

# An On-line Evaluation System for Optical See-through Augmented Reality

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## Abstract

*This work introduces a technique that allows final users to evaluate and re-calibrate their AR system as frequently as needed. We developed an interactive game as a prototype for such evaluation system and explain how this technique can be implemented to be used in real life.*

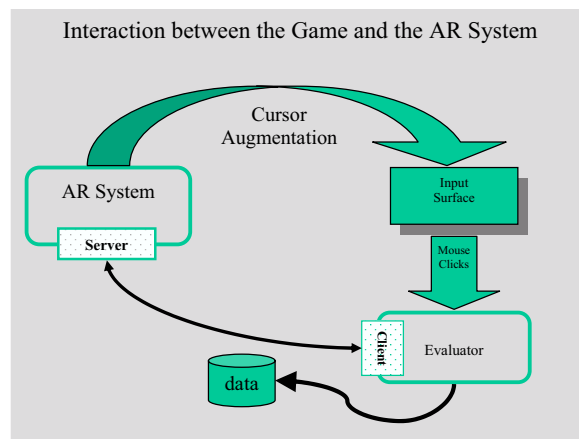
## 1. Evaluation

To address the issue of online, frequent evaluation, it is necessary to build an evaluation system that can be easily integrated into the users usual workflow. In general, the final use of the optical see-through HMD is to augment the user either for cognitive, document related, or for kinesthetic and psycho-motor, interactive workpiece, activities [3]. For example, ARVIKA aims at augmenting the view of the maintenance crew during an operation. In order to make sure that the user does not push the wrong button because of a calibration error, she needs to regularly get feedback on the accuracy of her optical see-through augmentation. There is a need for an additional medium to evaluate this and to communicate it to the user and her AR system. The best medium would be the users' own laptop, PDA or mobile computer. We talk about the user's PDA for simplicity, but it can also be any computer used regularly.

### 1.1 The Evaluation System

A simple, practical and efficient way of evaluating the optical see-through calibration is to augment the user's PDA. For example, the most elementary augmentation is to replace the PDA's mouse pointer with a virtual one. This idea is simple and elegant. The PDA sends the coordinates of the cursor to the AR system instead of displaying it on

the screen. The AR system then projects the cursor onto the optical see-through display. When the user clicks on targets of interest on PDA, the evaluation system compares the cursor's position with the expected one and evaluates the accuracy of the AR system. After a series of interactions the evaluation system can provide the user with quantitative error analysis and could eventually use this information to improve the calibration by adjusting its parameters.



The example implemented aims in particular at evaluating and improving the calibration of the users eye in respect to the displays. Imagine the following scenario: a maintenance person arrives at her working place and puts her optical see-through HMD on, turns on her PDA and checks her e-mails and/or browses the net for news. During this process she can choose to run the evaluation process. In this case, the cursor is the virtual one projected by the AR system. At the end of her usual interaction with her PDA, the system provides quantitative results of her display-eye calibration. This is done by comparing the users virtual clicks with their expected positions. The system compares this

result with previous data of the user's interaction with its different interfaces when working with real cursors. This allow the system to take into account each user's personal interactive abilities and hand-eye coordination.

## 1.2 The Evaluation Game

Video-games are recognized as having the ability to keep one's attention for a large span of time and requiring a large amount of user input. Moreover, they are highly accepted as a source of enjoyment. Our main idea here is to obtain as much input as possible, while keeping the user interested in the process by letting him enjoy playing an AR video-game.

In the simple game we have developed, the user shoots a static or moving target. We have chosen dinosaurs to be the targets, mostly because they are no more around to sue us for the harassment. The user must aim at the dinosaur's eye in order to have a successful hit. We turn off the system's mouse pointer on the client computer and the AR server displays a virtual cursor through the HMD. The target (dinosaur) appears at random locations for both static and moving cases. The evaluation system stores the user's initials, and statistical information such as the number of clicks/target, response time, positions of the virtual mouse and the target for each click.

## 2 Example AR system

We use the system described in [1] for testing our evaluation idea. It consists of an optical see-through HMD with a FireWire camera attached to it and visual markers used for tracking of the HMD. We also had a second set-up where we replaced the old I-glasses with a Nomad Virtual Retinal Display from *Microvision*. These AR systems employ the real-time Hoffman marker detection and decoding described in [2] for tracking and localization of the HMD and were calibrated by either SPAAM [4] or Easy SPAAM [1] methods against a calibration grid with visual markers.

For communication, we defined a simple protocol and used a Client/Server architecture, allowing the evaluation game to be integrated into any AR loop to evaluate the system independent of the calibration method, tracking technology, and/or HMD used by the AR system. One computer acts as an AR server, and is responsible for tracking and displaying the virtual objects. The server unit in our experiment is a Pentium III 750MHz with one GB of RAM. The client unit, a Pentium II 300 MHz laptop, is responsible for playing the game and collecting user's input.

In this experiment, a set of four visual markers positioned on top of the laptop were used to register the AR system to the screen. In order to obtain the best result, the final user needs to use similar markers or beacons as the ones used for the tracking and localization during the final

AR application. Twenty one subjects play-tested the system using the two different HMDs for dynamic and static targets with augmented cursors. The experiment showed that the system is quite practical and easy to use for evaluating optical see-through HMD. Detailed results and related discussions, as well as an in-depth explanation of the system will be presented in our future publications.

## 3 Conclusions and Future Work

We presented a new idea for evaluation and calibration of optical see-through HMD systems that employs the users' laptop or handheld computer to evaluate and re-calibrate the AR system. The final objective is to integrate this process into the user's everyday workflow without forcing her to go through additional processes. In our first step, we created a simple AR video-game which is played on the user's computer, while the cursor is projected by the AR system as an overlay. The next steps of this research could consist in two parts. First, the same concept could be applied for an easy calibration of optical see-through systems. Instead of the virtual/real point alignment for SPAAM or Easy-SPAAM calibration, the user can click on the virtual cursor projected onto her laptop or handheld computer display. Second, instead of playing a game, she can use the virtual cursor to interact with her regular interfaces, while reading e-mails or browsing the Internet. Locations of special buttons could be used for evaluation and re-calibration of the optical see-through AR system. This represents an ambitious and exciting goal, which is however quite practical and reachable.

## 4 Acknowledgments

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