Semantic Visualization in 3D Urban Environment
Taking Text as an Example

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Abstract: One important aspect of semantic data in computer visualization is to offer supporting and extra information of the environment besides the pure graphical information to system users. It is devoted to help them understand the visualization result better. This paper presents a way to visualize semantic data in 3D urban environment in form of text, which is similar to the issue of 3D labelling and annotation. Different objects in 3D urban environment need different annotation techniques. Occlusions, overlaps, readability, visibility and information density are problems encountered frequently, and several potential solutions are proposed accordingly. A primary test is done to compare the performances among three different text layout techniques: floating text, fading text, linking text. The result shows that floating text and fading text are well understood in a 3D environment, the former one maintaining good readability and visibility and the latter one efficiently avoiding occlusions. Finally several open questions are proposed in the discussion part.

1 INTRODUCTION

In recent years, visualization has been increasingly used in almost every aspect of our daily life. In town planning and urban development, urban data are essential for understanding the relationship between objects of the urban build environment. However, it is not easy to analyse such data due to the huge amount of urban objects, their multidimensional features and complex relations (spatial, temporal or logical). Hence how to convey information with high efficiency and accuracy becomes a critical issue.

Geometricdata is to provide spatial information to userswhich conveys information about location, shape and size of the space.While semantic data can provide extra and supporting information which can enhance the descriptionof the environment. This work is devoted to visualize semantic data in form of text in 3D urban environment, namely 3D annotation.

2 RELATED WORKS

According to Stefan et al. (2007), the term 'labeling' is more often referenced in cartography field, as placing names of objects is often used, while 'annotation' is a general term, which can be used for any type of information, such as symbols, figures or images.

A lot of works have been done in the field of 3D annotation, from the viewpoint of cartography or virtual reality. In (Hartmann et al., 2004); (Ali et al., 2005); (Gotzelmann et al., 2006) 3D annotations are used to help industrial product design. Stein and Decoret (2008) aims to improve the interactive functions of 3D annotations. Havemann et al. (2009) use 3D annotation to help the reconstruction process of historical objects. These works mainly focus on the annotation techniques for a single 3D object, which seldom take into account the 3D urban environment.

About placing annotations in 3D urban environment, (Stefan and Döllner, 2006) (Stefan et al., 2007) (Hagedorn et al., 2007) have separately discussed the annotation placement strategies for point features, line features, plane features and volume features, more often aiming at the annotation technique for a single object, such as where to place the annotation around a certain object, while not dealing lots of objects in a macroscopic view. (Klimke and Döllner, 2010) allows user to add and save script annotations in 3D urban environment to improve urban planning process.

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3 PROBLEMS AND LIMITATIONS

In most cases, annotated objects in 3D environment can be divided into one of the feature types below:

a) 0D feature, in most cases refers to point features that occupy a small spatial space while they are of importance and cannot be ignored, such as a tree, a control point, a bus stop, a tower or a single building, depending on scale.

b) 1D feature, which often means line features. They are objects that have spatial definitions in context of length while the width is neglected, such as rivers, roads, railways and border lines.

c) 2D feature, also known as plane features, which takes the width of objects into consideration such as squares, open spaces and water bodies.

d) 3D feature, also referenced as volume features, are objects that cover a large space in the environment such as icebergs, mountains, sky-scrapers, large buildings and building groups.

The problems and limitations of current annotation techniques can be summarized as:

a) No appropriate information density: information density of annotations in 2D environment has been tackled as annotation number maximization and size maximization problem (Alexander, 1999). In 3D environment, there is no such criterion.

b) Annotation readability and visibility are not guaranteed: in 2D environment, camera position does not influence the readability and visibility of annotations. While in 3D scenes, occlusions, overlaps occur frequently, which decrease the readability and visibility of annotations.

c) Low annotation diversity: in existing use-cases of 3D annotation, annotations are treated the same way. Human perception factors can be added to optimize the annotation result.

4 POTENTIAL SOLUTIONS AND PRIMARY TEST

4.1 Potential Solutions

In order to overcome limitations stated in section 3, here are potential solutions:

a) Firstly, text will be treated as pure text. It aims to place annotations that differ in size and colour and compare the effects among them.

b) After successfully placing annotations, a proper information density will be defined to ensure information is neither overwhelmed nor too limited.

c) Then, an optimization of readability and visibility is scheduled. The aesthetic layout of the annotations is important for system users to acquire information. Occlusions, low visibility annotations should be avoided while guarantying readability.

d) Finally, annotation diversity is needed to highlight important information to make the system more user-centred and user-friendly.

4.2 Primary Test

Having proposed potential solutions, we applied the first solution in a primary implementation with OpenSceneGraph(OSG), which directly supports text visualization. The urban environment is built by a CityGML dataset of Etteinheim, Germany.

Firstly, three types of text are placed:

a) Linking text: cyan text, which is set as always facing the initial viewpoint. There is a line connecting annotation and the annotated object;

b) Floating text: yellow text, which is set as always facing the current viewpoint to maintain readability. It floats on top of its annotated object;

c) Fading text: white text, which is set to disappear if it is to be occluded by another fading text and to appear if it is out of the occlusion scope.

The initialized annotation scene is illustrated in Figure 1 below:

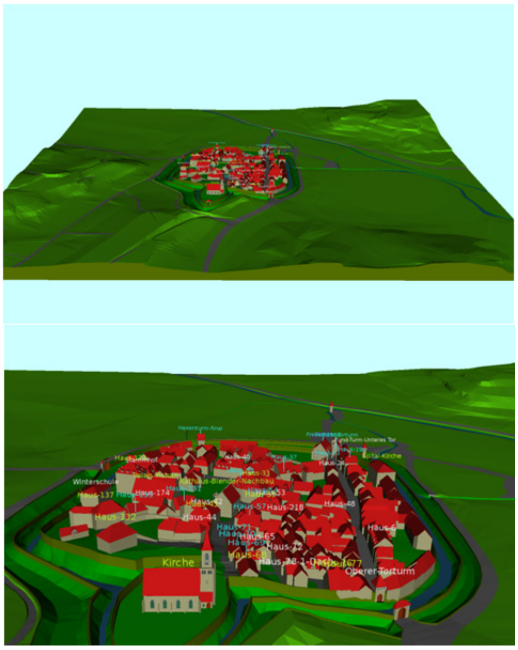

Figure1: Snapshot of the initialized scene graph.

Let's take'Haus-72' in the white rectangle as example to compare performances among these three types of annotations. Currently at this viewpoint, occlusions of linking texts and floating texts occur but not so much, and there's no occlusion among fading texts, as showed below:

Figure 2a: Viewpoint A for comparing performances of different types of annotation.

As viewpoint changes, 'Haus-72' disappears as it is occluded by'Haus-78-1-Dach', as showed in Figure 2b. While there are too many occlusions among the other two types of texts which make annotations unreadable. Fading texts remain clear.

Figure 2b: As viewpoint changes, fading text adjust themselves while the other two texts do not.

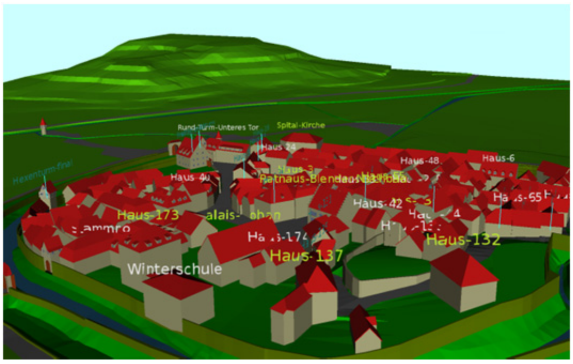

Figure 2c: Another viewpoint for the scene.

In Figure 2c above is another viewpoint of the scene after a rotation around the scene. Floating text and fading text still remain readable while linking text is hard to recognize. In order to better simulate the real 3D world, annotations can be set as linking text but readability can hardly be maintained.

Besides three texts described above, HUD annotation and annotation with a text-container are also placed as showed in Figure 3:

Figure 3: HUD annotation and annotation with a text container are also placed.

Texts in yellow are HUD (Heading up display) annotations which always stay as initialized to offer essential information about the system. The most important information of the system can be set as HUD annotation. Finally, annotations can be added as texture as using billboard as the text container.

5 DISCUSSION

Concerning fading texts, they allow users to see what they want to see easily by changing viewpoints. They adjust themselves to appear or not according to the possibility of occlusion. If the user wants to see some information of his interest, he only needs to zoom and adjust the camera position until he sees what he wants to see. So when there are a lot of annotations to place, fading text can be chose to annotate objects to avoid occlusions.

For linking texts, they maintain high relations with annotated objects. But if there are too many objects to annotate, linking lines will come across with each other, which will make the scene confusing. Hence linking text is applicable only when there are a few annotated objects to annotate.

For floating texts, they are similar to fading texts, but they will not avoid occlusions among annotations. So when there is a medium-scale dataset, floating text is preferred as it does not result in confusing connecting lines as linking text does while reducing the occlusion calculating time as required by fading texts.

This primary strategy to choose annotation type is dedicated to a general view. While for a single object, the annotation method needs to be specified accordingly. If annotations are placed on the space of annotated objects, they are called internal annotations. If not, they are external annotations (Hagedorn et al., 2007). In general, for point features, due to their limited space, external annotations are preferred. For line features, both external annotation and internal annotation can be used. For small line features where the space is not enough for embedding, external annotation is used. When line features are big enough to contain annotation, internal annotation is preferred. For plane features and volume features, in most cases, internal annotation is used. In real use-cases, things are more complex.

The information displayed in a single frame is limited, where an appropriate information density needs to be defined. Dating back in 1970s, (Töpfer and Pillewizer, 1966) set the primary guiding principle for information density in 2D visualization: Constraint Information Density, which requires the number of objects per display unit should be constant. Hence how to set a good information density of our own case in 3D environment?

As (Ware, 2004) states that visualization is the result how human beings perceive the world, hence human perception factors such as colours, textures, depths, lightness, brightness contrast and others, play important roles in computer visualization. Here how to take good advantage of human perception to help users better find out the information they need?

Finally the evaluation of annotations is a difficult problem too. How to define if an annotation result is good or not? Using mathematic way to calculate some factors such as occlusion ratio? Or should a group of user test is needed?

6 CONCLUSIONS, FUTURE WORK

In this paper, the problem of annotation in 3D environment has been discussed. Challenges and several potential solutions are proposed. Floating text, linking text and fading text are tested. Unsolved problems proposed in Section 5 will be tackled in the future such as how to define the proper information density. Then we will work to improve readability and diversity of annotations. Besides text, different kinds of annotation forms are expected to express semantic information, such as symbols or images. Then a formal evaluation with a large number of user tests will be done. Finally we will try to extend the applicability of our annotation technique into other applications such as augmented reality, 3D objects generalization and so on.

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