Linguistic Mechanism of Hypermedia Structure in 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

With the support of multimedia technology, electronic atlas is capable of managing, processing and displaying various types of information including text, sound, image, video, animation, table and digital map. The inclusion of digital map is its major character distinct from other multimedia products.

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.

1 Hypermedia and Multimedia Electronic Atlas

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”.

1.1 The Characteristics of Hypertext and 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”[Smith et al.,1987].

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 Analysis of Hypermedia Structure in Multimedia Electronic Atlas

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.

2.1 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.

2.1.1 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.

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.

2.1.2 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** 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** is 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** 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** 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** 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. 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.
2.1.3 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.

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.

2.2 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.

2.2.1 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.

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.

2.2.2 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 1)

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.

2.2.3 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".
2.2 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, 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 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.

3 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.

3.1 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.

3.2 Page Combination of Map Sheet

Fig. 1 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** gives the names of all map sheets in the map group; **List Box of hotspots Name** gives names of all hotspots
in the map sheet; **Bar of Map Names** gives names of atlas, map groups and map sheets; **System Tool Bar** is the collection of varied commands for the operation of reading atlas; **Windows for Accompanying Video** (optional) displays 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) can be 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** are 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.

### 3.3 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.

### 3.4 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.

### 4 Conclusion

The adoption of multimedia in 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, 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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