A Web-Based Public Participation System that Supports Decision Making

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Abstract

Public participation in making decisions regarding urban development projects is very important. In Japan, local governments must develop policies concerning area management based on discussions with local citizens rather than depending on the central government. Therefore, workshops with stakeholders have been conducted to discuss issues relating to urban projects, where visual tools, as well as the Internet - in a few cases - were used as a tool for collecting opinions. However there is a need to build an advanced Decision Support System (DSS) that facilitates a participative design process and expands stakeholder participation.

A web-based public participation system is introduced via this case study. Stakeholders utilize a developed system to visualize proposal alternatives, using virtual reality to provide their opinions, and then to share collected information and results. The proposed DSS aims to enhance the decision making processes by encouraging citizen involvement and participation during the project's developmental stages. The evaluation reveals that using effective visual and opinion collecting tools can motivate effective citizen participation while giving transparency and legitimacy to the decision making process. Utilizing the proposed DSS at workshops in conjunction with the Internet makes the collected opinions more reliable.

Keywords: Decision Support System; public participation; virtual reality; urban development

1. Introduction

The concept of the Decision Support System (DSS) is a broad one. The DSS is a decision aid that is used in all areas of scientific analysis and investigation (Ayeni B., 1997). Thus, its definition depends on the author's point of view. It is also known in literature as a computer system able to assist decision makers by analyzing issues and proposing solutions (Laurini R., 2001). Information systems are designed to interactively support all phases of users' decision-making processes (Mora M., Forgionne G., and Gupta J., 2003). In urban planning, the DSS has an important role, especially these days. In the past, the role of computer models and other tools was to allow planners — the technical experts — to better understand and visualize the urban development process, as well as to forecast the future more easily and accurately, with little or no need of public involvement. This concept is called "planning for the public". Lately, the dominant urban planning paradigm has changed. Urban planning is developing towards new modes that involve the participation of all stakeholders in all of the planning processes. This concept is called "planning with the public" (Braill R. and Klosterman R., 2003). Planners do not necessarily have all the knowledge and the ability to perform planning tasks alone. They should interact more with the public for whom the plan is being made (Ayeni B., 1997). The stakeholders, including decision makers and citizens — who are participating in reviewing past and present situations, discussing problems, challenges and opportunities — evaluate future image options to make the best decision which they all can support. So, DSS needs to be developed to utilize the new paradigm.

In Japan, it is very important to use the concept of "planning with the public" in the decision making process. There are many workshops that are held in each urban development project where citizens are engaged in the planning process. Several themes are discussed in these workshops such as present problems, project objectives, citizens' needs, and the future image of the area. However, planners face some difficulties in these workshops. One difficulty includes delivering the ideas to citizens in order to visualize the proposed alternatives. In turn, the developers and the local government have turned towards using spatial multimedia including text, photography, 3D computer graphics, animation, and – in a few cases – Virtual Reality to solve visualization problems in the workshops. Also, planners have noticed that the number of attendees in workshops is very low, and many of them are elderly people. So, the Internet...
has been used as a communication tool in a few projects along with the workshops to widen public involvement and increase participation.

2. Objectives and Methodology

The proposed study aims to:
- Effectively integrate the visualization processes – Virtual Reality "VR", 3D Animation – and the opinion collecting process to be conducted through the same interactive environment.
- Develop a DSS that supports expanding public participation, and shares information between stakeholders via this system.
- Encourage citizens to interact with decision makers by using effective visualization tools. This gives the collected opinions higher quality and makes them more effective.
- Facilitate an advanced tool to collect citizens' opinions, and share both the information collected and their results. This grants the final decisions more transparency and legitimacy.
- Evaluate the feasibility of the proposed system.

To achieve the above objectives, a prototype computer system was developed through a case study. This system was then evaluated by users.

3. Related Studies

There are various studies on the usage of virtual reality as a visualization tool, and the Internet as a communication tool for public participation in urban planning. Among these studies it is pertinent to refer to the following:

For example, Online Participation: the Woodberry Down Experiment (Smith A., et al., 2002). This is a study that uses online participation systems and the case study in the Woodberry Down regeneration project. The virtual reality in this project was built using VRML, and the collecting of opinions was conducted through a discussion forum on the website.

Shen Z., et al. (2002), introduced a study on the development of an on-line design collaboration system for public participation — a case study — in planning and designing public parks. It is an online public participation system based on VRML for designing public parks in Japan. The participation system included a make your own design feature in the game system by allowing users to insert park furniture in the design and then saving the design.

Moon T., (2004), introduced an on-line participation system applied to a railroad removal project in Jinju City, Korea. The collection of local information from users was done by an online questionnaire. The last stage entailed the assessment of alternatives by using VRML.

In the previous studies, the visualization in the VR environment was separated from the process of collecting opinions. The proposed DSS has unique features by adding functions to the VR environment by inserting the opinions directly, which facilitates more efficiency and saves users time and effort. As in the proposed DSS, each group of collected opinions is linked to their place by a "Cube" mark in the 3D interactive environment "Marker system". So, the VR environment is used to collect citizens' opinions and link them to their place in the proposal. Also, 3D animation is used to show video clips about the project inside the VR environment. A Poll system was also developed to better understand citizens' opinions concerning specific points that were reported by the planners, and then to share the results of this poll graphically.

4. DSS and VR – More than Just Visualization –

For years, visualization in urban planning was essentially performed through the delivering of an idea to the decision makers, whether in the form of paper maps, digital drawings, or 3D Animation. However lately, VR techniques are being developed and have a greater potential in the urban development field. They provide media in which we are able to encode both the existing condition and future image. They provide immediacy, accuracy, and clarity of the demonstration, which enables us to understand and disseminate this understanding in ways that are very different from those we traditionally used (Smith A., et al., 2002). In the proposed system, visualization using VR is not used as output visualization only, but also as an input visual interface, in order to insert and share citizens’ opinions, and to make the link between these opinions and their places in the virtual reality environment (Fig.1.).

Fig.1. Visualization Role in the Proposed System (Laurini R., 2001)

To design a DSS that solves visualization and expands public participation problems, we should understand the relationship between the parties that interact through the planning process. Laurini R. (2001) introduced the relationship between three parties: Decision makers, Territory they have to develop, and DSS. In this study, the Laurini diagram has been used, but a fourth party has been added. This party is Citizens. In the Diagram, citizens have been divided into two groups: citizens who interact directly with decision makers through workshops, and distant citizens who interact with decision makers through DSS (Fig.2.).

In this relationship, decision makers survey the territory to better understand its problems and then input their queries in a DSS to simulate the data. This allows decision makers and citizens to see how the territory evolves relating to their ideas through the workshops.
To expand citizens' roles in decision-making, DSS can be introduced via the Internet. So, more citizens can imagine the proposed idea from the DSS, and then participate with their opinions. Finally, after evaluating information received from the DSS, and after the simulated evolution looks satisfactory for the stakeholders, the final plan is most likely to be realized.

5. The Prototype Computer System

To conduct the prototype system, the authors selected a case study exemplified at Kyushu University, Japan. New Campus Planning Office (NCPO) members were selected as the decision makers. After discussions, the Plaza Urban Development Project, a part of Kyushu University's new "Ito Campus" project was selected.

After discussions with NCPO members, the authors carried out the following steps:
- Had discussions with the users (Kyushu University Students) about the plaza and its practiced activities.
- Had NCPO members introduce the project digital data (master plan, elevations…etc) to the planners.
- Developed a new comprehensive proposal by having planners survey the targeted area to collect data (panoramas, photos…etc).
- Created a website to introduce information about the project and to be used as a communication tool. The website included a chat room and a contact e-mail address to expand participation via the Internet along with the workshops.
- After discussions, introduced a 3D computer graphic as the original and proposed a model for the target area (Fig.3.).

5.1 Building the VR Environment

The software used to build the VR environment was Virtools Dev V.3. The plaza 3D model was exported to Virtools Dev, and the next steps were followed:

- Adjust the scene's lighting and materials for each component through the material editor.
- Add a character called Eva from the software library, and then add a human movement script to it, such as walking and running.
- Add three cameras to the scene: Beside Eva view (C1), Eva's eye view (C2), Bird's eye view (C3). These give users the ability to walk through the project from several viewpoints. The cameras can be activated by pressing the "A", "S", or "D" keys respectively (Fig.4.).

5.2 Adding Icons and 3D Animation

In this step, icons are added to the right side of the scene. They give users more options to move, remove, add, or re-add any group of elements in the scene. Thus, users can watch the future image alternatives, and at the same time they can find information about the project.

After these icons were added, a movie screen was created inside the VR environment, where users "walking through" the inside of the VR environment can stop beside the virtual movie screen and switch it on to watch a movie clip about the Ito Campus project. The movie screen is distinguished by a blinking ground area in front of it (Fig.5.).

5.3 Collecting Users Opinions via the VR Environment

This step is very important in supporting the technical and theoretical system aims. The Marker and Poll support system uses virtual reality for more than just a visualization tool. It is used as a visual interface to input data.

5.3.1 Marker System:

Marker System was designed so that the user navigating inside the proposed VR environment idea can write and share his opinion; also, he can comment on other people's opinions as follows:

1- By pressing on Look at Community board you will see Marks that previous users have inserted (Fig.6. step 1).
2- Press on Create a new Community Board, and then double click on any element – tree, shade, floor, etc –, and a ”Cube” mark will be inserted automatically on the element that the user selects (Fig.6. step 2). By clicking on this Mark an e-message board will open so the user can insert information, title, comment, and a password (user can go back to change his comment by using his password) (Fig.6. step 3).

3- By double-clicking on any other existing marks, the user can see their e-message board and the previous opinions. The user can insert his comment (Fig.6. step 4).

So that users can participate and share their opinions through the VR environment, the users’ comments are recorded inside text files on the server (each mark has its data file). This feature gives the planners and decision makers the ability to categorize and evaluate the collected opinions.

5.3.2 Poll System

In the Marker system the user has the right to insert any comment. But if there are some specific queries the planners want to introduce to the users, this is what the function of the Poll system is for. Planners post some queries, and then users insert their polls as follows:

1- Users are invited to the poll in the proposal in two ways: by clicking on the Poll here icon, or by clicking on the Poll here object (Fig.7. step 1).

2- By clicking on Poll here, a poll page is opened, and then users submit their selections (Fig.7. step 2).

3- By clicking on show results in the poll page, the results page is opened, allowing users to share results (Fig.7. step 3).
Utilizing these steps the authors have conducted a DSS that facilitates functions - shown in Fig.2.- as follows:
- Creating a simulation, by using VR as a visual interface to input citizens' opinions, as well as creating an intermediate environment to help the decision makers encourage and engage citizens in the planning process.
- Receiving planners' queries and users' opinions. It facilitates the sharing of information, which in turn gives the decisions more transparency and credibility.

5.4 Completing the Website

By conducting the DSS, full data about the project was introduced on its related website. It contains web pages to guide users on how to use the prototype and the steps that they should follow. As an alternative method, a chat room was created in case of the inability to use the Marker system. The website is opened to participants to evaluate the proposed system. The link is "http://media2.arch.kyushu-u.ac.jp/DSS/".

6. The Prototype Computer System Evaluation

The consequent troublesome application of the system may cause the image of DSS to be too difficult for some users. Therefore, in the early stages of developing the DSS it should be applied in simulated research settings, rather than real planning processes, to allow better improvement (Vonk G., et al., 2007). Therefore, urban planning postgraduate researchers and students at Kyushu University were selected to conduct this evaluation. They have two advantages: they are users of the Ito Campus – where the case study is – as well as already having knowledge concerning the decision making process in urban planning. A sample of 20 students and researchers from the urban planning department at Kyushu University were invited to make initial evaluations to prove the study objectives. This evaluation provides initial indicators about the system’s feasibility, its role in expanding participation, and its ability to support the related decision making process. However, in future studies, the prototype can be evaluated more broadly in a real planning process to generalize its results.

Accordingly, participants in the evaluation were invited to use the system. They were invited to access the case study website from their personal computers to use the system, and then fill out the questionnaire (Figs. 8, 9).

6.1 Using the Prototype Results

The participants then navigated the proposal; they spent an average of between two and four minutes walking through the VR environment to understand the proposal outline and then inserted their comments by using the Marker system. The system received 48 comments on a variety of topics. Some of the participants put marks on the plaza ground (Fig.8.) and wrote comments in its e-message board such as "the circles on the ground don't have functional aims", and "the floor color needs to be changed". Also the fountain received some comments in the same way such as "the fountain color is dark, it is not suitable", and "Fountain is ok". Other elements inside the proposal received comments also, but the important point is that the participants could understand the system and the procedure on how to insert comments.

After using the Marker system, participants answered questions in the Poll system. They all could insert their answers and share the results (Fig.10.). In the Poll system 40% of participants evaluated the proposal as a "very good proposal", and the same percentage evaluated it as a "good proposal", whereas only 10% evaluated it as a "bad proposal". Regarding the developing proposal, 65% of the participants thought that it needs to be developed again, whereas 35% thought that it was ok. These results give a clear vision for planners, decision makers, and the participants as well as an indication about the overall satisfaction of the proposal. Such results should be further considered through workshops and the general decision-making process.

6.2 Questionnaire Results

After browsing the website and navigating the proposal, participants were invited to fill in a questionnaire. It was divided into three parts as follows:
- Advantages and disadvantages of using the system.
- The system role in enhancing public participation.
- The system role in the decision making process.

6.2.1 Advantages and Disadvantages of Using the System

In the first part of the questionnaire, the participants are asked about their experiences in using computer graphics and the Internet, to know if the system is easy to use regardless of having any experience in using a computer. Eighty-five percent (85%) of participants had some experience using a computer. Only 20% of participants found some difficulties in using the system.
(Fig. 11).

Regarding the obstacles in using the system, forty-five percent (45%) of participants found some obstacles such as downloading the players and codecs\(^1\). In some cases their computers were also a little bit old, so they could not easily use the system\(^1\).

In other questions, the participants were asked to select tools that are the most difficult and most useful in the system; they had the option to select more than one tool. Twenty-six percent (26%) selected the Marker system – as the most difficult tool –, and 22% selected the keyboard controllers (Fig. 12.). Participants found the Marker system the most difficult tool because it necessitates carrying out multiple steps, such as "press icon to show", "press other icon to insert", "right click on the mouse to adjust", and then "left click on the mouse to insert a comment". It is difficult for any participant to understand all these steps by reading them alone, however if a video clip is added to the website explaining these steps, this tool will be more useful and easier to use.

Thirty-seven percent (37%) of participants selected Keyboard Controllers as the most useful tools, while 26% selected icons. These results are thought to be due to the fact that these tools are easy to understand and help participants in navigating the proposal well (Fig. 12.).

The last question was about the participants' suggestions to improve the system. Forty percent (40%) of participants introduced suggestions such as using the mouse to move inside the system. However, because the mouse is used when inserting comments, this request is difficult to fulfill. Other participants suggested adding more options in the Viewpoints function.

### 6.2.2 The System's Role in Enhancing Public Participation

In the second part of the questionnaire, the participants were asked if they had participated in any real urban projects. Seventy-five percent (75%) answered that they had not, but 65% of them stated that this system encourages them to participate in such projects (Fig. 13.). These results strongly reflect the important role of this system in expanding public participation. Workshops still have unique features that are of interest to many. For example 40% of participants preferred to participate in the decision making process by using both workshops and the Internet, whereas 30% selected only workshops, and 15% selected only via Internet (Fig. 14.).

The participants selected the effective visualization tool – VR – as the most motivating tool. It encourages them to participate via this DSS with 40% of selections; 36% of selections were for using VR as an environment to insert comments (Fig. 15.). The need to have experience using computers in order to use this system is considered the most important obstacle with 40% of participants' selections, and how long it takes to understand the system tools with 21% of the selections (Fig. 16.).

From the previous results, the authors can conclude that this system encourages young people – all participants were between the ages of 21 and 35 years – to participate because it helps them visualize the future image by using effective tools via the Internet, without having to spend much time and effort.

### 6.2.3 The System's Role in the Decision Making Process

In the third part of the questionnaire, the participants are asked about the benefits of the system in the decision making process. Forty-one percent (41%) of participants selected effective visualization, because it is very important to understand the proposal and then give more effective opinions. Next, 31% of participants selected sharing information (Fig. 17.). Regarding the negative aspects of the system 68% of participants selected...
"no-face-to-face discussions", because the user cannot express all his feelings by writing alone (Fig.18.). So this system is really effective in working along with — not to replace — the workshops trying to expand public participation.

Moreover, participants were asked about the reliability of the system's results during the decision-making process, and if the decision makers can depend on the tools used to make their decisions. Sixty-five percent (65%) of participants selected "Maybe" we can depend on the Poll system results. Forty-five percent (45%) selected "Maybe" for depending on the Marker system. The main reason for these results was that the participants worry about using the Internet as a source for opinions because it is not trustworthy, and anyone can insert false information. In the authors' opinion, according to the opinions and comments from the Marker and the Poll, these systems should depend on their related percentages. Similar opinions from the high percentage of participants should be considered, and any collected opinions with a low percentage can be neglected. The system administrator should filter any insults or inappropriate opinions.

Finally, sixty percent (60%) of participants selected that this system helps them in giving opinions with more quality and effectiveness, while 35% selected "Maybe". Forty-five percent (45%) selected that utilizing this system gives their decisions more transparency and legitimacy, and 25% selected "Maybe" (Fig.19.).

![Fig.17. The Benefits of the System](image)

![Fig.18. The Negative Aspects of the System](image)

![Fig.19. The Most Motivating Tool to/for Participation](image)

6.3 A SWOT analysis of proposed DSS:

6.3.1 Strengths

The questionnaire results pointed to three main strengths of the proposed DSS in the authors' current case study. The strongest point was that most participants in the evaluation found the proposed system an easy tool to navigate, by using keyboard controllers and icons to choose future image alternatives. So the quick and easy visualization functions – the VR environment – are seen as a highly useful tool. The strongest point regarding the decision makers was that the participants stated that they had the ability to link opinions and their places in the VR environment, which leads to easily arranging and categorizing collected opinions. The second strongest point for the decision makers was: using the DSS in terms of expanding public participation via the Internet.

6.3.2 Weaknesses

The authors' results indicate two main weaknesses of the proposed DSS. The first weakness is for the participants in the evaluation: the Marker system is a little difficult for non-skilled users in terms of ease of use. However, more helpful tools can be created to assist users in the Marker System, which allows for better understanding of the steps. Regarding the decision makers, the participants stated that using the system does not replace the use of workshops because of the great importance of face-to-face discussions. Thus the proposed DSS aims to both support and expand participation, and not to replace the workshops.

6.3.3 Opportunities

Questionnaire results and additional studies indicate a range of opportunities for the application of DSS technology in future urban design practices in conjunction with the current DSS. These opportunities are for both decision makers and citizens. The first opportunity from the point of view of the participants is encouraging more citizens to be involved in the decision making processes by distant contact, without spending much time and effort. Furthermore, using attractive tools similar to a video game overcomes the fatigue of workshops. The second opportunity is that most users found out that using advanced visualization tools will help in giving the collected opinions more quality and effectiveness. The third opportunity is granting the final decisions more transparency and legitimacy by sharing the collected information between all stakeholders.

6.3.4 Threats

The results indicate two threats that may have an effect on the realization of opportunities. The first is the technological gap; however we can use volunteers in the workshops to increase users' understanding by better educating them on how to use the system. The second threat is the mysterious world of the Internet, where some of the information cannot be trusted. The DSS has the ability to assign an IP address for each inserted opinion. The Poll system accepts only one poll for each IP address. However, this does not fully solve the problem. It is more effective to rely on the percentages of the collected user's opinions in terms of accuracy.

7. DSS Skeleton

By conducting the evaluation, the DSS skeleton was completed (Fig.20.). The proposed DSS can work effectively in conjunction with the workshops. The framework was divided into two main stages: the
Preparation stage and the Decision stage. Due to the subject and the design processes having changed from one project to another, each stage can be repeated as many times as necessary, depending on the project's scale and type.

Through this framework, the decision makers can introduce the objectives in order to discuss them with the citizens via the Internet, in addition to the workshops. The decision makers review past and present situations, and discuss problems, challenges, and opportunities. When they reach an agreement, the preparation stage is completed.

After preparing the proposal, users, through the visualization process, evaluate the proposal and participate by inserting their comments, and answering the decision makers' questions. The proposal is updated depending on collected opinions and workshop discussions, so they all can follow the proposal's developmental stages. Finally, they can decide on the best final decision that they can all support.

8. Conclusion and Future Plan

This paper introduces a web-based public participation system. Technically, it integrates communication and the visualization tools by facilitating them through the VR environment. Then a tool is used to insert and share citizens' opinions, the "Marker and Poll Systems", and to use other visualization tools like 3D animation.

The VR as a visualization tool is effective for the purpose of enhancing the understanding of the participation process. It is helpful in workshops regarding discussions on the context of proposed designs. Using VR as a visual interface for input data supports the relationship between stakeholders, and gives it more effectiveness.

In Japan, decision-making methods have been developed using advanced visualization and communication tools. A plaza at Kyushu University, Japan, was used to build a new prototype and used as the DSS for the planning committee. It was proposed to employ the system via the Internet and workshops, to solve any difficulties that might arise. Both methods still need to be used. The traditional methods are for people who have the time and desire to attend the workshops, while the new methods are for those who do not have the time to participate in the workshops.

From the perspective of users' evaluations, the influence of the proposed joint system appears to be positive. It opens the way to add more functions to the VR environment rather than just using it as a visualization tool. It has unique strengths and opportunities, but should be further developed to overcome its weak aspects and enhance its feasibility.

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Notes

1 Marker system is designed by using scripting language CGI; CGI is an abbreviation of Common Gateway Interface, a specification for transferring information between a World Wide Web server and a CGI program. A CGI program is any program designed to accept and return data that conforms to the CGI specification.
2 Poll system is designed by using the scripting language PHP that is used for web development, to produce dynamic web pages.
3 A codec (coder-decoder) is a device or computer program capable of encoding and/or decoding a digital data stream or signal.
4 The minimum system requirements to operate the proposed DSS: 1.6 Giga Core Duo processor, 1 Giga Ram, 512 Mega VGA Card, 1 Mega Internet connection speed.