Evaluating the Use of Ambient and Tangible Interaction Approaches for Personal Indoor Climate Preferences

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Abstract
In this paper we describe the preliminary results of a field study which evaluated the use of MiniOrb, a system that employs ambient and tangible interaction mechanisms to allow inhabitants of office environments to report on subjectively perceived office comfort levels. The purpose of this study was to explore the role of ubiquitous computing in the individual control of indoor climate and specifically answer the question to what extent ambient and tangible interaction mechanisms are suited for the task of capturing individual comfort preferences in a non-obtrusive manner. We outline the preliminary results of an in-situ trial of the system.

Author Keywords
Ambient Interface; Tangible Interaction; Indoor Climate; Individual Control; Peripheral Awareness

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation] User interfaces: Input devices and strategies

Introduction
Environmental factors, such as lighting, temperature and humidity are central to the perception of comfort in

Figure 1: MiniOrb interaction device (foreground) and sensor device (background)

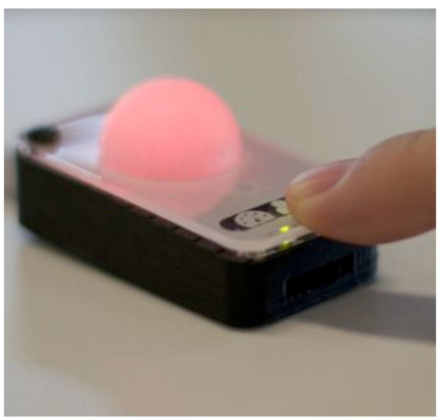

Figure 2: MiniOrb user interaction

office environments. Increasingly these factors are controlled by automated Building Management Systems (BMS). The automatic, sensor-based, adjustment of these comfort factors can potentially affect large numbers of office inhabitants, in particular in open office environments. Generally, centralised systems like BMSs do not account for individual inhabitant's preferences regarding indoor climate and proponents of 'adaptive architecture' argue that buildings should be able to respond to their inhabitants' needs. This 'user-centred' turn in building studies[3] highlights questions around how social relations, lived experience, and people's actual use of buildings play into the experience of indoor climate. There is now recognition that achieving energy efficiency in a building is not an engineering problem alone, but a complex and 'wicked' problem dependant on social-relations and patterns of use between inhabitants in a building [1]. There is also recognition of a need to move away from static, pre-defined and steady state models of comfort in order to achieve more sustainable levels of energy use in buildings [2].

The overall question we are addressing in our research is how to design systems that aid office inhabitants in controlling their localised office environments, as well as support the process of negotiating shared preferences amongst co-located inhabitants. However, affecting change to environmental conditions in shared offices, based on inhabitant preferences, poses a number of significant technical and social integration challenges. As a first step towards addressing these challenges we have focussed on the *personal input and interaction mechanisms* required to engage inhabitants in such a process and studied means of aiding inhabitants to record their personal preferences regarding a range of environmental factors. In this paper we present results of the implementation and initial evaluation of a system that uses a range of different ambient and tangible input and output modalities to display and record subjective office comfort levels.

MiniOrb Platform

We built a sensor and interaction platform consisting of three components: a) a local *Sensor Device* (see Figure 1, background & 6) situated on the users' desks that locally measures temperature, humidity, light levels and noise levels; b) an ambient and tangible interaction device, called *MiniOrb* (see Figure 1, 2 & 5), that displays the locally sensed environmental conditions and allows users to select and submit their preference ratings; and c) a mobile application, *MobiOrb* (see Figure 4), that provides an alternative interface that enables the display of sensed values and the input of user-preferences as precise measurements, rather then displaying them in an ambient manner.

MiniOrb device

The interaction device consists of three small LEDs that indicate different states, a piezo speaker, a button and a scroll-wheel potentiometer for user input, as well as a dome-shaped "orb", a frosted plastic cover which contains a bright RGB-LED. Values are displayed by matching the colour intensity of the orb, i.e. the higher the value the more intense the colour (each sensor category is represented by a different colour, see Figure 3). The device offers users three interaction mechanisms by combining the push button and scroll wheel: 1) *scroll wheel*: when users scroll the wheel they can choose one of the four sensor categories manually, 2) *push button*: this allows users to compare

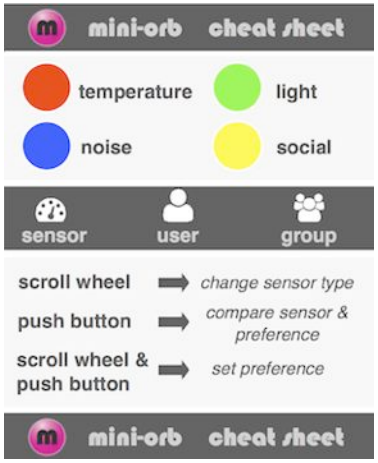

Figure 3: MiniOrb cheat sheet

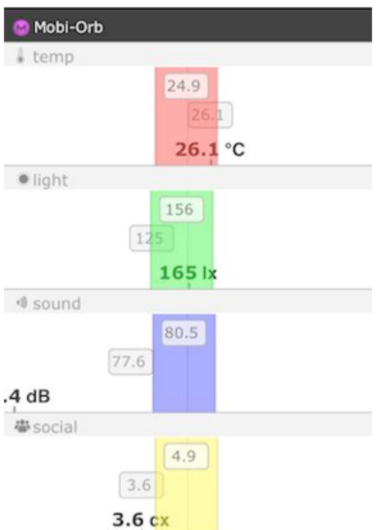

Figure 4: MobiOrb interface

their own preference against the sensed value. 3) *scroll wheel & push button*: this function allows users to enter preference values for any sensor category they selected.

MobiOrb application

The MobiOrb mobile application is an alternative interface that provides the same basic functionality as the MiniOrb device, but employs different interaction mechanisms. The mobile interface allows users to interact with specific sensor values (e.g. Temperature 26.1). Users can move one of four colour-coded sliders, representing different sensor categories, to record their preferences. The preference values are displayed inside the slider. The readings in bold at the bottom of each section show the actual sensor value using a sensor-specific unit. The detached grey bar in the middle of each section depicts the group average value. The mobile interface allows users to more accurately assess and set sensor values, but at the same time does not provide the same ambient accessibility as the MiniOrb devices that are situated on users' desks.

MiniOrb evaluation

The evaluation of the MiniOrb system was conducted through a series of user studies. In the context of this paper we report on the outcomes of a series of semi-structured interviews conducted following a two-week trial of the MiniOrb system. Study participants were recruited amongst the inhabitants of QUT's Science and Engineering Centre (SEC), a multidisciplinary research facility. We selected 12 participants who were co-located in one of the SEC's buildings. At the start of the trial a sensor device and MiniOrb interaction device were installed on each participant's desk. During the second week of the trial participants were offered to use the MobiOrb mobile application in addition to the MiniOrb device on their desk. After the trail completed we conducted a series of semi-structured interviews with 8 participants.

Study results and discussion

The interviews provided a nuanced picture of participants' attitude towards office comfort and their use of the different elements of the system. We will highlight three pertinent issues that warrant further discussion:

"Protest" vs. gradual vote

Due to the fact that the feedback mechanism of the ambient device uses colour intensity to visualise sensor and feedback values, the meaning of each colour intensity was open to interpretation. Our participants used the feedback mechanisms in two significantly different ways: a) to submit *gradual changes* based on the interpreted sensor value to indicate relative shifts in required comfort levels or b) to submit a *radical change* by setting the value to the minimum or maximum setting. The latter approach, here also referred to as a *"protest vote",* was used to express a strong feeling of discomfort and was similar to a yes/no voting approach, while the former approach aimed to provide a reasonably accurate indication of the desired value. Both approaches are valid, however the protest vote was less applicable on the mobile application, since users were able to see the specific value of their preference setting. Our participants reported that once they saw the results of their "protest vote" on their mobile interface they realised that they had set the preference value either very low or very high and that this setting did not reflect their actual preference. However, we believe that both approaches are useful

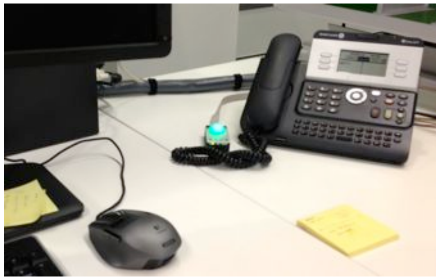

Figure 5: MiniOrb device on user's desk

Figure 6: Sensor on desk partition

and valid in the context of providing feedback on comfort levels and should be supported.

Minimal design trade-off

The minimal design of the interaction device was an important design consideration. The challenge was to build a small device that combined suitable ambient output mechanisms with a small number of tangible interaction mechanisms. The device had to support a suitable range of functionality without burdening the user with too much complexity. Based on the results of the interviews we believe that we overall succeeded in achieving this goal. With regards to its' "ambient quality" the device was perceived as fading into the background and being available when people wanted to interact with it. However, there were signs that not all of the intended functionality was used to the same extent. In particular, the group average reading was only used by a limited number of participants. This fact is possibly related to our choice of functionality that allowed users to compare the feedback value against the sensor value, but not the group average value. However, based on our user feedback we believe that adding further functionality would increase the likelihood that the device would become too complex for some users or require more extensive training. An alternative and potentially better design would be to remove rarely used functionality and represent this functionality on a separate device or interface.

Ambient vs. mobile interaction

It is too early, and beyond the scope of this paper, to conduct a conclusive comparison between the use of the ambient interaction device and the mobile application in the context of our study. However, the results of our interviews indicate that both interfaces fulfilled different and important roles. One of the most important aspects of the interaction device was its ambient nature. The fact that the device was located on people's desk meant that it acted as a constant reminder, which is a central quality when seeking to continuously solicit user input. The mobile device by comparison was appreciated for its straightforward and precise interface, that allowed users to provide specific feedback and understand the range of different sensor categories. Generally, the mobile interface was perceived as an extension that provided additional functionality to the ambient interaction device, rather than as a replacement of the ambient device.

Conclusions

We reported on the preliminary results of a custom-build sensor and interaction platform designed to record personal indoor climate preferences. An important contribution of our approach for ongoing research into understanding people's responses to indoor climate conditions is that it provides a method of recording preferences *in-situ* and *through time* and for encouraging people to reflect on their experience of indoor climate. Our research in this area is ongoing.

References

[1] Jaffari, S.D. and Matthews, B. From occupying to inhabiting – a change in conceptualising comfort. *IOP Conference Series: Earth and Environmental Science 8*, 1 (2009), 1-14.

[2] Shove, E., Chappells, H., Lutzenhiser, L., and Hackett, B. chappels. *Building Research & Information 36*, 4 (2008), 307-311.

[3] Verbeek, P.-P. *What Things Do: Philosophical Reflections on Technology, Agency, and Design.* Pennsylvania State University Press, Pennsylvania, USA, 2005.