Koubachi: A Mobile Phone Widget to Enable Affective Communication with Indoor Plants

Philipp Bolliger
bolligph@inf.ethz.ch

Benedikt Ostermaier
ostermaier@inf.ethz.ch

Institute for Pervasive Computing
ETH Zurich
Switzerland

ABSTRACT

We introduce *Koubachi*, a system designed to enable interaction between plants and humans. A plant is equipped with several sensors, which are connected to a wireless sensor node. By performing various measurements, the sensor node can determine the current health status of the plant. The user can access this data at all times through a small mobile phone application, a so called mobile widget. In case the node detects a change in the health status, the mobile widget is brought to the foreground in order to get the user's attention. We implement the principles of affective communication [8] to notify the user about the plant's health status since we believe that this special form of information propagation has various benefits compared to non-emotional communication.

1. INTRODUCTION

Taking proper care of indoor plants can be quite demanding. This is due to the fact that different plants have very different requirements regarding the amount of water, light and fertilizer they need. Furthermore, these demands may even change over the seasons. Thus it can necessitate a lot of time and knowledge to take care of an indoor plant. Our own experiences have shown that it is particularly cumbersome to learn about the plant's actual condition, i.e., if it has enough or maybe too much water, or if it needs more light, especially as we can only learn the plant's condition with a considerable time-lag. If the leaves turn brown, it is often too late. Even more so, a common practice to determine the current soil humidity is to actually stick a finger into the soil, certainly not very accurate and not always a pleasant experience. However, the care itself is a very satisfiable activity for most people as it gives the pleasurable feeling of accomplishment. Hence the idea emerged to give indoor plants new abilities to measure their health status and to communicate their needs to humans. In doing so, we want to make use of the fact that most people establish a relationship with their plants while taking care of them. Ideally, a plant should be able to appeal to human emotions in order to call attention. We believe that the simplest yet most effective method to achieve this goal is to use smilies, which are able to express emotions in a very human manner.

We believe that mobile phones are well suited as user interface device for this kind of application. Mainly because they are the most common electronic devices that people voluntarily and constantly carry around. Furthermore, people are used to utilize their phones for communication with other people, using both synchronous voice calls and asynchronous communication techniques like short messages. Our contribution is that we augment this communication paradigm to enable the communication with things, like plants, via the mobile phone.

In this paper we present the monitoring system and the mobile phone widget that is used to display the health status of a plant. We begin by surveying related work in Section 2. In Section 3, we outline the hardware used to build our prototype sensor board and describe the logic to determine the plant's health status. Further, in Section 4 we present the design concept and the interaction model applied to the user interface. In this section, we also describe the widget's implementation and its functionality. We present our conclusions and make an outlook onto future work in Section 5.

2. RELATED WORK

By today, it is almost a matter of common knowledge that personal mobile devices are most prominent components in many ubicomp systems [6, 7]. Moreover, Roduner et al. [10] have just recently shown the strengths of using mobile phones to interact with everyday objects. Since mobile phones are ubiquitous and people are used to check their phone often, for example to see if they received a new text message, we decided to use this platform in order to communicate the plant's condition.

A project with very similar goals is *Botanicalls* [5], which is carried out at New York University. Much like Koubachi, Botanicalls aims at building relationships between plants and humans. However, this project utilizes conventional telephone calls in order to inform humans about the needs of the plants. Although the telephone system is truly ubiquitous and as such a universal communication medium, we believe that answering or making phone calls in order to get information about a plant's current health status can become rather cumbersome and thus impedes building up a positive relationship. Our goal however was to enable a human-plant interaction that *"deliberately influences emotion"* [1], thus creating an affective way of communication with everyday objects.

The question of the right level of computational interpretation has also been raised in the *Vineyard Computing* project [3]. Using ethnographic research methods, the authors found

[1]From the definition of *Affective Computing* by R. Picard[8].

that the users, i.e., the vineyard managers, want to be provided with interpreted information rather than raw sensor data. However, they did not want the system to take action itself. The system should rather present data that suggests a tangible next step, so called *actionable data*. With Koubachi, we pursue a very similar goal. Instead of autonomously watering a plant upon a low soil moisture sensor reading, we provide the user with a simple and self-explanatory image that suggest to water the plant.

3. PLANT MONITORING SYSTEM

The main component of Koubachi is the monitoring system, which allows for the gathering, storage and processing of data that is vital to the plant's condition. In order to acquire a detailed picture of the plant's health status, we currently measure four different variables: the moisture of the plant's soil with a *Decagon EC-5* sensor, the light level using a *Taos TSL252R* sensor as well as the air temperature and humidity with a *Sensirion SHT71*. Figure 1(b) shows the different sensors attached to an actual indoor plant. All of these sensors are connected to a BTnode [4], a wireless sensor node, which allows us to store and process the data and which is able to connect to other devices using Bluetooth. The computation of the plant's health status is conducted autonomously by the node itself, in order to enable spontaneous notifications to different devices and users.

(a) EC-5 soil moisture sensor

(b) Sensors attached to a plant

Figure 1: Plant monitoring system components

We use an approach where the plant's health status is only updated when a critical boundary of one or more sensor values has been exceeded for a specific amount of time. This prevents rapid changes of the visualization and should avoid alarming the user when a suboptimal condition occurs for a short time only, e.g. a temperature drop due to a sudden ventilation of the room. These different parameters can be set individually for each type of plant. For some cases, since we record the data, we are able to indicate a critical situation before it actually happens. For example, we can warn the user that he needs to water the plant in the upcoming hours whenever the recorded soil moisture level shows a characteristic degression. We are also able to detect certain actions conducted by the human, like a watering of the plant. Figure 2 shows the progression of the soil moisture over the course of one week, in which three watering events can be clearly identified.

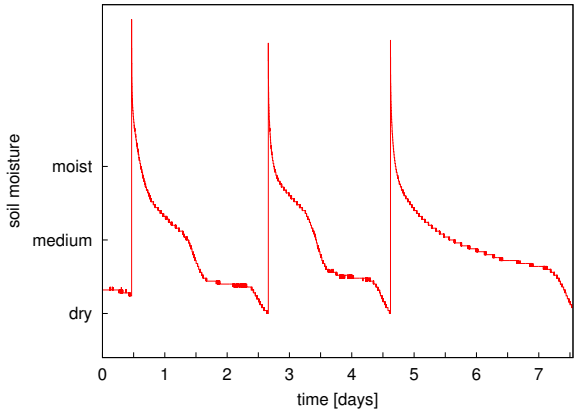


Figure 2: Exemplary progression of the soil moisture

Based on the input values from the sensors, the parameterized demands given by the type of plant that is monitored and the actual time and date, our health function will notify or alarm the user whenever the plant needs to be looked after.

To communicate the health status to the user's mobile phone, we use the BTnode's on-board Bluetooth radio. For example, if the user comes home and wants to check the status of his plants, he can start the Koubachi MIDlet[2] on his mobile phone. He is then presented a list of all his plants. By choosing a plant, he issues a query to the according BTnode, which will subsequently reply with the current status of the plant. Moreover, as the plant monitoring node should be able to autonomously alarm the user whenever a measurement shows a critical level, we store the Bluetooth address of the user's mobile phone on the BTnode. By doing so, we can always initiate a Bluetooth communication from the BTnode to the mobile phone whenever the phone is in range.

4. USER INTERFACE

We utilize affective communication by giving the plants the possibility to express their needs in the manner of *subtle expressivity* [1]. Thus, we aim to support the process of relationship building between plants and humans. We chose to apply this paradigm because of three main benefits: firstly, affective communication is universal for humans and is therefore not constrained by linguistic or cultural boundaries [8]. Secondly, we believe that emotional communication is a very effective means to motivate humans to do something [1] and thirdly, by using emotions, one is able to build up a relationship with his or her communication partner [2].

Although voice calls seem to be a practical technique to communicate with things and may transport emotions, we do not think that they provide a usable solution – because the interface is synchronous, cumbersome and the repetition of messages may start to annoy the user. On the other hand, message-based communication techniques do not seem to provide a feasible user interface. Hence, we decided to use custom visualizations in order to enable plants to express emotions by utilizing the mobile phone of the user.

[2]A MIDlet is a Java program for embedded devices.

4.1 Design Principles

We use the well-known "smiley" in order to visualize the plant's current health status. Such smilies are often used to transport emotions in on-line communication and are therefore well-known amongst users. As they imitate a human face, recognition of the intended message is done by interpreting the facial expression, which is intuitive and not hindered by cultural barriers [9].

(a) Way too hot (b) Too hot (c) Too moist

Figure 3: Smilies showing the plant's health status

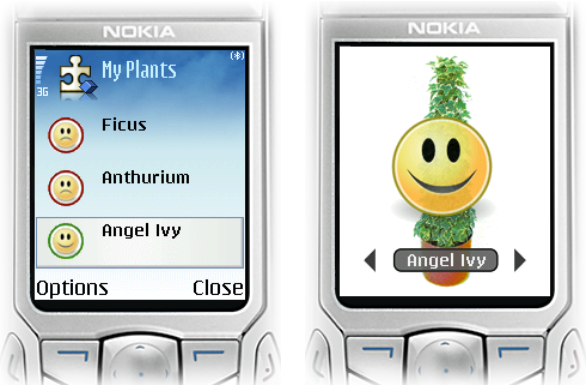
In our system, smilies can have three states: (1) A happy face, indicating that all parameters are within optimal values, (2) a neutral face, indicating that some parameters might pass tolerable values in the future, and (3) a sad face, indicating that one or more parameters of the plant show critical values. Furthermore, to advise the user of the concrete problem of the plant, we give additional visual clues. For example, if the plant has run out of water, the smiley will loll its tongue, whereas if too much water was given to the plant, the smiley will be depicted immersed in water, using a snorkel as shown in Figure 3(c). To further denote the severeness of a specific need, we amplify the smilies' meaning by displaying a three level indicator. Figure 3(a) for example indicates that the plant is in an environment where the temperature is too high. By looking at the thermometer one can tell that the problem is quite severe. The smiley shown in Figure 3(b) on the other hand indicates that the environment is only a little bit too hot. The humorous illustration of the plant's state is intended as we believe it will help to create a relationship between the human and the plant, much like it happened with the famous Tamagotchi[3] toy a few years ago. To make it easier for the user to link the smiley to the actual plant, we do not display the smiley free-standing but draw it on a picture of the plant as illustrated in Figure 4(b). To further increase the level of affection, the user can assign nicknames to his plants.

In order to make looking after the health status of the plant as convenient as possible, we decided to utilize so-called *widgets*, small applications that are continuously running or can be started quickly.

4.2 Interaction

Conventionally, "interaction" between the human and the plant has been the human caretaker providing water and a good environment and the plant responding by exhibiting healthy leaves and flowers. With Koubachi however, we introduce a new approach to human-plant interaction, distinguishing between *plant-initiated interaction* and *human-initiated interaction*. Plant-initiated interaction is always based on the Koubachi widget and starts with the activation of a plant's personal page, i.e., depicting the plant individually in full-screen. This only happens when the status of a plant (happy, neutral or sad) changes. Hence, the user is notified not only when the health status of the plant degrades, but also when it improves, thus avoiding to make a plant-initiated interaction something solely alarming.

By contrast, in human-initiated interaction, the user himself is activating the widget, i.e., he can check the current health status of his plants at any time. Based on information depicted in the widget or on own experience, the human is able to perform the appropriate care of the plants. It is expected that the user learns the needs of his plants with time, thus gradually reducing the number of situations of distress of his plants and therefore the amount of negative feedback from Koubachi.



(a) Overview screen (b) Personal page of a plant

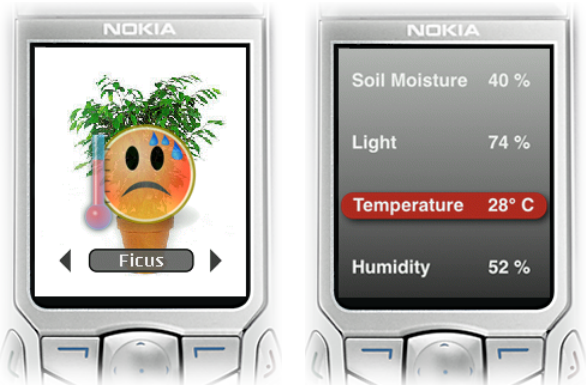
Figure 4: Screenshots of the mobile phone widget

4.3 Widget Implementation

As illustrated in Figures 4(a), 4(b) and 5(b), our widget implementation features three different views: (1) An overview of all plants attached to Koubachi, including their current health status, (2) a *personal page* of a plant, displaying it augmented with a smiley and additional information in full-screen and (3) a *detailed view* of the current sensor readings of a plant. We made the usage of the widget an enjoyable experience by utilizing a simple user interface, including appealing graphics and providing smooth transitions between the views. The widget is expected to run continuously in the background, both to enable plant-initiated interaction and to minimize the time it takes to access the widget.

We chose the concept of personal pages in order to create an emotional form of interaction and to improve usability. By showing each plant by itself, we are able to utilize the entire screen and provide the user a focused view on the subject, thus maximizing the impact of the depicted scene. In addition to that, we display the nickname of the plant below its picture. Personal pages of plants can be cycled through quickly by using the left/right arrow keys. Each personal page has also a "rear side", containing detailed data for the corresponding plant, which can be displayed using either the middle or the down key.

[3]Tamagotchi is a hand-held digital pet that needs to be fed and taken care of or else it will die.



(a) Personal page (b) Detailed sensor data

Figure 5: Front and rear side of a plant's personal page, indicating that the environment is too hot

For user-initiated interaction, the human is presented the overview screen. Here, all of his plants are listed with their nicknames and small smilies indicating their current health status. This way, the user can see the status of all of his plants at a glance. However, to learn about the specific needs of a plant, he can display its personal page since the status of a plant is only indicated by a happy, neutral or sad smiley, without any additional hints. He can do so by selecting the appropriate plant from the list.

For plant-initiated interaction, the widget is automatically activated and shows the personal page of the plant demanding attention the user (Figure 5(a)). If the user is interested in detailed data of the plant, he can instantly switch to the rear side of the personal page, containing the detailed view of this plant (see Figure 5(b)).

5. CONCLUSION AND FUTURE WORK

Building upon the principle of subtle expressivity [1] and using state of the art sensor technology, we developed and built a system that supports taking proper care of indoor plants. By using smilies to communicate the plant's current status, we support a pleasurable plant-human interaction that encourages the user to properly address the needs of his plants. A small hallway test with six people showed that the usage of the mobile phone widget is not only helpful but real fun. All six test persons were able to operate the widget without a word of introduction or explanation. Moreover, all test persons immediately understood the meaning of the smilies and intuitively knew which action to take.

Since the project is still in its early stages, we are currently improving the visualization by gathering feedback from users. Moreover, we plan to build more sensor boards in order to deploy the system to various different plants. Subsequently, we would like to conduct a larger user study to show the benefits of our approach. We are also planning to connect the sensor node to the internet, in order to allow for a true remote monitoring of plants.

6. ACKNOWLEDGMENTS

We would like to thank Christoph Bäni for building the first prototype and creating the artwork. We would also like to thank Marc Langheinrich and Robert Adelmann for their thoughtful reviews and advice.

7. REFERENCES

[1] T. Bickmore and R. Picard. Subtle expressivity by relational agents. In *Proceedings of the CHI 2003 Workshop on Subtle Expressivity for Characters and Robots*, 2003.

[2] C. Breazeal and B. Scassellati. Infant-like social interactions between a robot and a human caretaker. In *Special issue of Adaptive Behavior on Simulation Models of Social Agents*, 2000.

[3] J. Burrell, T. Brooke, and R. Beckwith. Vineyard computing: Sensor networks in agricultural production. *IEEE Pervasive Computing*, 3(1):38–45, January 2004.

[4] J. B. et al. Btnodes - a distributed environment for prototyping ad hoc networks. `http://www.btnode.ethz.ch`.

[5] K. Hartman, K. London, R. Bray, and R. Faludi. Botanicalls: The plants have your number. `http://www.botanicalls.com/`, December 2006.

[6] S. S. Intille. Designing a home of the future. *Pervasive Computing, IEEE*, 1(2):76–82, 2002.

[7] T. Kindberg, J. Barton, J. Morgan, G. Becker, D. Caswell, P. Debaty, G. Gopal, M. Frid, V. Krishnan, H. Morris, J. Schettino, B. Serra, and M. Spasojevic. People, places, things: web presence for the real world. *Mob. Netw. Appl.*, 7(5):365–376, October 2002.

[8] R. W. Picard. *Affective Computing*. MIT Press, 1997.

[9] K. Rivera, N. J. Cooke, and J. A. Bauhs. The effects of emotional icons on remote communication. In *CHI '96: Conference companion on Human factors in computing systems*, pages 99–100, New York, NY, USA, 1996. ACM Press.

[10] C. Roduner, M. Langheinrich, C. Floerkemeier, and B. Schwarzentrub. Operating appliances with mobile phones – strengths and limits of a universal interaction device. In *Proceedings of Pervasive 2007, Toronto, Canada, May 13-16, 2007*, LNCS, Berlin Heidelberg New York, May 2007. Springer.