Semantic Multimedia Analysis and Processing

Foreward

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Preface

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List of Figures

List of Tables

Contents

1

Spatiotemporal Event Visualization on top of Google Earth

Event
OpenLayers
Google Earth
Google Maps
Geovisualization
Geovisualization
Event
Geovisualization
Event
Google Earth

CONTENTS

Several types of information objects (like, for example, events, sites of interest etc.) can be better visualized on top of spatial representations, since the location of these objects is an important object feature. Several types of spatial representations (i.e. canvases, maps, diagrams, spatial plans etc.) have been used throughout the human history for the visualization of such information.

The use of interactive maps on the Web has become very popular nowadays, especially after the development of robust interactive Web map infrastructures like the OpenLayers, the Google Earth and Google Maps.

In addition, the exploitation of several types of mobile devices (i.e phones, tablets etc.) has allowed the development of location based services. A requirement for those applications is the strong support for geographic context including map distances, paths, time, location of objects and presentation of the objects on the map, awareness (location of services or friends near-by), etc. The *geovisualization* (essentially the visualization on top of maps) is of special interest, since it conveys geolocation information.

In this chapter we will review the research that is relevant to the geovisualization of events and will present our recent research for the geovisualization of events on top of the Google Earth 3D interactive maps, with respect to their spatial and temporal features.

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1.1 Introduction

The spatial representations (i.e. canvases, maps, spatial plans etc.) that have been used throughout the human history allow for the better visualization of several types of information objects (like, for example, events, sites of interest etc.), since they also depict the (absolute or relative) location of these objects.

An important type of visualization on top of spatial representations is the *geovisualization*, short for Geographic Visualization, which refers to a set of tools and techniques supporting geospatial data analysis through the use of interactive visualization [43]. The widespread use of the computers in every-day life in the last decades has allowed using such spatial representations in electronic format. The development of the Web and the need for interaction with spatial representations have led to the increasing use of interactive maps, especially after the development of robust interactive Web map infrastructures like the OpenLayers[1], Google Earth[2] and Google Maps[3]. Information geovisualization allows to exploit the interactivity of these infrastructures and is facilitated from them.

In addition, the exploitation of several types of mobile devices (i.e phones, tablets etc.) has allowed the development of location based services. A requirement for those applications is the strong support for geographic context including map distances, paths, time, location of objects and presentation of the objects on the map, awareness (location of services or friends near-by), etc.

Events and sites of interest may be also associated with multimedia content that is easily annotated with contextual information, since such information is automatically captured by modern GPS -enabled devices (like cameras, mobiles, tablets, etc.).

In this chapter, we focus on event geovisualization, since many important practical applications in several domains (like, for example, education, culture, tourism, real estate etc.) are associated with events or they can be described by events. In addition, event processing has recently attracted a lot of attention in both the business and academia [10]. We also present our recent research for event geovisualization on top of the Google Earth 3D interactive maps, with respect to their spatial and temporal features.

The rest of the chapter is structured as follows: The state of the art in event modeling is discussed in section 1.2, information geovisualization is surveyed in section 1.3, the *EVISUGE (Event VISUalization on Google Earth)* system that we have developed for the geovisualization of events on top of the Google Earth 3D interactive maps is described in section 1.4 and the chapter concludes in section 1.5.

[1]OpenLayers, http://www.openlayers.org/
[2]Google Earth, http://earth.google.com/
[3]Google Maps, http://maps.google.com/

1.2 Event Modeling

In this section we examine the state of the art in event modeling. Formally, an *event* is an occurrence within a particular system or domain; the term event is used to describe both the real-world occurrence and its computerized representation [10]. Examples of real-world events include accidents, marriages, baptisms, invited talks, debates, lectures, disasters like fires and floods, battles, experiments, product presentations etc.

Typically, a real-world event is recorded using only media such as video or pictures and audio; however, the events are usually associated with some spatial information that can be described on top of spatial representations and also have some associated metadata (i.e. actors, time etc.) which are used for further processing or filtering these events. Today's multimedia capturing devices are often equiped with a GPS receiver and can automatically capture a lot of contextual information (like, for example, GPS location, compass, azimuth), which can be manipulated to automatically register the 3D natural environment of the picture or video captured [6], [5]. This eliminates the need for extensive manual editing for the systematic capturing of multimedia events and their context.

Systematic real-world event capturing should associate and exploit all the contextual data with the captured audiovisual content in order to offer better cognitive clues to the viewer and allow exploitation of the metadata for workflow processing. For example, in a battle event the multiple media may capture the scene of the battle (armies involved, weapons etc.); spatial information such as maps may record the location and movement of the armies involved and the metadata may be used to record date and time as well as names of people involved in the battle.

Complex events are important in modern applications of business processes like business intelligence. In business intelligence, events or event patterns may be tracked to determine certain conditions that are important to the intelligence of the organization. A very promising research direction in business applications and business intelligence is the *semantic modeling of events* [21] [33] [17] [13] [38] [7] [14]. Event Processing Architectures are becoming very important in business processing applications [21]. Although Event Processing Architectures may seem to contrast to Service Oriented Architectures (SoA), researchers mostly agree for their complementarity, with the Event Processing Architectures covering better the asynchronous requirements of business processing. An Event Driven SoA is a hybrid form combining the intelligence and proactiveness of the Event Driven Architectures with the SoA organizational capabilities [23], [21].

semantic modeling of events is also an active research area in multimedia. The *MPEG-7 semantic Model* allows for the modeling of events and includes, among others, modeling of actors that are participating in the event as well as

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the event time and place. The MPEG-7 semantic Model is in a high level, but the extensibility mechanisms of MPEG-7 can be used to give powerful domain specific semantic descriptions of events in specific domains while still remaining completely within MPEG-7 [38]. The semantic MPEG-7 descriptions can be also transformed in logic based languages such as OWL for further processing and inference [39]. A related recently expanding area of research is the automatic extraction of semantic events from video sequences [3].

Modeling such aspects as camera parameters, camera location, camera movement, subject movement, light and sound locations, etc. is necessary for the representation of the multimedia capturing of events. The use of such parameters for capturing quality multimedia is studied in the cinematography area, where rich bibliography exists [1] [34], [4], [22], [30], [18]. These principles can be taken into account when producing guidelines for taking specific shot types. Some research related to cinematography tries to capture the rules for good cinematography into language or expert system constructs, often with the objective to automate the presentation of virtual reality scenes in games and elsewhere [9], [12].

While rich literature exists in the area of semantic event modeling and event-based multimedia modeling, as well as in cinematography principles, very limited research exists in generic tools and methodologies for systematically capturing multimedia events and their context, including the spatial context and the context of capturing. Such tools should be based on models that associate composite events with the locations where the events took place and the time of the event evolution. In addition, they should facilitate the modeling of the capturing processes in space and time and its associations with the event evolution. This will facilitate the visualization of the events, the shot capturing processes and the actual multimedia captured. Without such models the capturing process is very expensive and slow, and the visualization possibilities limited, overtaxing the cognitive capabilities of the users.

Should the above discussion be taken into account, the representation of a real-world event on a map should include:

1. The spatial information of the event, which is represented by its position on the map.
2. The event participants (both actors and objects).
3. The temporal features of the event.
4. The representation of any relevant events (including sub- events and preceding/following/parallel events).

These real-world event representation requirements are satisfied by the *MOME (MObile Multimedia Event Capturing and Visualization)* event representation model [27]. Interrelated real-world events may be combined in MOME to form scenarios; the later are visualized through the visualization of their component events, with respect to their spatiotemporal order. An important feature of the MOME model is that it supports the real-time multimedia event capturing that exploits smart devices (like, for example, cameras with automatic GPS coordinate capturing capabilities). It can also accommodate domain specific descriptions for the events, which include domain-specific knowledge systematically captured as described in [38]. In addition, the MOME event model can be mapped to the MPEG-7 [33] and MPEG-21 [29] standards (used, respectively, for multimedia content description and for the interaction with multimedia content).

1.3 Information Geovisualization

The spatial representations are useful for information visualization, since several types of information objects have a spatial component. In this section we will review the research literature regarding information geovisualization. The research challenges on which we will focus are information visualization on top of GIS (in section 1.3.1) and event geovisualization (in section 1.3.2).

1.3.1 Visualization on top of GIS

A *Geographic information system (GIS)* is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. A GIS uses spatiotemporal (space-time) location as the key index variable for all other information [42]. An important application of the GIS is the presentation of information on top of them that also allows the exploratory spatio-temporal visualization [24]. An example of such an application is the city exploration application of [28] that helps users identify interesting spots in a city using spatio-temporal analysis and clustering of user contributed photos.

Another important research direction is the *Time Series Data visualization* on top of maps. Such an application is the TimeMapperWMS, which allows users all over the world to visualize the dynamics inherent in the Antarctic Iceberg time series [35]. The TimeMapperWMS has been built on top of the *Web Map Service (WMS)* [26] and uses the *Scalable Vector Graphics (SVG)* [40] in order to produce *animated maps* (i.e. maps on which animation has been applied in order to add a temporal component displaying change in some dimension [41]). The authors of [37] present a 3D visualization approach to address some of the challenges in effective visual exploration of geospatial time-varying data; Their system also provides a holistic display of the spatio-temporal distributions of the data on a geographic map and employs standard visual-analytical tools (like, for example, interactive data mapping and filtering techniques) to support exploratory analysis of multiple time series.

The modern cameras provide integrated GPS technology, thus allowing the automatic capture of the geographical context of the images taken; in addition, they allow wireless connection to computers. This way, the *geotagged*

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Mashup

images (i.e. images annotated with their geographical context) may be easily integrated in GIS and associated with spatial objects. A *spatial object* may be an individual which relates to a semantic concept in an ontology [6], [5]. Through this relationship, the user can see semantic information about the visited space (for example, when visiting a room, the user may see who resides in this room or the room functions).

The geotagged images have allowed the development of spatial information processing and retrieval frameworks [6], [5], [19]. The *SPIM (SPatial Image Management)* framework [6], [5] provides a picture database that allows users to store and view their photos. Along with the photos, the users can view personalized semantic maps, annotated with semantic objects described using ontologies. These maps are supplied from a remote server. Photos with position only information as well as photos with both position and direction information can be visualized on top of the maps and be associated with semantic objects. Several algorithms that allow interactive exploration of the picture contents have been implemented. In addition, the framework employs the use of image processing and other algorithms to enable the automatic annotation of the photos. In [19] a conceptual framework and a methodology have been developed that allow analyzing events and places using geotagged photo collections shared by people from several different countries. These data are often semantically annotated with titles and tags that are useful for learning facts about the geographical places and for detecting events that occurr in these places. The knowledge obtained through the analysis performed on them may also be utilized in sociological and anthropological studies as well as for building user centric applications like tour recommender systems.

Among the latest popular developments of the GIS technology were *Google Map Mashups*, i.e. the Google Earth and the Google Maps interactive Web map infrastructures. Since the Google has provided Application Programmers Interfaces (APIs) for them (the Google Earth API[4] and the Google Maps API[5], respectively), the Google Map Mashups have been extensively used for the presentation of multimedia content related with sites and events of interest. Some examples of this type of functionality are listed below:

- The Natural History museum of Crete allows presenting information about several types of birds on top of Google Maps[6].
- The Virtual Bulgaria project allows presenting, on top of Google Maps, panoramic views of several points of interest (cultural, touristic etc.) in Bulgaria[7].
- The DC Crime Visualization[8], which is an event visualization mashup of

[4]Google Earth API, https://developers.google.com/earth/
[5]Google Maps API, https://developers.google.com/maps/
[6]The Natural History Museum of Crete, *http : //www.nhmc.uoc.gr/portal/?q = birds_amari*
[7]The Virtual Bulgaria Project, http://www.bulgaria-vr.com/
[8]DC Crime Visualization, http://www.geovista.psu.edu/DCcrimeViz/app/

violent crimes in the District of Columbia that has been developed using the Google Maps API.

- The data-mining system presented in [8], which deals with very large spatio-temporal data sets has exploited the Google Earth in order to display the data mining outcomes combined with a map and other geographical layers.

An important type of GIS that has practical applications in several domains (i.e. environmental sciences, military, computer assisted cartography etc.) is the *Historical Geographic Information System* (also written as Historical GIS or HGIS). A HGIS is a geographic information system that may display, store and analyze data of past geographies and track changes in time [44]. The Google Earth interactive Web maps are the GIS infrastructure utilized for the China Historical GIS [2].

Another recently popular Web map infrastrucre is the OpenLayers, an open source JavaScript library for displaying maps in any Web page. It provides a JavaScript API for building rich web-based geographic applications, similar to the Google Maps APIs. OpenLayers is highly extensible and it serves as the foundation of all the web mapping interfaces. OpenLayers accesses data through industry standards and it may overlay multiple standards-compliant map layers into a single application. Some examples of OpenLayers-based applications are listed below:

- The *Community Almanac*[9], which is a collaborative community building and story telling application developed for the Orton Foundation.

- The *Vespucci*[10] collaborative mapping tool, which takes advantage of the versioning capability of GeoServer[11] (a software server written in Java that allows users to share and edit geospatial data). Vespucci has been used by Landgate, the government authority responsible for land and property information in Australia.

- The *Styler*[12] interactive styling application for geospatial data.

- The *RAE Geospatial Map*[13], developed by the *Greek Regulatory Authority for Energy (RAE)*, which provides user-friendly tools for navigating, querying, searching, measuring and selecting areas of interest. Using the map, RAEs customers may be informed about the status of their energy facilities and can search, visualize and retrieve information from RAEs resources.

[9] The Community Almanac, http://www.communityalmanac.org/
[10] Vespucci, http://demo.opengeo.org/vespucci/
[11] Geoserver, http://opengeo.org/technology/geoserver/
[12] Styler, http://suite.opengeo.org/geoserver/www/styler/index.html
[13] Greek Regulatory Authority for Energy, http://opengeo.org/publications/rae/

Google Maps
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Event Geovisualization
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1.3.2 Event Geovisualization

The events have a spatial component; thus, a challenging research direction is that of real-world event visualization on top of spatial representations.

Some event visualization applications developed on top of spatial representations are presented below:

- The application presented in [11], which allows the spatiotemporal visualization of battles on top of a canvas.
- The Trulia Hindsight[14], which animates, on top of the Microsoft Virtual Earth platform, housing construction by year, providing prospective buyers a quick overview of the historical development of a neighborhood. The events are represented by circles of different colour, which are not interactive.
- The AsthMap application[15][16], which is a mashup for mapping and analyzing asthma exacerbations in space and time, developed on top of the Microsoft Virtual Earth[16] platform. The events are also represented by circles, but the circles are now interactive and allow the retrieval of event attribute data.
- The DC Crime Visualization that allows the interactive presentation of the violent crimes in the District of Columbia on top of Google Maps. The DC Crime Visualization was the basis for the development of an event animation code library that extends the Google Maps API [31] [32].

The above applications can be distinguished in the ones that need advanced event support for complex events, like [11], and the more "lightweight" ones that are visualized on top of maps like the HidInsight, the AsthMap and the DC Crime Visualization.

The importance of the event geovisualization applications has led to the development of generalized frameworks that allow event geovisualization for different application domains.

The SpatialKey[17] [15] is a collection of templates, built on top of the MapQuest[18] platform, which provide a suite of geovisualization techniques for spatiotemporal information, including event animation. In addition, it allows the users to upload their own data. The most important limitation of the SpatialKey is that it cannot easily accomodate applications like that of [11], which need advanced event support.

The MOME mobile multimedia event capturing and visualization framework [27] implements the MOME event model and allows the spatiotemporal visualization of complex events on top of spatial representations. Based on the

[14] Trulia Hindsight, http://hindsight.trulia.com/
[15] The AsthMap Application, http://indiemaps.com/asthMap/
[16] Microsoft Virtual Earth, http://www.viawindowslive.com/VirtualEarth.aspx
[17] The SpatialKey, http://www.spatialkey.com/
[18] MapQuest, http://www.mapquest.com/

MOME model, we have implemented the EVISUGE system [36], which allows complex event visualization on top of the Google Earth (see section 1.4 for details).

1.4 The EVISUGE (Event VISUalization on Google Earth) System

In this section we present *EVISUGE (Event VISUalization on Google Earth)* [36], a system that allows the visualization and management of real-world scenarios on Google Earth. An EVISUGE scenario is composed of events, which are represented according to the MOME event representation model that we have developed. These events are visualized on top of the Google Earth 3D interactive maps, with respect to their spatial and temporal features. We demonstrate the EVISUGE system through real-world scenarios: The specification, navigation and visualization of a naturalistic route, the spatiotemporal representation and visualization of battles and the visualization of weather conditions.

Compared with existing applications developed over interactive Web maps (see section 1.3 for details), the major advantage of the EVISUGE system is that it allows complex event geovisualization in addition to the presentation of multimedia information and/or simplified event visualization. Compared with earlier event visualization applications like [11], it allows event visualization and integration on top of interactive Web maps and not only canvases or other proprietary diagrams.

In the following sections we discuss in detail the conceptual model of the EVISUGE system (Section 1.4.1) and the EVISUGE system architecture and functionality (Section 1.4.2) and we present the real-world application scenarios that we have already implemented on top of the EVISUGE system (Section 1.4.3).

1.4.1 The EVISUGE Conceptual Model

In this section we detail the *EVISUGE conceptual model*, which allows the scenario and event representation in the EVISUGE system.

The *scenario* is the central entity in the EVISUGE conceptual model. An EVISUGE scenario has a name and a textual description, is composed of events and is associated with spatial objects that represent the scenario participants. An EVISUGE event is associated with the event time, the actor roles involved in it and its sequencing information.

The event capturing requirements that were taken into account in the design of the conceptual model of the EVISUGE system include:

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EVISUGE
Scenario
Naturalistic Route
Battle
Weather Conditions
EVISUGE
Event
Geovisualization
Event
Event
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EVISUGE
EVISUGE
Scenario
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1. Capturing of the event *spatial aspects* such as integrating maps and diagrams with additional relevant details.
2. Capturing and representation of the event *actors*, their spatial representations, locations and movements during the events.
3. Capturing of the *real scenes* that relate to the events using audiovisual material (photos, video, and sound).
4. Capturing the event *time* considering absolute and relative times with respect to other events, as well as demarcating the beginning and the end of shots that relate to a specific event for easy event browsing and extraction.
5. Representation of the *multimedia capturing process* with respect to space and time (camera location, direction, angle, movement, etc.) on top of the maps in order to facilitate the visualization of the spatial context.
6. Representation of the *event workflows* and mechanisms to facilitate the scheduling and preparation of the event capturing and the complete coverage of all the component events.

Since the MOME event representation model satisfies the above-referred requirements [27], we have decided to adopt it for the representation of EVISUGE events. The MOME model includes concepts that belong to the following four major categories:

1. Concepts that describe the *events* and the *multimedia shots* taken to capture those events. An event may be associated with structured *Spatial Objects*, the event *Time*, and *Event Shots* that represent the audiovisual capturing of the event. An event shot is a multimedia item (i.e. image, video or audio segment) capturing the event. The time associated with an event is referring to a specific time interval and it takes the relative sense of time.
2. Concepts used for the *logical spatial event representation*. The events are associated with *physical spaces* that may be described by *spatial objects*. These objects may be represented in the form of diagrams on a spatial representation of the event site (e.g. map, canvas etc.) with a semantic meaning provided by the spatial object itself or without any semantic meaning indication at all. The events are also associated with *Roles* that semantically describe the event participants.
3. Concepts used for the *logical spatial shot representation*. A shot spatial representation describes the original and final locations and the camera parameters, the sound and light equipment on top of the spatial event site representation, in the same way that the event concepts were represented on top of it. The representation shape may change during the capturing process.

4. Concepts used for the *physical representation of the events and shots* described on top of maps or other spatial representations like diagrams or 3D views. The concepts of this part of the model are responsible for mapping the logical event representation to (one or more) other representations as required. To do this, rotation, translation and scaling of the logical representations may be required. The logical representations mapped on the site map are called physical representations. A physical representation has a location on the site map as well as shape and possible movement.

In the MOME model, the events belong to complex event types that may be composed of events belonging to simpler event types. The metadata captured for each event depend on its type. Events are captured by multimedia shots that belong to shot types. Events and multimedia shots may be associated with maps and/or diagrams. Shots are described by the position (captured by a GPS device or otherwise), direction (compass) and camera movement of the shot placed on a diagram of a scene that describes the event, as well as with other parameters. The shot types are associated with visual descriptions; these can be used for learning and preparation for multimedia capturing of events of a particular type.

The concepts used for the representation of scenarios and events in the EVISUGE system are depicted in the UML class diagram of Figure 1.1. This diagram essentially contains the MOME concepts together with the concepts that are necessary for the representation of the EVISUGE scenarios and shows the relationships between them.

According to the class diagram of Figure 1.1, an EVISUGE *Scenario* is composed of *Events* and is associated with *Spatial Objects*. The *Events* may be complex, since an EVISUGE *Event* may be composed of simpler ones. The *Events* are also associated with the *Time* that they occur, the *Event Shots* that capture them, their *Sequence Description* that specifies their temporal order and the *Roles* (of type *Object*, *Person* or *Crowd*) that are involved in them. The *Spatial Objects* may also be complex, since they may comprise other *Spatial Objects*.

Notice also the MOME meta-modeling facilities (i.e. metaclasses) on the upper right part of Figure 1.1; the metaclasses include *Event Type*, *Sequence Description* as well as the *Roles Involved Type* and its sublcasses *Object Type*, *Crowd Type* and *Person Type*. The EVISUGE meta-modeling facilities allow the instantiation of a scenario to result in the instantiation of all the events associated with it.

The instantiation of the EVISUGE conceptual model that was outlined in this section is demonstrated in the real-world scenarios presented in section 1.4.3.

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EVISUGE
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Time
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Object
Person
Crowd
Spatial Object
Spatial Object
MOME
Event
Role
Object
Crowd
Person
EVISUGE
Scenario
Event
EVISUGE
Scenario

EVISUGE
EVISUGE
EVISUGE
MVC
EVISUGE
Scenario
Scenario
Google Earth
Google Earth
EVISUGE

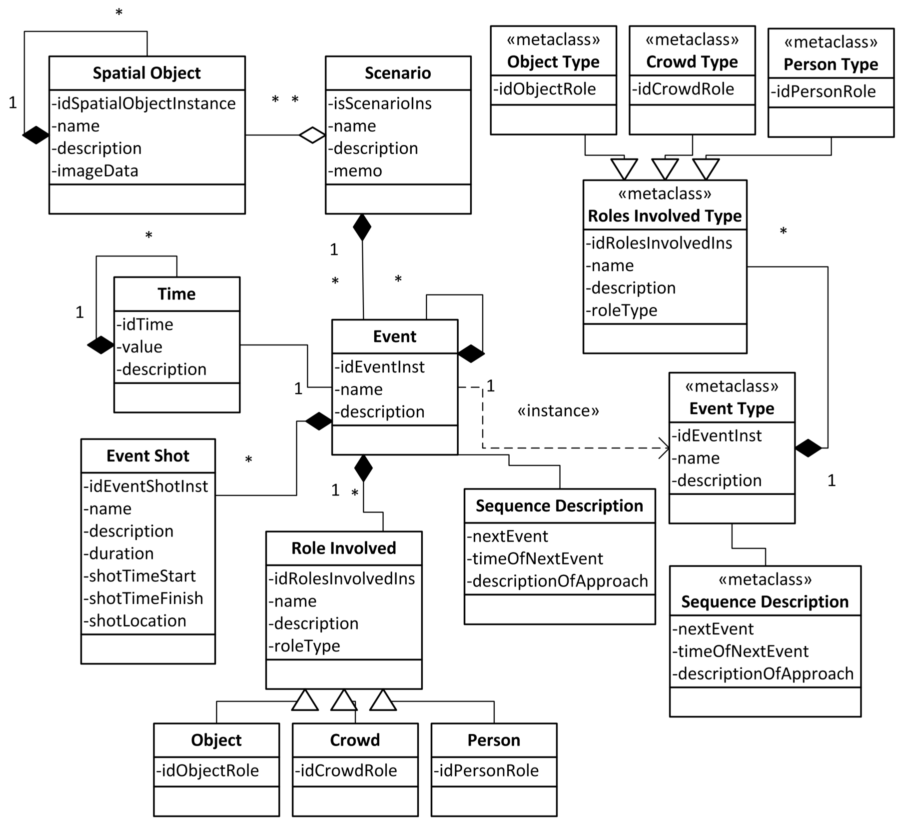


FIGURE 1.1
The EVISUGE Conceptual Model. The instantiation of a scenario results in the instantiation of all the events associated with it.

1.4.2 The EVISUGE System

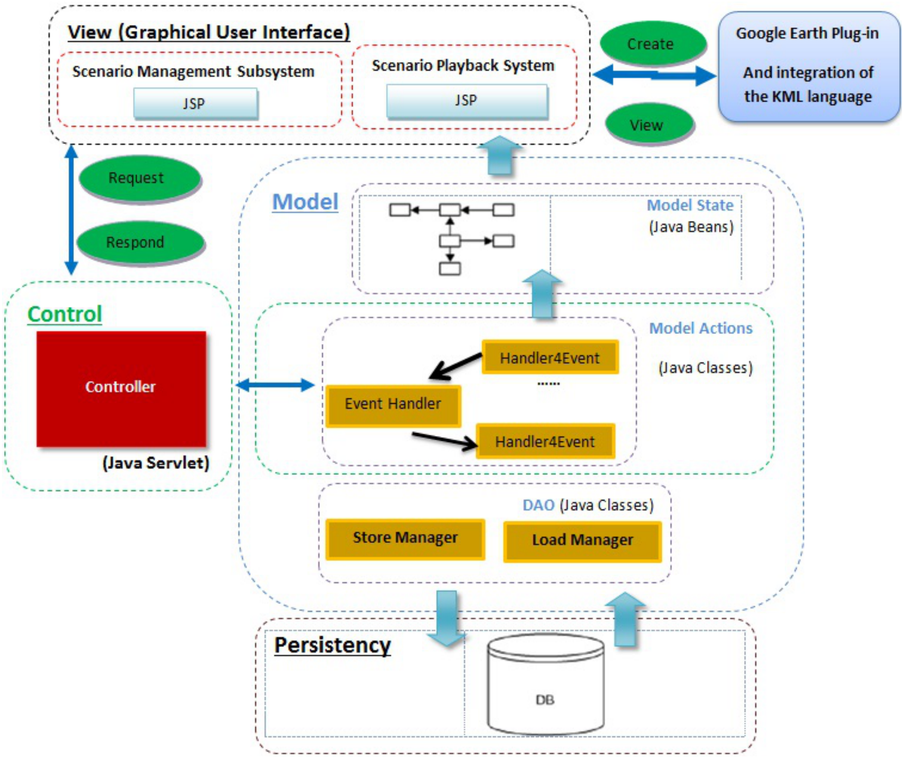
In this section we present the EVISUGE system in terms of system architecture and functionality.

System Architecture. The EVISUGE system architecture (depicted in Figure 1.2) is based on the *MVC (Model-View-Controller)* [20] design pattern.

The *View* layer is the Graphical User Interface (GUI) of the EVISUGE system and interacts with the end users for scenario management and playback. Both scenario management and playback are performed on top of the interactive 3D Google Earth maps. In order to achieve this, we have utilized the Google Earth plug-in[19] and the KML (Keyhole Markup Language) [25].

The *View* layer sends the requests that are generated from the user actions to the *Control* layer, which encodes the EVISUGE system logic. As a

[19]The Google Earth Plug-in, http://code.google.com/intl/el-GR/apis/earth/



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Event
Scenario

FIGURE 1.2
The EVISUGE System Architecture

consequence, the complex event processing that takes place in EVISUGE is performed in the *Control* layer, which is implemented as a Java servlet.

The *Control* layer also interacts with the *Model* layer, which allows for the transparent handling of the information stored in the persistency layer (i.e. the system database).

As is shown in Figure 1.2, the EVISUGE system comprises two subsystems:

1. The *Scenario Management Subsystem*, which allows scenario and event management (creation/editing/deletion), even capturing, as well as the specification of scenarios that are composed of existing events.
2. The *Scenario Playback Subsystem*, which allows:
   (a) The playback of both scenarios and events.
   (b) The navigation of the routes specified in the scenarios and the visualization of the associated events. The users are also allowed to interact with the scenario visualizations by clicking on the

EVISUGE
EVISUGE
Scenario
Scenario
Scenario
Scenario
Scenario
Scenario
Scenario
Event
Event
Google Earth
EVISUGE
Scenario
EVISUGE
EVISUGE

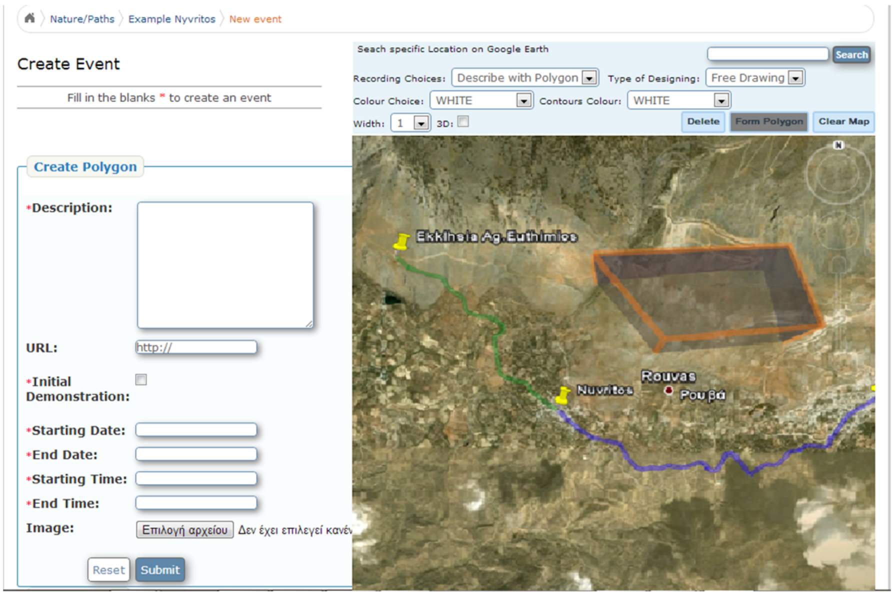

FIGURE 1.3
The EVISUGE Scenario Creator Interface

(2D or 3D) representations of the objects that are visualized on the maps and view the information associated with them.

Functionality. Table 1.1 presents the most important use cases that are related to the core functionality of the EVISUGE system. We distinguish two main actors that may be interacting with the EVISUGE system:

- The *scenario observers*, who are accessing the system in order to navigate through the existing scenarios. The scenario observers may also annotate the existing scenarios.
- The *scenario creators*, who specify the scenarios, register the scenario events and appropriately represent these events on Google Earth.

A snapshot of the EVISUGE user interface during scenario creation is shown in Figure 1.3 (the EVISUGE user interface currently supports Greek and English speaking users). The functionality offered by the system is accessible through the navigation bar (on the upper part of Figure 1.3).

The user interface of the EVISUGE system has been designed according to the following principles:

1. *Ease of navigation*, which is achieved through the navigation bar.
2. *Functionality grouping*, in the navigation bar, of the categories and subcategories of the functionality offered in the system.

3. *User notification*, in the navigation bar, of the category/subcategory of the system functionality that the user is currently using.
4. *User guidance*, through the links offered to the user in the navigation bar.
5. *Consistency*, since the same user interface layout has been followed in all the system screens.
6. *Appropriate color selection*, so that the user interface is not tiring for the end-users and has the look and feel of a robust application.

1.4.3 Real-world Application Scenarios

In this section we describe the specification and visualization of real-world application scenarios that we have developed, as case studies, on top of EVISUGE. These scenarios belong to the three types of scenarios that we have thoroughly examined and are fully supported in EVISUGE : The *naturalistic route scenario* type, the *battle scenario* type and the *weather condition scenario* type.

1.4.3.1 Naturalistic Routes

We describe here the specification, navigation and geovisualization of a naturalistic route scenario in EVISUGE . In particular, we present the scenario of the Nyvritos-Gergeri route navigation (Nyvritos and Gergeri are two villages located in south-eastern Crete, that attract a lot of tourists due to their natural beauty).

The structure of the Nyvritos-Gergeri route navigation scenario is depicted in the object diagram of Figure 1.4. As is shown in Figure 1.4, the scenario is represented by the Scenario class instance “Navigation of the Route Nyvritos-Gergeri”. Since the route from Nyvritos to Gergeri passes through the Sellia village, this Scenario instance comprises the Event instances “Movement to Sellia village” and “View of Nyvritos village”. The “Movement to Sellia village” event is a complex event that contains the event “Movement to Gergeri village”.

For the representation of this scenario in the EVISUGE system, several MOME concepts have been instantiated; for example, the road that is followed is represented in EVISUGE as an instance of the “Participating Spatial Object Shot” MOME class. Table 1.2 presents the MOME concepts and their associated instances that are used for the representation of the “Movement to the Sellia village” event contained in the scenario.

In the object diagram of Figure 1.5 we provide a more detailed view in the corresponding part of the structure of the scenario of Figure 1.4. In particular, we focus on the Event instance “Movement to Sellia village” that is part of the Scenario instance “Navigation of the Route Nyvritos-Gergeri”. As is shown in Figure 1.5 , the Event instance “Movement to Sellia village” is associated

Scenario
Scenario
EVISUGE
Scenario
Scenario
EVISUGE
Naturalistic Route
Scenario
Battle
Scenario
Scenario
Naturalistic Route
Geovisualization
Naturalistic Route
Scenario
EVISUGE
Scenario
Scenario
Scenario
Scenario
Scenario
Event
Event
Event
Event
Scenario
EVISUGE
MOME
Spatial Object
Shot
MOME
MOME
Event
Scenario
Scenario
Event
Scenario
Event

Object
Event
Time
Spatial Object
Event
Scenario
EVISUGE
Scenario
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Scenario
EVISUGE
Scenario
Scenario

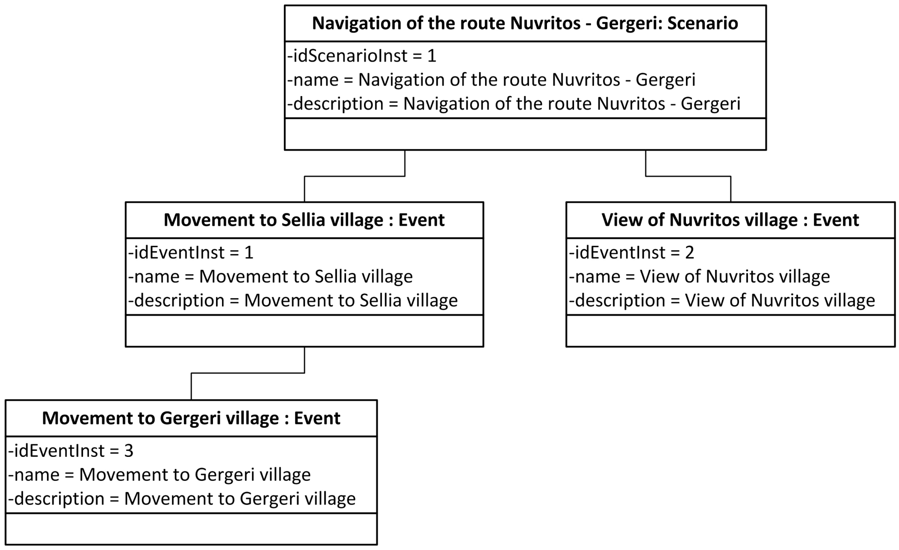

FIGURE 1.4
Object Diagram that shows the structure of the Nyvritos-Gergeri route navigation scenario

with the road that should be followed (represented by the "Road" instance of the SpatialObject class), the car used (represented by the "Car" instance of the Object class) and the time that this event takes place (represented by the "Day of the movement to Sellia village" instance of the Time class).

The spatial objects that participate in an event may also be structured; for example, in the object diagram of Figure 1.6 we present the "Village" instance of the SpatialObject class, which represents a village (i.e. Gergeri, Sellia or Nyvritos). The "Village" instance comprises other SpatialObject instances:

- The "Buildings" instance, which represents the village buildings. The "Buildings" instance is also structured, and comprises the "Church" instance, which represents the church of the village and the "House" instance, which represents the village houses.
- The "Roads" instance, which represents the village roads.
- The "Square" instance, which represents the square of the village.

The representation discussed above can be specified by a scenario creator using the EVISUGE scenario management subsystem. Once the scenario is specified and stored in the EVISUGE database, it can be visualized by a scenario observer, who may also navigate the route Nyvritos-Gergeri, using the EVISUGE scenario playback subsystem.

The visualization of the Nyvritos-Gergeri route navigation scenario in the

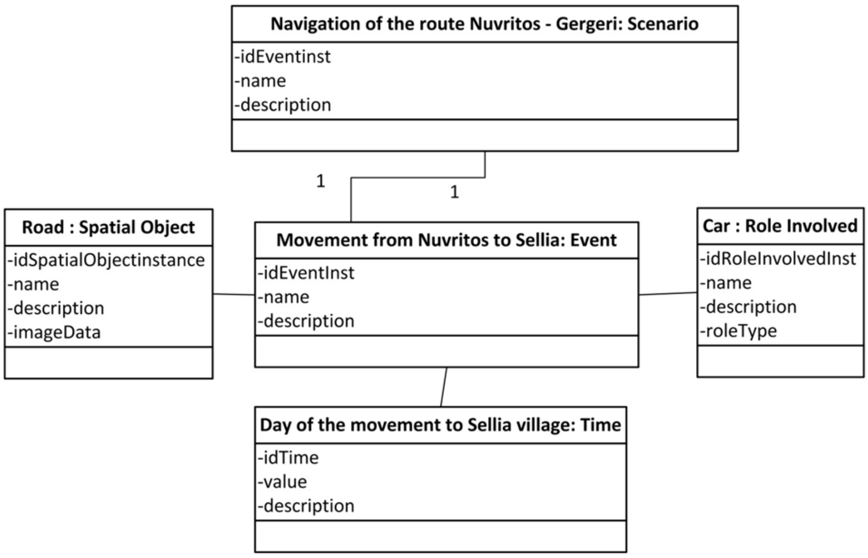

FIGURE 1.5
Detailed Object Diagram for a part of the Nyvritos-Gergeri route navigation scenario

EVISUGE
Google Earth
Scenario
Event
Event
Shot
Event
Shot
Event
Scenario
Scenario
Google Earth
Battle
Scenario
Scenario
Battle
Scenario
Battle
Battle
Crowd

EVISUGE system is presented in Figure 1.7. As is shown in Figure 1.7, some textual information about the route is placed on the top of the Web page presented to the user, while the route is visualized in Google Earth. The route navigation scenario events are visualized according to their temporal order and are represented by polygons that allow interacting with them in order to view relevant information as well as the event shots. The event shots provide multimedia information about the events that is available in specific points of the route. The current point in the route navigation is denoted by the position of the 3D model of a car that follows the route. The observer may browse the scenario using the scenario playback bar and the buttons associated with it, which are placed at the bottom of the Google Earth window.

1.4.3.2 Battles

As a case study of the battle scenarios, we have worked out the scenario of the battle of Marathon. This scenario is associated with the Marathon valley and the time of the battle and has as participants the Greek army and the Persian army. The initial positioning during the playback of the battle of Marathon is presented in Figure 1.8

The two participant armies are essentially crowds, which are represented on the map using polygons that change shape according to the movements that makes every army (or a part of it) in specific time points (see Figure 1.9). Notice that, since several parts of the armies may move simultaneously,

Event
EVISUGE
Scenario
Event
Shot
Event
Event
Weather Conditions
Scenario
EVISUGE
Event
Google Earth
Google Earth
Scenario

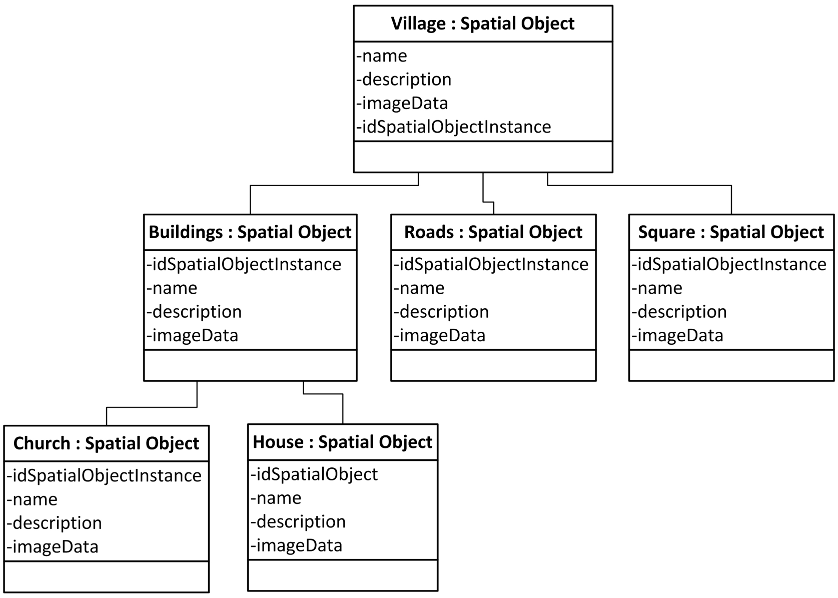

FIGURE 1.6
Object Diagram for the detailed description of the structure of a village

the parallel event visualization support offered by EVISUGE is required for this scenario type. The event shots include photos of the event locations as well as photos of cultural heritage objects (e.g. amphora drawings, wall paintings etc.) that depict the events.

1.4.3.3 Weather Conditions

As a case study of the weather condition scenarios, we have worked on the spatial representation of the temperature in an area in specific time points. In the current version of the EVISUGE system we do not support "live" events (like, for example, the real-time visualization of the temperature changes) because Google Earth does not yet provide support for the real-time update of objects visualized on top of Google Earth maps. As a consequence, we cannot "feed" the scenario visualization with real-time data and have an up-to-date map of the temperatures of the area that is presented.

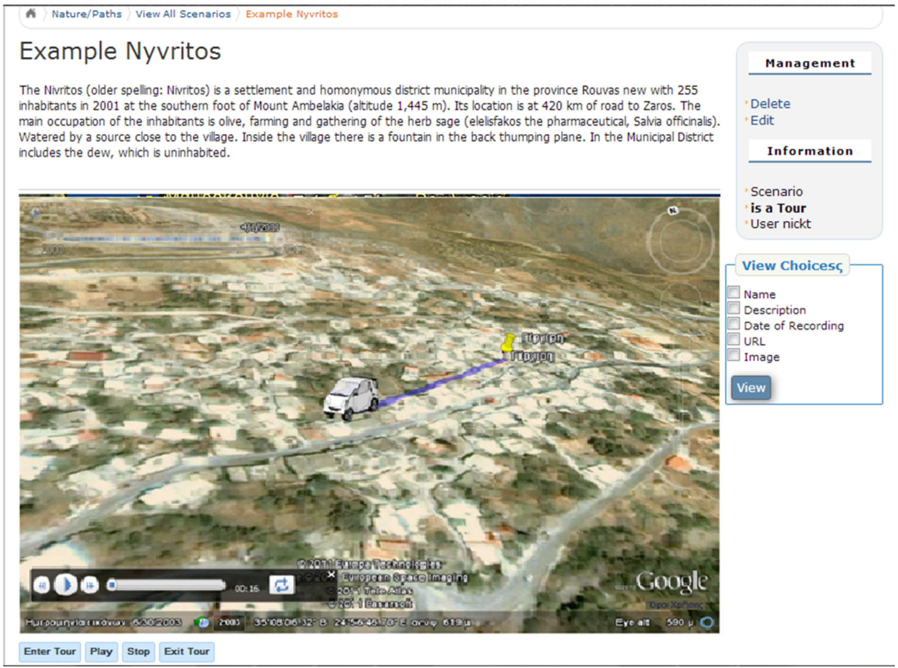

FIGURE 1.7
Visualization of the Nyvritos-Gergeri route navigation scenario

1.5 Conclusions

The use of interactive maps on the Web has become very popular nowadays, especially after the development of robust interactive Web map infrastructures like the OpenLayers, the Google Earth and Google Maps.

Since many important practical applications in several domains are associated with events or they can be described by events, we focus in this chapter on event geovisualization.

In particular, we have reviewed the relevant research and we have presented our recent research in the EVISUGE system for the visualization of events on top of the Google Earth 3D interactive maps, with respect to their spatial and temporal features.

OpenLayers
Google Earth
Google Maps
Event
Event
Event
Geovisualization
EVISUGE
Event
Google Earth

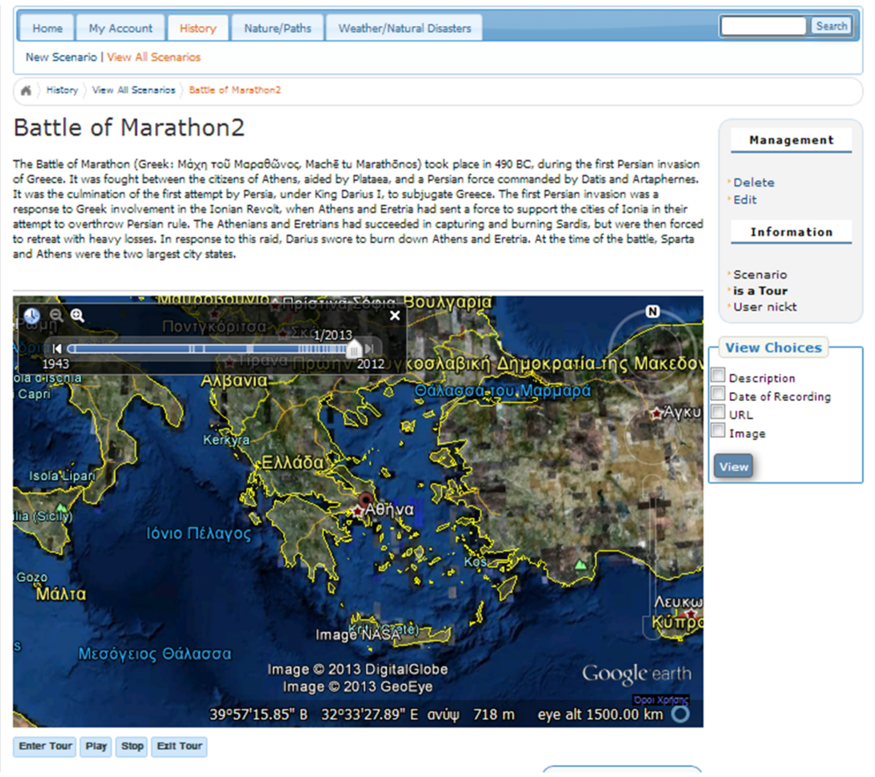

FIGURE 1.8
Initial positioning of the battle of Marathon

Primary Actor	**Goal**	**Description**
Observer	Scenario navigation/visualisation	Interactively navigate through a scenario that contains one or more events.
Observer	Scenario search	Perform a keyword-based search to retrieve the most related scenarios.
Observer	Scenario annotation	Manage (create/delete) textual annotations/comments for a scenario during its visualisation.
Observer	Scenario metadata personalization	Select the scenario metadata information that will be projected during its visualization/navigation. This metadata refer to the events and the objects that are related to the specific scenario.
Observer	Scenario browsing	Browse through the existing (already stored) scenarios.
Creator	Scenario management	Manage (create/edit/delete) a scenario. A scenario comprises one or more events.
Creator	Event management	Manage (create/edit/delete) an event. The manipulation of an event is related to its spatial-temporal characteristics, its descriptive information (along with any multimedia information) and its representation (schema, fill/outline color, etc.) in Google Earth.
Creator	Create parallel events	Create events with temporal overlapping.
Creator	Manage event temporal information	Manage (create/edit/delete) the temporal information (i.e. begin/end time) in order to compute the event duration.
Creator	Manage event image information	Manage (attach/delete) an image to an event.
Creator	Manage event 2D/3D representation	Manage (create/edit/delete) the 2D/3D representation schema of the event. The schema is selected from a draw suite and may have a 3D representation. During the editing, the background and the outline colors are also specified.

TABLE 1.1
The most important Use Cases of the EVISUGE System

MOME	**EVISUGE /Route Navigation**
Event Shot	Movement to the Sellia village
Participating Spatial Object Shot	Road
Logical Spatial Shot Representation	Representation of the car on the road
GPS Point	GPS points for the representation of the car and the route
GPS Representation	Set of GPS points for the representation of the car and the route
Physical Representation	Representation of the movement to the Sellia village using a line and the car representation
Shot Site Map	Google Earth Map
Geographic Map	Google Earth Map
Digital Elevation Model	Google Earth Map
Shape	The route line and the car representation shape
Point	GPS representation points for the Google Earth shape representation
Movement	Utilization of GPS points on the route representation, from the route beginning to its end
Color	Line color

TABLE 1.2
Association of the MOME Event Representation Model Concepts with their Instances in EVISUGE that represent the movement to the Sellia village in the Nyvritos-Gergeri route navigation scenario.

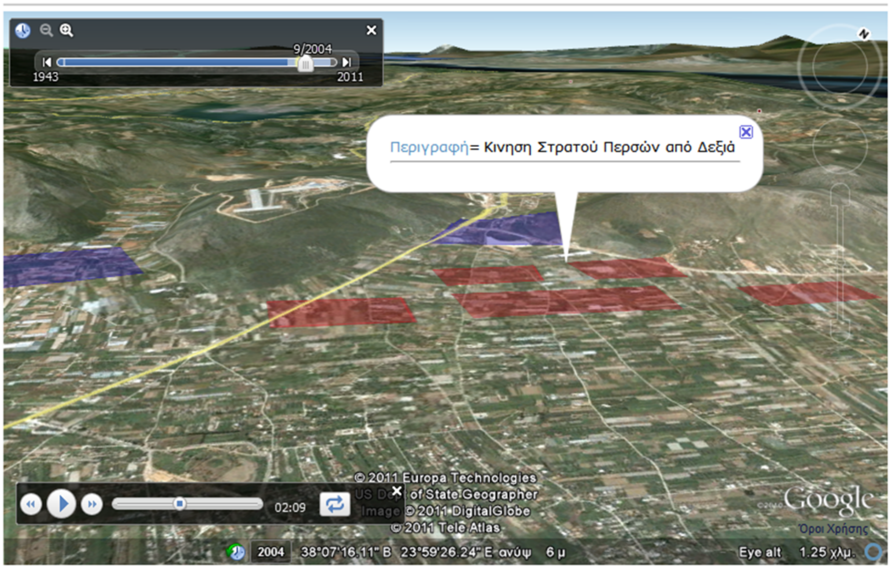

FIGURE 1.9
Visualization of the scenario of the battle of Marathon

Bibliography

[1] D. Arijon. *Grammar of the film language.* Silman-James Press, 1991.

[2] M. Berman. Modeling and Visualizing Historical GIS Data. In *Spatio-Temporal Workshop*, 2009.

[3] M. Bertini, A. Del Bimbo, C. Torniai, C. Grana, and R. Cucchiara. Dynamic pictorial ontologies for video digital libraries annotation. In *Workshop on multimedia information retrieval on The many faces of multimedia semantics*, MS '07, pages 47–56, New York, NY, USA, 2007. ACM.

[4] B. Braverman. *Video Shooter: Storytelling With DV, HD, And HDV Cameras.* DV Expert Series. Taylor & Francis Group, 2005.

[5] S. Christodoulakis, M. Foukarakis, L. Ragia, H. Uchiyama, and T. Imai. Semantic maps and mobile context capturing for picture content visualization and management of picture databases. In *Proceedings of the* 7^{th} *International Conference on Mobile and Ubiquitous Multimedia*, MUM '08, pages 130–136, New York, NY, USA, 2008. ACM.

[6] S. Christodoulakis, M. Foukarakis, L. Ragia, H. Uchiyama, and T. Imai. Picture Context Capturing for Mobile Databases. *MultiMedia, IEEE*, 17(2):34 –41, April-June 2010.

[7] C. Colombo, A. Del Bimbo, and P. Pala. Semantics in Visual Information Retrieval. *IEEE MultiMedia*, 6(3):38–53, 1999.

[8] P. Compieta, S. Di Martino, M. Bertolotto, F. Ferrucci, and T. Kechadi. Exploratory spatio-temporal data mining and visualization. *Journal of Visual Languages & Computing*, 18(3):255 – 279, 2007. Visual Languages and Techniques for Human-GIS Interaction.

[9] S. Drucker, T. Galyean, and D. Zeltzer. Cinema: a system for procedural camera movements. In *Proceedings of the 1992 symposium on Interactive 3D graphics*, I3D '92, pages 67–70, New York, NY, USA, 1992. ACM.

[10] O. Etzion. Event Processing - past, present and future. In *Proceedings of VLDB*, volume 3, pages 1651–1652, 2010.

[11] T. A. Galyean. Narrative Guidance. In *Proceedings of the AAAI Spring Symposium Series, Symposium on Interactive Story Systems: Plot and Character*, pages 52–55. Stanford University, 1995.

[12] M.. Gleicher, R.. Heck, and M. Wallick. A framework for virtual videography. In *Proceedings of the 2nd international symposium on Smart graphics*, SMARTGRAPH '02, pages 9–16, New York, NY, USA, 2002. ACM.

[13] J. Horkoff, A. Borgida, J. Mylopoulos, D. Barone, L. Jiang, E. Yu, and D. Amyot. Making data meaningful: The business intelligence model and its formal semantics in description logics. In Robert Meersman, Herve Panetto, Tharam Dillon, Stefanie Rinderle-Ma, Peter Dadam, Xiaofang Zhou, Siani Pearson, Alois Ferscha, Sonia Bergamaschi, and IsabelF. Cruz, editors, *On the Move to Meaningful Internet Systems: OTM 2012*, volume 7566 of *Lecture Notes in Computer Science*, pages 700–717. Springer Berlin Heidelberg, 2012.

[14] S. Hubbard and K. Hornsby. Modeling Alternative Sequences of Events in Dynamic Geographic Domains. *Transactions in GIS*, 15:557–575, 2011.

[15] Z. Johnson. SpatialKey: Insanely good geovisualization, year=2008, url=http://indiemaps.com/blog/2008/08/spatialkey-insanely-good-geovisualization/.

[16] Z. Johnson, M. Harrower, E. McGlynn, R. Roth, D. Sickle, and A. Woodruff. Development of an online visualization tool for the mapping and analysis of asthma exacerbations in space and time. In *Proceedings of the NACIS 2007. St. Louis, MO.*, 2007.

[17] V. Kantere, I. Kiringa, and J. Mylopoulos. Supporting Distributed Event-Condition-Action Rules in a Multidatabase Environment. *World scientific*, 16(3):467–506, 2007.

[18] S.D. Katz. *Film Directing Shot by Shot: Visualizing from Concept to Screen*. Michael Wiese Productions Series. Wiese, 1991.

[19] S. Kisilevich, D.A. Keim, N. Andrienko, and G. Andrienko. Towards acquisition of semantics of places and events by multi-perspective analysis of geotagged photo collections. In Antoni Moore and Igor Drecki, editors, *Geospatial Visualisation*, Lecture Notes in Geoinformation and Cartography, pages 211–233. Springer Berlin Heidelberg, 2013.

[20] C. Liu. *SmallTalk, Objects, and Design*, chapter 11, pages 115–126. iUniverse, 2000.

[21] D. Luckham. *The Power of Events: An Introduction to Complex Event Processing in Distributed Enterprise Systems*. Addison Wesley, 2002.

[22] J.V. Mascelli. *The five C's of cinematography: motion picture filming techniques*. Silman-James Press, 1998.

[23] A. Michlmayr, F. Rosenberg, P. Leitner, and S. Dustdar. Advanced event processing and notifications in service runtime environments. In *Proceedings of the second international conference on Distributed event-based systems*, DEBS '08, pages 115–125, New York, NY, USA, 2008. ACM.

[24] N.Andrienko, G. Andrienko, and P. Gatalsky. Exploratory spatio-temporal visualization: an analytical review. *Journal of Visual Languages and Computing*, 14(6):503 – 541, 2003.

[25] Open Geospatial Consortium (OGC). OpenGIS KML Encoding Standard (OGC KML), url=http://www.opengeospatial.org/standards/kml/.

[26] Open Geospatial Consortium (OGC). Web Map Service, url=http://www.opengeospatial.org/standards/wms/.

[27] A. Panteli, C. Tsinaraki, L. Ragia, F. Kazasis, and S. Christodoulakis. MObile Multimedia Event Capturing and Visualization (MOME). In *Proceedings of FTRA Conference Multimedia and Ubiquitous Engineering (MUE 2011)*, pages 101–106, 2011.

[28] S. Papadopoulos, C.s Zigkolis, S. Kapiris, Y. Kompatsiaris, and A. Vakali. City exploration by use of spatio-temporal analysis and clustering of user contributed photos. In *Proceedings of the 1st ACM International Conference on Multimedia Retrieval*, ICMR '11, pages 65:1–65:2, New York, NY, USA, 2011. ACM.

[29] F. Pereira. The MPEG-21 Standard: Why an Open Multimedia Framework? In D. Shepherd, J. Finney, L. Mathy, and N. Race, editors, *Interactive Distributed Multimedia Systems*, volume 2158 of *Lecture Notes in Computer Science*, pages 219–220. Springer Berlin Heidelberg, 2001.

[30] A. Rosenthal. *Writing, Directing, and Producing Documentary Film.* Southern Illinois University Press, 2007.

[31] R. Roth and K. Ross. Extending the Google Maps API for Event Animation Mashups. *Cartographic Perspectives*, 64:21–40, 2009.

[32] R. Roth, K. Ross, B. Finch, W. Luo, and A. MacEachren. A user-centered approach for designing and developing spatiotemporal crime analysis tools. In *Proceedings of GIScience*, 2010.

[33] P. Salembier and J.R. Smith. MPEG-7 multimedia description schemes. *Circuits and Systems for Video Technology, IEEE Transactions on*, 11(6):748 –759, jun 2001.

[34] M.A. Schreibman. *The Indie Producers Handbook: Creative Producing from A to Z.* Crown Publishing Group, 2012.

[35] Becker T. Visualizing time series data using web map service time dimension and svg interactive animation. master thesis, International Institute for Geo-Information Science and Earth Observation (ITC), February 2009.

[36] N. Tarantilis, C. Tsinaraki, F. Kazasis, N. Gioldasis, and S. Christodoulakis. Evisuge: Event visualization on google earth. In *Semantic Media Adaptation and Personalization (SMAP), 2011 Sixth International Workshop on*, pages 68–73, dec. 2011.

[37] S. Thakur and A. Hanson. A 3D Visualization of Multiple Time Series on Maps. In *2010 14th International Conference Information Visualisation*, pages 336–343, Los Alamitos, CA, USA, 2010. IEEE Computer Society.

[38] C. Tsinaraki and S. Christodoulakis. *The Handbook of MPEG applications: Standards in Practice*, chapter Domain Knowledge Representation in Semantic MPEG-7 Descriptions, pages 293–316. Wiley Publishers, 2010.

[39] C. Tsinaraki, P. Polydoros, and S. Christodoulakis. Interoperability Support between MPEG-7/21 and OWL in DS-MIRF. *Knowledge and Data Engineering, IEEE Transactions on*, 19(2):219 –232, feb. 2007.

[40] World-Wide Web Consortium (W3C). Scalable Vector Graphics (SVG) Full 1.2 Specification, url=http://www.w3.org/TR/SVG12/.

[41] Wikipedia. Animated mapping, url=http://en.wikipedia.org/wiki/Animated_mapping. Wikipedia, The Free Encyclopedia.

[42] Wikipedia. Geographic Information System, url=http://en.wikipedia.org/wiki/Geographic_information_system. Wikipedia, The Free Encyclopedia.

[43] Wikipedia. Geovisualization, url=http://en.wikipedia.org/wiki/Geovisualization. Wikipedia, The Free Encyclopedia.

[44] Wikipedia. Historical Geographic Information System, url=http://en.wikipedia.org/wiki/Historical_geographic_information_system. Wikipedia, The Free Encyclopedia.

Index