Measuring and visualizing attention in space with 3D attention volumes

Thies Pfeiffer - Bielefeld University

Paper Summary by Prateek Bhatnagar

My role in the project team is to implement 2D and 3D eye gaze tracking heatmap data collection and visualisation. These heatmaps and their data will be used for optimisation of procedures when working with trainees, placement of training graphics and information as well as for performance evaluation of the trainees in our sister project. This paper aligned very well with the implementation I would be working with. The paper discusses 2 approaches for mapping 2D eye gaze tracking data to 3D coordinate points; namely "Geometry based approach" and Holistic Estimation. However it only implements the Holistic approach. Furthermore the paper also discusses and implements 2 kinds of visualisation techniques - 3D scanpaths(fig 1) and Heatmaps(fig 2).

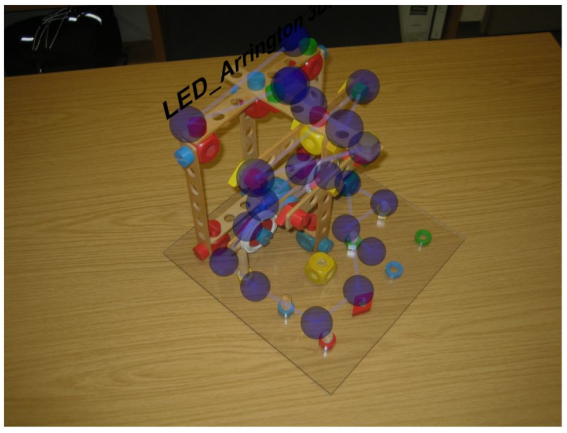

Fig 1

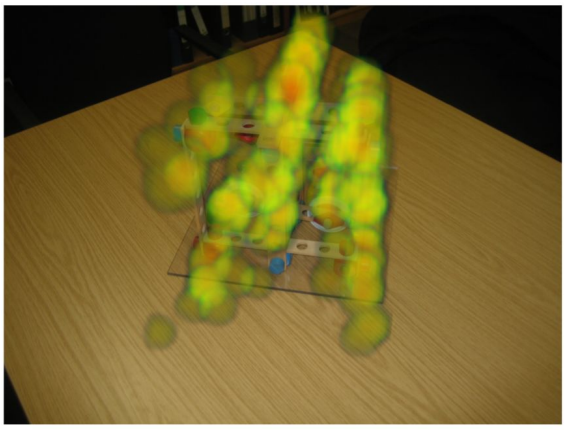

Fig 2

The key factors that interested me in this project were the Holistic estimation method and the 3D scanpath visualisation.
The Holistic method implemented by the project involves using binocular eye gaze tracking in order to triangulate the position of the 3D point of focus of the eyes. This method disregards the actual 3D geometry of the target point.
3D scanpaths although similar to heatmaps have some key modifications made to them. This scanpath implementation involves distinguishing regions of interest by using spheres with their diameters directly proportional to the quantum of interest in the region i.e. higher interest regions have larger spheres on them, these spheres are simply connected to each other using lines. These modifications make them suitable for evaluation of individual performance. A key drawback of this visualisation is that it is not suitable for integrating multiple subjects data into a single visualisation. Figure 3 shows this problem

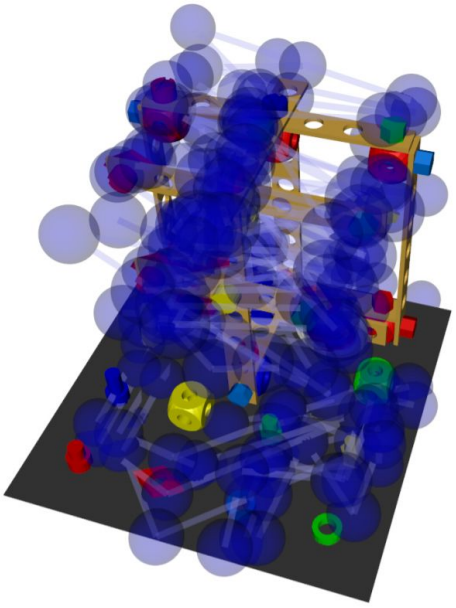

Fig 3

The experimental setup requires using an outside in body/head tracking system to get the position of the head and then performing certain transformations to get the position of the eyes. This is done to get the position of the head on a fixed 3D space. This was one of the key drawbacks of this implementation as it requires recalibration for each new user. Furthermore it also introduces multiple new sources of error.
The implementation also uses a physical model of an object with a known 3D model to perform the experiment - this limits its implementation in any form of dynamic or real time environment.

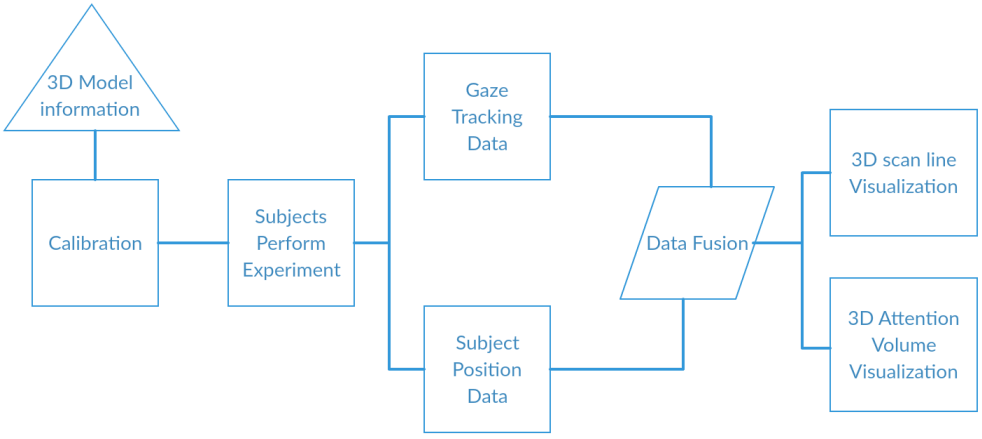

Fig 4

The experimental process is described as follows:

1. Calibration for eye position of user and loading 3D model information for the object being viewed

2. **Subjects are directed to perform the experiment - focus on specific locations on the physical object**
3. **Once the experiment is complete the user's gaze tracking data as well as the head position and orientation data from the tracker are fed to a Data Fusion module**
4. **This data is then used to produce the visualisations**

This procedure is depicted in Fig 4

The work presented in the paper was helpful in confirming that the Holistic Estimation method can be used in our projects implementation for 2D to 3D eye gaze projection
The discussion about the drawbacks of using a Geometric approach was quite helpful to understand what such an implementation would be suitable for. The different visualization approaches discussed by the paper were extremely helpful in understanding their merits and demerits.
However, there were a few key drawbacks as well - the processing of the data and the visualisation heavily relied on a known pregenerated 3D physical model, the use of an outside in head position tracking system may lead to another source of errors as well as recalibration for each user.

The paper was able to help me establish that multiple types of visualisation may be more helpful for our project - Scanpaths may be used for individual performance analysis while Heatmaps may be used to analyse aggregated data from multiple users.
Furthermore i will be able to avoid the key pitfalls observed in this paper just by virtue of using the HOLOLENS due to its SLAM capabilities as well as inside out head tracking. As I also have access to binocular eye tracking capabilities I will be able to implement either of the 3D point projection methods discussed.