Plant Lab: an environmental education e-laboratory

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Abstract. We describe an environmental education e-laboratory that allows various experiments involving sensing and monitoring plants and their environment using communication media commonly available at home. including wireless (WiFi), and mobile telephony devices.

1 Introduction

We all know that plants are living entities with various needs, but even though they are common in many homes, humans tend to take them for granted. It is also true that a typical modern home contains a large number of sophisticated devices and technologies, but they do not usually interact with the plants.

We have designed and tested an enviromental education e-laboratory that allows us to study the effects of computer augmented human-plant interaction to change the perception of people about other living entities. This we do by expanding users concept of plants by giving them access to the communication media common in the modern home (computer, internet, PDA, mobile phone).

An e-laboratory can be local, remote or virtual. A local e-laboratory is a real laboratory that has been enhanced with computer-based technology, sensors and effectors. A remote laboratory can be defined as a laboratory with a real-world presence that allows participation from a remote place. A virtual laboratory can be defined as a computer system that models a place, situation or the like, conductive to experimentation, investigation or observation. In previous work[1-3] we have explored various aspects of remote and virtual laboratories for robotics applications.

Another relevant topic that we have been exploring are tangible interfaces, which involve using real objects to interact in a more natural way with virtual worlds [4, 5]. We have extended this concept to the exploration of computer augmentation of real environments, in particular those involving plants, in order to extend the plants functionality in what can be called real virtuality [5, 6]. From these experiences we have developed a prototype educational environmental e-laboratory that allows users to monitor and control certain aspects of plants, even in a remote fashion through the internet, and thereby develop empathy for plants.

Users interacting with computer generated (virtual) or computer enhanced worlds use interfaces, and so are in reality using metaphors. Metaphors allow users to "connect" actions carried out in the real world with what happens in these applications. Although much of the work in this area has focused in the visual aspect, other important aspects of interfaces should not be neglected. Tangible interfaces have been shown to connect the user to the virtual world [7–9]. In a similar fashion, interfaces that allow users to have contact with plants provide them with a better understanding of the plant's "feelings" and "needs". The changes the soil the where the plant is placed experiences during a certain time are processed and analyzed by a computer program that infers the current status of the plant. This information, when processed according to the embedded model of the plant, can suggest a response or a message to be sent to the user. Thereby the user can also use this model to imagine that he is actually establishing communication with the plants, and thereby establish a bond with them. The user has some control of the plant's status by watering it, medicating it and watching its progress through a web cam. The use of the communication media constitutes a form of augmented reality that can help the user interact with and manage the plant and its environment.The use of the internet allows this to happen remotely. All this is the basis for our first experimental setup, an "e-mail plant", [5, 6].

One important aspect is that one normally has more than one plant at home. It is important to incorporate applications for managing many plants. Managing many virtual reference entities simultaneously can be complicated and therefore must include the interaction between the plants. Plants communicate by chemical messages, but only the plants that are potted in the same soil or that are in the same common area receive these messages. To improve this communication process we have empowered the plants with the means to remotely exchange chemical messages, thus constituting a "plant chat" system. This is basically our second experimental setup[5, 6].

In the following we explain in more detail our experimental setups and how they have been shown to users.

2 e-mail plant

Our first prototype application for the plant e-laboratory is an e-mail plant. A simple sensor is attached to the plant and when it is determined by our program that humidity is too low (the plant needs to be watered), the system sends an e-mail to the user or list of users. In fact, the very first version we exhibited (at X-Teresa, 19 March 2003) was smart planter that included a sensor and a LED, as one can see in figure 1, but no emailing. We then incorporated extra hardware to connect to the computer and allow emailing, as can be seen in figure 2)

The system consists of a humidity sensor embedded in the soil where the plant has been placed, connected to a circuit that discretizes this signal and sends them to a PC through the serial port. From there, a java application sends e-mails to users on a list and attaches a text file describing the status of the plant. Users introduce their e-mail address into the PC application that adds it to the mailing

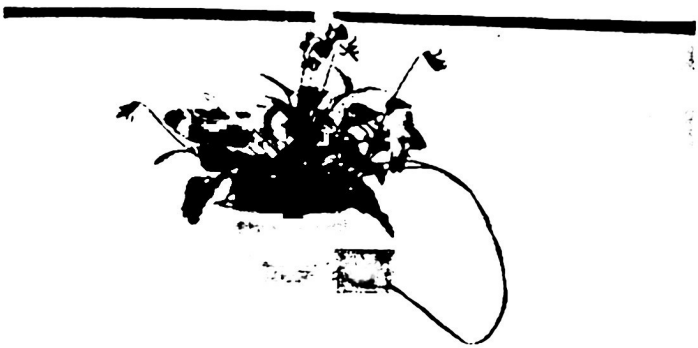

Fig. 1. Smart Planter

list and thus sends messages to every address on it. The system sends one or several messages reminding users that the plants need watering. A simple java application on the screen of the control computer shows the status of the plant as well as to what addresses mail is being sent.

This application was developed using a very simple sensor and a black box that interprets the sensed status of the plant. Different plants require special humidity, minerals and other different factors such as PH levels, so more complex sensors can also be used.The status of these extra variables must be stored in micro-controller memory so the user can adjusr the application for a specific plant.

With this simple application we intend to make the user think that there is actual communication with the plant. The user thus feels empowered to interact with another living entity. Despite the fact that users know that this kind of direct interaction is not possible, they establish the necessary metaphors creating stronger emotional bonds with the plant.

A prototype of this application was exhibited as an art piece at Galera Myto, a trendy art gallery in Mexico City (September 12th, 2003), and in Casa Frisac, a government "house of culture" in Mexico City. (December 3rd, 2003 - January 20th, 2004). For this version, the simple sensing mechanism was deemend sufficient. One interesting aspect of exhibiting in an art gallery was the reaction of people to the piece in this context. The daily interaction of users with e-mail services made the computer's screen used to send the e-mails seem natural to most users. They perceived a flow of "love and care" to and from the plant. This overcame the barriers that computers (and technology in general) still generate in this kind of audience. We have not yet tested the interface with the general public, but we

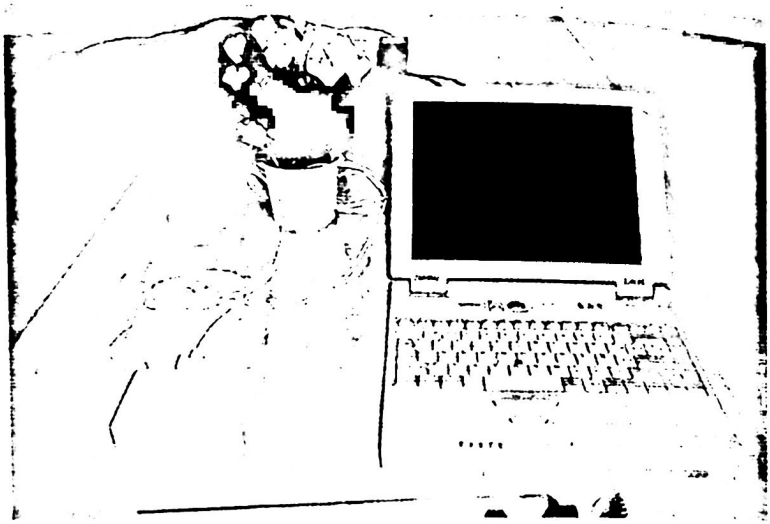

Fig. 2. Email plant

expect a similar reaction since most patrons of the gallery were not technically inclined. In all cases, people were really surprised with the application. People immediately requested us to use their e-mail addresses. They really wanted to see whether they would "really" get e-mail from a plant, although they knew that the mail was not "really" from the plant. Users seemed to react to the virtual affection bond and cared for the status of the plant. More sophisticated viewers that had knowledge of conceptual art reacted intellectually, but everybody reacted by becoming emotionally attached to the plant. From the reactions observed in the galleries, one can conclude that users would probably want to have something like this at home.

A second version of the interface (Figure 3) was produced for an exhibit at The Valenzuela-Klenner gallery in Bogotá (November 21, 2003). Since in this case the plant was to be in Mexico, and the viewers in Bogotá, a web version including a WebCam had to be developed.

The interface is still unobtrusive, although the impact is reduced because the viewer can see the image of a plant, but not the plant itself. Still, users are greatly empowered because the setup can be in a different place than the user. Of course, if you are far from the plant, there must be a way of watering it. Therefore we added a computer controlled water pump (of the type used in water fountains, as shown in figure 4). Now the user can not only know the status of the plant, but actually do something about it. Still, we decided that we could do other interesting things if we had more than one plant. This is described in the next section.

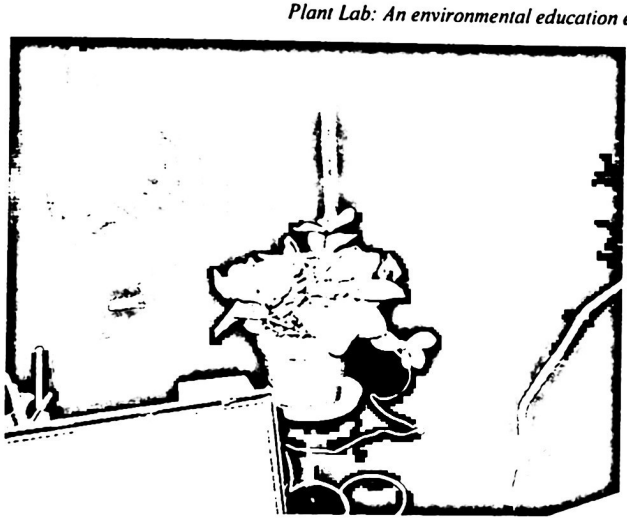

Fig. 3. Web Plant

3 Chatting Plants

It is well known that natural "messages", such as the change of color of a plant, for example, mean that it is dry or something else is wrong. There are many other phenomena that stress plants. Plants communicate with each other trough chemical means. Salicylic acid, for example, can transmit to a neighboring plant the message that all is well. Our second experiment, which we called "Smart Garden" is an interface that inserted in this context explores the relationship of plants amongst themselves, as well as between humans and plants. It can be mounted in a garden or indoors, always with a networked component. A preliminary version can be seen in figure 4.

In this case we sense not only humidity but also acidity (PH) in the soil and by doing this we intercept, decode, transmit (through internet) and reinterpret messages between plants by applying the detected substances remotely. The system can be thus be considered as an "internet chat" between plants, in their own chemical language. The system also translates these messages to humans, either physically present or remote. The user can thus follow the status and "conversation" of the plants, as well as directly control the environment via the computer, via a mobile phone or through a WiFi capable PDA. Although the system has not yet been exhibited in galeries, the videos of the prototype application have been shown at several conferences. The reaction of people is even stronger than that of the email plant. The concept of plants communicating amongst themselves and humans eavesdropping enhances the environmental education aspect of the system. The complete chat applications for PDA and mobile phone are still being worked on.

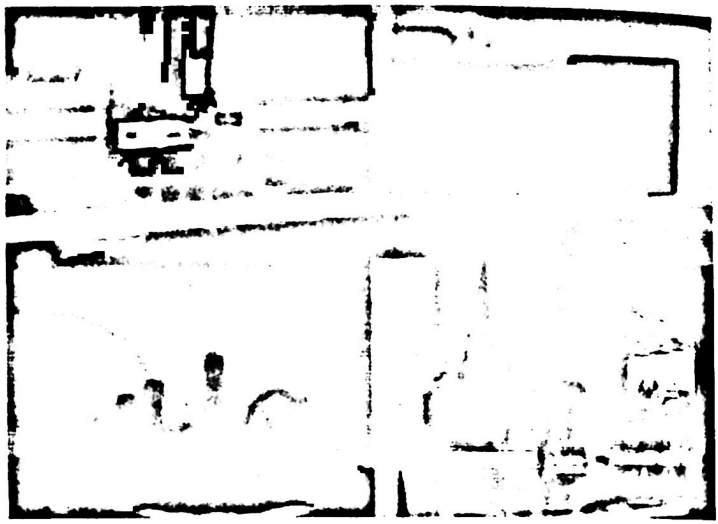

Fig. 4. Chatting Plants

4 Conclusions and future work

In the testing we have performed so far in several venues and with different installations, suspension of disbelief is achieved and plants seem to email them or chat with each other. Users find this to constitute attractive applications they would like to have in their home. it also enables them to change their understanding of plants and their environment, so we think the system can go beyond the stage of art installation or technology demo, and become a full fledged kit for an environmental e-laboratory suitable for a typical home and using the communication media available there (computer, internet, wireless (WiFi) capable PDAs and mobile telephones). This could entail being capable of sensing many other variables of the plant or its environment, as well as developing more effectors, giving the users more precise information and control. Since the system has to be costumized to each plant, a system that would detect the type of plant automatically would be interesting. But, if the intention of the laboratory is to educate people about the fact that plants are living entities that require attention, even the simple sensors and effectors shown achieve this goal.

A first version of the WiFi PDA interface is shown in figure 5 (above). The mobile telephony interface consists of sending SMS messages instead of emails. This has been implemented and the interface using an SMS server is shown in figure 5 (below). For the final implementation we need the cooperation of a mobile phone company.

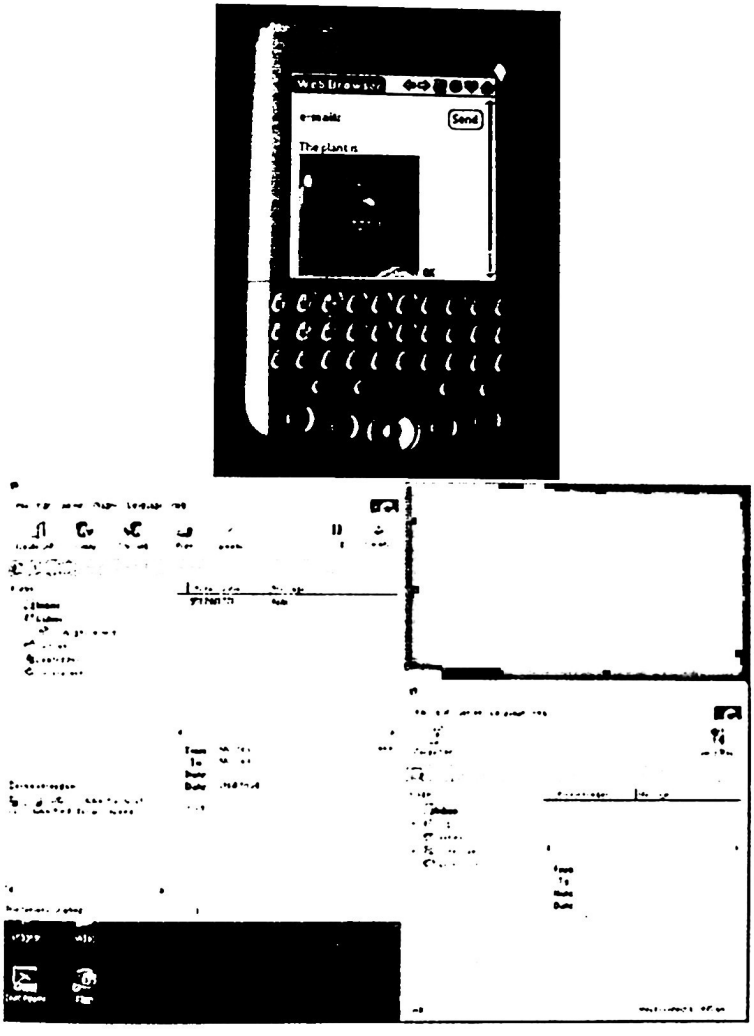

Fig. 5. WiFi PDA Plants (above)and SMS server sending message (below)

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Part III

Data Mining, Qualitative Models