Lars Grunske, Janet Siegmund, Andreas Vogelsang (Hrsg.): SE 2022,
Lecture Notes in Informatics (LNI), Gesellschaft für Informatik, Bonn 2022 51

How EvoStreets Are Observed in Three-Dimensional and Virtual Reality Environments

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Abstract: We present our paper published in the proceedings of the 27th IEEE International Conference on Software Analysis, Evolution and Reengineering (SANER). In an experiment in which 34 participants had to analyze cloning in existing software systems using the EvoStreets visualization, we found indications that the movement patterns of the participants differ depending on whether they are in a 2.5D (pseudo-3D; monitor with keyboard and mouse) or virtual reality (VR) environment. In a follow-up study, which we present in this work, we analyzed the results of this experiment in more details, to examine whether not only movement is affected by these environments, but also the way how EvoStreets are observed. Beyond that, the paper proposes six visualization and user interaction concepts that are specific to the kind of environment.

Keywords: Software Visualization; Virtual and Augmented Reality; Code Cities; EvoStreets

1 Summary

In order to assist developers in software maintenance tasks, different kinds of visualizations have been developed in the last decades. One of the most promising visualization concepts is the *Code-City* [WL07] metaphor and its derivative EvoStreets [St13]. In previous studies [SKR19a, SKR19b] we compared EvoStreets deployed in different environments, namely 2D (orthographic; monitor, keyboard and mouse), 2.5D (pseudo-3D; monitor, keyboard and mouse), and VR (head-mounted displays and hand-held controllers), to find answers to the question whether a certain environment is better suited for analyzing software clones than the others—in all three environments, the size of the virtual representation of the participants was chosen so that they are perspectively located in a city with large buildings. We could not find statistically significant differences among the three environments with regard to the time needed by the participants to solve the tasks we had set as well as the correctness of the supplied answers. According to our results, there seems to be a trend that comparing blocks in the 2.5D environment is more error prone than in 2D and VR, though [SKR19a]. Also, we found evidence that the *path length*, *average speed*, and *occupied volume* differ significantly between the 2.5D and the VR environments [SKR19b].

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In [SKR20] (the paper presented in this work), we extracted so called *viewpoints* from the positional data of [SKR19b]. A viewpoint consists of a spatial position and the duration spent at that particular position—we call this time *residence time*. With regard to viewpoints we tried to answer the following research questions: *i) Do the two different environments, 2.5D and VR, effect viewpoints?* and *ii) Are there patterns regarding the changes of viewpoints that are specific to the 2.5D and VR environments?* We found that the height of viewpoints and the distance between consecutive viewpoints is significantly lower in the VR environment for two out of the three tasks. Although we could not find enough evidence to confirm our hypotheses (see [SKR20] for more details), we found indications that the height of viewpoints becomes larger at later phases of an analysis in the 2.5D environment for two out of the three tasks.

Conclusions: The results of our studies can be concluded as follows. Neither of the environments seems to be better suited for analyzing software clones in EvoStreets than the others. However, in 2.5D users seem to prefer viewing EvoStreets from farther away and to increase the distance to the city in the process of visual analysis. As a result, greater distances have to be covered by the users in 2.5D to view the EvoStreets under examination from different angles. Based on our findings, we proposed six different visualization and user interaction concepts in our earlier paper [SKR20] that adapt to the characteristics of the 2.5D and VR environments.

2 Data Availability

Our data of the experiment are available online[3]. The ZIP archive contains the two CSV files *TaskData.csv* and *ViewPoints.csv*, as well as the file *README.md* which describes the structure of the CSV files.

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