PlantAid: An ambient display to teach users to recognize house plants visual cues regarding their needs

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ABSTRACT
House plants can bring joy to their owners, but initial investigation showed that younger people can have problems taking care of them. Through mapping plant sensor inputs transmitted to an ambient display we look into how to teach users to recognise needs of plant through visual cues. ÂÍWe explore how shape change and lighting can be used to represent different states of need in plants. We made an evaluation from which we found that shape change is a good way to mediate the state of plants and to make the user feel connected to the interface. From the evaluation we also found that the user had difficulties with the colour mapping, which for further work can be evaluated using longer user tests focusing on learning plant maintenance.

ACM Classification Keywords
H.5.2. User Interfaces

Author Keywords
Ambient Interfaces; Learning; Shape-Changing interfaces;

INTRODUCTION
The majority of people are delighted having access to plants in their environment. Many younger people however, have trouble taking care of their house plants, resulting in them avoiding plants in their homes or only keeping low-care plants such as cacti. Making sure a plant is healthy is influenced by many different variables, such as light, temperature, water, air quality and nutrients - variables that can be confusing to a first time plant carer. By 20 brief semi structured interviews and a subsequent questionnaire we discovered that many young people wishes to keep plants in their home, but have no knowledge of what is required to maintain the health of them. Additionally the interviewees responded that they were interested in learning more about their plants and how to take care of them.

With inspiration from this initial investigation, we looked into how it is possible to teach users to recognise the visual cues that plants naturally show in response to needs. We try to address this problem by mediating the natural cues of the plants through an ambient display. Through exaggerating the plants natural display we seek to teach people to recognise needs such as a lax plant caused by low turgor due to water shortage. In the case of plants, household objects that do not require immediate attention, we try to design according to the calm technology principles such as described in Mark Weiser and John Browns article "The Coming Age of Calm Technology" [6].

In the following section, related work, we will position our work in relation to existing research on ambient interfaces and shape change aswell as existing related products. In the concept section, we introduce our ambient display and elaborate on its purpose. After that we will go more in depth with the different components of the prototype and the technical implementation. This will be followed by an evaluation section explaining the prototype was tested and how the user responded to it, which is reflected on in the evaluation section. After that the discussion section will explain the most interesting findings and suggest explanations and possible solutions to these while the last section will conclude on the project as a whole.

RELATED WORK
The concept of augmenting household plants with monitoring systems is not new, but existing technologies, such as PlantLink and Flower Power [4][2], push their information to the center of the users attention with smartphone notifications. *Instead of various information sources competing against each other for a relatively small amount of real estate on the screen, information is moved off the screen into the physical environment*[7, p. 2] With PlantAid we move away from presenting digital information in GUI's that require the center of the users attention and towards the periphery instead.

Pousman and Stasko specify this by defining the behavioural characteristics of ambient information systems (AIS)[3] to a) Display information that is important but not critical. b) Can move from the periphery to the focus of attention and back again. c) Focus on the tangible; representations in the environment. d) Provide subtle changes to reflect updates in information (should not be distracting). e) Are aesthetically pleasing and environmentally appropriate. The qualities of switching between the center and periphery of attention is similar to the natural qualities of plants. With the thrifty faucet[5], Hemmet et al. was able to trigger a wide range of emotional reactions from the users through using shape-changing and organic user interfaces. They propose that these kinds of emotional reactions can create awareness about situations such as

water consumptions. With ambient displays Xiang et al. introduces the key characteristics of Ambient Intelligent learning environments[1]. They describe how learning in the real world, has various advantages. One advantage is that *learning in the physical real world can increase not only the authenticity of the learning task but also the stimulation of the learner.*[1, p. 2]

We explore how ambient displays can support teaching the users the natural cues of plants, by exaggerating the mediated information. With shape change we furthermore explore the use of triggering emotional reactions to motivate users to care for their plants.

CONCEPT

PlantAid consists of an ambient display and sensor components for each of the users plants. Each of the sensor components detects room temperature and soil moisture level of a plant and transmits the data to the ambient display that shows the data. The sensor can be set to three different states; one for plants that need water often and high temperature, one for plants that need water regularly and normal temperatures and plants that need water sparsely and varying temperature. The sensor component will detect when the plant needs attention and as reaction light up an LED and transmit it to the ambient display. The ambient display is a centralised system to communicate the needs of the plants. The aim of mediating the needs through shape change and light is to make the interface seem alive and thereby invite the user to care for the plant. The ambient display imitates a plant and if a sensor component detects that a plant needs water the ambient display will change shape and colour into a withered plant. In the same way the ambient display will show the signs that real plants show when they get too much water or are placed in a too hot or too cold environment.

When a user buys a plant the he or she will start by looking at the information about the plant and then set the state of the sensor component and put it in soil of the plant and the ambient interface will then be able to mediate the transmitted information. If the user has more plants it will display information about the plants that need attention. The user will then be noticed through the interface and the sensors of the plants in need of attention will light up. If more plants need different ways of care the user will have to look at the plant and decide what is wrong with this plant considering the feedback the ambient display shows.

The goal is to make the user develop awareness in regard to their plants and an understanding of the different needs depending on the plant species. Through this we aim to teach the users to maintain their plants on regular basis and to recognise the natural cues of the plants.

Since the information that is mediated in the ambient display is not critical for the user and neither urgent to the plants, the interface is using the qualities of the ambient display to stay in the periphery of the attention as long the user have more important matters[3] to attend to. The aim of the shape change is to *provide subtle changes to reflect updates in information*

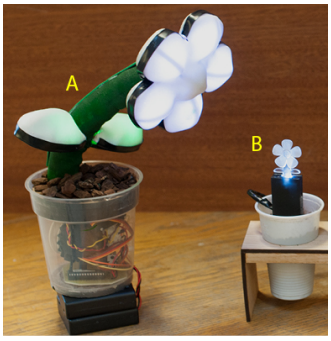


Figure 1: The two parts of the prototype. A) the ambient display and B) the plant sensor component.

as well as motivate the user through emotional triggers[5] to complete the task of maintaining the plants.

THE PROTOTYPE

The prototype consist of two parts - an ambient display and a sensor component to monitor as seen in figure 1. The ambient display imitates a flower that displays information about a plants condition. This information is transmitted from the sensor component that monitors a plants condition regarding to the temperature and the moist level of the soil.

The ambient display

The ambient display can mediate information in two different ways; through shape change and through different colours of light in both the leaves and the flower. The shape-changing stalk is used to communicate if the soil of a plant has an unhealthy moist level. The curve of the stalk changes discretely to reflect how critical state the plant is in [3]. The lights in the leaves illustrate if the moist level is either too high or too low. The temperature is mediated through the light in the flower.

In figure 2 the five states of the leaves along with the orientation changes in the stalk are shown. Figure 2a shows the display if the plant is drowned, where the leaves light up with a bright yellow colour and the stalk is most curved. The figure 2c shows the plant as healthy, the colour of the leaves are white, while the stalk is upright, where 2e shows the driest state of the soil, this is displayed with a bright green colour and the stalk is similar to 2a in its most curved state.

Figure 3 shows three states of the flower's lights. Figure 3a shows the light of the flower when placed too cold, figure 3b shows the display when the temperature is okay, and figure 3c shows the display if the plant is placed too hot. The flower is able to show lighter colours of both blue and red to respectively show the temperatures of lightly cold and hot.

Technical implementation

The ambient display consists of an ATmega8 micro controller which controls a 180 degree servo, an Xbee and two neopixel RBG LED strips. The system is powered with two power sources and two voltage regulators is used to provide the right voltage to the components. Neopixel RGB LEDs were chosen for the leaves and the flower since they have to communicate information with different colours of light. The Neopixels

(a) The soil is way too wet. (b) The soil is a little too wet. (c) The soil is healty. (d) The soil is a little too dry. (e) The soil is too dry.

Figure 2: These five pictures illustrates how the prototype provide feedback through the leaves for the user.

are externally powered to relieve the voltage divider. The ATmega8 micro controller receives the signal transmitted by the sensor through an XBee Module S1. The XBee only takes 3.3v so a voltage regulator is used to input the right amount of voltage.

We achieved the shape change in the stalk through building a skeleton of circle shaped pieces of wood with springs in between making it a spine-like structure. Each joint consists of a pull spring and a push spring so the stalk only can bend in one direction. This is seen in figure 4. Trough this structure we pulled a line that was connected to a 180 servo enforced with laser cutted gears to increase its drag power. With this construction the stalk is able to arch when the pull of the servo increases. When the line is in a relaxed state the stalk should return to its baseline. We, however, had to put an additional elastic band on the back of the stalk because it had problems returning to its initial state.

The tecnical part of the prototype is seen in Appendix in figure 5 and figure 7.

The sensor component

The sensor component monitors the moist level of the soil and the temperature of the room. Also the sensor component transmits the information to the ambient display which then displays it. It also has a LED that lights up if the plant's condition is bad.

Technical implementation

The sensor component consists of an ATmega8 micro controller that controls a temperature sensor, a moist sensor, a LED and an XBee. The system is powered with one power source and two voltage regulators are used to provide the right voltage.

The sensor component is divided into two parts. A part with the moist sensor and an LED that can be placed in the soil and another part with the rest of the components. The moist sensor and LED is put in a little black acrylic box with a little acrylic flower on top lid up by the LED. The rest of the components are stored in a wooden box. This is seen in Appendix in figure 6.

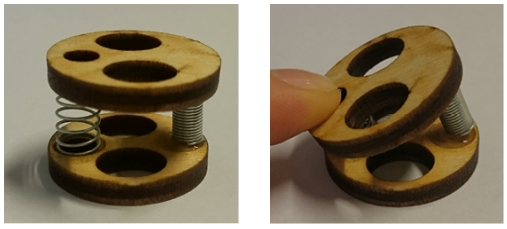
The sensor component measures the temperature and the soil moistness of the plant. This is achieved through a DS1820 Temperature sensor and an YL-69 Soil Moisture Sensor. If the plant is either outside its healthy temperature range or moist level, a LED lights up to signal that the plant needs attention. The XBee transmits the moist level and temperature of the plant to the ambient display.

EVALUATION

The focus of the evaluation was on the users' understanding of the information that the ambient interface mediates. We evaluated the prototype on a user from our target group, a woman age 26 living in a one-person-room in a dormitory, and with little knowledge on how to keep plants. We started the evaluation by explaining to her some basic facts about about plants our prototype is based on, and afterwards challenged her to understand some different scenarios using the ambient display. At times she was asked to elaborate or to answer questions. During the evaluation the user had quite a hard time

(a) A plant is too cold. (b) All plants are good. (c) A plant is too warm.

Figure 3: The ambient displays different colours of the head depending on the temperature of the plants.



(a) Each joint consists of a push spring and a pull spring. (b) The joint when it is squeezed together

Figure 4: One joint of the stalk.

figuring out which colours in the ambient display indicated which state. She understood that the shape change was meant as a mediator for increasingly needing attention. When the leaves and the crown was lit with the white light the user thought it needed to be taken care of. She found it natural for the leaves to be green and a colourful head, and took it as no indication that the flowers needed attention. She understood that the blue colour in the crown indicated the temperature for the plant was too cold and needed to be taken care of. When the leaves at the ambient display turned yellow she knew something was wrong, but to her the yellow colour indicated that the soil was dry, which was the opposite of what was intended to be communicated. When we revealed to her that over watered soil would cause the leaves to turn yellow she instantly recognised the mapping. Our test person easily spotted the three states of shape change in the stalk, but did not map it to the plant soil being too dry. She agreed that shape change was a good mediator for the necessity of attention as a fine indication for how soon the plants needs your attention.

The combination of a single ambient display and a sensor component for each plant to be monitored made sense for her. However she had a hard time figuring out from the ambient display how to handle the situation if two plants needed attention for different reasons. At first her intuition was to pull out one of the affected sensor components and then act upon the feedback provided by the sensor component still transmitting data.

A picture from the evaluation can be seen in Appendix, figure 8.

DISCUSSION

Our test person did not understand our colour pattern because she did not think we was consistent in our choices. We initially chose to map the colour true to the nature. When working with light we faced a problem when we wanted to shine with a dark colour. We were thereby forced to abandon our initial mapping and chose to indicate dry soil with green light. That particular colour was perceived as a healthy plant and caused confusion. Based on these inputs we chose to use different colours for displaying the stages of the leaves; yellow is now indicating too moist soil; green a healthy plant, and a dark purple is mapping too dry soil. We chose to change the colour of the crown as well.

We chose to change the colour for a comfortable temperature to yellow, because of the user not being able to map white to any flower beside snowdrops. Which is neither conflicting with red or blue. Red and blue for temperature indication is not colours representative in plants from natures side but our test person fully understood our intentions and how to act upon the ambient display. Even though our test person had difficulties with the leaves mapping yellow for over watering, she was set on learning the link, as long as it was provable that these colours was the same in nature.

The evaluation shows that there is some difficulty with the mapping between the ambient display and the sensor components if more than one plants need help. The idea behind this problem is that the user would build up his or her collection of plants while having the display and therefore slowly build up a knowledge of how the different plants needed to be maintained. This way the user would know which of the flowers would require maintenance. Letting the ambient display show information for more plants, also enables the users to care for more plants at at once. Instead of attending to one flower, and then afterwards be informed of another plants needs. In the case of two sensor components calling for help, the user would have to figure out which plant would need what kind of care. The user foresaw that she would workaround this by lifting on sensor up and see what the other plant needed of assistance. A solution to this problem would be letting the ambient display schedule, in the case of several plants have different problems, the most critical problem first.

Future Work

Future work could include a more in-depth study on how our ambient display can change the users' habits in maintaining their plants. To do so would require users to bring home the prototype to use it over a time span. This will lead to a deeper understanding of how many of the aspects of PlantAid, such as the shape change and the ambience, will motivate the users and function in the context of everyday use. With the prototype we did not pay attention to saving energy because we wanted to test and debug in the shortest possible time. For the studies ranging over a longer period of time we would be interested in a device not consuming electricity that fast by only transmitting data once a hour or even less.

The colour was also a challenge as to how it can map the temperature and soil moist to colours in a consistent way throughout the product and at the same time map to nature in a way that will teach the users about plants. For future work in relation to this challenge it is also important to examine how the information from more than one plant can be displayed without confusing the user or distort the colour mapping.

In order to make the sensor components smaller and cheaper for the concept to be more realistic, it is relevant to look for cheaper and smaller wireless modules than the XBee that greatly influences the size of the sensor component. This is also an issue for the hygrometer, though this component is easier to hide. Smaller components would add to our concept and to the aesthetics of the product.

CONCLUSION

In this paper we propose PlantAid, an ambient and shape-changing display which teaches younger people to take care of their plants. We evaluated the prototype and found that there are challenges in mapping temperature and soil moistness in a way where it is both consistent and teaches something about nature. We also found that there are technical boundaries in regards to recreating the preferred colour for the mapping with RGB LEDs. The evaluation showed that a lot can be done in this area concerning the representation of aid needed for one or more plants. The evaluation showed that shape change successfully mediated the attention needs of the plant. Furthermore it showed that the user felt an emotional connection to the display. Regarding the learning part we did not succeed in evaluating whether people learn anything from PlantAid. In

future work this could be tested because it is one of the main thoughts about our concept and data are showing people are struggling to learn how to keep them for a longer period of time.

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APPENDIX

Figure 5: All the parts of the prototype.

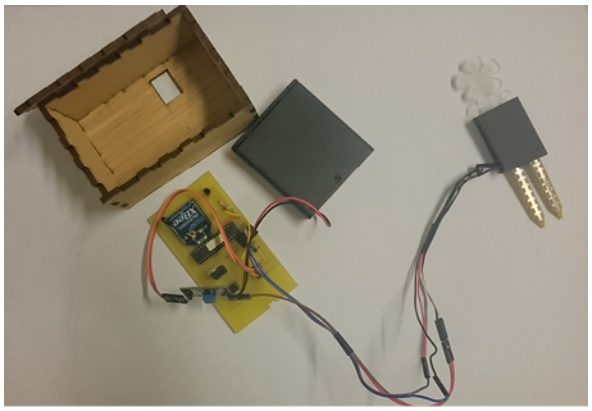

Figure 6: The sensor component with the different parts.

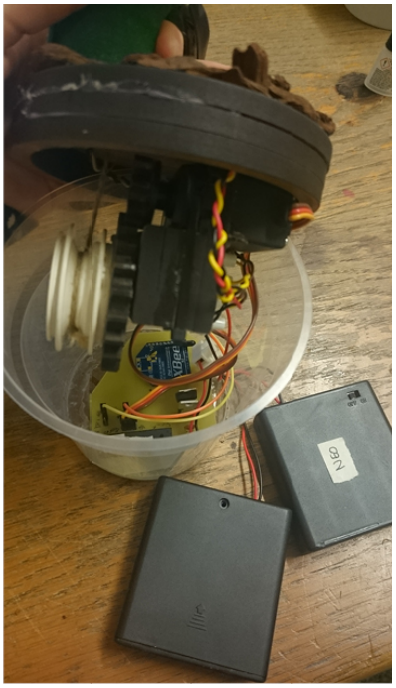

Figure 7: The technical implementation of the ambient display.

Figure 8: The user tries to understand the feedback from the ambient display.