

# Adapting to Registration Error in an Intent-Based Augmentation System

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## ABSTRACT

An ongoing research problem in Augmented Reality (AR) is to improve tracking and display technology in order to minimize registration errors. However, registration is not always necessary for users to understand the intent of an augmentation. We discuss how the ideas of communicative intent can be used in AR to ameliorate the effects of registration errors. We have developed a set of AR visualization techniques for augmentations with specific communicative intents that adapt to changing registration errors and demonstrate the use of these techniques.

**KEYWORDS:** Augmented Reality, communicative intent, registration error

## INTRODUCTION

Numerous researchers have demonstrated the potential of Augmented Reality (AR) (the use of see-through head-worn displays to overlay graphics on the physical world) as a user-interface paradigm for various application domains. The key advantage of these systems is that they situate the graphics *in situ* and support hands-free interaction. One significant hurdle that must be crossed when creating AR applications is to register the graphics with objects in the world: to integrate graphics accurately with physical objects, both the user and the objects must be accurately tracked (at least with respect to each other), and the whole system must be accurately calibrated. In some domains, such as medicine, accurate registration is required. However, we believe that in many situations precise registration is not as critical. For example, if a maintenance system (such as the KARMA system [1]) instructs a repairperson to move a lever on a machine, and there is only one such lever in the area being augmented, precise registration may not be necessary.

Thus, registration requirements are not absolute: they depend on the domain, the specific context of use, and the communicative intent of the augmentation. Seligmann and Feiner describe communicative intent as a high-level description of what is to be communicated [3]. They explored communicative intent deeply in the context of the automated design of graphical presentations, and demonstrated their system (IBIS [3]) in an interactive AR domain (the KARMA system). In KARMA, they took

into account the basic differences between AR and static 3D images: user control of the camera and the presence of unchangeable physical objects. However, they designed their system assuming perfect tracking and registration, ignoring the inevitable uncertainty in the system created by imperfect sensors and displays. We believe that, in many cases, it should be possible to use knowledge of the uncertainty of the physical world to design augmentations that a user can understand, even when the registration error arising from this uncertainty is significant.

Our work is based on the observation that humans are good at leveraging contextual cues to interpret ambiguous situations. Consider the previous KARMA example. If the augmentation of the lever is not registered with the physical lever, but there is only one lever and the augmentation is near it, a repairperson should understand that the augmentation refers to the physical lever. Conversely, if there are multiple levers, but the one in question is below a unique feature (such as a button), adding a representation of the button to the augmentation may be enough to allow the human to choose the correct lever.

## THE AIBAS PROJECT

The goal of AIBAS (an *Adaptive Intent-Based Augmentation System*) is to understand how knowledge of the communicative intent of an augmentation can be leveraged to simplify the creation of AR applications that work well in real-world situations with “good enough” tracking and registration. We demonstrate how such knowledge can be used to reduce the impact of registration errors by supporting the programmer in creating augmentations that contain sufficient visual context for a user to understand the intent of the augmentation. Our goal is to empower programmers by providing a conceptual framework and the associated tools to support the creation of augmentations that function in the presence of registration error. Our longer-term goal is to create a toolkit with “AR widgets” that allow a wide variety of AR applications to be built in a straightforward manner.

We have designed visualizations for two style strategies aimed at providing sufficient visual context to allow the user to understand the intent of the augmentation in the

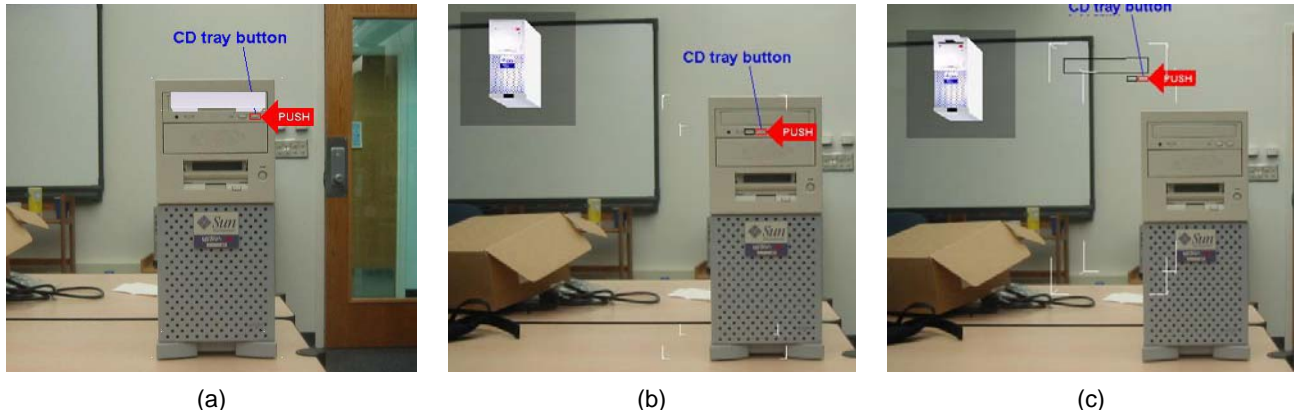


Figure 1: Augment a Scene with Virtual Objects. (a) Perfect registration. The CD tray button on the front of the computer is highlighted, an animated CD tray opens and closes to show what happens when the button is pushed, an arrow points to the button telling the user to "push," and a label identifies the button. The color red is used for the outline and the arrow to draw focus to the CD tray button. (b) Small registration error. The edges of the computer are used to show the relative location of the CD tray button and a feature (an outline of another button) is drawn to give context. The CD tray animation is moved to an inset window so it does not interfere with the other augmentations or the user's perception of the context objects. (The CD tray in the inset is closed.) (c) Moderate registration error. A second feature (the CD tray door) is added to the context. (The CD tray in the inset is open.)

presence of registration error. We assume that the underlying system provides the programmer with a continuous estimate of registration error, using the techniques we have described in our previous work [2]. Both visualizations adapt to the registration error by showing more detail as the error increases.

The first visualization is designed to provide *general visual context* of an augmentation in the physical world, so that a user can understand (roughly) what the intended target of an augmentation is. Our current approach is to highlight features of the parent object, and show more feature detail as the registration error estimate increases. For example, in Figure 1, the corners of the computer are highlighted, making the structure of the computer and the location of the CD button and CD tray apparent.

The second visualization is designed to show the *detailed visual relationships* between an augmentation and nearby objects in the physical world. Our current approach is to highlight a unique collection of objects near the target of the augmentation in the physical world, allowing the user to differentiate between the augmentation target and other parts of the physical world that are similar. For example, the visualization in Figure 1 allows the user to easily distinguish between the CD tray button and the other buttons on the front of the computer by highlighting more nearby objects as the registration error increases.

## CONCLUSION AND FUTURE WORK

We have designed four demonstration prototypes to show how our context strategies can be used to implement

specific communicative goals for a hypothetical set of maintenance tasks on a computer. These examples show our strategies being used to augment hidden objects, unique visible objects, ambiguous visible objects, and a scene with virtual objects (Figure 1.) Each example represents a broad class of augmentations common in AR systems.

Currently our application is working on a desktop, using a static image background and receiving position reports from a simulated tracker that lets us simulate error using a 2D graphical interface. Our next step is to implement these strategies in an HMD with a live tracking system. We will then conduct a set of experiments to test the utility of this approach and of our current visualizations.

## ACKNOWLEDGEMENTS

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