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## Augmented Reality Computer-Aided Drawing (AR-CAD)

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## AUGMENTED REALITY COMPUTER-AIDED DRAWING (AR-CAD)

### THE NEED

Design visualization plays a critical role in achieving an accurate, shared understanding of the design. Conventional 3D visualization applications, which were designed to help designers and engineers to understand easily a complex structure, have limitations in conveying an understanding of complex structures since their models are presented with certain constraints on users' interactions with the design model. Augmented Reality Computer-Aided Drawing (AR CAD) helps users to comprehend a space more effectively by letting users visualize and interface with designs in a more intuitive way. At Purdue University, the prototype AR CAD system is being developed for exploring the benefits of supporting design, and ultimately construction, with various modes of Mixed Reality, going beyond the desktop-monitor-bound interface.

### THE TECHNOLOGY

While Virtual Reality (VR) replaces the entire real world with virtual images, Augmented Reality (AR) superimposes virtual images on the real world. Augmented Reality (a most useful form of Mixed Reality (MR)) is a popular concept for using computers to overlay virtual information onto a view of the real world. In 2000, Phillip Dunston then at the University of Washington in Seattle and his research team presented the initial concept of AR CAD developed for supporting design and construction. The AR CAD concept is the addition of an AR assistant viewer to standard CAD to provide a more intuitive interaction with design models.

The AR CAD tool enables the generation of virtual design spaces that may be used not only by the design function, but also to support the development and execution of construction plans. The experimental prototype can provide the piping detailer with the ability to explore the CAD design in non-immersive (AR) virtual reality modes.

The system consists of the following components (see Figure 1):

- A modeling computer running AutoCAD® or other modeling software
- An AR computer running the Augmented Reality viewing software (the AR interface).
- A head mounted display (HMD) with small camera attached

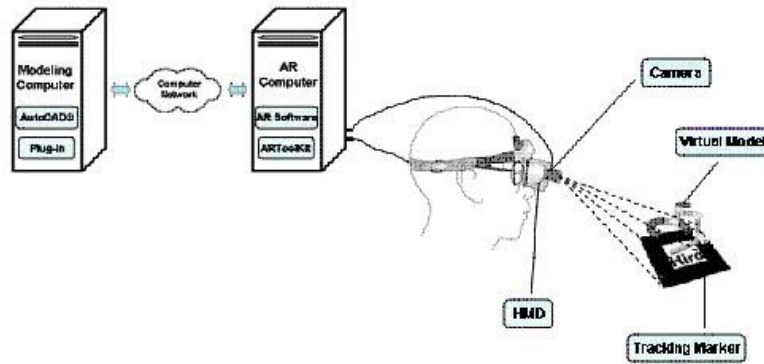


FIGURE 1 COMPONENTS OF THE AR CAD PROTOTYPE

The AR computer runs an augmented reality application that allows a user to see virtual 3D models superimposed over the real world. This application is supported by a software library called ARToolKit, a free Augmented Reality tracking library developed at the Human Interface Technology Laboratory (HIT Lab) at the University of Washington. ARToolKit is a C software library that uses computer vision techniques to precisely overlay virtual models onto the real world. The AR application receives the 3D model information through the network communication and then instantly creates a 3D virtual model of the design.

Also connected to the AR computer is a lightweight HMD with a small video camera attached. The computer performs image processing on the video image from the camera to find specially marked tracking cards. The user's head position, via the camera, can be calculated from a tracking card and a virtual model can then be overlaid on the card. The resultant composite image is fed back into the HMD for the user to see. The outcome is a view of the real world with 3D virtual models inserted for real time interaction (see Figure 2).

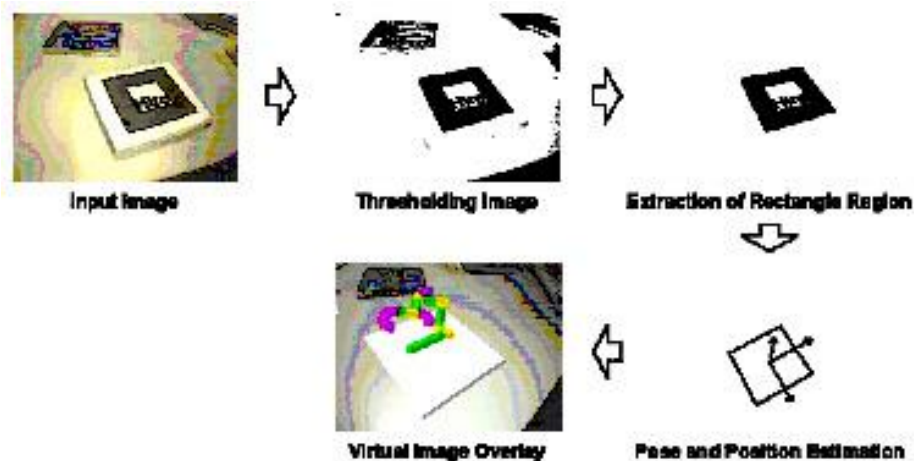


FIGURE 2 THE PROCESS OF VIDEO-BASED MARKER DETECTION AND OVERLAY OF VIRTUAL OBJECTS



This display technique enables the user to easily view the model from any perspective above the card. It is envisioned that the detailer uses the system as follows. The user sits at the modeling computer producing a CAD model of some pipe layout for a new building. Beside the detailer is a tracking card and a lightweight, camera-equipped HMD. Periodically, the detailer may want to inspect a less abstract representation of the model. After clicking an “export-model-to-AR” button in the CAD package, the detailer can look at the card through the HMD and see a 3D version of the CAD model. The detailer can pick up the card and manually manipulate model for a critical inspection. The detailer can also transition to a fully immersive perspective to inspect the design up close and from within. When satisfied, the detailer can remove the HMD and return to modeling.

The main features of the AR CAD prototype are as follows:

- **Automatic Conflict Detection:** The program can automatically detect any conflict or interference appearing among the pipe objects. If there is a conflict, the interfered objects will be highlighted as wire frame elements on the screen rather than the default solid model representation (see Figure 3).

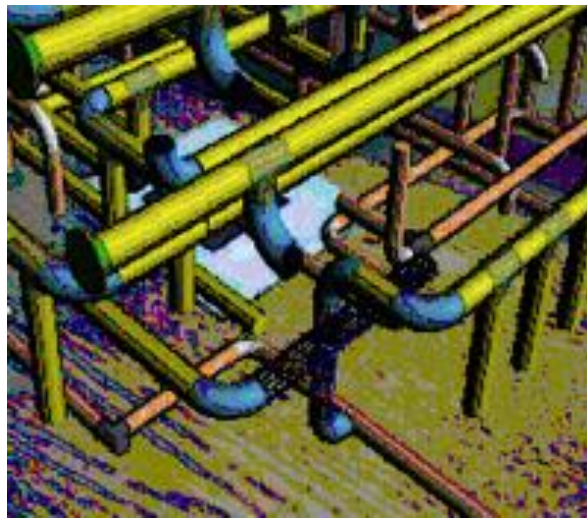


FIGURE 3 WIRE FRAME REPRESENTATION IDENTIFYING OBJECT INTERFERENCES

- **Objects Selection and Manipulation:** If a certain object is selected (activated), the wire frame of it will appear on the scene, which makes the designer easily recognize which object is activated so that the user can use the mouse to move and scale any object activated and also use the keyboard to rotate the object along local x, y, z axes. Brief information describing the selected object is shown as a text string at the bottom of the screen.
- A zooming feature has also been added to the AR module.



## BENEFITS

Potential benefits for the application of AR to the AEC industry include the following:

- Improved Design Comprehension: AR CAD features a more natural mode for changing views of the model and completely understanding the model content.
- Improved efficiency in the individual design detailing function.
- More efficient collaboration for design collaborations where maintaining an accurate shared understanding of the design model is critical.
- Error reduction due to the automatic interference detection.
- The experience of CAD modeling in a real environment context.

## STATUS

AR CAD system is functional, having the features listed above. Another potentially beneficial function under development is a transparency mode. This rendering mode can provide distant objects with a degree of visibility even if the view is obstructed by nearer objects. Also, we are in the midst of adding a fly-in feature that will provide an immersive VR view of the design space. Another important planned development is polygonal data extraction: use ObjectARX SDK to obtain the 3D model geometric information in the format of polygonal data. Thus any standard 3D CAD object can be duplicated and visualized by the AR CAD system, eliminating the current restriction to piping systems.

Based on the AR CAD prototype, Mixed Reality – based collaborative virtual environment (MRCVE) is also under development to realize an intuitive design review collaboration through face-to-face conferencing or virtual space conferencing (see Figure 4).

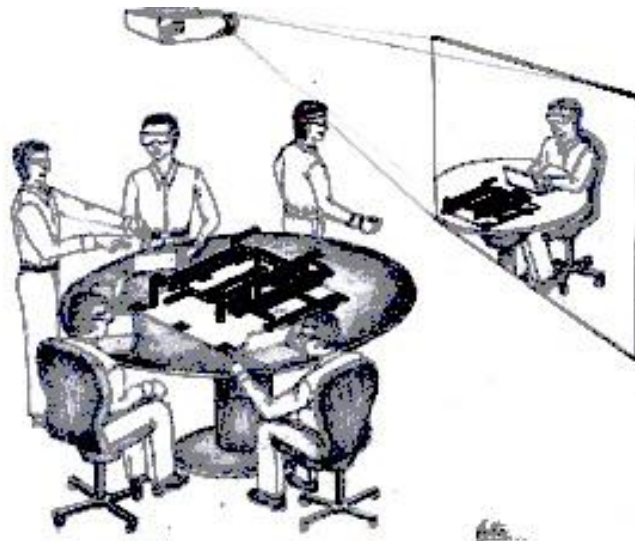


FIGURE 4 ILLUSTRATION OF MRCV SCENARIOS



## **BARRIERS**

The application of the current AR CAD systems developed is limited to piping.

The system requires some special equipment and high performance computer systems.

Quantitative research on benefits is not available.

## **POINTS OF CONTACT**

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