

From Micro to Macro: An Exploration into the Structure of Multimedia Electronic Atlas

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Abstract With hypermedia technology the structure of a publication can be re-arranged to accommodate the more easy cognition of the idea and concept transferred by it by linking the concepts which are represented by different media forms into an integrated concept. Essentially multimedia electronic atlas is a kind of electronic publication, which has many common characters with ordinary CD-ROM publications. For the deeper exploration of electronic atlas it is very important to understand the internal and general structure of the new media structure. The aim of this paper is to discuss the internal structure of multimedia electronic atlas as a whole by applying the methodology of linguistics.

Key words Linguistic mechanism, Hypermedia structure, Multimedia Electronic Atlas

In order to reveal the multimedia structure and the effect it may have on the map readers, it is necessary to examine the internal information primitives involved in electronic atlas and the relations that may exist between them, so as to improve the multimedia structure by rearranging the linking between these information objects so that the information can be better expressed and transferred. Linguistic methodology proves to be a useful tool to examine multimedia structure.

It should be noted that the linguistic mechanism discussed in this paper refers to the macro linguistic mechanism, which involves a variety of elements such as paragraph, discourse, text as well as other information like graph, video and so on. Accordingly, the linguistic methodology is a cognition mode and research methodology, which is not concerned with any specific natural language.

1 Hypermedia and Multimedia Electronic Atlas

1.1 The Characteristics of Hypertext and Hypermedia

Hypertext is “an approach to information management in which data is stored in a network of nodes connected by links. Nodes can contain text, graphics, audio, video as well as source code or other forms of data.”[Smith & Weiss,1988]. The hypertext with multimedia information is called “hypermedia”.

The advantage of hypermedia over other traditional information systems lies in one of its most important characteristics that hypermedia can provide flexible and nonlinear service for storing and accessing information and thus “its ability to produce large, complex, richly connected, and cross-referenced bodies of information”[].In this network structure, a node often represents certain concept or idea in certain information form and thus has some semantic features. Links connect concepts or nodes together so that readers can navigate between various concepts. The starting and

target nodes of a link are called the reference and the referent respectively.

1.2 Multimedia Electronic Atlas Based on Hypermedia Technology

Multimedia electronic atlas is based on hypermedia technology. Besides all information types that constitute the traditional hypermedia information structure, hypermedia technology includes a new type of information, spatial information, which is represented by a variety of digital maps (such as vector, raster and hybrid maps) as well as their newly introduced linking forms. These linking forms mainly include:

- ◆ the links between the map and its internal objects, such as the link between the area of a county in the reference map and the referent detailed map of the county,
- ◆ the links between the maps as well as their internal objects and other non-spatial information, such as the link between the area of a county in the reference map and the referent verbal introduction to this county or a video clip.

2 Linguistic Mechanism of Hypermedia Structure

Hypermedia structure is in correspondence with the cognitive procedure of human beings, especially their reading procedures. When we read for certain purpose, we are used to non-linear chunking. We keep referencing back to what we have read during our reading. We even frequently consult some relevant materials such as books, figures, pictures and so on. Then our minds will arrange the individual concepts into a network and consequently form the final conclusion.

2.1 Functional Linguistic Mechanism of Hypermedia Structure

In hypermedia environment, hypermedia product is a media to transfer message from the author to readers. The author encodes the messages in an unprecedented manner, which is featured with its varied information types, flexible organizations, and diversified representing forms, in order that information can be transferred more efficiently. On the other hand, the users can obtain much more information in a more direct way by perceiving hypermedia products.

All the nodes in hypermedia such as text, image, sound, animation, video as well as map are exclusively popular forms to transfer information. In hypermedia environment, however, they have certain characteristics respectively with regard to their specific contents and functions.

- ◆ **Text:** Text is the basic form of message transferring. It refers to the written form of natural languages, which includes plain text, formatted text (such as tables);
- ◆ **Image:** Image transfers non-verbal messages, which readers can directly obtain with visual perception.
- ◆ **Sound:** Sound transfers both verbal (mainly spoken) and non-verbal messages. Messages transferred by sound can be gained by readers' sense of hearing.
- ◆ **Animation & Video:** They both transfer image sequence and sound accompanied. In computer environment, except for some minor differences in content and form, both of them can be considered equivalent in terms of technological realization.
- ◆ **Map:** Map can be regarded as a special form of image. It is unique in content as well as the related human cognitive schema. It is an important tool for human beings to transfer spatial information.

Program is considered as a necessary element for realizing hypermedia in computer environment,

because both creation of hypermedia by the author and browsing of hypermedia by readers are controlled by computer programs. The program at a node of hypermedia structure exists as a referent node, which is triggered by a link. This program can not be classified as a form of message transferring. It is more like a mechanism of message conversion. The message, which is transferred through the link, is transformed (including information abstracting, processing, and visualization) by the program at the node so as to make it easier for readers to obtain and comprehend.

Accordingly, hypermedia structure is correspondent with natural languages in function. They both transfer varied messages between the author and readers by encoding-transferring-decoding.

2.2 Formal Linguistic Mechanism of Hypermedia Structure

In addition to the functional linguistic mechanism discussed above, it is more important to study the formal parallelism of hypermedia with language. This feature can be manifested mainly in the following aspects:

- ◆ Different information forms can be classified into varied language units, which are hierarchical with regard to their structures and meanings. Different cognitive levels correspond with the different levels of language units;
- ◆ Language units include some syntactic rules that are formally recognizable and irrelevant to their meanings. These rules determine the mechanism of combination of language units as well as generation of higher-level language units.
- ◆ Language units which are defined with certain meanings constitute semantic structure by means of semantic rules and eventually form the proposition which is intended for the readers.

Traditional written text structure has included a typical linguistic mechanism. In hypermedia structure, a new mechanism, information reference mechanism, is added to the sequentially arranged written text. This mechanism enables readers to divorce themselves from words, phrases, sentences, paragraphs and even textual structures and form a reader-oriented semantic information with hyperlinks. As a result, another linguistic structure of information is constituted, which is independent from the traditional discourse structure of written language.

Moreover, the adoption of hypermedia information helps to build up a macro linguistic mechanism between natural languages and other information forms. Hypermedia structure maintains the structural features of written languages. Besides, the two are consistent with each other in terms of semantics and concepts. There are only some differences in the forms of language units as well as their potential relations in syntax and semantics.

3 Linguistic Analysis of Hypermedia Structure in Multimedia Electronic Atlas

Multimedia Electronic Atlas is a newly developed media in recent years. It belongs to electronic publications in its social function. This product is the combination of the visualized digital maps with other information forms. Its content of electronic maps varies, according to different themes, in position, which means the content may serve as the leading information or appear in form of quotation.

According to linguistic methodology, the study on a language system should start with its language units, syntactic structure and the semantic structure. The language system is considered to be

composed formally of the syntax-governed language units such as words, phrases etc., and semantically of such language units as sememes which are governed by its semantic system.

3.1 The Language Unit in Multimedia Electronic Atlas – Node

Language units refer to the constituents in hypermedia structure that is comparatively independent in meaning. The node is the content and object of messages in hypermedia structure, which can be composed of varied types of information and diversified representing forms. The recursion and hierarchy are the most typical characteristics of language units. That means that the language units at higher level may be constituted by the language units at lower level according to certain relation and thus the nodes at higher level may include some nodes at lower level.

Generally speaking, the study on language units in hypermedia structure can be carried out in two aspects: semantics and syntax. The former is concerned with the content of information and related to the encoding and decoding of varied information forms in hypermedia structure. The latter concentrates on the information form and is connected with the various representing forms of information and their realization of in computer environment.

3.1.1 Semantics-Related Language Units

From semantic point of view, the traditional hypermedia structure includes a variety of information forms such as text, picture, table, sound and video. They are important means of transferring messages for human beings. These messages are perceived through different senses, processed and analyzed in human minds and eventually obtained by the readers.

The major difference between multimedia electronic atlas and traditional hypermedia lies in the adoption of map in the former. In principle, map can be regarded as a special form of image. In most cases, it is abstracted, symbolized and individualized spatial image.

In the above mentioned information form, text, image, and static map belong to static information; and sound, video as well as dynamic map dynamic information. Besides, these information forms are diversified in dimension. For instance, text is of linear structure, while image and graph are planar.

All semantics-related language units are in correspondence with certain concepts and cognitive results at some specific stages of the whole cognitive process. For example, in a text, a word, a sentence, a paragraph and whole article respectively belong to some language units at different levels, the semantic meanings that they convey can be graded from low to high, and their corresponding concepts and cognitive results also vary from low to high accordingly.

3.1.2 Syntax-Related Language Units

In hypermedia structure, different forms of language units can be classified as different levels in structure. In other words, the comparatively complex information can be described in limited forms by means of abstraction and generalization. The type of language units which is categorized according to the form without consideration of the specific meaning is called syntax-related language units.

In order to describe comprehensively the expressive forms of language units in hypermedia structure, we may neglect the specific meanings of language units and divide their syntactic representing forms into five major types.

- ◆ **Character String:** Character string refers to a sequence of letters or characters. It is a syntactic form for written language and thus often used in text files.

- ◆ **Audio Clip:** Audio Clip a sequence of audio scales with different frequencies. It can represent both artificial (such as spoken language, music etc) sounds and non-artificial (i.e. natural) sounds.
- ◆ **Bitmap:** Bitmap is a planar matrix composed of a variety of gray values or colors. It represents the graphs or images generated by means of photography, drawing and calculating. Its objects cover all physical or nonphysical phenomena. It can be represented by means of reproduction, abstraction and artistic processing. It may also be used to represent written language.
- ◆ **Bitmap Sequence :** It is the sequence composed of bitmaps, which can demonstrate the chronological changes in graphs or images. Bitmap sequence can represent video, animation as well as dynamic characters and graphs.
- ◆ **Graphic Database:** Graphic database is the set of graphic primitives that are composed of points, lines and areas. The digital map based on spatial database is a typical form.

The five types of language unit can represent many semantic types of information in fewer syntactic forms of realization. However, all semantic information is to be represented by means of one or more of these forms. For example, a paragraph may be realized via all these forms except graphic database. They constitute the data form at the nodes of the multimedia electronic atlas, of which a multimedia electronic atlas is eventually composed.

Therefore, divorced from the semantic meaning of the language system, the study on the syntax of language units can help understand the general structure of multimedia. Owing to its general applicability, the general structure is of great help for design, realization and interpretation. In addition, it is also important for authoring tools of hypermedia as well as the design and realization of reading tools.

3.1.3 The Hierarchical Structure and Combination of Language Units

Hierarchical structure is one of the most important features of a linguistic system. Every language unit includes certain hierarchical features in form and structure, which range from simple to complex. Figure 1 illustrates the internal hierarchical structure of some syntax-related language units

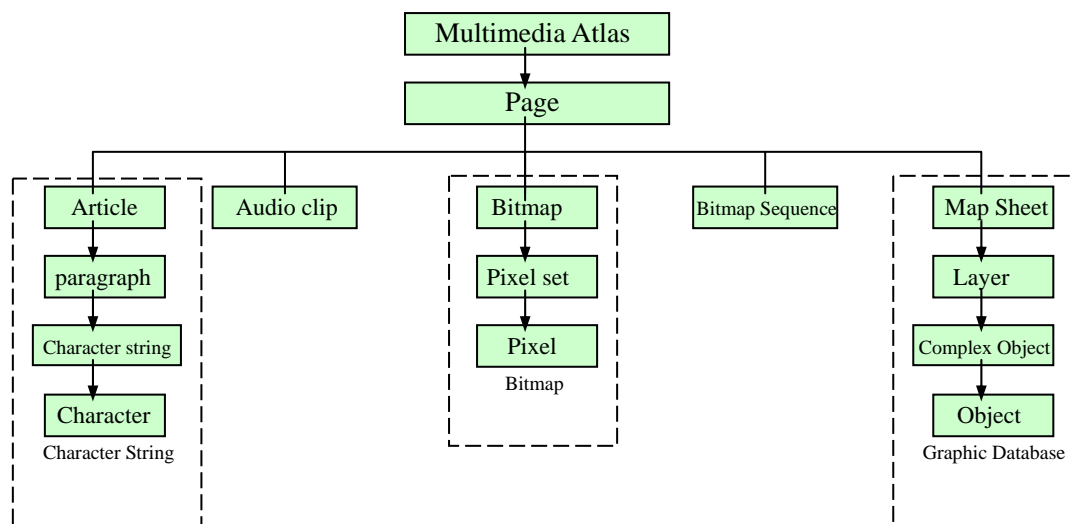


Fig. 1 Internal Hierarchical Structure of Syntax-related Language Units.

The formation of the illustrated internal hierarchical structure of syntax-related language units is governed by syntactic rules in form and semantic rules in meaning. It should be noted that although audio clip and bitmap sequence can be further divided into smaller language units --- for instance, bitmap sequence can be divided into frames --- they are taken as the lowest language units in this context, because multimedia electronic atlas usually does not involve any units at lower levels.

Besides the internal combination of language units, the combination of different types of language units is a unique and important chunking process in multimedia electronic atlas. Its major function is to constitute a language unit by combining various types of language units so as to provide readers with a language unit of higher concept. This language unit is supposed to be more comprehensive in terms of semantics and is mainly represented in form of page. Page is a popular language unit in hypermedia structure. It can be syntactically defined with any types of lower language units. Various types of language units that are semantics related are combined to represent a comprehensive semantic concept.

3.2 Syntactic Structure in Multimedia Electronic Atlas: Combination and Linkage

Syntactic structure refers to the varied types of combination and linkage between language units. In contrast with semantic structure, syntactic structure is a formal structure of the language units and their combination and linkage, which is independent from their specific meanings.

Syntactic structure mainly consists of language units that are defined with various relations. As a multimedia electronic atlas involves a large number of information types and formal language units, the defined relations between them are quite complex. Generally speaking, however, a multimedia electronic atlas can be divided into three internal levels of the same type of language unit, which are syntactic relation, page combination and association, as well as linkage.

3.2.1 Internal Syntactic Relation of the Same Language Unit

Multimedia electronic atlas involves five language units, namely character string, audio clip, bitmap, video clip and graphic database. All of the five belong to certain independent language form or code system employed by human beings to transfer messages. So each includes certain independent syntactic system of its own. The internal syntax of the language units defines the relations between the varied units and thus is the generation mechanism of the hierarchical structure of the language units. For instance, text of natural language constituted by character strings is a typical example of language system. Its syntax is the control rules made up of words, phrases, sentences, paragraphs and articles, whose relations in general belong to linear arithmetic. The arithmetic between such language units as graphs and images in graphic system is much more complex because it is often planar or even multi-dimensional. Moreover, besides the distributive relation of the language units at the synchronous level, audio and video also involve distributive relation at the diachronic level.

Although the internal syntactic relations between different types of language units are complex but rather important for transferring messages in multimedia electronic atlas, fortunately, except for language units, it is not necessary to thoroughly comprehend the detailed syntactic mechanism which constitutes the language units. This is because most of the interpretation involved in reading of multimedia electronic atlas is undertaken by human beings.

3.2.2 Page combination and Association

Page is the basic unit that constitutes multimedia electronic atlas. It is a language unit constituted by various types of lower-level language units via planar combination and association. This language unit can convey independent semantic concepts and is represented by a series of images on the

screen, possibly accompanied with sounds. (See Figure 2)



Fig. 2 A Page of Multimedia Electronic Atlas

Page structure is static in a sense. It is composed of any language units in accordance with their defined planar positions in distribution. These relations are termed combination, which are divided into three categories.

- ◆ **Accompanying:** the relation between audio clips and other types of language units.
- ◆ **Juxtaposition:** the relation between the language units which are located at different positions in a same page without overlapping with each other.
- ◆ **Overlap:** relation between the language units that overlap with each other transparently or not transparently.

Page combination is a kind of planar structure. Its relations such as juxtaposition and overlay can be realized in many diversified forms according to the position, size and arrangement of various language units. For example, in Fig 2, the icons at the bottom are arranged in a row. The structure of the window is designed with one on the left and three on the right. They are fundamental forms in terms of the design and realization of multimedia electronic atlas.

At the same time, page structure is also dynamic. The language units in combination may be replaced by other comparable language units so as to generate a new page. This vertical substitution between language units is called association. For instance, the bitmap sequence in the information window at the top corner can be substituted after certain operation by such types of language units as bitmap or character string. The graphic database can change according to the interested area by user in different scale. Association can be generally classified into two types:

- ◆ the substitution between different types of language units such as bitmap for character string, bitmap sequence for bitmap and so on;
- ◆ the substitution between same types of language units such as the more detailed graphic database representation for the comparatively more general one, the ordered character strings for unordered ones, etc..

Page association is a diachronic relation. Its diachronic mechanism of language units strengthens the

expressiveness of the page and enriches the information to be transferred.

3.2.3 Linkage

Link is another important content in hypermedia structure in addition to node. It establishes a reference mechanism between nodes so that hypermedia messages can form an interrelative network structure. In this way, readers can navigate between varied nodes and create some new concepts or propositions that are beyond what individual node can provide.

In terms of syntax, links can be established between any syntax-related language units. In multimedia electronic map, the reference node in one page is linked to another page that includes the referent node by means of link. Links must be bi-directional at any circumstances to make sure that users can return to the starting node when necessary. Besides, the link at the reference node should be labeled with certain semantic modifier so that user can reach the right node as intended, for there exist some links, each of which is corresponding with several nodes. For example, the node "Wuhan City" in the graphic database can be linked to the map of "Hubei Province" according to "Administrative Affiliation", as well as to the text file "A Brief Introduction to Wuhan" according to "Textual Description".

3.2 Design of Semantic Structure - Cognitive Modal in Multimedia Electronic Atlas

Semantic structure refers to the composition of messages that multimedia electronic atlas is intended to transfer. It is realized within the framework of its syntactic structure, and is closely related to the designed cognitive modal.

The first step is the design of language units. The five syntax-related language units provide many forms to convey information. The designer can choose an appropriate form to represent certain semantic element. For instance, a place can be represented by either character strings or bitmaps. The environment of a factory can also be described by means of character strings as well as photos or video. The next step is the design of the contents of pages. The designer should adapt to the contents that the page is to include when he/she designs page combination and association with various semantic elements or semantics-related language units. This flexible design enables a page to convey concepts and information independently and more comprehensively so that the contents of the involved pages can represent all intended information in an integrated way. The design of page contents determines the range of the messages that a multimedia electronic atlas is to cover. The last step is to establish a flexible linkage mechanism. Although every individual page can convey some comparatively independent information, hypermedia structure generated by linkage mechanism offers readers more flexibility. By means of "navigating", readers can form some cognitive conclusions, which can not be provided by traditional linear reading.

4 A Case Study of Hypermedia Structure in a Multimedia Electronic Atlas

This section illustrates a case study of "An Authoring Tool for Electronic Atlas: Atlas98", which is developed by the authors, to examine how to design of hypermedia structure in multimedia electronic atlas. This system, which is written in Visual C++ 5.0 on Windows platform, consists of an authoring system of electronic maps and a reading system of electronic maps. The former is used for making of multimedia electronic atlas, and the latter is to be published with the product of multimedia electronic atlas for readers to use.

Examinations on the design of hypermedia structure should also be carried out from two aspects: syntax (design of forms) and semantics (design of contents). Nevertheless, this section will focus on the syntactic aspect because it is mainly concerned with the authoring tool for multimedia electronic atlas, whose purpose is to design a software system intended for the making of multimedia electronic atlas, and thus is supposed to be divorced from semantic factors as much as possible.

4.1 Overall Structure of Multimedia Electronic Atlas

The overall structure defined in Atlas98 includes the prologue, preface (map group), major map, map sheets, embedded maps, epilogue, and background music. Both prologue and epilogue are represented by bitmap sequences. The preface is a bitmap page in which all map groups of the atlas are listed. The user can choose the needed map groups that represent various types of information.

Each map group includes a major map and several map sheets. The former represents the major content of the map group and can be defined as image, text or video. A map sheet is a page that represents the information related to certain specific content. It is the major constituent of the map group. Embedded map is a special type of map sheet whose name does not appear in the list box of map sheet. Only by means of link can it be referenced. Background music may be defined in map group, map sheet or hotspot. It may also be accompanying music or verbal interpretation.

4.2 Page Combination of Map Sheet

Fig. 2 is an illustration of the major interface of a map sheet provided by Atlas98. The language unit at page level is set by the system. The size and position of most windows can be adjusted. Its major contents include:

- ◆ **Window of Map sheet:** mainly used to display vector electronic maps, i.e. the graphic database of maps; can also display raster map or pictures mainly composed of texts and images; usually composed of background, and hotspot, which can be hot word, point, line or area.
- ◆ **Window of index map:** displays the overall map of the whole area as well as the position of the current window.
- ◆ **List Box of Map Sheets Name:** the names of all map sheets in the map group
- ◆ **List Box of hotspots Name:** names of all hotspots in the map sheet.
- ◆ **Bar of Map Names:** names of atlas, map groups and map sheets.
- ◆ **System Tool Tar:** the collection of varied commands for the operation of reading atlas
- ◆ **Windows for Accompanying Video** (optional): the video which is played in a continuous loop during the process of reading the map group, such as an advertisement etc..
- ◆ **Background Music** (optional): music or verbal interpretation.
- ◆ **Window for Multimedia Information:** displays such messages as text, image, graphics, video and so on, which are related to the hotspot.
- ◆ **Windows for Input and output of other messages:** windows for entering parameters such as inquiry and displaying the result. For example, when inquired about the best riding itinerary by bus, the starting stop and the destination need to be input as the parameters from Window of List Box and the result also needs to be displayed in a message window.

The first seven windows are permanent windows, and the last two temporary ones. The pages of permanent windows are of juxtaposition, while pages of temporary windows often overlay with one another.

4.3 Page Association of Map Sheet

The associative structure of pages mainly lies in the feature that the language units at page level can be internally substituted by one another. It mainly includes:

- ◆ **Window of Map Sheet:** displays map sheets and embedded maps in turn. When a map is displayed, maps with varied scales and maps covering different areas can be substituted for one another by operations like zooming and scrolling.
- ◆ **Window for index map:** generates and displays the position and area of the current map in the overall map in real-time mode.
- ◆ **List box of map sheet names:** remain unchanged in the map group.
- ◆ **List box of hotspot names:** displays hotspot names obtained in accordance with varied inquiry conditions in real-time mode.
- ◆ **Map Names Bar:** displays the names of map sheet and embedded maps in real-time mode.
- ◆ **System tool bar:** reflects the accessibility of certain function in real-time mode by graying out or activation.
- ◆ **Window for Accompanying video** (optional): may display in turn varied types of video messages in semantic terms, such as advertisements of different enterprises, or video clips related to map sheets at different positions.
- ◆ **Window for multimedia messages:** displays in turn messages related to hotspots such as texts, images, graphs, tables and video clips; controlled by the user.

4.4 Linkage Mechanism

Linkage is an important feature of multimedia electronic atlas. By means of linkage, readers can establish their own cross-map sheet, cross-media and flexible cognitive strategies on the basis of the concepts and information of map sheet.

From syntactic point of view, the hotspots in Atlas98 serve as a tool to activate links and can be classified into three types: point line and area. On the other hand, hotspot can semantically be represented by any information forms except sound. In general, Atlas98 provides the following types of link.

- ◆ **Major map - map sheet link:** the major map is often bitmaps, reflecting the major contents of a map group. From the hotspot represented by map names readers can directly enter its corresponding map sheet.
- ◆ **Map sheet - embedded map link:** embedded map is the further explanation of certain hotspot in a map sheet. From certain hotspot in a map sheet, readers can enter another map sheet/embedded map that provides detailed explanation of this hotspot. For instance, readers may enter the map of Wuhan if they click at the hotspot of Wuhan City in the map of Hubei Province
- ◆ **Map sheet/embedded map - Map sheet/ embedded map link:** this link helps enter another related Map sheet/ embedded map from certain hotspot in a Map sheet/embedded map, which makes the map reference recursive.
- ◆ **Map sheet/embedded map - multimedia information link:** the window for multimedia information can be displayed at the click at certain hotspot in the Map sheet/embedded map, where readers can consult related texts, pictures, videos and so on.

5 Conclusion

First, the adoption of multimedia in multimedia electronic atlas brings about some changes to the present situation that the traditional atlas lacks diversity in terms of information form. Moreover, the employment of hypermedia structure changes the linear reading mode of the traditional atlas, which is mainly based on pages, and thus greatly promote the feasibility of non-linear reading mode, which is mainly based on information reference. This paper makes a study on the hypermedia structure in multimedia electronic atlas with linguistic methodology. Especially, the examination on its syntactic structure indicates that the structure is a system composed of varied types of language units that is collectively affected by the internal syntactic mechanism, external combination and association and linkage mechanism. Therefore, the study on the structure is of great importance for designing the structure of multimedia electronic atlas and developing the authoring tool for the making of electronic atlas.

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