International Workshop on Visual Analytics (2012)
K. Matkovic and G. Santucci (Editors)

HeatCube: Spatio-Temporal Data Visualization with GPU-Based Ray Tracing Volume Rendering

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1. Introduction

Analysis of spatio-temporal data has become critical with the emerge of ubiquitous location sensor technologies and applications keeping track of such data. One application area is location based services for GSM networks. In this work we propose an interactive framework to detect patterns and anomalies for quality control and customer behavior analysis. As it is depicted on Figure 1, our framework improves 2D heatmap method in a 3D fashion by using volume rendering, which we call HeatCube.

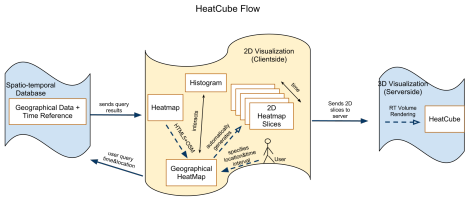

Figure 1: *HeatCube Server/Client Framework.*

2. HeatCube

Our framework is composed of two main steps. First step involves the visualization of geographic data using a color-coded heatmap. With the purpose of analyzing the data with different distributions, we designed a heatmap similar to Hotmap [Fis07] which uses logarithmic color scales. In our heatmap design, each data point is represented with a radial color gradient on the map to make a smooth transition between data points. In addition, radial gradients are aggregated for data clustering. As a part of our framework, we implemented a fully interactive heatmap system that works on top of OpenStreetMap in which users are able to pan and display their data at any zoom level. This system automatically generates and stores the corresponding 2D heatmap images when users query data with selected time period, time frequency and extend. In the meantime, these heatmap images are automatically passed to the second step to construct HeatCube.

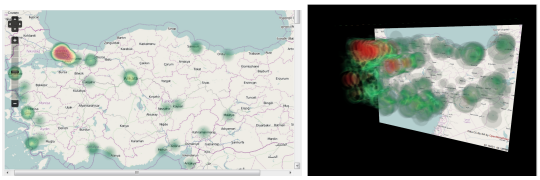

Figure 2: *Heatmap and HeatCube representation of the same data in 1 hour and 24 hours respectively.*

For the generation of HeatCube, our framework takes advantage of volume rendering which is a useful technique to visualize spatio-temporal data [SWW*11]. Using GPU-based ray tracing algorithm, our system quickly and automatically constructs volume representation of the heatmap images generated in the previous step. These images are stacked on top of each other so that each slice represents the data density of a specific time. As a result of volume rendering, interpolation between heatmap map slices help users to percieve the change of geographic data over time in a smooth way. By walking through HeatCube's 3D environment with the camera, users view their spatio-temporal data with different angles to detect patterns and anomalies.

References

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