A METHODOLOGY FOR DEVELOPING A MEDICAL MULTIMEDIA EDUCATION SYSTEM BASED ON AN INTRODUCTORY TEXTBOOK

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Abstract

We describe a methodology for converting an introductory cardiology textbook to a multimedia education system. The developed system is based on commercially available tools and the created environment includes pictures, video, sound and database support. The scenario is based on a university course textbook with the addition of related information from a variety of sources. The application targets mainly educational needs of university medical schools and health care services in rural areas.

Key words: Multimedia, Medicine, Education.

1. Introduction

Today medical textbooks are widely used in the educational institutes to provide the students with the necessary information on certain topics. The evolution of computer systems and the development of a variety of peripheral components: I/O devices simultaneously, brought a second revolution in the area of publishing and production of educational tools. A broad spectrum of equipment types which can process different forms of data as well as the increasing capacity of storage media offered the basic components needed for the development of multi-device, multi-source computer learning facilities. The potential for the usage of the equipment for the presentation of knowledge in different forms seems enormous. The material can be presented simultaneously enhanced by pictures, sound and video and is affected by sequences of actions that a user can comprehend. Those possibilities give a dynamic character to the presented subjects resulting in faster and better learning facilities. Many basic university courses have been transcribed into multimedia systems for use both by students and teachers. Medicine is an area where the combination of different kinds of information is required offering a fertile ground for development of multimedia applications. The potential applications are not restricted only in learning tools or the transcription of books. Recently we have seen multimedia information systems used

for home health care support, contributing a lot to the quality of life of long term patients [1]. Our work named HIPPOKRATES falls in the category of transcribing basic courses in learning tools. Three reasons have lead us to the development of HIPPOKRATES:

· the need for new media in education in medicine.
· the need for flexible learning
· the need for a user friendly cardiology learning tool for nonspecialized doctors and doctors in other fields.

We had to take a challenge with the development of the described application, which came from the fact that textbook was used as reference in the specialized area of cardiology. There were two main factors that were taken into account during the development of this system. The first is that system will be used as an educational tool for an undergraduate course at the University of Ioannina and the second it will be used as a reference for nonspecialized doctors who work in health centers in rural areas. Both groups of users need a guiding tool in cardiology to supplement their knowledge and skills in actions as the interpretation of certain symptoms. In the field of medicine one of the basic procedures require the interpretation of a number of data collected either through direct observation by the doctor or through the use of equipment. Particularly for the targeted user groups this procedure will be the main concern as well as taking some action in urgent cases, since further treatment of a patient will require the participation of more specialized and experienced medical staff. HIPPOKRATES is designed to assist the doctor at first level with the purpose of offering the user with a friendly learning tool in contrast to a simple linear text book. The form and the design of the application should produce a fast, precise and informative system in order to meet the described goals.

In this work our needs were very specific regarding the material for development and the targeted users group. Some of the multimedia general rules were not of great importance. We have developed the title using the TOOLBOOK® application environment because it was the best compromise we could have between the multimedia rules and the availability of hardware configurations by the targeted group of the application users. Our basic concern was the proper use of the available space for the execution of the application as well as the total time required for a user to go through the whole system. Our work belongs to the general category of restructuring information from the form of linear text to the form of non-linear or hypertext presentation [2-3].

2. The Content of the Book

The book [4] consists of eight chapters and each one refers to a major subject of the discipline. The major goal of the book is to provide the reader with a comprehensive first level approach which includes not only scientific knowledge, but also practical guidelines needed in cardiology. The chapters are represented in the developed multimedia title in the same manner, with minor grouping changes. The content of each chapter is:

Chapter 1: Collection and interpretation of clinical data.
The clinical tests and the resulting data are described. The methods of interpretation are presented linked to different illness cause.

Chapter 2 : Medical examination.
All the possible medical examinations which can be performed are included. Certain procedures are described in detail.

Chapter 3: The main functional cardiac syndromes.
The possible main syndromes in the different functions of heart are described as well as the appearance of symptoms in different clinical tests.

Chapter 4 : The major anatomical syndromes.
The anatomical problems of different parts of heart are introduced. The possible causes are described along with potential corrective surgery.

Chapter 5: Treatment methods in cardiology.
Medication, invasive and non-invasive treatments (equipment) and changes in lifestyle are some of the topics included.

Chapter 6: Treatment of major cardiac syndromes.
Certain procedures for the treatment of the main cardiac syndromes and illnesses are included.

Chapter 7 : Relation of circulatory problems to other systems.
The interdependence of heart problems with other systems of the human body are examined.

Chapter 8: Urgent Cardiology.
Possible problems which need immediate treatment are included.

3. Methodology

The text is written in natural language and it is directly related to an introductory cardiology textbook [4]. All chapters of the book were scanned by experts (medical doctors and computer scientists). The sections of each chapter passed a categorisation process. Through this process the paragraphs are categorised in main

and secondary. A paragraph (or section) is characterised as main if the medical expert labels it as important and it is required to be included as it is. Each of these paragraphs is assigned a separate template. In contrast a paragraph is characterised secondary if the described subject will not be included as it is. Usually a summary of a secondary paragraph is used. The resulting text forms a major paragraph and a special page is assigned to it.

The medical expert categorises the text into meaningful sets with the assistance of multimedia experts. At the same time the text is scanned and considered, according to its content, to investigate the possibility of inclusion of other data (text, pictures, video, sound). The purpose of this action is to complement the text and to provide the user with an integrated learning tool. Finally the process is completed by associating the particular text and information through hot-words with other related information of any form in the system. This associated information most likely, has been categorised and organised in a different group of screens.

The main paragraphs appear as independent buttons on each screen and the associated text is more extended. The secondary ones are grouped together in group buttons. The associated text is combined into brief presentations with a composite title.
The methodology is built on the following procedure:
1. Text scanning for hot words
2. Grouping of hot-words
3. Hot-words for sound
4. Hot-words for pictures
5. Hot-words for video

Our target was to introduce the user into a friendly environment which drives him/her naturally into the different parts of the multimedia title. Thus different subjects are grouped according to the basic procedures a doctor follows when he faces a cardiological problem. The text analysis is divided into two categories:
1. Text that describes a complex situation (cardiac incidence, medical examination).
2. Special words in the text.

In the first category we import all related data in the appropriate form in order to enhance the text descriptions. On this way we associate with the particular text all or most of the available information in any form (video, sound) in a way that the user can have the closest view to realistic descriptions. In the second category we associate special words inside the text with some form of data. Usually those special words

belong to the medical terminology and they are associated with the description of other cases (a complete screen with different forms of information) or one particular form of information (often text).

4. Coherence

One of the main issues for a multimedia application is how well the information included can be understood and how well the underlying network created by the links of the connected "pages" is presented as a meaningful and natural sequence [5]. In our work we have to take into account the fact that we interpret a textbook into a multimedia title which imposes one more question. How well does the resulting work represents what the author of the initial book was intended to mean. In our case it was easy to circumvent this obstacle for two reasons: first because the text is highly technical not leaving many options for different interpretations. The second is that a medical doctor (experienced cardiologist) participated in the group of authors. Another issue which arises in applications of this type is that usually the way a text is written requires or creates a cognitive overhead [6]. What is meant by this term is that a certain amount of information is either considered known or is implied in a certain way as somebody goes through some media. Since our user groups are limited and have a certain level of knowledge we can overcome the first kind of cognitive overhead factor. The second kind of this hiding information can be meaningful by choosing the links so that they have a general meaning. Each screen represents a basic unit of information composed of a number of "pages" itself. The linking of each screen with the different forms of information should have a semantic message that makes the navigation through the application not only easier but meaningful. This way we can avoid the problem of getting lost in an overwhelming information load [6].

5. Semantic Network

There are a few ways which can be used in order to enhance the coherency of a hypertext application. One way is to give a semantic meaning to each link connecting the different forms of information. On this way we construct a semantic network which results from the association of the different kinds of information and the meaning of the association. The different semantic links can have the meaning based on the content of the different information forms. We have mentioned above that our basic unit is a screen which consists of a number of associated information data forms as well as a number of buttons which can be used to control the navigation. Each

screen has a semantic meaning in a form of a header which represents in most of the cases a section of the book. The different information forms are then associated with each screen with a semantic link and each meaning could be one of the following [6]:

"is illustrated by"
"appears in the cardiogram"
"appears in the x-rays"

Having as basic unit the screen - section which is a composite form of information [6] we need to determine the semantics of the links connecting the hierarchical structure of the system. A natural way would be to give each link in the hierarchy the label :

" consists of "
" is analysed to"

If we exclude the links that make up the screens connecting the different forms of information the rest of the semantic structure is purely hierarchical. This is natural since our system is based on a textbook and this hierarchy is a reflection of the linear nature of the text [7]. The only exception in this hierarchical semantic structure at the screen level can be considered the case of hot words. Hot words is a special kind of text which is encountered inside the regular text and correspond to another screen (usually its title). The hot word actually is a semantic link with the label :

"strongly related to"
"is encountered too in"

6. The Organisation Network

With this term we mean the organisation of the system in meaningful units for the user to increase coherency of the user perspective. Strongly related to this network are the navigation paths and tools. Usually a multimedia application targets different groups of users or users of different level. We target the same user group as the textbook. That gives a restricted character to the organisation network since we do not need different navigation paths. The main navigation path can transfer the user one screen forward or backward at a time. The only alternative to the navigation path just described is with the use of the index.

7. Template Design

The application enters into a main screen which has the logo HIPPOKRATES an animated presentation of the heart cycles. Clicking on the heart leads to the basic

template which has three elements, two groups of buttons and an anatomical picture of heart. The first group of buttons actually brings the user to the main path of exploration and the whole structure of the application is built on child screens which result from this group of buttons. The child screens can reach three levels down (Figures 1-2).
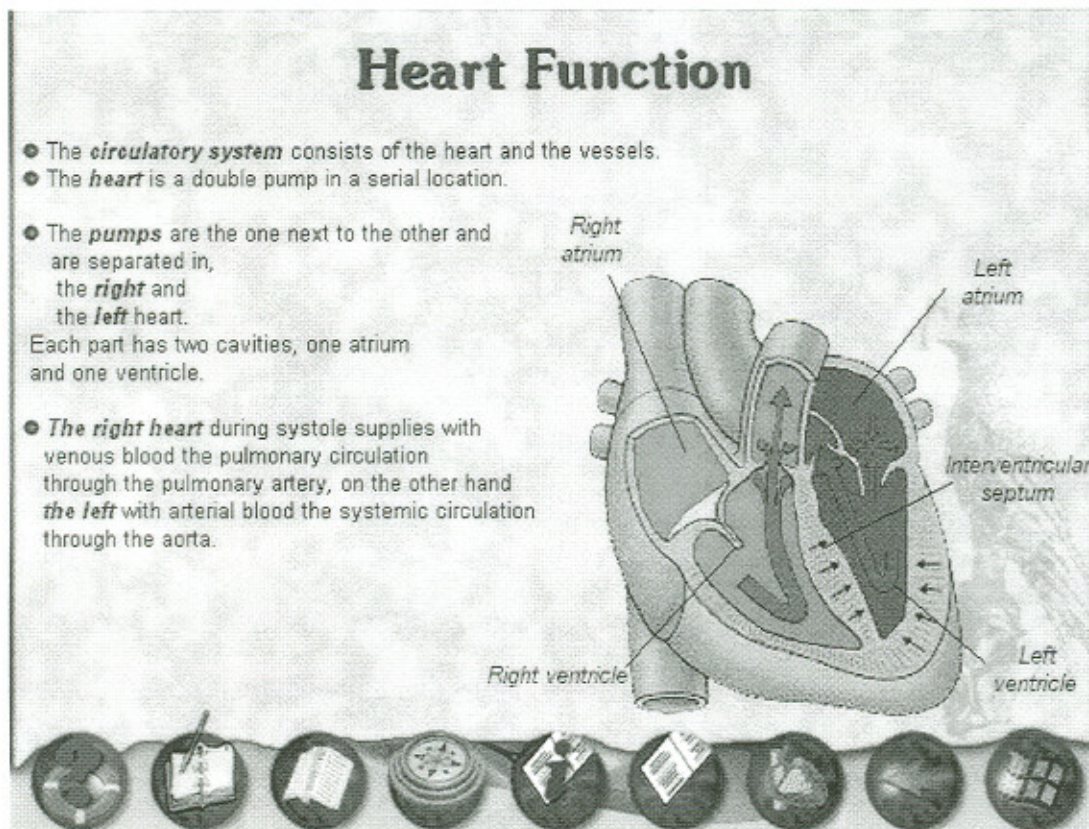

Figure 1: Application Template Design.

Dyspnea of Cardiac Origin

When it is assured that the dyspnea is organic, the next question is if the circulatory lessiom or others systems lessiom are responsible.

The cardiac dyspnea comes from lung conjestion.

Depending on the severity of the situation and the mode of developement the dyspnea appears in the following forms:

- Exertional dyspnea
- Paroxysmal dyspnea or cardiac asthma and
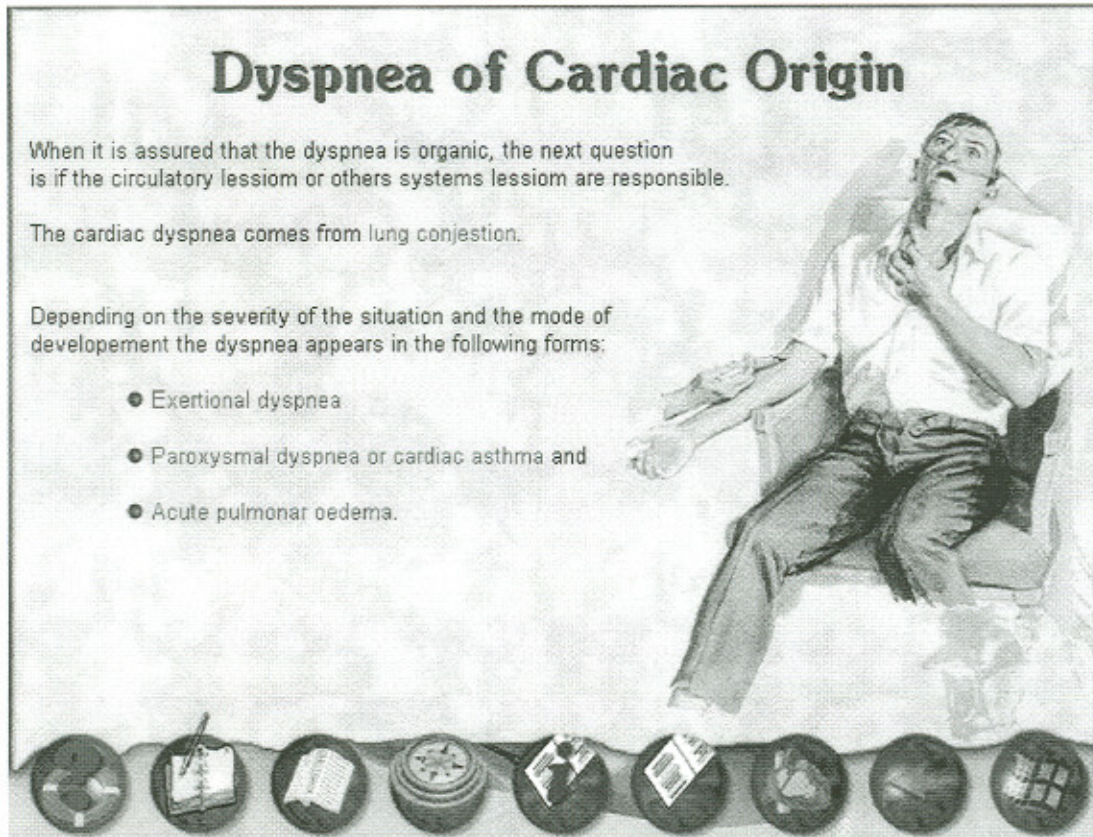- Acute pulmonar oedema.

Figure 2:   Basic Navigation Screen.

Each of the buttons of the first group of the initial screen refers to a chapter of the book. A small summary of each chapter appears in the form of a label each time the mouse cursor passes over the button without pressing it. The second group of buttons are the auxiliary buttons which actually appear in every screen and provide the user with a set of facilities. This set of buttons actually constitutes a complete navigation tool. This group of buttons is divided into two subsets. One subset of these buttons provides information about the content of the application and the way a user can operate it.. The other one includes all the buttons which are translated into navigation actions. From each chapter button in the initial screen we drive the user to the first degree child screen which again has two groups of buttons. In the first group each button, this time, corresponds to one of the paragraphs of the chapter. The second group provides again with similar navigation facilities like in the basic group. Finally other forms of information might appear on the screen depending on the content of the chapter.

From each paragraph button the system drives the path to the second degree child screens where usually the basic text appears as well as the associated information. In some cases it is necessary to divide a paragraph to two or more sections each one with different title and content. In this case instead of having a second degree child screen with the text we have another group of buttons leading to each subsection. For the text a special effort was made to make it fit in one text window. Finally the anatomical picture of heart besides the description of the different parts can be used as a navigation button that leads to a path that describes the anatomy of the heart. The organisation of this path is not different at any aspect from the other chapter screen sequences described above.

8. Screening the Paragraphs for Associated other Forms of Information

This was the most difficult part of the design of the multimedia system because the decision for the inclusion of the associated forms of information was proved to be a very complex task. After many attempts we finally decided to follow two policies. From the context of each paragraph and from the educational needs each paragraph was given a characterisation as a synthesising or analysing paragraph. This characterisation was based on type of the paragraph. If it was trying to present a complex, more general situation like the description of heart attack it was characterised as synthesising. If the attempt was to analyse a case into the consisting parts (e.g. describing the main clinical tests for arrhythmia) then it is characterised as an analysing paragraph. This procedure is not always possible since the type of a paragraph can be interpreted in different ways. Such an action naturally leads to a policy of associating the relative information. In a synthesising paragraph we try to give a complete picture of the whole entity described by the paragraph and video data together with sound is considered the best solution. If video is not available for the case we replace it with animation or still pictures. In the case of an analysing paragraph the associated data are presented separately and they focus on the details like a cardiogram. Sound might be presented too.

In addition to paragraph characterisation for the forms of associated data the text was scanned for hot words. In our case we have already described this paragraph or situation with a different screen in another place because of its importance. Therefore by associating this word with a whole screen we avoid repeating the presentation of the total information without relaxing its importance. For example in the screen including the paragraph describing heart attack at the point where the text has the words "heart attack might be preceded by dyspnea" the word dyspnea can be

defined as a hot word. By clicking the hot word "dyspnea" the whole screen describing dyspnea (belonging to another chapter) appears.

9. Navigation

The navigation in this application is not complicated and follows the flow of the information. Mostly the organisation of information is hierarchical in the sense that each chapter-button leads to a template with section-buttons. The section-buttons include in their title enough information about the content, and in some cases if this is not considered adequate a small summary appears when the mouse points at the button. The section-buttons can lead to subsection-buttons and so on for some levels. In this sense navigation can follow the hierarchical structure of the application. The only exception are the hot-words which are included in the text and allow the users in some cases to jump to a different page (Figures 1-2).

This page does not belong to the hierarchy at that point but its content is strongly related to the text. Not all hot-words allow jump in the hierarchical navigation. There is only one way to return back and this is to the previous page. The only alternative to this is the "exit" button that terminates the program. A special index facility has been added to the system as a special chapter in order to facilitate faster navigation.

10. The Temporal Design of the System

The kind of information that is presented at the same time to the user and the allowed actions characterise to a certain extent the overall picture, and affect the result and the success of a learning tool. There are no rules that apply to the temporal design of a multimedia system. But there are practical guidelines, that somebody can apply to such an application, which are based on the existing expertise [8]. One of these rules is that the amount of simultaneous information presented each time should be limited in order to keep the user concentrated. There should be a consistent way of constructing the simultaneous presentations and the possible actions to allow the user to have a uniform impression through a learning session in the system. One way of keeping track of the temporal characteristics of a multimedia application is to design it using timelines. This is a way to represent the lifetime of a form of data presented to the user and each one of them is initiated by user actions (e.g. clicking on a button) [8]. In our case the only action that initiates the timeline of a form of data is the clicking on a button or a hot-word. All the forms of data last through the next clicking of the user which marks the end of the presented information or the

advancement in the next screen through the navigation path. The only exception to that rule are data presented in video format, where the end of the lifetime is marked by the end of the video.

11. Concluding remarks

With this work we were able to describe a multimedia learning tool based on a first level cardiology textbook. The purpose of the final product was to offer to nonspecialized doctors and medical school students a better form of learning material than the usually found in a book. By incorporating different forms of relevant data in a more dynamic and stimulating manner we wanted to surpass the restrictions imposed in learning by linear text. According to our opinion this is more important in fields like medicine where crucial decisions are made on the basis of on line perceived information. With this product we have not exploited the potential of the contemporary multimedia technology but we have produced a system that can be used by the majority of the interested professionals and medical school students.

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