A Participatory Virtual Studio for Environmental Planning

Yibin Zhao[1,3], Hui Lin[1,3] Haoruo Yi[2] and David Chen[3]

[1]Joint Lab for GeoInformation Science (JLGIS), Chinese University of Hong Kong, Shatin, N.T., Hong Kong, P.R. China.
[2]Chinese Academy of Forestry Science, Beijing, P.R. China
[3]Deparement of Geography and Resource Management, Chinese University of Hong Kong
Shatin, N.T., Hong Kong, P.R. China.

Abstract

Public participation is a progress of "consensus building" about particular decision-making. Because of some intrinsic blemish, traditional public participation method always diminishes the range of public involvement. Rapidly growth of the Internet makes it one of the most massing accessed public media. Internet has an additional interactive mechanism rather than traditional public medias. Meanwhile Web GIS has developed into a mature Internet mapping and spatial analysis toolkit. Internet together with Web GIS launch a channel to get mass participation in a spatial referenced decision-making. This paper explores the use of Web GIS and other technologies to overcome the interactive information access barriers to secure a participatory process in the environmental planning. A Web GIS based Virtual Studio system is developed to demonstrate the concept. Keywords: Geographic Information System, virtual studio, participatory planning

I. BACKGROUND AND RELATED WORKS

Public participation is a progress of "involving people in particular decisions, problems, project, or progress" to get 'consensus building'. Traditional public participation approach is a classic paternalistic approach. In traditional paternalistic mode, the government invites some people to participate in a process on terms defined by the government in accordance with government needs. Another approach that is always used by the government is that government compiles some brochures about the incoming or ongoing projects, decisions, or processes, and dispatches these brochures in public place. In some respects, public participation should consider as many people as possible affected by the decisions. The rise of the Internet over the past decade has created many opportunities for its use in a variety of fields [5, 6, 7, 8, 12]. One area where the Internet can be used to great advantage is for the enhancement of participatory democracy in environmental decision-making, or what is called public participation in environmental decision-making.

Some researches that take advantage of the mass access of the Internet have been conducted in urban planning and community planning [2, 5, 6, 8]. Most of these applications can only fulfill part of the public participation work, and they are text-based comments or feed back collection tools on the Internet or just online survey system and rather few can serve well in spatial referenced environment decision-making problem. Seldom of these applications provide interactive mechanisms that make the participants feel that they are participating in a decision-making process and are making their view voiced.

One of the generally accepted definitions of geographical information system (GIS) is that it is an advanced computer toolbox for input, storage, editing, manipulation, analysis, visualization and output of spatial data. GIS technology has progressed rapidly during the past decades; the focus of most researches and development activities has been placed on the development of single-user systems. However, demands from group based environmental decision-making require the distribution of both GIS data and application, especially when "semi-structured public policy issues are addressed" [1]. This brings the rapid growth of distributed geographic information (DGI) service [9]. With the advance of DGI service, GIS services have begun to appear on the Web ranging from simple digital map demonstrations and references to GIS use, through to more complex online GIS and spatial decision support systems, thus GIS is no more a computer system only, it is undergoing a digital transition with a shift in emphasis from processing to communication, from system to service. There is also a growing Web GIS industry as well; with many GIS vendors and third-party companies developing software that enables the widespread distribution and retrieval of geographic information via the Internet [10]. The mass accessibility nature of Web GIS will also contribute to the study presented in this paper.

Web based multi-criteria evaluation (MCE) integrated with GIS have proved functional in capturing general public's preference of particular spatial problem among alternative choices [13]. But there are few studies available to evaluate the benefits of integration of Web GIS and environmental models to the environmental decision-making. This paper present a research conducted in Hong Kong which intended to investigate the potential of enhancing the reliability of a spatial referenced environmental decision-making by enabling public participation with a Virtual Studio on the Internet. Professionals

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together with the general public and the planners may virtually participate in a decision-making process in this Virtual Studio over the Internet. Forest fire behavior simulation is selected as an essential factor in the planning of this case study. Mopanshan Mountain, Sichuan, China is selected as study area in the study, moreover most test data and the fire behavior model parameters are made available in virtue of some early study done by Chinese Academy of Forestry at Beijing, China.

II. METHODOLOGIES

Capturing users' requirements

Expected end users of this Virtual Studio system fall into three categories: the planners, the related domain experts and the general public. Based on the analysis of the requirements from both the general public and the planners, some features are identified as essential for an online participatory decision-making supporting system.

- First of all, this system shall provide relevant textual description about the project/planning;
- Functional tools are needed to help the general public to understand and learn the spatial referenced background database;
- Since that a complex phenomenon wildfire in the forest is selected as a key factor in this case study, there should be some user friendly interfaces to help end users to perform a wildfire spreading simulation;
- User comments mechanism must be set up to collect users' suggestion and comments towards different aspects about the project/problem;
- Lastly, this system will be an online system that can be accessed via Internet that can benefit from the mass accessibility of the Internet.

Multi-tiered system architecture

Multi-tiered system architecture is designed to demonstrate concept of a Virtual Studio. There are altogether 3 tiers within this system: client side user interface, Web server platform, and a GIS workbench (Web GIS with application model) as illustrated in Figure 1.

In this Virtual Studio, client tier indicates the front interfaces designed to aid the end users to conduct their operations. Functionalities of these graphical user interfaces should include project background and study area information description (textual), study area digital map browsing tools, fire simulation runtime parameters initializing tools, forest fire simulation result map display, as well as user comments submitting tools (textual and graphical).

The Web server will deal with the communications between the client side and the GIS workbench. GIS workbench encloses the fire behavior simulation module and a Web GIS. The GIS workbench will handle the map operations, fire spreading behavior simulation and maintenance of a spatial database.

About wildfire behavior model

According the study of Countryman and Rothermel, fire behavior is a product of the environment in which the fire is burning. Countryman presented the concept of the fire environment-the surrounding conditions, influences and modifying force that determine the behavior of a fire (see Figure 2). Topography, fuel, weather, and the fire itself are the interacting influences that make up the fire environment. This is illustrated as a fire environment triangle with the fire in the center.

The changing states of each of the environmental components-fuel, topography, and weather – and their interaction with each other and with the fire itself determine the characters and behavior of the fire at any given moment. Changes in fire behavior in space and time occur in relation to changes in the environmental components. From a wildland fire standpoint, topography does not vary with time, but in space. The fuel component varies in both space and time. Weather is the variable component, changing rapidly in both space and time.

Fire behavior index includes the rates of spreading (ROS), fire intensity, ect. These indeicators are the basic of the wildfire behavior simulation, the fire fighting and the fire lost estimation. Wildfire behaviors have been proven a very complex progress. The best-known model in forest fire spread is Rothermel's ROS model [11]. It allows the forecast of the ROS and the reaction intensity knowing certain properties of the fuel matrix and environmental conditions in which the fire will occur.

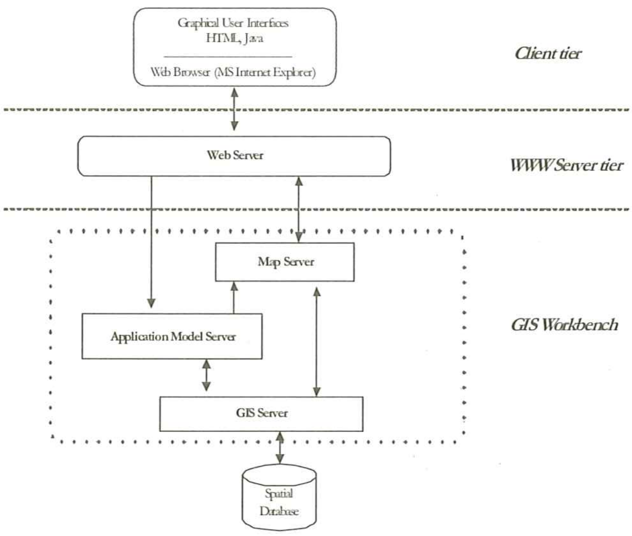

Figure 1. Multi-tier architecture of the virtual studio

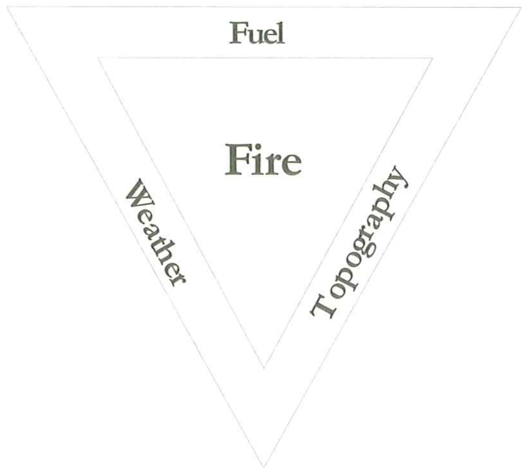

Figure 2. The fire environment triangle illustrates the influencing forces on fire behavior: fuel, weather, and topography. The fire in the center signifies that the fire itself can influence the fire environment. Based on Countryman [4]

RS = f (fuel_particle, fuel_array_arrangement, wind, fuel_moisture)

or

$$R = A \times K_f \times K_{mt} \times K_g \times K_w$$

and

A is an empirical parameter, a combination invariable that decided only by the fire environment;
K_f is a value that decided by fuel bed;
K_{mt} is a value that decided by the weather (air temperature and air humidity);
K_g is a value that decided by the configuration of topography;
K_w is a value that decided by the wind;

Since that the fire behavior model itself is not the main concern of this study, Rothermel's model is simplified for this case based on the following assumptions:

- Rothermel's model [11] is representative of the fire's speed of propagation.
- Small-scale winds like slop winds that caused by local temperature difference are ignored in this case.
- Vegetation is homogeneous within each cell.
- Since data of configuration of each fuel particle is not available in this case, effect of fuel particle on fire behavior is brought into fire spread formula as a constant that got from laboratory experiment data. This constant is fit only for data set in this experiment area.

An integrated solution

A wildfire behavior simulation model is developed with Java language based on Rothermel's fire behavior model [11]. Since the main purpose of this study is to demonstrate the concept of how to enhance the public participation in environmental decision-making with GIS and IT technologies, and forest fire simulation in ecological planning just act as a pilot study for this research; consequently, this study would not concern on the accuracy of the fire spreading simulation. So Rothermel's fire spread model is simplified when encoding with Java language.

Virtual Reality Modeling Language (VRML) is used to construct a three-dimensional (3D) digital elevation model (DEM) of the study area. A Java class (the Wildfire growth model) embedded web page will handle the fire simulation runtime parameters initialization and wildfire behavior simulation presenting. The last part of the client side user interface is a user comments submitting form.

And then the Java fire behavior simulation model is enclosed with a Web GIS and run on a dual CPU computer. The Web GIS here chosen is ESRI™ ArcIMS®3.0. Microsoft™ Internet Information Server (IIS) running on a Microsoft™ Windows NT Server is selected to handle the communications between the server and the clients. IIS embeds response result into a Hyper Text Markup Language (HTML) page and then sends the page to the client side via Internet. The HTML viewer of ArcIMS is customized with HTML and JavaScript to build client side interfaces.

III. MODELING THE FIRE BEHAVIOR IN ENVIRONMENTAL PLANNING

Forest fire is identified very important to the forest. Both wildfires and controlled burning significantly affect forest management activities from timber harvest scheduling to reforestation and thinning operations. Wildfire is considered a risk factor to ecological security [14]; meanwhile controlled burning can reduce the wildfire risk in the forest. Therefore, forest fire disaster should be taken as an essential factor for forest management as well as the planning in the forest. Consequently the wildfire behavior predication becomes significant for all the planning related to forest. Common scenarios would be, for example, where to sit a fire watchtower or a fireplug in the country park.

Wildfire can be seen as a factor that interacts with its environment [4]. Such background information as fuel bed property, configuration of topography, among the fire environment can be represented into GIS layers; while weather data will act as runtime environment to the simulation system as runtime environment parameters. Based on many computer based wildfire behavior research [3, 10, 11], a typical wildfire behavior simulation system can be demonstrated with the following figure (Figure 3).

Inputs of a typical forest fire simulation system include fuel bed description data (fuel type and its configuration), topography configuration and weather data, what is called fire environment in Countryman's fire triangle [4]. Outcomes of the simulation include rate of spread (ROS), direction of

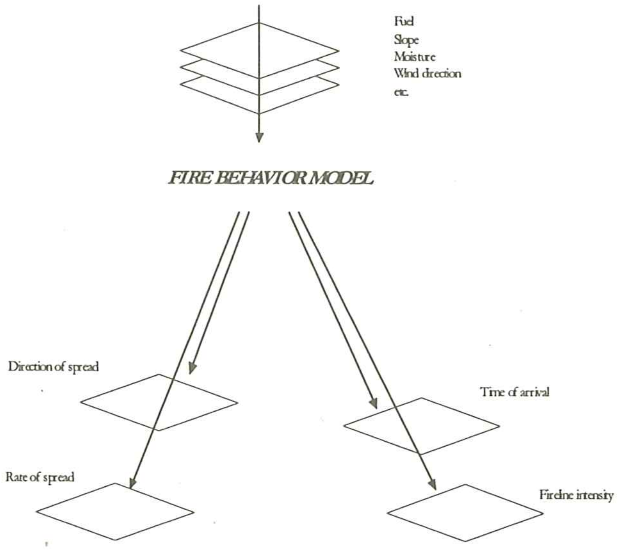

Figure 3. A typical wildfire behavior simulation system

maximum spreading speed and intensity of fire line. These environmental variables are presented as GIS data layers if modeling the fire behavior with GIS and outputs of the system are presented as parameters or GIS layers. Figure 4 illustrates the concept of modeling fire behavior with GIS.

In this study, Web GIS is employed to model fire behavior in the Web manner. Both environmental data layers and GIS module are located on the server side as a component of the Virtual Studio.

IV. PARTICIPATING IN THE PLANNING WITH THE VIRTUAL STUDIO

The goal of this study is to investigate the potential of enhance reliability of the environmental decision-making by enabling public participation with a Virtual Studio on the Internet. With this Virtual Studio, professionals together with the general public and the planners may virtually participate in the decision-making process with this Virtual Studio over the Internet. A set of integrated toolbox, composed by background information description web pages (in both spatial and non spatial ways), wildfire simulation scenario defining panel, users feedback collecting toolboxes, and user discussion bulletin board, has been developed in the Virtual Studio to aid the users in the decision making process. The following is a detailed description of each of these tools.

Background information browsing module

Figure 5 and Figure 6 are snapshots of user toolkits. All these tools can be accessed with Microsoft Internet Explorer from Internet. A web page containing descriptive information about the project will be put at the first page of the web site. Users can get a general image about the project, for example objectives, significance of the project and methodologies used in the planning. Tools shown in Figure 5 help users to browse 2D and 3D digital maps of the study area. Figure 6 illustrates some tools that empower end users to browse spatially referenced database about the study area, such as digital maps and geographically referenced tabulate data. Tools shown in Figure 6 aid users to perform some basic spatial analysis such as buffering, feature searching and spatial query. These tools have user-friendly interfaces that are marked with either words or icons. These words or icons marked on the tools make these tools so understandable that even the general public users can know the function of the tool easily.

Wildfire spreading simulation

Once the users get general information about the study area and some issues of the problem/project, end user may specify the runtime parameters and carry out a wildfire simulation in the virtual studio with the following tools shown in Figure 7 and wildfire simulation result will be sent back to the end user and displayed as thematic map as shown in Figure 8.

Comments representation

Feedback of public participation may appear in various forms: letters, comments at meetings, and responses to questionnaires, etc. For a spatial referenced environmental project, there may be one more kind of result: draft plan map. Therefore, besides an online guest books to serve for textual comments and suggestion (Figure 9), this Virtual Studio contains a graphical comments submitting panel, as shown in Figure 10. A set of tools on this panel enable users overlay related database stored in their local computer. With the graphical comments submitting panel, three types of graphics may be drawn and submitted by the end user: point, line and polygon. These

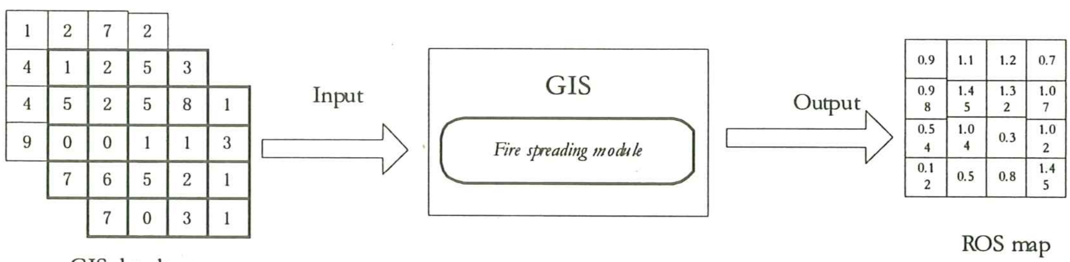

Figure 4. Modeling fire behavior with GIS

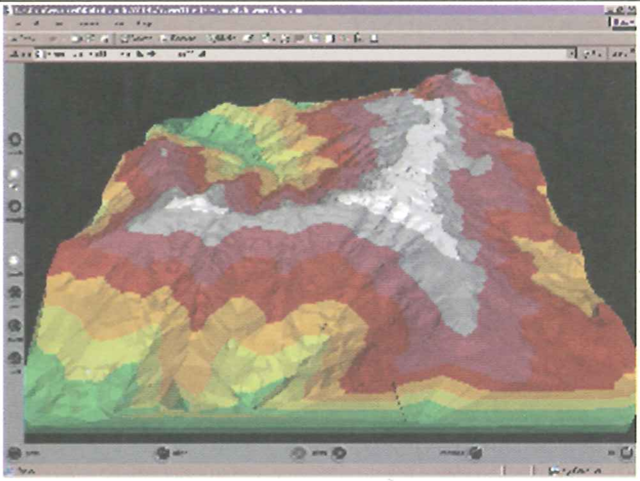

Figure 5. 3D environment map browsing tools

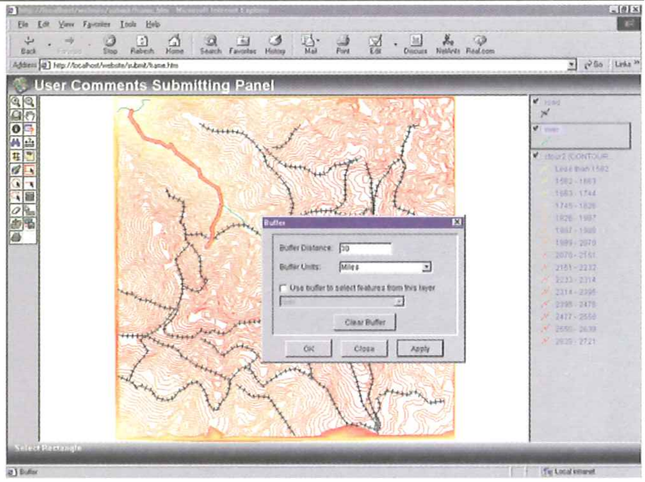

Figure 6. GIS toolkit

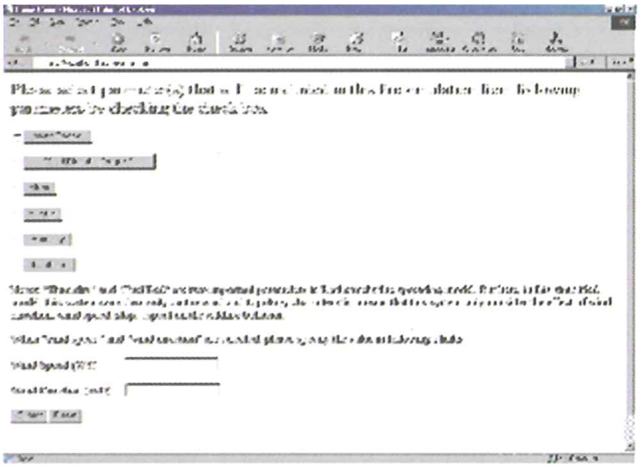

Figure 7. Forest fire simulation runtime environment parameters initializing page.

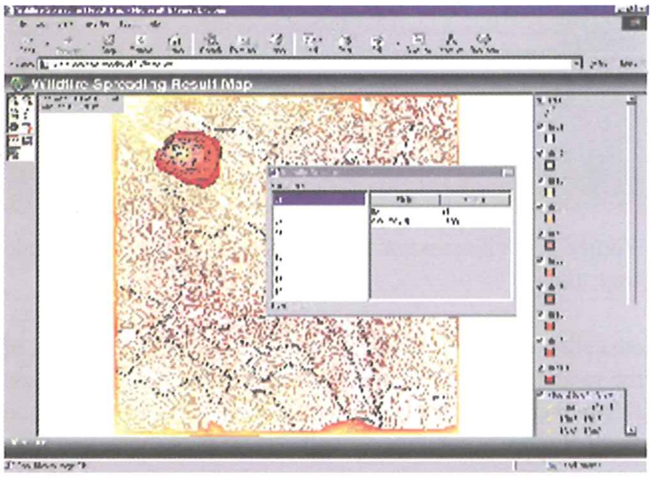

Figure 8. Forest fire simulation result map displaying and feature query

graphical comments are then coded with Extensible Markup Language (XML) and transferred to the server side. The planner and server as reference in draft plan revising will collect these comments.

This panel is what this virtual studio differ from other public participation system. It enables the general publics represent their ideas with the free-hand-drawing just like what they did on the white board in the public meeting in the tradition at public participation manner. To each user, he or she may think that he/she is revising the draft plan from the planners and is making his/her view known.

Administrative issues of the virtual studio system

All graphical comments from the related domain experts and the general public are stored in a database on the server side. These graphical feathers can be reviewed by the planners on the server side and act as references together with the textual comments on the online Guest book. One of the important usages of these submissions is that they serve as reference when the planners begin to revise the draft plan.

V. CONCLUSIONS AND DISCUSSIONS

This Virtual Studio launches a channel for the decision-making bodies to collect diverse viewpoints about how to improve the quality and acceptability of the plans. For example, problems like where to place a fireplug or wild land fire watchtower in a country park. Secondly, with a few modification works on the spatial database and the project description page, the textual/graphical user comments submitting tools and the online discussion bulletin board are capable of carrying out the job of feedback collection about proposed planning. At the same time, by joining in and leading an efficient and fair discussion, planners can determine the public's grassroots feeling about a proposed project. The third potential application of this Virtual Studio is in the area of education or scientific research. Although the fire models (ROS model and fire spreading model) chosen in this Virtual Studio project are simplified, they are adequate for use in general education. With the inclusion of additional data and the development of more complex models, the use of this Virtual Studio can be extended into the professional arena. A predictable obstacle lying on the way of deploys this kind of virtual studio system to the

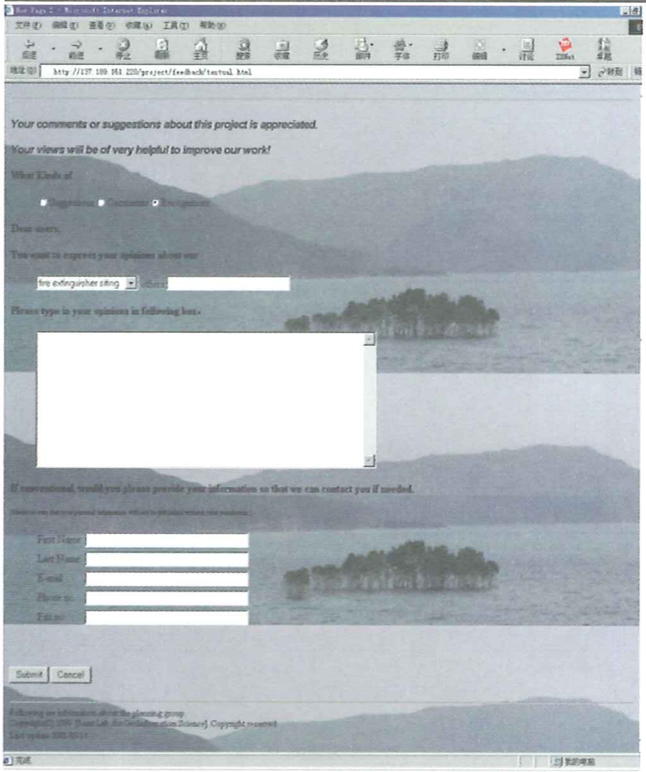

Figure 9. Online textual user comments/suggestions submitting tools

education or scientific research is the accuracy requirement of the model, for instance the fire behavior model in this case. Regarding the behavior/progress model in environmental study, a more accurate model always leads to more computation power requirement, and in an Internet environment this also means more Internet traffic. Future researchers in this field may find their way by deploying multi-agent approach to this enhance its capability of computation and system interaction.

So far this study involved the use of fixed data set (fuel type, DEM, etc) for wildfire simulation, however it is expected that this virtual studio can be used to estimate the impact of different fuel bed (tree types) to the fire behavior, and this estimation will act as guidelines for the development of this forest. If we switch the emphasis to other model in Ecology, such models as minimum cumulative resistance (MCR) model can be added as a module into this virtual studio.

Since this developed virtual studio system is still a prototype level system, there must be room that can be improved in the future. Firstly, according to this study, it does not intend to get very accurate fire behavior simulation result, so the fire behavior model used here is an approximately, simplified Rothermel model. Secondly, this is a heavy server/light client diagram run on PC, it can't handle everything well if there are too many user requests simultaneously, and following version of this system will be a mature one with a balanced architecture.

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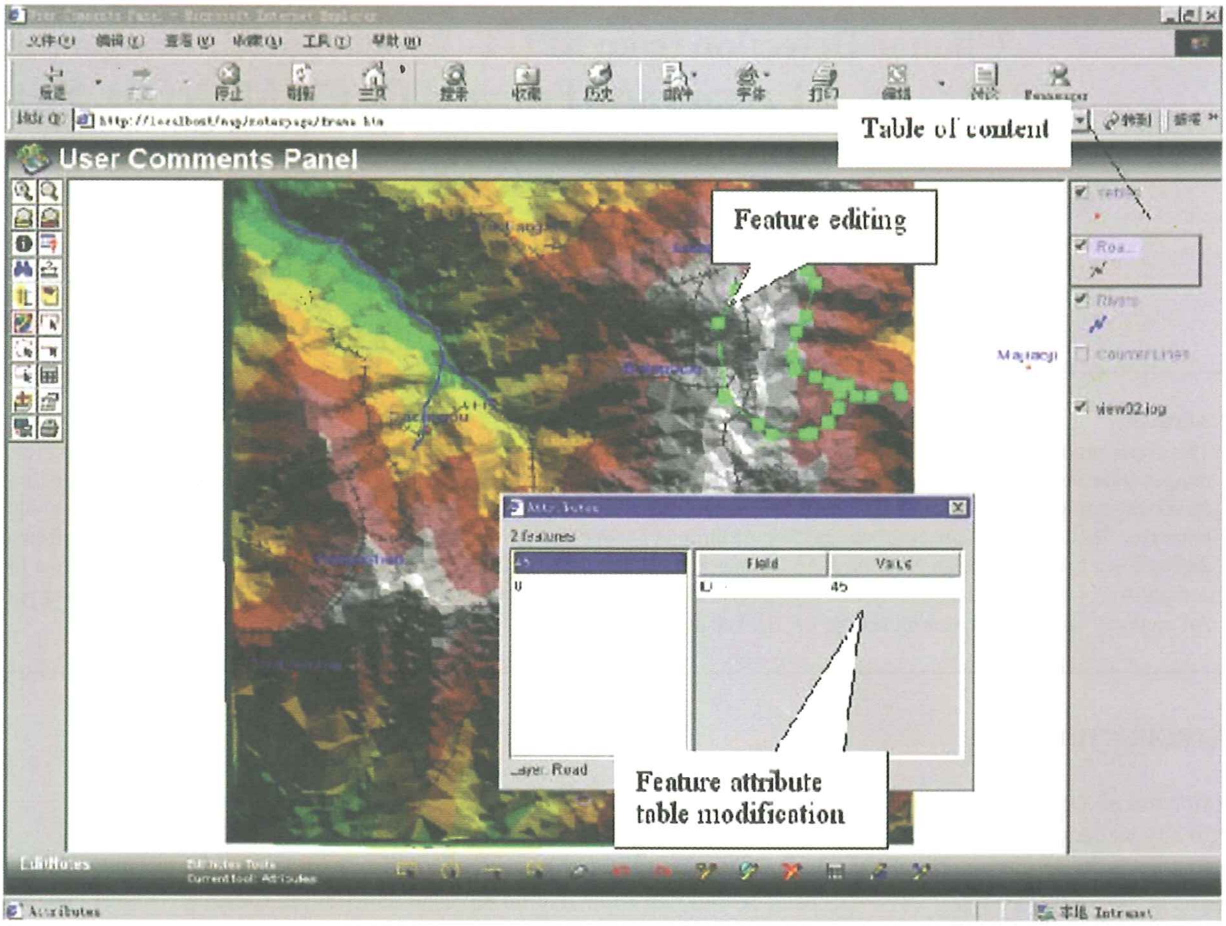

Figure 10. Graphical user comments submitting tools