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Real-Time External Labeling for Interactive Visualization in Virtual Environments

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REAL-TIME EXTERNAL LABELING FOR INTERACTIVE VISUALIZATION IN VIRTUAL ENVIRONMENTS

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ABSTRACT

A real-time external labeling algorithm has been developed to explore the potential for applying annotation and visualization to virtual reality environments, which manages label placement in the projections of virtual 3D models on the view plane. The approach intends to place labels with visual constraints, such as no overlapping, intersections, and occlusions, close proximity to the model parts, by adjusting external annotations' positions concerning available space in the view plane. This algorithm is based on the projected model's contour and adapts to camera viewpoint changes within interactive frame rates. It solves the visibility problem of annotations and operates in real-time when the model is rotated. The results show that the proposed method can improve user understanding of complicated 3D models and can be applied to interactive virtual environments.

Keywords: external labeling, annotative visualization, view management.

1 INTRODUCTION

Illustrating complex objects composed of distinct parts is essential in many application fields, such as technical illustrations, anatomy drawings, and maps. Labeling the short textual annotations that connect the visual and verbal information plays a critical role in efficiently understanding the objects. One of two main labeling methods, external labeling, has been studied in computer science from a theoretical and practical point of view over the last twenty years (Bekos, Niedermann, and Nöllenburg 2019). However, most researchers focus on studying the labeling problem from a fixed viewing specification or restrict labeling objects (Niedermann, Nöllenburg, and Rutte 2017, Cmolık and Bittner 2019). This paper presents a general real-time external labeling algorithm to place labels automatically with visual constraints.

2 TERMINOLOGY AND CRITERIA

Labels represent textual or symbolic descriptions of the model's parts. Geometrically, the label is defined as the axis-aligned rectangle containing the attached information of the feature. An illustration with external labeling consists of a figure, many labels outside the figure's contour, and a line segment connecting the label with its part. The line segment is called the leader line. Straight line segments are only used as leader lines in this paper. One endpoint of the leader line is restricted to be the center point of the part in this paper. The other endpoint of the leader is a point on the boundary of the label, which is restricted to one corner or midpoint of one particular edge of the label.

The list of rules adapted to the needs of dynamically externally labeling point features is as follows. The label should be placed entirely outside from the point feature with a small leader line length. The number of leader crossings should be minimized. There is no label overlapping. The labels are distributed evenly.

3 ALGORITHM CORE

The proposed method is a screen-space technique operating in a view plane where the 3D models are projected and keep track of the projections on the view plane of all the portions of the 3D model. The method adjusts the labels' positions at every frame to ensure that rules are satisfied in a dynamic environment. Firstly, the screen is divided into four regions, and the anchor points of the model are placed into these four regions, accordingly. Then, the number of anchor points in each zone is adjusted to make the density of each area consistent. Next, the initial value of the reference point is calculated, and the initial value corresponds to the coordinate value of the label. After that, the annotations in each partition are checked for intersection or overlap, and if so, they are adjusted. Following this, a global list of labels is maintained for detection of intersections or overlaps, and overlapped labels or labels intersecting leader lines are adjusted.

4 EXPERIMENTAL RESULTS

The proposed approach has been implemented in the Unity game engine to demonstrate its unique ability to place labels automatically, shown in Figure 1.

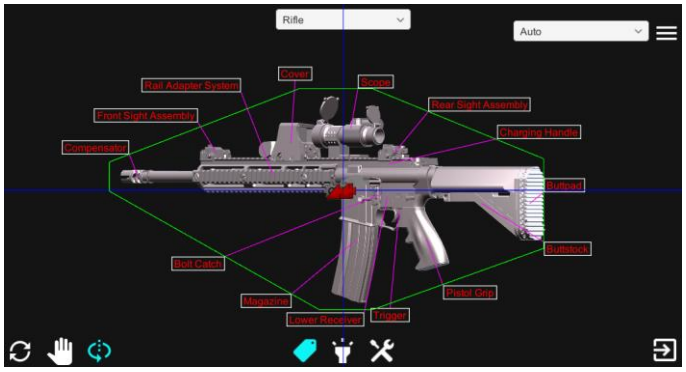

Figure 1: Label placement of the 3D rifle model created with the proposed method.

5 CONCLUSION

This paper implements a point-feature annotation placement strategy for automatically labeling 3D models rotated about the vertical axis and has experimented with it in several objects. The implementation operates in real-time and provides a smooth transition between changing models. Therefore, it can be applied in interactive applications.

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