Using Eye-Tracking for Enhancing the Museum Visit Experience

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ABSTRACT
A smart context-aware mobile guide may provide the visitor with personalized relevant information from the vast amount of content available at the museum, adapted for his or her personal needs. Earlier studies relied on using sensors for location-awareness and interest detection. This work explores the potential of mobile eye-tracking and vision technology in enhancing the museum visit experience. We report here on satisfactory preliminary results from examining the performance of a mobile eye tracker in a realistic setting.

CCS Concepts
• **Human-centered computing → Interaction techniques → Pointing.**

Keywords
Mobile guide; Mobile eye tracking; Personalized information; Smart environment; Context aware service.

1. INTRODUCTION
With the progress of technology and the spread of handheld devices, many systems were developed to support the museum visitor and enhance the museum visit experience. The purpose of such systems was to encourage the visitors to use devices that provide multimedia content rather than use guide books, and as a consequence focus of the exhibits instead of flipping through pages in a guide book, as surveyed in [1]. A key challenge in using mobile technology for supporting museum visitors' is figuring out what visitors are interested in. This may be achieved by tracking where the visitors are and the time they spend there [5]. A more challenging aspect is finding out what exactly they are looking at [3]. In recent years, eye tracking and image matching technology have reached a reliable degree of maturity that can be used for identifying what the user is looking at [4]. This work aims at exploring the potential of mobile eye tracking technology in enhancing the museum visit experience by integrating this technology into a mobile museum visitors' guide, so to enable the use of machine vision for identifying visitors' position and object of interest, as a trigger for personalized information delivery.

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2. PREMINIARY RESULTS
We try to answer the question: **How can the use of mobile eye tracker enhance the museum visit experience?** For that we will design and develop a system that runs on handheld device and uses Pupil eye tracker for identifying objects of interest, and following [2] delivering multimedia content museum visitors [4]. But first, it was important to examine the performance of the mobile eye tracker in realistic setting. For that, we have conducted several small-scale user studies onsite.

Figure 1. The finger points where the participant is asked to look at. The green circle is a fixation point.

1.1 User study 1: Looking at a grid cells
Five students from the University of Haifa, without any visual disabilities participated in this study, they were asked to look at wall-mounted grid of 20*20 cm cells, from a distance of two meters and track a finger (fig 1). On every cell that the finger pointed at, they were asked to look at for approximately three seconds. Data was collected for determining the measurement accuracy. On average, fixation detection rate was ~80% (most missed fixations were in the edges/corners – see table 1).

Table 1. Experiment details.

Cell #	6	18	19	23	24
Missed	5	5	3	5	5

During the study we ran into several practical problems. The Pupil Dev eye tracker that we are using is not fitted for every person. It consists of two cameras, the first for delivering the scene and the second directed to the right eye for detecting fixations. In some cases when the device is not fitted correctly, the vision range got smaller and parts of the pupil got out from the capture frame (fig 2). As a consequence no fixations were detected. Another limitation was that when using the eye tracker with tall participants, they have to step back from the object which negatively affects the accuracy.

User study 2: Looking at an exhibit
In this study we examined the accuracy of the eye tracker in a realistic setting. One participant (1.79m tall) was asked to look at exhibits at the Hecht museum. Several exhibits where chosen with different factors and constraints (fig. 3 and 4). The main constraint in this case is the distance from the exhibit since the visual range

gets larger when the distance grows, and mainly we have to cover all the objects that we are interested in. Table 2 presents the objects height from the floor and the distance of the participant from the object. The next step was to examine fixations accuracy after making sure that the participant is standing in a proper distance. The participant was asked to look at different points in the exhibit/scene. In the gallery exhibits, the scan path has been set to be the four corners of the picture and finally the center of it. Regarding the vitrine exhibits, for each jug one point at the center has been defined. It's important to note that the heights/distances relation is for visual range (having the objects in the frame of the camera) and not for fixations detections. Since missed fixations could be as a result of a set of constraints and not the distance from the object, thing that we have not examined yet.

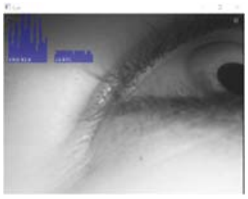

Figure 2. An eye image.

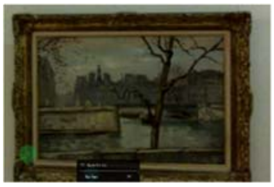

Figure 3. Gallery exhibition.

Figure 4. Vitrine backlighted exhibition.

Table 2. Experiment details (cm) – top left shelf in fig. 4.

Exhibit	Width	Height	Height from floor	Distance)
Vitrine shelf	80	25	150	150
	80	15	120	230
	80	20	90	310
	80	15	40	390
Gallery	60	67	150	200

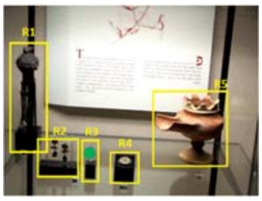

Figure 5. The yellow rectangles are the regions around each object. The green point is the fixation point.

Figure 6. Harsh light conditions and low-height (left). Object too big to fit in one frame (right).

1.2 User study 3: Image based positioning

When a visitor enters a museum, s/he may walk around or stand and look at an exhibit. We have to distinguish between these two cases. To recognize the event of looking at an exhibit, we set a time interval (three seconds) of looking at a scene. We use this as a trigger for starting a matching process, comparing the scene camera frame with a set of existing position-representing images. The matching procedure yields a set of scores and the image with the highest score is selected as the visitor's position. During the study, a person walked in the museum and looked at exhibits. When he looked stably at an exhibit for about three seconds, the matching process started, and the position identified. After applying mapping transformation on the fixation point, we got the object of interest (fig 5). On average, the process took two seconds.

3. CONCLUSION AND FUTURE WORK

We conducted these small-scale user studies in order to gain initial first-hand experience with the eye-tracker in a realistic setting. Furthermore, we tried to clarify which exhibits are appropriate to be included in our future study and, given the limitation of the device, what portion of the museum exhibits may be included in general. Not surprisingly, we got 100% accuracy rate when we examined the device in the art wing since all the pictures are placed in ideal height. Regarding the archeological wing, it is considerably more challenging, since objects are placed in different heights and have unequal sizes. As a result the visitor may have to stand far away from the objects in order to get them into the mobile eye-tracker front camera frame, a fact that can negatively affect the visit experience. In the case of archeological wing we approximate that about 60% of the exhibits may be detectable with the current device. Regarding the low-height exhibits we don't know yet whether they can be considered or not. More challenging exhibits are these that are placed in harsh light conditions or placed in low height (fig 6 left) and/or these that are too large to fit in one frame (fig 6 right).

The next step in the study is to design and build a museum mobile guide that extends the use of mobile eye tracking as a tool for identifying the visitor position and points of interests. We will use the eye-tracker scene camera captures and the collected gaze data to develop a technique for location-awareness. We will evaluate the system in a user study in a real museum to find out how the use of eye tracker, integrated with a multimedia guide can enhance the museum visit experience. We expect to contribute to the nowadays context aware mobile museum visitor's guide technology.

4. REFERENCES

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