

The Development of 3D Story Visualiser and Its Evaluation

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Abstract

The primary goal of this work is to demonstrate that it is possible to create a system that can interpret language descriptions and generate a corresponding virtual environment. This representational transformation is accomplished by implementing real world knowledge and current theories of language and perception. The proposals have been implemented as a prototype system 3D Story Visualiser (3DSV). This paper describes the prototype evaluations and discusses the results obtained from experiments made using the system.

1. Introduction

There is a clear need for such an application: [1] claims that it is important to help children to understand spatial cognition. [2] finds that such help can encourage children to enhance their spatial knowledge by giving them the chance to explore space under their own command. [3] also suggests that it would provide a more positive contribution to a child's development of spatial thinking if the spatial exploration process were directed by adults. Clearly, computer technology now plays a major role in children's lives, from the classroom to the home. Traditional media such as books and films can only depict space to a limited extent by text description or images, but the new digital environments can enhance this by representing navigable space [4]. The research of [5] indicates that a 3D virtual environment is undoubtedly a superior environment for presenting spatial information. 2D graphics lacks significant spatial and realistic features when compared with 3D graphics. [6&7] suggest that a 3D virtual environment has the potential to be an ideal learning environment.

The main aim of this research was to develop a system that enables a non-specialist to generate an interactive 3D virtual environment [8]. This paper

describes an application of the 3DSV system which seeks to aid children's spatial understanding. There are three main parts in this system: Language Component, Knowledge Base Component and Graphical Component. The system is highly pipelined and incremental and the input text is processed through these layers before finally being visualized. The system works as follows: Once the text has been entered, the language component analyzes it to extract the information and output a formatted semantic representation as XML; then the output is parameterized by the knowledge base component and is converted into a low-level data structure using a process termed 'visual semantic representation'; and finally the graphic component uses the information to visualize the scene.

The purpose of the present evaluation was to determine whether this prototype has the potential to be used as an assistant tool for enhancing the ability of children to understand attributes of objects and spatial relations by constructing a virtual environment; and furthermore, to examine if it has the potential to be developed as a tool to help children to learn English. The evaluation also aims to determine the advantages and the weaknesses of the current prototype in order to make recommendations for future development. [9] notices that usability should include one or more of the following four factors: usefulness, effectiveness, learnability and attitude. The purpose of the usability evaluation described here is thus to ensure the creation of a prototype system 3D Story Visualiser that provides:

- Usefulness. We must establish the degree to which the prototype system provides utility and functionality that enables a user to achieve his or her goals [9]. It was hypothesized that the 3DSV's features and spatial environment might enable children to enhance their spatial skills by portraying or organizing visual information in such a way that makes relationships among images and concepts; it was also hypothesized that the 3DSV narrative feature and unique 3D spatial environment may have

the potential for further development as a tool to help children to learn English.

- Ease of Use (effectiveness). Users must be able to achieve the goals of interaction with the software in a direct and timely manner, such as whether the system can be used easily and efficiently to create a virtual environment? How well does the resulting tool respond in terms of speed?
- Satisfaction. This relates to the users' attitudes towards the use of the system and can be measured on various scales such as comfort or discomfort experienced. It usually refers to the user's feelings and opinions of the system, and whether or not usability objectives meet their needs.
- Performance. This refers to the responsiveness of the system to allocate its computational resources and the time required to respond to the number of tasks processed [10].

The value of the prototype as a tool for children to create virtual environments can also be measured in terms of Ease of Use and Learnability. Learnability has to do with how soon a user can get started and learn to operate the system after some predetermined period of training [10].

2. Evaluation Procedure

This experimental test took place in two schools in Hunan Province, China: Zhuzhou Fifth School and Changsha Tian Jabin School. The participants were randomly selected and there were a total of 30 participants (age between 10-12 year), with 15 in each location taking part in the experiments. [1] explains that in Piaget's model [11], the skills of visual/spatial integration and auditory/visual integration begin to appear during the "concrete operations stage (ages 7-11), and would continue to develop through the formal operation stage (ages 12-16 and beyond)." After discussing this with the relevant English teachers and some experts, they recommended the selection of 10-12 year-old students because the children within this age have already studied English several years. In China, according to requirements of the English teaching curriculum, children of this age must have achieved related skills, *i.e.* children should be able to use English for making sentences with basic grammar and a small amount of vocabulary. However, they learn this second language mainly through the textbook and without much other related practice. In particular, they lack any significant capability to describe a surrounding environment in English. These are the two main reasons to select this particular age group of students. The evaluation procedure comprises two subtasks:

- Experiment on Virtual Environment Generation. In this experiment, participants use the 3D Story Visualiser to generate a virtual environment based on language descriptions.
- Experiment on Real-time Manipulations. This experiment examines real time interaction within an already-established virtual environment. The user can manipulate objects by using both language instructions and a pointing device, *e.g.* a mouse.

The participants first received a brief written instruction describing an introduction to the test, statements concerning the test policy and privacy issues and explaining the basic procedure for using the prototype system. The experiment proceeded with a 5 minutes oral explanation and example demonstration; after this all the participants were asked to describe a scene that they may use later by using the words given to them. (It was disappointing to observe that most of them wrote down only two or three lines.). This was then followed by 20 minutes of usage of the system. Immediately after completing the experiments, participants were asked to answer a series of questions to rate the overall prototype system. This was based on the IBM Computer System Usability Questionnaire [12]. It comprises 18 usability related assertions (in both English and Mandarin Chinese), each of them having a seven-point scale, ranging from 1 (strongly agree) to 7 (strongly disagree), with open fields for comments. We have extended it with some background questions about the participants.

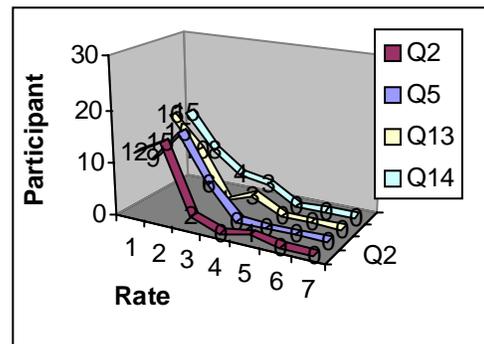


Figure 2 Usefulness Assessment Results

3. Results

From the results of the pre-questionnaire we can find that most of the students have learned English more than 2 years, which means that they should theoretically have enough knowledge to describe the simple environment in English. From the following summarization of the result of the pre-questionnaire it shows that 83% of the people feel confident about

using computers; 80% of the people like to use computer; and 73% of student like using computer for drawing picture. The final evaluation results of the individual criteria of the main usability study are displayed below.

Four questions are related to the usefulness assessment as show in Figure 2. Most of the participants found the experiences are more enjoyable overall than the ordinary drawing which they have done (Q2, Mean = 1.77, Std. Dev = 0.86). They also believed that this system would make it easier to perceive the scenes by using virtual environment (Q5, Mean = 1.90, Std, Dev = 0.71). Sixteen of participant strongly agreed and the ten very much agreed that the system could help students have well understanding spatial relations and attributes of objects (Q13, Mean=1.70, Std, Dev = 0.95). 90% of participants agree that this system could help students improving and learning of their English (Q14, Mean=1.83, Std, Dev = 1.02). The overall usefulness rank is strongly favourable in that the participants gives a mean satisfaction of 1.80 (Std. Dev. = 0.086).

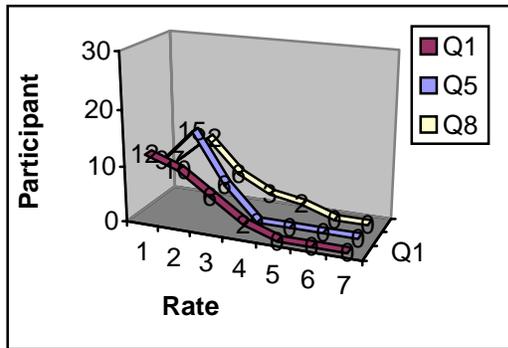


Figure 3 Ease of Use Assessment Results

Figure 3 shows there are three questions were included to assess the ease of use. Twenty-two of participants felt very satisfied and six felt satisfied about how easy it is to use the system (Q1, Mean =1.93, Std Dev = 0.94). Twelve participants felt strongly satisfied about it and gave a rating of 1. The other one question (Q5) is also connected with usefulness and has already been mentioned. Participants found that the manipulation of the virtual objects of the scene by combining both language instructions and pointing device is easy or very easy (Q8, Mean = 2.37, Std. Dev = 1.16). This brought the overall ease of use rank as very much satisfied with a score of 2.04 (Std. Dev=0.26).

In the satisfaction assessment results as show in Figure 4, most of participants felt satisfied to very

satisfied with how easy it is to use the system (Q1) except two in neutral (Mean=1.93, Std Dev=0.94). 100% of participants felt satisfied to work with this system (Q10) by ranking 2. All of them were glad to take part in this experience (Q11) and 97% expressed that they would enjoy using the software again (Q12). The overall of result about satisfaction assessment is encouraging with score of 1.77 (Mean=1.77, Std Dev=0.28).

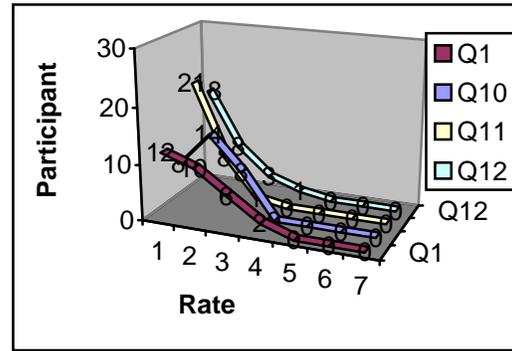


Figure 4 Satisfaction Assessment Results

As shown in Figure 5, the result of question 7 about the Learnability assessment shows that most of them strongly agreed about how easy it is to use the system and gave the ranking 2.23 (Mean=2.23, Std. Dev=0.90). Some of them expressed delight and surprise that they were able to create a virtual scene within such a short time.

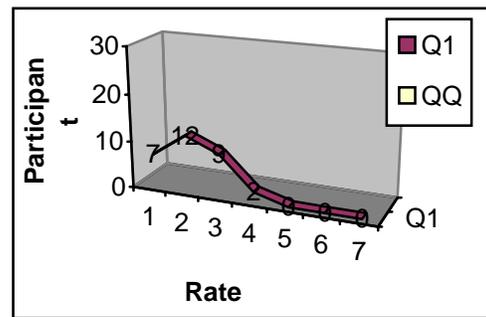


Figure 5 Learnability Assessment Results

The mean responses concerning the GUI of the 3DSV prototype received the lowest rating of all with a neutral point on the scale of 4.33 (Q9, Mean = 4.33, Std. Dev = 0.99) showing that the interface of the system was acceptable but not inspiring. Most of the final comments mentioned about the graphic user interface, suggest that the interface could be made simpler; or it could be improved by integrating three separated windows into one, etc. From the result of the Q15, lots of participants (23:5) expressed that they prefer both of voice and text input rather than text only (see Figure 6).

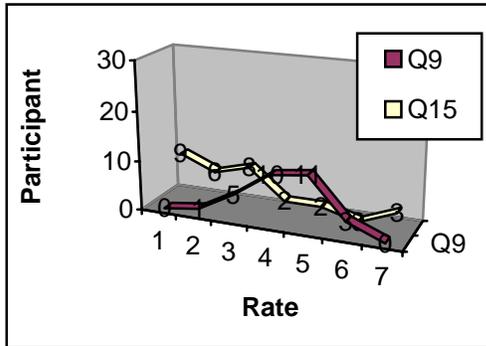


Figure 6 GUI Assessment Results

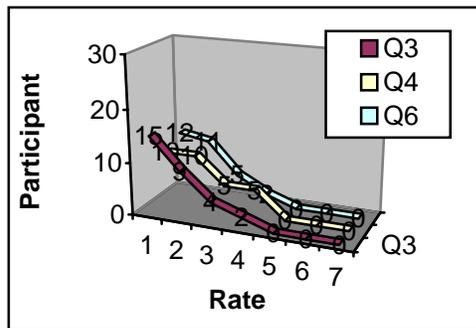


Figure 7 Performance Assessment Results

The results of the performance assessment in Figure 7 shows that the rating of the system response to the inputs received score of 1.77 (Q3, Mean = 1.77, Std. Dev = 0.94). Only two participants found the system response to be less than expected and gave a neutral rating 4. Fifteen participants felt strongly satisfied about it and gave a rating of 1. Twenty-five of the participants found the corresponding output of giving text is correct and as expect (Q4, Mean = 2.17, Std. Dev = 1.09), the other five in neutral. Twelve of participants strongly agreed, eleven very much agreed and five agreed that they could efficiently complete the tasks by using this system (Q6, Mean = 1.90, StdDev = 0.92).

4. Discussion

An analysis of the results of the experiments described above has made it possible to draw some conclusions related to our main usability objectives. The overall conclusion is that the subjective opinion of users regarding the prototype system was very good (Mean = 2.11, Std. Dev = 0.48). We find that the results are satisfactory concerning the usefulness of the system and the questionnaire shows that most of the participants say they were very satisfied. This indicates that this prototype system provides the utility and functionality that enables the user to generate various

3D virtual environments. The prototype system has been considered particularly easy to deploy, while most participants ranked the ease of use as very good.

The best score and second best score were given for the use of the system, such as Q11 and Q12 which supports the assertion that the original goal of designing an easy-to-use 3D visualization system has been met. In the 3DSV environment, the narrative, visualization and interactivity features enable the users to explore the virtual environment, thereby drawing attention to the relationships between objects. Through these features, it provides an opportunity for children to enhance their spatial knowledge by building more complex virtual environments, and the English learners took the opportunity to positively engage in this process. This was demonstrated clearly by the comments from the participants. None of them had used this kind of software before and most of them liked the idea of creating virtual environments by using language descriptions. Many of the participants agreed strongly that this system could be used to help them to improve their understanding, it would increase their interest in learning English and, more importantly, it would help them to improve their understanding of spatial relations and attributes of objects through the generation of the virtual environment. Several of the teachers who were in attendance during the whole of the test, expressed surprise at the significant improvements shown by all of the children after using the software; the final products of the children were clearly more complicated and better organized when compared with the ones they produced initially without the aid of the prototype tool. Examples that demonstrate this are presented in Figure 8. The teachers agreed that the major benefit of this prototype lies in its potential to enhance the spatial knowledge and encourage the children to improve their ability to understand and create English expressions through “playing the text to visualization game”. Informal observation showed us that children did enjoy using the 3DSV prototype and found it to be fun. This raises the issue: What does 3DSV has to offer that traditional media or other available applications might not? One possible answer lies in its real-time interactive and text to visualization features, and the navigable virtual environment, which provides a novel opportunity to bring text to life in a navigable world.

After reading the instructions, participants were able to generate efficiently their own virtual environments. The overall system satisfaction chosen by the participants was very good, which implies that there is some room for improvement, as the ranking was affected by the interface of the system. The GUI of the system received the lowest score and the participants

stated that they would prefer one world containing all the models rather than separate windows. This is due to the limitation of Java Applet, but this can be addressed by using client-service architecture. This will be considered further in the section on future work. Another suggestion from the participants is they would prefer a system can handle both text and voice input. Based on the observations and participants' comments, several improvements to the prototype system are recommended. An error exception handler is needed to help the users to make modifications. Currently the prepositions used in the system only relate to a single object, and this should be extended to handle two objects, such as *a ball is between a box and a vase*. This can be achieved by defining a relative rule in our knowledge base component, as the language component is robust enough to handle this kind of sentence. Some of the participants suggested improving the quality of the environment, such as adding more material, making the elements more realistic and creating basic animation. All of these indicate that there is a need to improve the language and graphic components, expanding the Knowledge Database to deal with more complex tasks.

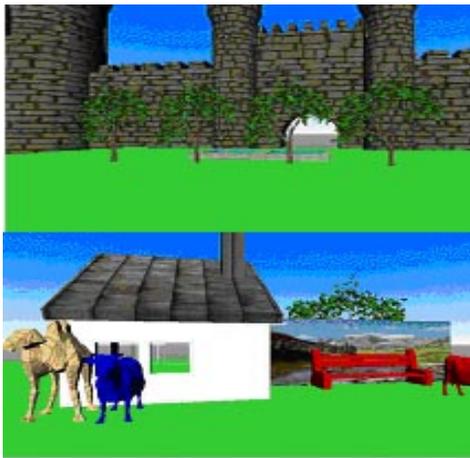


Figure 8 Virtual Environment generated from description

5. Conclusion and Future Work

This paper presents an evaluation that is used for measuring the capabilities of the prototype system 3D Story Visualiser. In terms of its usability, it shows that the method presented in this research works successfully in practice in the experiments. Furthermore, the prototype system developed was

functionally sound; it is low-cost, compatible with standardization and provides cross-platform capability. It also offers real time interactivity and contains an extensible database for further development. The greatest advantage of the system developed lies in its potential that could be evolved as tools for children to create a real time interactive virtual environment, the feature of “what type is what see” and spatial environment can help them enhance the knowledge of spatial relationship and improve their interesting of learning language. More importantly, the evaluation gives valuable suggestions for potential improvements, which will technically guide our future research efforts in this direction.

6. References

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