Bringing People and Places Together with Dual Augmentation

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Abstract

This paper describes initial work on the Domisilica project at Georgia Tech. We are exploring the dual augmentation of physical and virtual worlds in Domisilica and applying this novel concept to support home life beyond the boundaries of the actual house. We will demonstrate applications of dual augmentation in supporting distributed communities through a home (the Regency) and a specific appliance (CyberFridge), both of which serve as a communications link between physical and virtual worlds. Three specific types of communication are supported: direct (supporting real-time user-to-user interaction), indirect (interaction mediated by devices such as games, a refrigerator, etc), and peripheral (supporting awareness of subtle information).

Keywords: Augmented reality, augmented virtuality, home, ubiquitous computing

1 Introduction

Physical barriers such as time and distance have traditionally stood in the way of successfully building communities which are not located in a single geographic area. Yet, in today's world, more people live alone, existing communities are becoming more stratified, and new, distributed communities are being created [21]. Examples of geographically dislocated communities are families where children move out to different places, couples who live in different cities, and researchers who work in different institutions but share common interests. Our project, Domisilica [15], provides an infrastructure to support physically distributed communities. Our hypothesis is that by combining and integrating the types of spaces most effective at supporting physical communities (homes, conferences) with spaces which are successful at supporting virtual communities (eg MUDs/MOOs) we will be able to better support distributed communities. MUDs/MOOs are particularly well suited to this integration both because of their history of successful community building (eg the MediaMOO project[6]) and because they use a metaphor of people, places, and things which maps naturally onto real-world places. One project which demonstrates this real/virtual integration is Jupiter [19], which provides home workers with access to a virtual model of their office place. Activity in Jupiter's virtual space is displayed in it's real counterpart, and vice versa. We call this combined augmentation of a physical space and its virtual model *dual augmentation*.

After providing an overview of dual augmentation, its two components (augmented virtuality and augmented reality), and their applicability to community building, we will describe the ways in which spaces and artifacts in them can support casual communities (such as families). Three modes of communication are outlined: direct, indirect (through devices), and peripheral. The CyberFridge project is described to illustrate indirect and peripheral communication through a dually-augmented device. Next, we will describe our initial efforts with dual augmentation in an existing home, the Regency, and examples of how it supports each type of communication. We conclude this paper by discussing our ongoing work to expand dual augmentation throughout the home and between homes in a virtual community.

2 Background

Dual augmentation is a combination of augmented reality [9, 10] and "augmented virtuality". An *augmented virtuality* is a mirror world [11] whose computational state depends in part on some other environment (virtuality or reality). In the past, virtual spaces have been augmented by other virtual spaces [12] and by physical spaces [2, 19], as in the Domisilica project. Most approaches to *augmented reality* enhance the user's perception of and interaction with the physical world in some way, either through visual means [9], or sound [18, 4]. Rather than changing the user's perception of the environment, we augment reality by changing the environment itself. This means either changing the behavior of devices (such as when a light is turned on) or adding computers and displays throughout the environment (an approach inspired by work in ubiquitous computing [26]).

An example of changed behaviors is the Neural Network House [17]. Physical spaces are monitored so that they can be modified for optimal behavior (such as minimize fuel or electricity consumption). There are a variety of mechanisms available for controlling and monitoring the environment. A simple and cheap approach is to use X10[3] to control the power supply to devices combined with repeating IR for more programmable features. A more sophisticated control mechanism is CEBUS [1] , which allows actual programs to sit on physical devices. This is an industry standard that we are working toward as our long-term solution.

The ParcTab/Pad ubiquitous computing project [25] and the PALplates project [16] both demonstrate adding new computing objects to the environment. The idea is to provide access to new services and information "on location". Another approach to this is to bring the interaction into the hands of the user. Two projects which demonstrate physical interfaces are the Tangible Bits work [13] by Ishii, et. al. and the Digital desk [27]. These take the idea of adding displays to the real world to an even more integrated level.

Augmentation has been used to foster collaboration [7, 5] for work environments, but although computer use has been studied in the home [24, 14], very little work has been done in exploring the type of computer-supported conferencing that might be appropriate to non-work settings. One exception to this is MUDs: A variety of casual social groups have grown and been studied ethnographically [23, 8, 20] in these solely virtual environments.

3 Dual Augmentation and Communication

We implement dual augmentation by integrating the real and virtual environments at a very fine-grained level. This involves spreading the communication mechanisms throughout the environment. The idea is to provide little bits of many types of data rather than lots of only a few types of data. The resulting environment should allow users to communicate indirectly through a varied set of interactive devices as well as directly through audio, video, or typing. In addition, it should provide peripheral support for communication, allowing users to be aware of subtle information normally only available to people in the same room as each other.

For example, a friend virtually visiting the kitchen might see that the lights were on, and the residents had done something active recently. Looking further, the visitor might notice that there was a new virtual note on the refrigerator door. After reading it (a shopping list), she would know that the kitchen was out of coke, a fact she could confirm by viewing the contents of the refrigerator (left, Figure 1). Meanwhile, a person in the kitchen might hear speech indicating the arrival of a virtual visitor and announcing who she was followed by a description of her actions viewing the note and opening the refrigerator door. If the visitor created a new note, it would automatically appear on the display attached to the refrigerator door (right, Figure 1). All of these actions are implemented in the CyberFridge project, and they illustrate just a few of the potential avenues for indirect and peripheral communication.

CyberFridge is an example of a dually augmented device. A refrigerator in the real world and it's corresponding model in the MUD have been connected. The MUD's model holds state information about the real refrigerator, and also contains pointers to virtual objects which have no real world counterpart but are related to the refrigerator (such as the notes described above). The real refrigerator updates the MUD when it's state changes (via a daemon) and uses a display to show users virtual information provided by the MUD.

In order to create a dually augmented space, we use the ideas described above in many devices spread throughout a room, and also augment the room itself. This physical space can mediate communication between users in several ways:

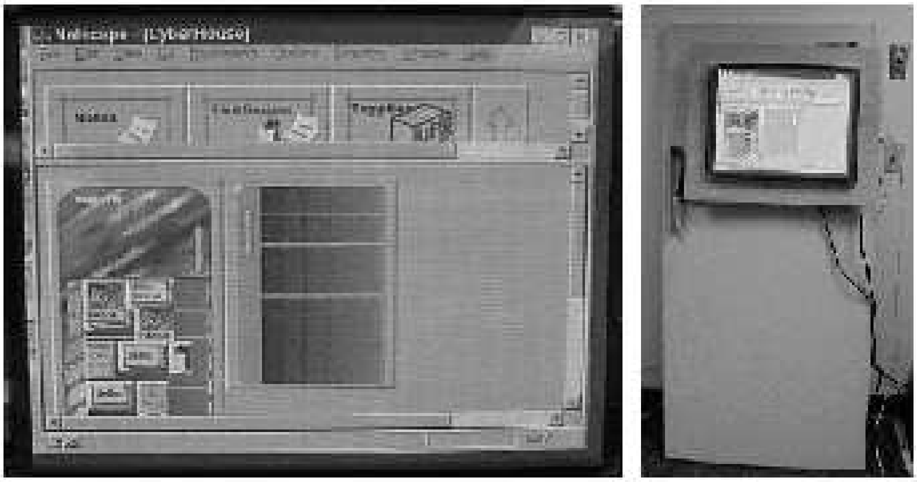

Figure 1: Left: A view of the contents of the refrigerator generated dynamically from the state of it's model in the MUD. This model is kept up to date by a bar-code reading system. Right: A picture of a display mounted on a sample refrigerator door.

- It can serve as a direct conduit, possibly translating between media along the way, such as text to speech.
- It can give users peripheral awareness of each other [22] (eg. by updating a display when a user makes a relevant change, as in CyberFridge).
- It can allow indirect communication through interactive augmented devices such as game boards, lights, VCRs, refrigerators, etc.

These types of connections are equally accessible to both remote users (visiting an augmented virtuality) and local users (in an augmented physical space). In fact, ideally users should not know which type of place other people are in. This is possible because all interactions go through one central model of the spaces involved (a MUD). Figure 2 depicts the relationship between the model, the home, and remote and local users. The users each are in different spaces, but using techniques of dual augmentation, the system may map aspects of those spaces onto each other with the help of the MUD.

4 The Regency

The Regency (the home of one of the authors of this paper) extends the ideas demonstrated by CyberFridge to the devices and rooms of a whole house. The Regency started out as a home-automation project, and those aspects of the system are in daily use. We extended this initial system by connecting it to the MUD in order to support dual augmentation. This is done by sending information about state changes to the MUD in order to maintain a consistent virtual model, and displaying information provided by the MUD in the home.

The Regency demonstrates each of the three communication mechanisms described above (direct, indirect, and peripheral). For example, the system will generate messages announcing the presence of remote visitors and speak in audio anything they "say" (type). In this example, the system is acting as a direct conduit between users. An example of how the system supports peripheral awareness is its way of indicating the level of idleness in a room: it flickers the lights like a brown-out as a warning that it may turn them off (since the room is not being used). Indirect communication is supported through notes left on the refrigerator door [1] and through a system for delivering high-priority e-mail by immediately paging the user via either the house phone network, a personal pager, or computer-generated sounds depending on her location.

In addition to the various augmentations available to a resident in the home (described above), the Regency also supports remote users. Available interfaces depend on the capabilities of the remote user's

[1]This is a feature of the CyberFridge project, and is not currently installed in the Regency home.

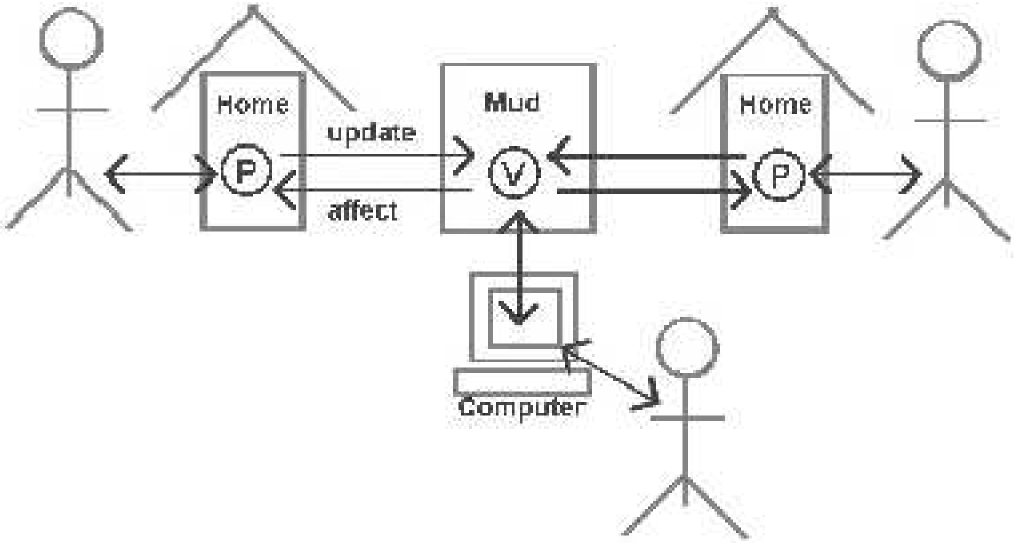

Figure 2: A physical object (P) and its virtual counterpart (V). The virtual object is "augmented" both by Internet information (eg a URL) and by update information about its physical counterpart. The physical object is "augmented" if the virtual object can affect its state. Users can interface either with the physical objects (directly) or with the virtual ones (through a selection of user interfaces).

system, and include a GUI (seen in Figure 1) , audio output, and the standard MUD text-based UI. The MUD can be viewed as a lowest common denominator of communication: information from the home is translated into the mud, and then reconstructed in an appropriate fashion depending on the remote user's choice of interface. This sort of heterogeneous communication (demonstrated in [5]) is uncommon in most collaborative environments.

5 Conclusions and Future Work

In summary, we have discussed how dual augmentation can support a broader range of interactions across an augmented physical and virtual space. Users reap the standard benefits of augmented reality on-location, and can access real-world information not normally available when remote. We have demonstrated a dually augmented device (CyberFridge), and shown how those ideas can be extended into a whole home (the Regency). These projects illustrate an infrastructure to support three main types of communication between users: direct, indirect, and peripheral. The effectiveness of each method of communication (or any combination of methods) is a subject for future study. We are especially interested in experimenting with the ability of very subtle indirect and peripheral interactions to convey a sense of presence.

Although augmenting just one home is a tough problem on it's own, we feel that the most interesting applications arise in a situation when many homes are joined in a virtual village. How does a home better support virtual visitors? Is it possible to mix together two real spaces, so that each participant feels that the other is a visitor in their home? What are the implications of the system's support for monitoring someone else activity both for maintaining a relationship and for privacy? These questions can best be answered by putting the system into use in a real community.

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