

Google Glass for Personalized Augmentations of Data Visualizations

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ABSTRACT

There are occasions when data displays have certain information items which should only be visible to a subset of the display's viewers. This could be classified information, private information, or simply information only of interest to specific viewers. We explore the use of Google Glass as a means to augment the display's visual content with these types of private data, superimposing them seamlessly. The display itself could be a desktop display or a large display wall. We constructed a prototype for the former and discuss three case studies.

Keywords: Google Glass, Visualization, Personal Data.

1 INTRODUCTION

Visualization as a means to gain insight into data has become ubiquitous and many types of data displays are now available. Often these data displays are shared among several people, either within a collaborative data exploration activity or as part of a visual information presentation. In these settings, there can be occasions in which some aspects of the data require security clearances, only held by a subset of the attending viewers. Expressed as visual representations, these might be annotations of the data points, certain links among the data points, and others. For example, given a graph, only group leaders might be allowed to view certain information about the nodes, and the links between them, as opposed to regular participants. Conversely, there might be information only of interest to some of the viewers, while perceived as clutter by others.

Early work by Henrysson [1] described how this private information could be exclusively provided on mobile phones. Wagner et al. [2][3] explored to develop augmented reality applications via a handheld PDA device registered to the display. All these applications required users to position the device by hand similar to a magnifying lens. This arguably took some effort. It also was not entirely private since bystanders could read the PDA display as well.

Google Glass is a relative newcomer on the scene and it has none of these drawbacks. Its small, embedded display is tightly linked to the viewer's gaze and close to his or her pupil. The display has real-time update rates, offering users personalized data visualizations while maintaining privacy at the same time. In the following, we describe our Google Glass-based personal-augmented data visualization framework and present some use scenarios. Our prototype currently supports only desktop displays but it could be extended to display walls as well.

2 DESCRIBING THE SYSTEM

The Glass is connected to the computer hosting the display and has access to the visualization image. This enables it to compute

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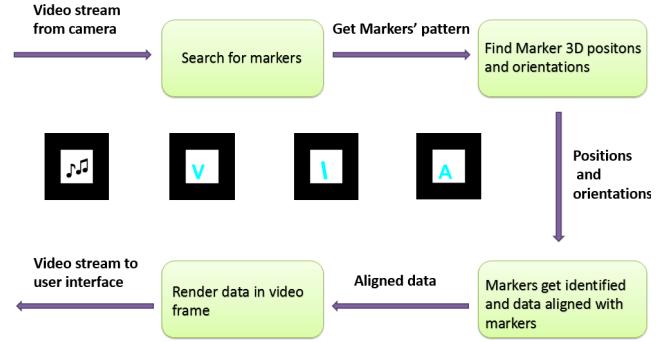


Figure 1: Workflow of our framework

the accurate positions of the private augmentations, once the location of the visualization relative to the display is known. For this, it uses a set of markers unobtrusively embedded into the visualization to identify its location and expresses it in camera space. The workflow of our system is as follows (see Fig. 1):

1. The processors on the Glass search through each video frame for the specially designed markers.
2. The Glass uses the coordinates of the markers to compute the position of the on-Glass camera relative to the markers.
3. According to the scale of the recognized markers and the specific design, the private data is aligned with the markers, drawn on top of the video, and output to the user interface.

In Figure 1, the squares in the center are some marker examples we used for initial training. With this procedure, users can see the data overlaid onto the real world through the Glass display.

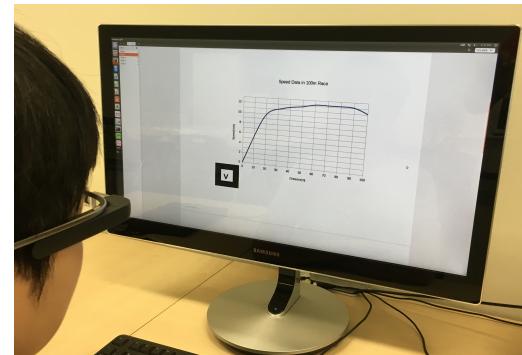


Figure 2: A person wearing Glass and using our system.

2.1 Implementation and setup

We utilized Nyartoolkit for Java, a wrapper of the ARToolKit [4][5]. The ARToolKit is a library of functions that can track markers with recognizable pattern and allows virtual imagery to be superimposed over live video of the real world. Nyartoolkit for Java is often used with augmented reality applications – in our framework, we employ Nyartoolkit to process the live stream from Google Glass's camera.

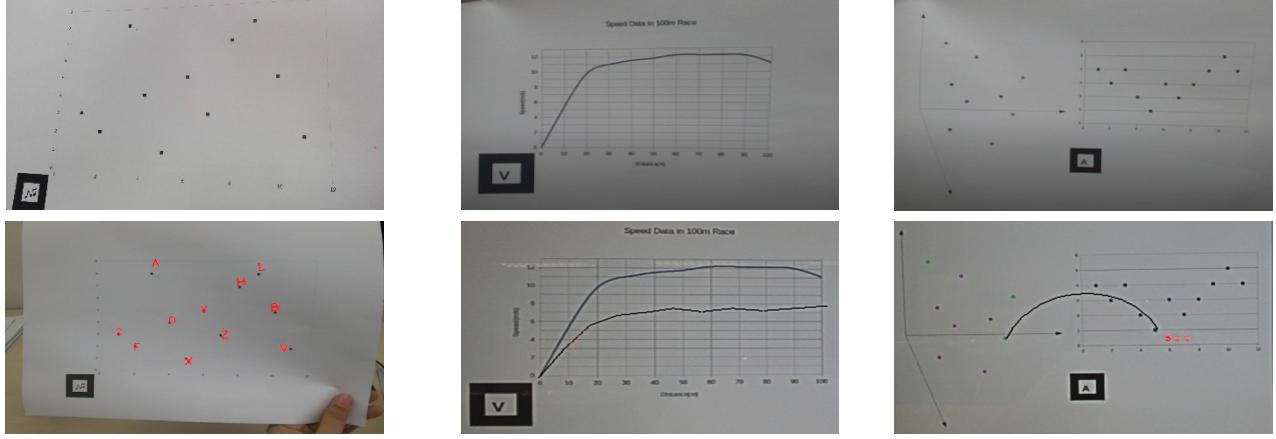


Figure 3: Our three use scenarios. Top row: common display; Bottom Row: display as seen by the user wearing Glass, augmented with private information

Our framework is implemented in Google Studio, the official IDE for Android. We first designed and generated the markers with the recognizable pattern in the online ARToolKit marker generator and added the pattern file into the program code. We tested our framework both with a computer display and print-outs.

3 INTERFACE AND USAGE SCENARIOS

We designed three use scenarios to test and showcase our framework. Fig. 2 shows the most basic setup in which the user wearing the Google glass sits in front of a PC monitor. Other setups may have the user standing in front of a larger, shared display or even a display wall. The on-screen results of our use scenarios are shown in Fig 3. In each of the three columns, the top image shows the original graph and the bottom image represents the private view only the Glass-wearer is experiencing.

The first column pictures a scatterplot printed on paper where each point has hidden attributes and only users with special permission can view them. In the Glass wearer's view, each point's extra information is positioned adjacent to it. A possible real life scenario might be a performance review among sales people in a company, viewing a visualization of two variables, say, number of acquired customers and revenue achieved. Regular employees would only see the distribution (row 1) as a general indicator how the company is doing, while a higher-level manager or supervisor wearing the Glass would see the names or initials of each employee plotted next to the respective data point.

The second column shows a line plot of a certain person's speed data in a 100 m race. Another participant wearing the Google Glass could then privately compare his or her own running data with the posted one without needing to share these (possibly embarrassing) data with the other viewers. Likewise, an employee of the company in the example above (wearing the Glass) might see his or her point annotated but not those of others.

The third column is an application example which has two graphs – two scatter plots of different variables where the points in the two graphs refer to the same group of people. A specific user wearing the Glass could then see only his or her own data being marked and connected, but not that of others.

4 CONCLUSION AND FUTURE WORK

We have described a framework that empowers people to view personal, private, or classified data through a casual head-mounted augmented reality device such as the Google Glass. We

validated the functionality and applicability of our system with three use cases. There are clearly many more such use scenarios.

One limitation of our Glass-based framework (and probably other similar applications) is that it works only if the user is within a short distance from the markers. If he or she is further away, we found that it will be difficult for the system to recognize the markers and consequently it fails to show the expected information or puts into the wrong place. Another problem is that computational power is limited on the Google Glass. Since the computational load for the video stream processing is heavy, the generated heat can cause the processor to stop working for a few seconds. This leads to loss of immersion.

Next, we plan to optimize the system to make the tracking faster and work more robustly. We also plan to conduct a user study to test the system's ease of use and efficiency in practice. New directions, such as aligning the whole view in the screen, and not only the markers, with the real word will also be explored.

We also plan to port our system to a large display wall. This will require tracking of the Glass and the wearer's head orientation and gaze. All this can be achieved by using a camera-based system such as OptiTrack (<https://www.optitrack.com>) and markers attached to the Glass. Alternatively, one could use the Glass camera to sense special or natural markers in the viewed visualization and so gain location information for placing the private annotations. Our initial experiments revealed that cameras can be a much faster and more accurate way to achieve this goal.

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