What we talk about when we talk about sensors in HCI?

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ABSTRACT

This extended abstract investigates the question: how do we make sense of sensors within HCI and everyday automation? In practical terms, sensors are input devices for computers that can either be triggered by intended human activities, or by any other changes in the environment of the computer. We introduce the term ecological scale from Gibson, to help make sense of the different environmental scales by which humans live and sensors operate. Further, we propose some distinct areas for further research into the application of sensors within HCI and everyday automation.

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1 INTRODUCTION

We know little about the ways in which humans relate to sensors in everyday life. This paper is an investigation into how we humans relate to and understand sensors. What is a sensor? How do we talk about sensors? Does it matter if users are informed about what sensors there are - and what they detect and possibly capture? These are guiding questions that we are interested in exploring here.

The primary contribution of this work is (i) to outline a vocabulary for understanding ways that we do and do not experience and relate to sensors in everyday life (ii) to introduce the term ecological scale to say something about what "humans" experience and what computers can detect and register (iii) point to some areas where critical, thoughtful research is welcomed with respect to the use of sensors.

This paper argues that what is needed is a robust framework for *talking about and understanding how sensors are experienced* and relate this to the HCI field. Indeed, the origin of this work can be traced to the authors own difficulties and challenges in understanding and talking about how sensors are experienced when investigating the domestic use of semi-autonomous moving things equipped with novel sensors.

The remainder of the paper is structured as follows. First, the term sensor is described and defined. Then the ecological scale is introduced as a way to talk about the use of sensors. Finally, we open up and discuss some ideas about future research areas within human-sensor relationships.

2 SENSORS IN HCI

In the Norwegian language, the word "føler" (literally translation: "feeler") has been used to describe a mechanism that detect changes in the environment. An example is for detecting liquid level of water tanks by a "føler". However, this word has gone out of fashion, and is currently replaced by the word "sensor". Interestingly, a censor is something different, but again in the Norwegian language a "censor" is also a "sensor". Censor is derived from Latin, cencere, and means "to appraise, value, judge". And indeed, it feels like some sensors on autonomous computing things are acting as censors today.

A very broad definition of a sensor is: a device that detects some physical quantity from the environment and converts this into a signal that can be received and read by an observer or by an instrument. It is a physical object made for the purpose to detect events and changes in the environment, and then provide a corresponding output. In practical terms, it is an input device for a computer. It is something, a thing, that sense some physical characteristics of the environment.

Within computing and HCI, a sensor is a device that detect physical events and send this information to other computing equipment. It is a technical term that is currently widely used in fields such as ubiquitous computing [7], wearable computing [1], internet of things, AI, machine learning and robotics [5]. A sensor element is the fundamental transduction mechanism that converts one form of energy into another. A sensor is the sensor element including its physical packaging and external connections. And finally, a sensor system consists of sensors and the corresponding signal processing hardware.

The word sensor, etymologically, stems from sentire - to perceive. According to Merriam Webster, the first known use of the word is ca 1928 to describe a device that detects physical characteristics of the environment. The noun sense, understood as the human faculty of perception is much older. The activity of sensing, to sense, understood as "to perceive by the senses" as human activities is something that we are familiar with. Humans make sense of the world, and use the five sense faculties; visual, auditory, olfactory, gustatory and tactile. We humans do not have sensors, but eyes, ears, noses, tongues and bodies with skin.

Practically speaking, what counts as sensors in HCI? A recent article in ACM Interactions introduces and describes the Alphabet Inc´s radar based motion sensor [8]. The radar counts as a type of sensor within HCI, intended to be applied for sensing hand gestures for example. Is the button [3] found on touch screens, physical keyboards and lifts examples of sensors?. The button is realized with sensors, but in everyday language we do not talk or think about a button as a sensor, even though it is a device that senses some change in the environment.

What then about microphones? A microphone is a transducer that converts sound into electrical signals, so by definition it is a sensor. However, in everyday language we do not talk about this technology as a sensor when used as part of telephone systems or music systems. However, when the microphone is applied in order to detect noise level for some reason, in might be described as a sensor. The same goes for cameras, thermometers and IR sensors for detecting human movement.

3 ECOLOGICAL SCALE

Actions, perception and movement of the different organisms take place on what Gibson call the ecological scale [2]. Humans everyday experience can be said to take place on a human scale, with our perceptual visual field, auditory field, tactile field and olfactory field. These fields, with their own scales gives us the conditions for the possibility of experiencing ourselves and the environment. Your auditory field for detecting movement is perhaps constrained by the building you are in, you can hear some walk directly outside your door, but not on the floor below you. Gibson foreground movement of the organism, and state that the perceptual apparatus is very much linked to the mobility of the organism. We are in the process of experiencing our environment from a locational perspective, while continuously moving eyes, the head and other limbs when awake and alive. This is assumed to be at rest when sleeping and of course do not to our knowledge happen when declared dead. The human scale of perception, and hence sensing, of the environment is something that we are familiar with [6]. We are not familiar, most of us, with the ecological scale of a trout or an ant for example, but we can imagine that the actions of these organisms take place on a different ecological scale than the human scale, with different sensing in water and underground than we humans are familiar with.

We share places and environments with things in our homes. In the MECS project, we have shared the domestic place with autonomously moving things that move on their own. The ways in which the autonomously vacuum cleaner navigates and moves back to the charging station is based on the "sensor scale" of the vacuum cleaner and not the human scale. It can detect far better the signal from the base station, something that is not in reach on the human scale, it is simply not possible to perceive by the sensory faculties of us humans. It is difficult for a human to move around in the pitch dark, but of course this can be achieved by training, and by focusing on this task for arranging the environment. Moving adequately in the dark is possible for an autonomous vacuum cleaner with the appropriate sensor scale.

Human scale and the *Sensor scale* might be useful for thinking and talking about sensors within HCI? First, we need to know about the sensor scale of systems, in order to figure out and make sense of what part of the physical environment is detected. Secondly, it is of primordial importance with respect to protecting privacy to know about the sensor scale. For example, the "ultra-wide band sensor scale" enables human activity information to be detected and collected through walls, whereas the GPS sensor scale does only work in a line of sight fashion – albeit over long distances. Thirdly, it is of importance when designing appropriate feedback, to communicate relevant information about the conditions, characteristics and content of the sensing taking place. Lastly, Universal Design could possibly benefit from these concepts. These topics are described below.

3.1 Knowing where sensors are and what they do?

There are more questions than answers on this issue. How to provide the user with information about what physical events that are detected? We suggest that the user at any time can request to get information about what sensors are available, and what physical events that are detected. Secondly, we also would like to see clear instructions on how to control the sensor, i.e. turn it on and off. Lessons learned can be taken from ways that network strengths (sensor scale of the antenna(s)) is represented on mobile telephones visually and auditory – if the sensors (antennas) are black boxed, or hidden from the human scale.

Moving things, "robots" are equipped with sensors for the purpose of facilitating autonomous wayfinding and navigation. Especially when working with domestic moving things, it is important to know about the sensor scale; will it be able to navigate in the dark? Will it detect the small mouse, or the breathing of an infant?

3.2 Sensors and privacy

A condition for the possibility of negotiating privacy [4] is that we know what networked technologies sense in our environment. An explicit sensor scale declaration gives possibilities for the user to find out about, and make decisions about what technologies to bring into the home for example. The example with sensors scale that does work across walls indicate that this is of importance for taking privacy seriously. It will not do to place a system with certain sensory scales out of human scale in all cases.

3.3 Sensors and feedback

The pilot light is often used in order to tell if a key is pressed or not in lifts. This feedback from the sensor state is valuable for the user, for her to make sense of what is going on. For microphones, the red indication when the microphone is active is valuable (and legally required) in some situations, to give the user information about the state of the microphone as on or off. A long forgotten feedback mechanism that was valuable for plain old telephones was the sidetone. The mechanism that made you hear some of the audio picked up by the microphone from the loudspeaker makes the experience of using a fixed phone for many people better than what is the case with mobile phones (where there is no sidetone), especially before the call is placed - but also during tele conversations.

3.4 Sensors and universal design

Sensors have many possibilities for facilitating support for humans. An example is IR sensors that enables humans to visually see different temperatures in the environment, and even things in the dark. To apply the concept of sensor scale for the purpose of working with inclusion by making services universally designed has been important, is important and will continue to be important.

4 CONCLUSIONS

We have introduced the concept of ecological scale from Gibson, and described "human scale" and "sensor scale". This was done in order to get a vocabulary to talk about conditions for possibilities of sensing the environment among humans and contrasting this from sensing of the environment taking place by sensors. We would like to discuss the role of sensors in everyday automation, and possible ways to let user experience control when encountering automated and autonomous systems.

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