Geometry Education in the Augmented Classroom

Demo Proposal for ISMAR 2002

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Abstract

Current geometry and mathematics education still relies heavily on traditional tools such as pencil and paper to teach complex 3-dimensional geometry. In this demonstration we show an augmented reality based 3D geometry construction environment called the Augmented Classroom. It is intended to be used by high school students and teachers in an interactive, collaborative manner and to blend seamlessly into an everyday classroom situation. Tangible, tool based interaction provides a simple and intuitive user interface. Support for multiple users and spontaneous collaboration encourages team work and simplifies supervision. The system we demonstrate is based on the *Studierstube* platform and integrates mobile augmented reality, collaboration, and a tangible user interface.

Geometry construction in augmented reality

Although at a first glance a software for mathematics and geometry education is similar to a CAD package, its goal is fundamentally different, namely to expose fundamental geometric properties to the user rather than arriving at the target construction as quickly as possible. Our interactive AR geometry construction software promotes and supports exploratory behaviour through dynamic geometry, i.e., all geometric entities can be continuously modified by the user, and dependent entities retain their geometric relationships. For example, moving a point lying on a sphere results in the change of the sphere's radius. All construction steps are carried out via direct manipulation in the physical 3D space around the users. The system currently supports construction of primitives, intersections, normal lines and planes, symmetry operations, Boolean operations and measurements.

Setting

The setup we will show at ISMAR consists of two wearable augmented reality kits composed of back pack computer, stereoscopic see-through head mounted display with camera, and custom pinch gloves for two-handed input. One kit is worn by the tutor; the second one is available for use by participants. Both users can move around freely, since the kits are equipped with battery power for all devices and wireless LAN cards for communication. Furthermore, there will be a small table, serving as a place for collaboration between the two users.

To enhance the classroom situation and for spectators not wearing an augmented reality kit, we provide an overhead projection that can also be used to view 3-dimensional content attached to markers. By moving a marker in front of the projection surface, its contents are shown on the projection.

Fig. 1: Demonstration of the Augmented Classroom at a local high school science fair.

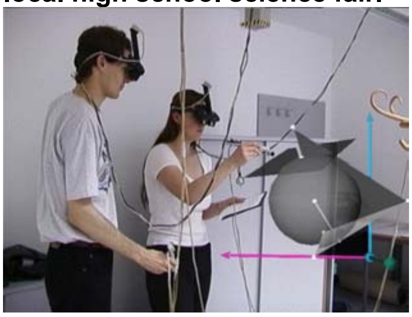

Fig. 2: Two users working on a geometrical construction in collaborative setting.

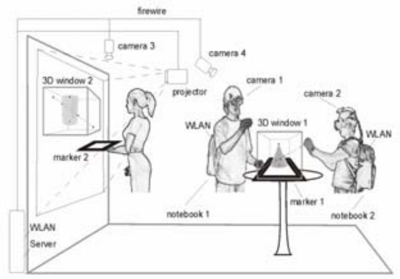

Fig. 3: Schema of the proposed setup. Two users interact with a construction, while a third user inspects a finished model.

Fig. 4: Interacting with models in front of a projection screen.

Studierstube platform

The *Studierstube* platform on which the Augmented Classroom is built brings together advanced augmented reality features in a unique way. A strong distributed shared scene graph infrastructure enables collaboration between independent mobile AR kits. Dynamic loading and sharing of multi-tasked AR applications between several hosts together with support for tool based interaction allow the users to load and share constructions by handling tangible markers, to print a snapshot of their work or to save it to file. The combination of these features into a single system allows the simple development and setup of a complex application like the Augmented Classroom.

Fig. 5: Tracked pinch glove with pressure sensitive thumb for 3D direct manipulation and wrist mounted touch pad for 2D user input.

The story

In the following section, we describe shortly how a demo session at ISMAR could proceed.

Ann, a participant interested in our work arrives at the demo site. Bob, an assistant, helps her with putting on the AR kit and the gloves. Carla, the tutor, is already wearing her kit and waits at the table. Carla hands a marker, that she previously initialized by using a tool marker, to Ann. The marker shows a cone and Ann gets used to the new AR experience by turning the marker around, viewing it from different perspectives. Carla shows her how she can use her hand to grab the tip of the cone and move it around, changing the height of the cone.

Fig. 6: Mobile setup mounted on a pack bag.

In the meantime, David arrives, who is also interested in what is going on. Since at the moment there is no AR kit available, Bob walks to the projection screen and shows him some models that were created by visitors, and explains some details about them. David finds one model, showing the intersection of a cone and a sphere, especially interesting, and so he takes the marker and moves it near the printer. An image of the model, that David will take home as a souvenir, is automatically printed.

Ann already discovered how to create points in the space around the cone, and defines a plane. Carla explains the various conical sections she can create by interactively moving one of the three points defining the plane. Carla saves this configuration for later use by holding a tool marker next to the model.

Fig. 7: Helmet worn by the user with a camera, orientation tracker and HMD.

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