/>
  <IsAppliedBy rdf:Resource="#Exercise1"/>
</EXPOSITION>
```

4. Editing

```
Definition of an Algorithm

An algorithm is a set of actions that allows the realization of a specific treatment.

In other words an algorithm is a set of operating rules to apply in order to solve a problem.
```

4. Multimedia Management

Designing pedagogical hypermedia following the methodological approach we submitted implies to be able to deal with pedagogical, conceptual and multimedia interactions. Through the existing experience in the field of education, designers are used to dealing with pedagogical and conceptual interactions. They can reasonably adapt their skills for the particular case of pedagogical hypermedia. However, multimedia interaction is a new parameter to take into account. In order to help designers, we submit a typology of media (Figure 7) along with a set of element to help choosing a type of media depending on the pedagogical goal (Figure 8).

In order to help managing the multimedia interaction, each media function has to be explicitly identified and chosen. We submit four functions to characterize the set of media composing a IU:

- The main function for one unique media representing the core of the information
- The redundancy function for the media reformulating the main one
- The complement function for the media adding secondary information to the main one
- The emphasizing function for the media accompanying the main one without giving real information

The Figure 9 gives examples of application of function for each media.

<table>
<thead>
<tr>
<th>Media</th>
<th>Senses</th>
<th>Dimension</th>
<th>Temporality</th>
<th>Nature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written text</td>
<td>Sight</td>
<td>Spatial</td>
<td>Static</td>
<td>Elementary</td>
</tr>
<tr>
<td>Speech</td>
<td>Hearing</td>
<td>Temporal</td>
<td>Kinetic</td>
<td>Elementary</td>
</tr>
<tr>
<td>Sound effects</td>
<td>Hearing</td>
<td>Temporal</td>
<td>Kinetic</td>
<td>Elementary</td>
</tr>
<tr>
<td>Music</td>
<td>Hearing</td>
<td>Temporal</td>
<td>Kinetic</td>
<td>Elementary</td>
</tr>
<tr>
<td>Picture</td>
<td>Sight</td>
<td>Spatial</td>
<td>Static</td>
<td>Elementary</td>
</tr>
<tr>
<td>Didactical picture</td>
<td>Sight</td>
<td>Spatial</td>
<td>Static</td>
<td>Composed</td>
</tr>
<tr>
<td>Animation</td>
<td>Sight</td>
<td>Spatial + Temporal</td>
<td>Kinetic</td>
<td>Elementary</td>
</tr>
<tr>
<td>Audiovisual</td>
<td>Hearing + Sight</td>
<td>Spatial + Temporal</td>
<td>Kinetic</td>
<td>Composed</td>
</tr>
<tr>
<td>Interaction</td>
<td>Hearing + Sight + Action</td>
<td>Spatial + Temporal</td>
<td>Dynamic</td>
<td>Composed</td>
</tr>
</tbody>
</table>

Figure 6: Simplified example of application of the design process

Figure 7: Typology of media
<table>
<thead>
<tr>
<th>Media</th>
<th>Characteristics</th>
<th>Pedagogical examples of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written text</td>
<td>Thinking – Concentration – Rereading – Persistence</td>
<td>Complex information, demonstrations, definitions</td>
</tr>
<tr>
<td>Speech</td>
<td>Persuasion – Subjectivity – Evanescence</td>
<td>Short and important information, sensitization, insistence, redundancy, explanations</td>
</tr>
<tr>
<td>Sound effects</td>
<td>Designation</td>
<td>Meta-information, attract attention</td>
</tr>
<tr>
<td>Music</td>
<td>Emotion – Memorization</td>
<td>Effect on concentration, atmosphere</td>
</tr>
<tr>
<td>Picture</td>
<td>Universality – Multiple meanings – Non-trustable – Contextual</td>
<td>Illustration, esthesticism, visual memorization</td>
</tr>
<tr>
<td>Didactical picture</td>
<td>Spatial – Synthetic – Organized – Normalized</td>
<td>Complex information, information hardly formulated by language</td>
</tr>
<tr>
<td>Animation</td>
<td>Dynamic</td>
<td>Temporal processes, attract visual attention</td>
</tr>
<tr>
<td>Audiovisual</td>
<td>Dynamic – Captivating</td>
<td>Seduction, persuasion</td>
</tr>
<tr>
<td>Interaction</td>
<td>Implication – Pleasure</td>
<td>Concrete, experimental or real information, entertainment</td>
</tr>
</tbody>
</table>

Figure 8: Parameters for media choice

<table>
<thead>
<tr>
<th>Function</th>
<th>Main</th>
<th>Redundancy</th>
<th>Complement</th>
<th>emphasizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written text</td>
<td>Classical case of written exposition (book)</td>
<td>Reformulation of a main text, example, description</td>
<td>Demonstration, detailed explication</td>
<td>X</td>
</tr>
<tr>
<td>Speech</td>
<td>Classical case of oral exposition (lecture)</td>
<td>Reading of a main written text</td>
<td>Additional definitions of some words of the main text</td>
<td>Slogan to insist on an pedagogical aspect</td>
</tr>
<tr>
<td>Sound effects</td>
<td>X</td>
<td>X</td>
<td>Typical sound (a motor sound in a mechanical context for instance)</td>
<td>Focalization of the attention</td>
</tr>
<tr>
<td>Music</td>
<td>X</td>
<td>X</td>
<td>Extract in a music teaching context</td>
<td>Musical ambient</td>
</tr>
<tr>
<td>Picture</td>
<td>X</td>
<td>X</td>
<td>The photo of an important character (author, scientist, …)</td>
<td>Background picture</td>
</tr>
<tr>
<td>Didactical picture</td>
<td>Technical diagram, charts, …</td>
<td>Graphical formulation of a main text</td>
<td>Map (when studying history for instance)</td>
<td>X</td>
</tr>
<tr>
<td>Animation</td>
<td>X</td>
<td>Dynamic representation of a didactical picture</td>
<td>Example of process quoted in a main text</td>
<td>Metaphorical association between an animation and a concept</td>
</tr>
<tr>
<td>Audiovisual</td>
<td>Description of a process</td>
<td>Description of a process described by a main text</td>
<td>Commentary personified by a virtual character</td>
<td>Short entertaining video-clip</td>
</tr>
<tr>
<td>Interaction</td>
<td>Virtual world used to immerse the student</td>
<td>Illustrative simulation</td>
<td>Virtual experience to concretize a concept</td>
<td>Game</td>
</tr>
</tbody>
</table>

Figure 9: Examples for each association function-media
5. CONCLUSION AND PERSPECTIVES

In this paper, we have showed that an approach based on an explicit structuring help in taking into account the interaction inside a set of multimedia information. This approach is especially relevant in the field of education, since the way the information is presented determines the way it is learned.

We applied our method to design a pedagogical hypermedia, used to teach computer sciences (the basics of algorithmic). This hypermedia has been experimenting for one year in our university, in a real learning situation. It is yet too early to extract real conclusions, but it seems fully positive in term of acception by the students.

The next step is to realize a software environment that assist in the application of the method. This environment will help the designers through each step, offering a set of tools to achieve the pedagogical survey, the modeling, the drafting and the editing.

We are also studying some secondary benefits that our approach can bring such as the reuse and sharing of the contents, the multi-support edition or the constitution of an ontology of the pedagogical documents.

6. REFERENCES


Stéphane Crozat, Philippe Trigano, Olivier Hû, « Set of criteria for evaluation and design of multimedia applications in instructional context », MMM’99, Ottawa, Canada, October 1999.


