DualCAD: Integrating Augmented Reality with a Desktop GUI and Smartphone Interaction

Alexandre Millette, M.A.Sc., and Michael J. McGuffin, Ph.D.

École de Technologie Supérieure, Montreal, Canada

INTRODUCTION

While Augmented Reality (AR) head-mounted devices (HMD) allow for *quick* control of a 3D virtual scene, they can suffer from ambiguous commands and lack the *precision* offered by traditional GUI interfaces that use a keyboard and a mouse.

Computer-Aided Design (CAD) is one application where both quick and precise controls are desirable.

Past work has greatly explored the possibilities of using either a desktop environment *or* an AR HMD for CAD software, but very little work has tried to join the two. We ask:

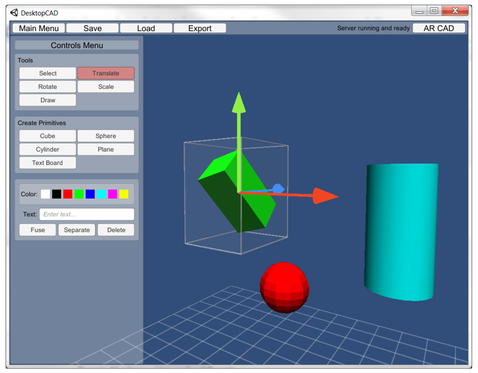
- What would be the gains from joining desktop and AR?
- How can we improve current AR interaction techniques?

BACKGROUND

A mouse is excellent for precise work when only 2 DoF need be controlled at a time, and can be faster than a 3D input device in simple positioning tasks [Bérard 2009, Wang 2011]. However, users sometimes need to quickly sketch geometry in 3D, or reposition/rotate virtual objects with the aid of snapping, in which cases high precision is not required, and having a 3-or-higher DoF device is faster than a mouse [Fuge 2012, Hinckley 1997, Toma 2012]. Ideally, a system should allow both kinds of input.

Fuge et al. [2012] describe a modeling interface that uses hand tracking for "rapid generation and manipulation of ideas", stating "surface representations are [later] exported [...] to a commercial CAD system for further" operations. Again, this motivates a system that can allow for both kinds of input: rough 3D input, and precise 2D input.

Some previous work has used handheld surfaces for AR (e.g., PIP) [7, 8, 13, 43, 44, 50]. Such handheld surfaces can be used to stabilize input from a finger or stylus. Our work leverages and extends this.



OBJECTIVES

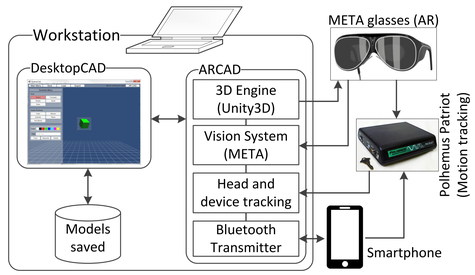
- Explore the combination of CAD software for desktop and for AR by developing the prototype DualCAD, which should :
  - Minimize time and effort required to switch between modes;
  - Leverage advantages of each mode.
- In order to maximize the advantages of the AR mode, investigate, propose and implement new interaction techniques:
  - Using a **smartphone**;
  - Facilitating certain CAD use cases.
- Demonstrate the prototype to domain experts and solicit recommendations.

MATERIALS

A single laptop hosts the entire system, but it can be distributed over multiple machines. We used the META 1 headset as the AR HMD and Unity3D as the rendering engine.

A smartphone was used as the main AR input device since it is widely available, can be tracked in 3 degrees of freedom (DoF) and has a high resolution touch display. The Samsung Galaxy Note 4 was chosen because of its stylus support. The smartphone communicates with the workstation through Bluetooth and is tracked in 6 DoF with the Polhemus Patriot.

The system was built using C#, C++ and Java.



THE PROTOTYPE

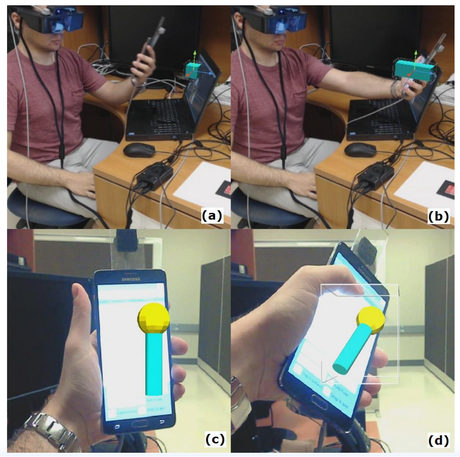
DesktopCAD mode:

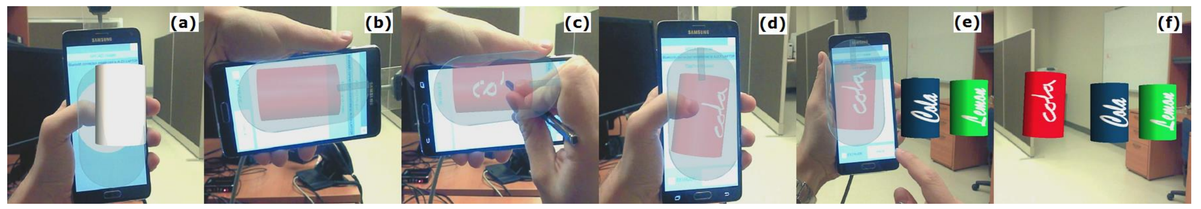
- A traditional GUI interface.
- Can be used to create/translate/rotate/scaling/edit 3D models.

ARCAD mode:

- The 3D models appear in front of the user.
- The user controls the scene through hand gestures and the smartphone.
- Menus and details are displayed on the smartphone's display.
- Gesture-based "Marking Menus" enable eyes-free operation.
- Bimanual interaction techniques:
  - Enter commands with the device and control with other hand;
  - Select objects with one hand and control with the device in the other.
- 6 DoF tracking allows natural translating and rotating at the same time.
- Transformations using the smartphone:
  - Direct contact with virtual objects for a more intuitive control;
  - OR indirect contact for less tiring manipulations.
- Stylus allows editing textures right on the display.

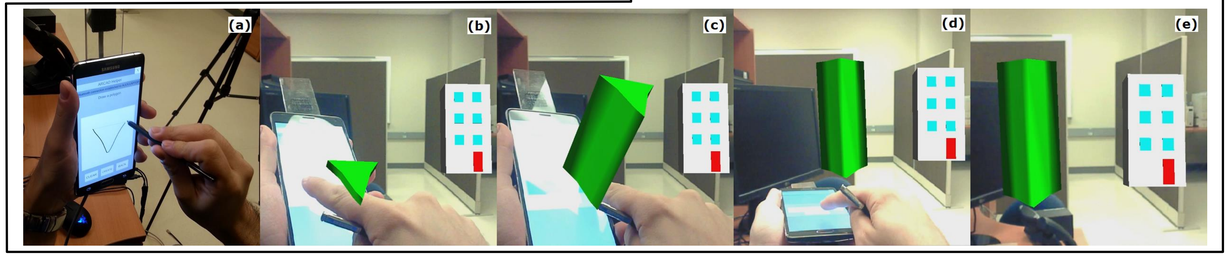
A single click or touch is enough to switch instantly between modes.





Touch-and-Draw: drawing on a screen far away from the object or drawing in midair both feel unnatural. This technique simulates having the object in our hands.

Draw-and-Drop: extrusion is an important operation in modern CAD software. This is the AR equivalent, making use of the stylus and 6 DoF of the smartphone.



NEW INTERACTION TECHNIQUES

Draw-and-Drop:

- Typical CAD use case: modeling complex geometry.
- Step 1: draw a 2D polygon
- Step 2: slide your finger to extrude a prism.
- Step 3: cut and place the object in the scene.
- The prism can later be remodeled.

Touch-and-Draw:

- Typical CAD use case: editing the texture of a complex mesh.
- Step 1: Attach the mesh to the smartphone.
- Step 2: Position the mesh by moving the device or rotate it by sliding your finger on the screen.
- Step 3: Draw with the stylus, as if it were a real object.
- This allows a more natural way of drawing, with haptic feedback.

INFORMAL USER STUDY

5 expert users with 3 to 10 years of experience in CAD and 3D modeling were asked to perform various tasks using DualCAD.

What was noted :

- Complex tasks were done quickly, with minimal explanations;
- Users were especially quick to leverage the 6 DoF provided by the smartphone;
- Some users had a hard time dividing their attention between the virtual scene and the smartphone display;
- Users often tried using unsupported gestures to accomplish the tasks.

Comments from the users :

- ARCAD would shine in tasks of assembly and of visualisation;
- ARCAD is less precise than desired for certain tasks, but this is alleviated by easily switching to DesktopCAD;
- No agreement on whether AR or VR was best suited for CAD tasks;
- Users prefer to be bare handed, yet admit to liking the reliability of the smartphone.

RECOMMENDATIONS

Current HMDs offer poor Field-of-View, but are promising none the less.

Current CAD software would greatly benefit from adding a AR/VR mode to their system.

Although current HMD lack good resolution, it is often better to display critical data in the user's vision, leaving details for the smartphone.

Users enjoy both natural hands-free gestures and precise smartphone-assisted controls: let them choose on the fly.

The system should recognized unsupported gestures in order to guide the user towards the right techniques and offer a learning process.

Parametrize the opacity of the AR HMD, from fully transparent to VR.

Offer natural techniques to accomplish complex assembly tasks in AR, but leave the more precise modeling tasks to the desktop environment.

CONCLUSIONS

We created DualCAD, a prototype CAD system joining traditional desktop interfaces with a state-of-the-art AR environment involving a HMD and a smartphone which allows greater precision and reliability.

We introduced 2 new interaction techniques leveraging the smartphone.

The prototype and techniques were shown to domain experts and their feedback was collected.

We propose several recommendations for future work related to CAD and AR HMD interaction.