A Spatial-Person-Temporal Online History Educational System

JIA-JIUNN LO
Department of Information Management
Chung-Hua University
707, Sec.2, WuFu Rd., HsinChu
TAIWAN, R.O.C.

CHUEN-JUNG CHANG
Department of Information Management
Chung-Hua University
707, Sec.2, WuFu Rd., HsinChu
TAIWAN, R.O.C.

HSIAO-HAN TU
Department of Information Management
Chung-Hua University
707, Sec.2, WuFu Rd., HsinChu
TAIWAN, R.O.C.

SHIOU-WEN YEH
Department of Applied Linguistic and Language Study
Chung-Yuan Christian University
200 Chung Pei Rd., Chung Li, Taoyuan
TAIWAN, R.O.C.

Abstract: - Traditionally, students acquire history knowledge from hardcopy textbooks. They are usually lost in the geographical space and confused about the relationship between different history events. A history event includes information about “who initiated the event”, “what happened”, “when it happened”, and “where the event happened”. Person, space, and time are indispensable elements for history events. This research developed a spatial-person-temporal online history educational system. This system is based on SPATO (Spatial, Person, Action/Attribute, and Temporal Object), hence, named as HES-SPATO (History Educational System based on SPATO). HES-SPATO is developed based on the Sharable Content Object Reference Model (SCORM). SCORM promotes efforts to create flexible learning materials with reusability, durability, accessibility, and interoperability. SPATO, the backbone of the proposed system, is an object to specify “where”, “who/whom”, “what”, and “when” about history events. By integrating SPATOs with different types of assets, SCORM-based history learning materials such as SCOs, lessons, and courses can be formed accordingly. With application of the temporal logic to reason the temporal relationships between history events, HES-SPATO makes it possible to present history events in sequences with animation to clearly illustrate the dynamics of history events. In addition, the GIS concept of information layers is applied to develop the student interface. With the developed student interface, students can select features, displayed with different layer, to realize history events more clearly, in the manner they want, zoom in to see features at closer range, view variety supplement learning materials at the same time, and view SCOs according to his own progress and steps. Also, the interface can only display space information directly related to the history event, as defined in SPATO, to reduce the problem of cognitive overload.

Key-Words: - history educational system, SCORM, GIS, spatial-temporal model

1 Introduction

Traditionally, students acquire history knowledge from hardcopy textbooks. They are usually lost in the geographical space and confused about the relationship between different history events. A history event includes information about "who initiated the event", "what happened", "when it happened", and "where the event happened". If presenting all information about the event in multiple formats at the same time, students will understand the relationships among history events more efficiently and effectively.

Currently, lots of historical materials are delivered on Internet [1,2]. Since history is highly related to geographical space, some researchers included geographic information into history educational systems and developed their systems based on GIS (Geographic Information Systems) [3,4]. There are several advantages for applying GIS concepts to develop history educational systems. Using GIS technology is useful for spatial information integration. Through the bridging of time and space, and by efficiently gathering, saving, editing, managing, analyzing and displaying every form of spatial information, it can successfully integrate various types of spatial data and digital information management system, and further demonstrate the values of data in different views [5,11,12]. Those systems can store, retrieve, map, and analyze geographic information about history, hence, increase the understandability. However, history events happened in sequences. Though those systems can present historical data for different times with the concept of information layers of GIS, the dynamics of history events cannot be clearly presented. Without presenting related information of history events step by step may make those systems not sufficiently understandable for students, hence causes the problems of information and cognitive overload. In addition, person is the most important element for history events and is indispensable to history. Therefore, not only the spatial and temporal components but also the person component should be included in the history educational system model.

History instructors need more computer skills to use GIS for creating learning materials. The ability of computer operating is a bottleneck of history instructors so that only few products exist nowadays. In addition, not all history experts and instructors are good at information technologies so that they cannot easily create electronic history learning materials. Design and development of standards need to be put in place to ensure consistency and transferability of skills. Designers and developers of on-line learning materials may have variety of software tools for creating learning resources. These tools range from presenting software packages to more complex authoring environments. They can be very useful in allowing developers the opportunity to create learning resources that might otherwise require extensive programming skills. The Sharable Content Object Reference Model (SCORM), part of the Advanced Distributed Learning (ADL) initiative, promotes efforts to create flexible learning materials with reusability, durability, accessibility, and interoperability [10]. To this end, a SCORM-based spatial-person-temporal history educational system architecture is developed. The goal of SCORM is to create flexible learning materials by ensuring content that is reusable, interoperable, durable, and accessible, regardless of the content delivery and management system [10]. SCORM achieves its goal with the use of SCOs (Sharable Content Object) that are composed of assets. In order to identify SCO, assets, or any other kinds of learning materials, ADL proposed "meta-data", which means "data about data", to identify and locate learning materials by managers, learners, designers, programmers and other interested in education and training [6].

To this end, based on SCORM, this research applies the GIS concept of information layers to develop the student interfaces to integrate the person, spatial and temporal information of history events and applies the temporal logic to reason the temporal relationships between history events so that the history events can be presented in sequences to clearly illustrate the dynamics of history events, hence, make the learning materials more understandable. Furthermore, the proposed system can present only the related information to students to reduce cognition overload.

2 The System Architecture

The proposed history educational system is based on SPATO (Spatial, Person, Action/Attribute, and Temporal Object), adopted from SATO (Spatio-Temporal-Attribute Object) proposed by Raza and Kainz [15]. Hence, the proposed system is named HES-SPATO (History Educational System based on SPATO). HES-SPATO has nine components as illustrated in Fig. 1.

The nine components in HES-SPATO are Asset Pool, SPATO, SCO (Sharable Content Object) Base, Lesson Base, Sequencing Constructor, Sequencing

Template, Manifest Transformer, Manifest Template, and Course Base.

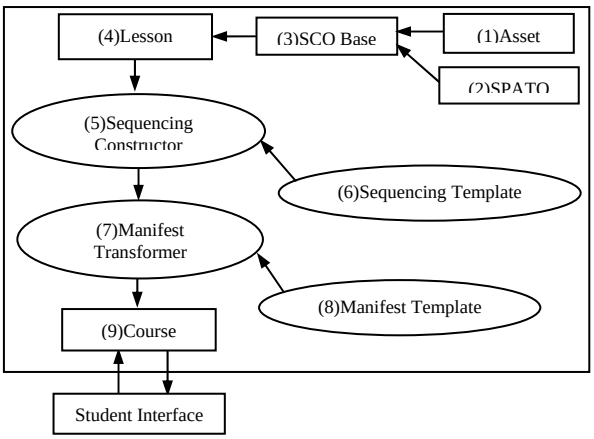

Fig. 1: The system architecture

3 SPATO

History happened in a dynamic world in which the time element plays a vital role. A data model can help us to understand the dynamic processes of history. Allen [7] described the dynamic aspects of the world with events, processes, actions, activities, and accomplishment. The discussion on the concept of space-time has been covered for a long time. Modeling of space and time is known as spatial-temporal modeling. It attempts to define the real life phenomena through objects and their relationships and constraints [14]. Static and dynamic real worlds need different techniques for description and modeling. Wachowicz [16] introduced a conceptual framework called Time Geography for capturing the semantics of space and time. Time Geography represents space and time within a general equilibrium framework. Time and space are seen as inseparable in this framework. Raza and Kainz [15] proposed that reality can be perceived as an object for modeling purposes. They used cell complexes for representation of spatio-temporal objects and developed a Spatio-Temporal-Attribute Object (SATO) for modeling the spatial-temporal data model. This approach presents space, time, and spatial-temporal data at the same time. STAO is useful to record the geographical data along time, such as the usage of land, population of a space, etc.

The word "history" is composed of "his" and "story". Person is the most important element for history events and is indispensable to history. Though successfully applied to spatial-temporal data model such as urban applications, it is difficult for SATO to model history events that are centered by persons. Therefore, this research extends STAO into SPATO (Spatio-Person-Temporal-Attribute Object) for modeling the history data model. SPATO is the backbone of HES-SPATO. It specifies "who" initiated the history event, "whom" the event influenced, "what" they did, "when" the event happened, and "where" the event happened.

Persons are the core of history events. PersonClass defines the actor initiating the event, persons whom the event influenced, and any other related persons of this event. It can be a specific person such as "Tsau-Tsau", a group of people such as troops, or a role such as an emperor. TemporalClass defines when the event happened. Structural aspects of time can be defined as linear, branching, and cyclic, each with numbers of temporal operations such as before, after, during, meet, etc. In the linear time model (single axis), time advances from past to future in a totally ordered fashion. In the branching time model (multiple axes), time advances from past to present, where it then splits into several time lines; it may also have many pasts and a single future. In the cyclic time model, time repeats itself after an interval [15]. HES-SPATO only considers the linear time model for history events. SpatialClass represents the space where history events happened. A space can be 0, 1, or 2 dimensions. A 0-dimension space is a point in the geographical space such as a city. A 1-dimension space is a line in the geographical space such as a river. A 2-dimension space is an area in the geographical space such as a country. Action/AttributeClass captures the thematic mode of reality by defining the characteristics of SPATO. It describes the narratives and features, such as number of solders in a troop, of the event.

SPATO is a logical object rather than a physical file in HES-SPATO. It presents the elements of a history event by integrating assets stored in the Asset Pool. A SPATO includes pointers for linking "Space", "Person", and "Action/Attribute" assets to form a history SCO which is able to present history events in sequence along the historical time line when these assets are integrated with the "Time" component specified in SPATO. A SPATO is defined as SPATO<ObjectID, SpatialClass, PersonClass_actor, PersonClass_acceptor, Action/AttributeClass, TemporalClass_start, TemporalClass_end>. ObjectID is the unique feature to identify a SPATO. SpatialClass specifies the geographical location where the event happened. PersonClass_actor specifies the person who initiated the event and PersonClass_acceptor specifies the person whom the event influenced. Action/AttributeClass specifies what the event was. TemporalClass_start specifies when the event started and TemporalClass_end specifies when the event ended. For example, for the event "Mary had fought

against John at school from 1900 to 1901." The SPATO is defined as <"object001", "school", "Mary", "John", "fight", "1900", "1901">.

If an SCO includes two SPATOs, it implies that there is a relationship, such as before, after, overlay, or any other temporal relationship of time intervals, between events and the designer wants to present not only the events but also the temporal relationship between the events. The temporal relationship between events can be represented and inferred based on time logic proposed by Allen [7].

Since SPATO is object-oriented in nature, the SPATO class diagram can be modeled (Fig. 2).

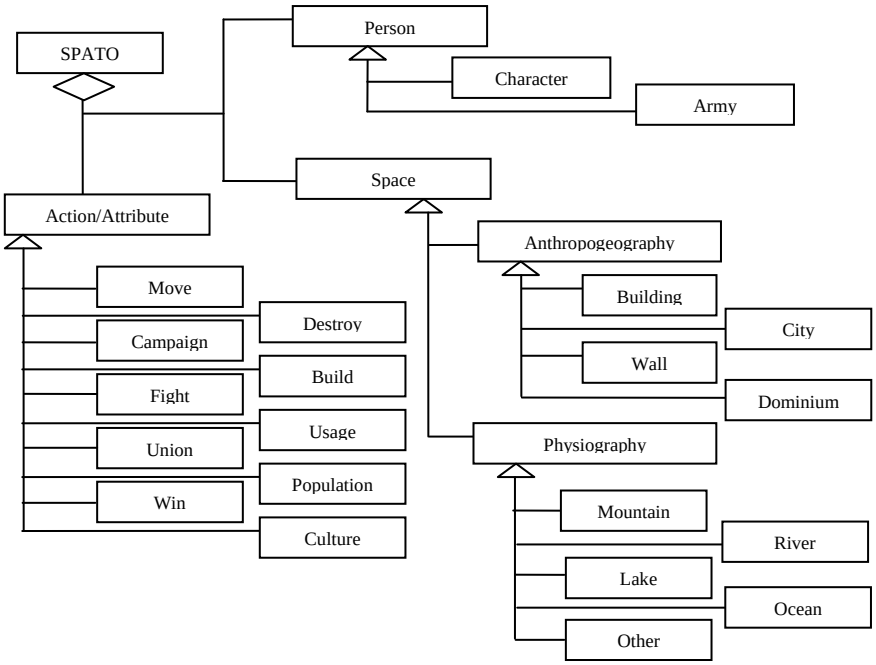

Fig. 2: SPATO class diagram

4 Student Interface

For a long time, people have studied history with models such as map. In the last decades, it has become possible to put these models inside computers. These computer models for maps make up a GIS. In a GIS, students can study not just maps, but all possible information related to maps. With the right data, students can see whatever they want, land, rivers, political boundaries, and thousands of other things, in whatever part of the world interests students [13]. A GIS map is composed of many separate, overlapping information layers, each of which has its own meaning [9]. To make a map, as many layers as users want can be added. Layers may contain features or surfaces. Using GIS technology is useful for integrating spatial information. Applying such concept of information layers, temporal and spatial attributes of people, events, and objects are integrated in spatial-temporal coordinates. In addition, on a GIS map, features can be displayed at different sizes. Students can zoom in to see features at closer range. As students do so, the scale of the map changes. Zooming gives students a closer view of features within a smaller area without changing the amount of detail in the features. How much detail features have depends on the layer the student use [13]. In HES-SPATO, the GIS (geographic information system) concepts are applied to develop the student interface so that students can view courses integrated with person, space, and time. Fig. 3 illustrates the HES-SPATO student interface.

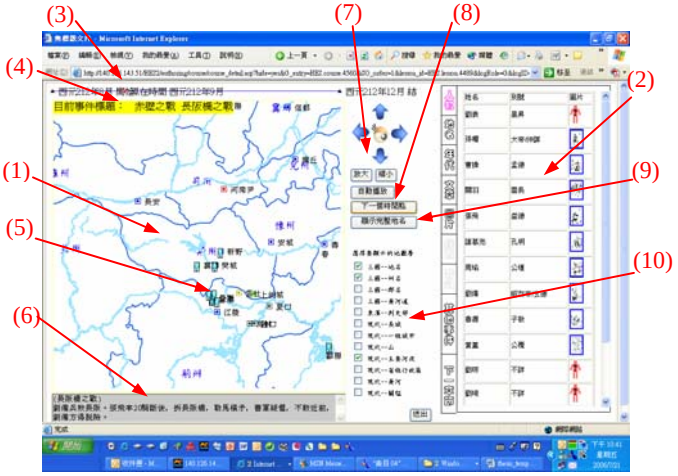

Fig. 3: Illustration of HES-SPATO student interface

(1) Main frame: It presents a lesson which includes history SCOs (integrated by SPATO and person,

space, action/attribute assets). By applying the temporal logic proposed by Allen [7] to reason the temporal relationships between history events, HES-SPATO can present history events in sequences with animation, hence, make the learning materials more understandable. HES-SPATO also integrates the person, spatial and temporal information of history events for increasing the understandability of learning materials.

(2) Supplement data: All related supplement data is showed on this frame. Learners can freely select different types of supplement materials.
(3) Time line: presenting the time defined in SPATO of history events.
(4) Event title: presenting the name of the current history event.
(5) Person: participants of the history events.
(6) Real-time information: a short sentence used to point out the key content of the animation of a history event.
(7) Map view controller: Learner can view any part of the map by using zooming and panning tools.
(8) Animation controller: With SPATOs, SCOs can present the dynamics of history events in sequences with animation. Students may pause or repeat the animation. They may let the system show the animation automatically or show the animation step by step by themselves.
(9) Space name display controller: It is used to switch between displaying only directly related space names and displaying all space names.
(10) Map layer controller: Students can choose features, displayed with different layer, as they want. For instance, a student may choose to display three features, background maps, mountain and river, as well as city or display two features only, background map as well as mountain and river.

According to the theory of cognitive learning, because humans have limited short-term memory capacity, information should be grouped into meaningful sequences [8]. Therefore, too much information should not be presented to students at the same time. Some history educational system present all space information such as city names, whether related or not, at the same time. By doing so, it causes the problem of cognition overload. In HES-SPATO, courseware designers, in SPATO, define the related space to be presented in SCOs. For Fig. 4, ("The War of Chr Bi"), in SPATO, courseware designer define the direct related spaces, "Jing Jou" and "Chr Bi", to display. In addition, students can disable the city layer. By doing so, Fig. 4 is more concise and understandable than Fig. 5 that displays all space information in the same area.

An experimental system of HES-SPATO, taking the Three-Kingdom of Chinese history as an example, is illustrated at http://140.126.143.51/HES2.

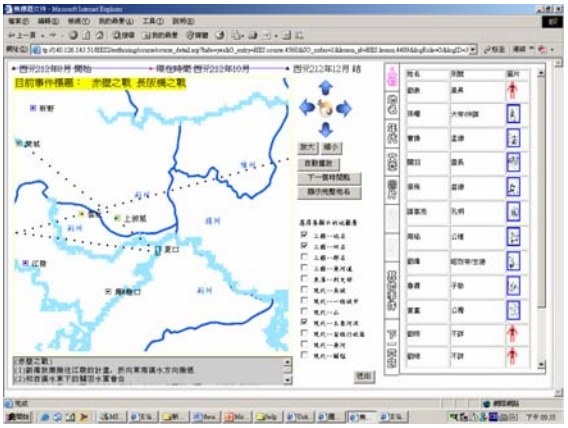

Fig. 4: Map layers only display space information directly related to the history event

Fig. 5: Map layers display all space information in the same area

5 Conclusions

HES-SPATO, a history educational system based on SPATO, is developed to integrate the indispensable elements of history events such as person, space, and time for increasing the understandability of history learning materials. It is based on SCORM, to ensure reusability, durability, accessibility, and interoperability of electronic materials. SCORM achieves its goal with the use of SCOs. In HES-SPATO, history SCOs are formed by integrating SPATOs with the associated "Space", "Person", and "Action/Attribute" assets, stored in the Asset Pool. SCOs, then, form other SCORM components such as lessons and courses accordingly. Therefore, SPATO serves as the backbone for HES-SPATO. SPATO is composed of four components, SpatialClass, PersonClass, Action/AttributeClass, and TemporalClass. It specifies "who" initiated the history event, "whom" the event influenced, "what" they did, "when" the event happened, and "where" the event happened. With SPATO, a history educational system with sharable learning objects that are integrated with spatial, person, and temporal history information can be implemented.

HES-SPATO applies the temporal logic to reason the temporal relationships between history events. The temporal logic makes the history events can be presented in sequences, hence, make the learning material more understandable. In addition, the GIS concept of information layers is applied to develop the student interface. With the developed student interface, students can select features, displayed with different layer, to realize history events more clearly, in the manner they want, zoom in to see features at closer range, view variety supplement learning materials at the same time, and view SCOs according to his own progress and steps. Also, the interface can only display space information directly related to the history event, as defined in SPATO, to reduce the problem of cognitive overload. With the developed features, HES-SPATO can effectively increase the understandability of history learning materials.

Acknowledgments. This research is supported by National Science Foundation of Taiwan (NSC 95-2520-S-216 -002-MY3) and Chung-Hua University (CHU-95-2520-S-216-002-MY3).

References:

[1] http://culture.edu.tw (in Chinese)
[2] http://ccts.ascc.net (in Chinese)
[3] http://ccts.ascc.net (in Chinese)
[4] http://cls.admin.yzu.edu.tw (in Chinese)
[5] Academic Sinica (Taiwan), Introduction to Chinese and Taiwan Historical GIS, http://ccts.ascc.net/download/presentation_20050128_en.pdf
[6] ADL, SCORM Content Aggregation Model Version 1.3.1, Advanced Distributed Learning, USA, 2003
[7] Allen, F.J., Maintaining Knowledge about Temporal Intervals, *Communications of the ACM*, Vol. 26, 1983 pp. 832-843.
[8] Anderson, T., Toward a Theory of Online Learning, In: Anderson, T., Elloumi, F. (eds.): *Theory and Practice of Online Learning*, Athabasca University, Canada, 2004, (http://cde.athabascau.ca/online_book/ch2.html)
[9] Haag, S., Cummings, M., McCubbrey, D.J., *Management Information Systems: For the Information Age*, 4th edition. McGraw-Hill Irwin Companies, Inc., 2004, p. 191
[10] Learning Systems Architecture Lab, *SCORM Best Practices Guide for Content Developers*, Carnegie Mellon University, USA, 2003
[11] Liao, H.-M., Yen, E., Fan, I-C., The Construction of the Spatial-Temporal Contents Integrated System Using WebGIS, *The Second Taipei International Conference on Digital Earth*, Taipei, 2004 (in Chinese)
[12] Lo, F.-J., Literary and Geographic Space-Time Information System Design and Application: Take Sushi's Poems for Example, *The Second Taipei International Conference on Digital Earth*, Taipei, 2004 (in Chinese)
[13] Ormsby, T., Napoleon, E., Burke, R., Groessl, C., Feaster, L., *Getting to Know ArcGIS Desktop: Basics of ArcView, ArcEditor, and ArcInfo*, 2nd ed., ESRI Press, Redlands, CA, USA, 2004
[14] Raza, A., *Object-Oriented Temporal GIS for Urban Applications*, PhD Thesis. University of Twente and ITC, 2001
[15] Raza, A., Kainz, W., Cell Tuple Based Spatio-Temporal Data Model: An Object Oriented Approach, *ACM GIS'99*, 1999, pp. 20-25.
[16] Wachowicz, M., *Object-Oriented Design for Temporal GIS*, Taylor & Francis, UK, 1999