Social Context Awareness in Pervasive Computing

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Abstract

Current pervasive computing devices' Achilles heel is the inability to understand social context, which leads to overly complex systems to mitigate the resulting effects or simply fail when encountering new situations and environments.

This paper shows how these devices could be improved and simplified by applying the results of research in the field of social robotics.

Keywords: pervasive computing, context awareness, social robots.

1. Introduction

Mobile devices like cell phones have become a part of our everyday life, yet they don't know how to behave socially because they don't have any information about the social context.

They will ring without inhibition during a classical concert or will remind its owner with beeps of a (in the current situation fully unimportant) task without understanding the current mood of the human.

There are a lot of other examples of devices not sensing contextual information before action. More advanced systems use simple heuristics to improve the conceived quality of service. Unfortunately, things are not as easy as having one or two sensors and determine with this input how to act - screensavers will turn on during presentations (because they measure time of no input to the device), cars will close doors when engines are running (even if the driver is outside).

So a *bit* of context-awareness can harm the cause more than helping it [3].

In an attempt to approach this problem, some researches came up with the idea of central databases where contextual information would be stored [5], others proposed XML schemas to contain description of actions dependent of context [4]. Generally, one tried to increase the number of sensors and heuristics to improve contextual awareness. The down-sides of this strategy are eminent: designers of pervasive computing systems must care about too many kinds of how context should influence behavior. It is not possible for these systems to adapt to new situations[1] and they are prone to error in high noise or chaotic situations.

Explicitly modeling the environment[2] leads to complex systems which can only successfully solve problems in a constrained environment.

Social robots on the other hand are capable of engaging in social contact and can interpret and react to human gestures, mimics and moods. Their constructions are influenced by models of human development, social and physical interaction. Works like [1] and [2] show how it is possible to approximate human interaction (both social and physical) with relatively simple elements. The resulting robots don't suffer disadvantages like conventional context-aware devices described earlier.

Combining these two fields of research would result in more stable and easier to create and maintain pervasive computing devices, which could adapt themselves easily to new situations.

2. A sociable robot

To better illustrate what sociable robots are capable of, it will be shown by the example of *Kismet* [2]. It is a robot showing motivations and reactions comparable to a human baby.

Kismet is capable of conveying intentionality, which is considered to help a human maintaining a natural, intuitive, flexible and robust relationship with a robot. It has a face with eyes, eyebrows, ears, eyelids, lips and a mouth. All of these parts (including the head) are movable and allow Kismet to express emotion and interest.

Like a four-month-old infant is more likely to look at a moving object than a static one, Kismet shows preference for certain simple stimuli.

It imitates the behavior of human infants with the help of three basic feature detectors:

1. Human face finding

[1] Because the modeling of environment is *explicit and thus fixed.*
[2] the classic artificial intelligence approach

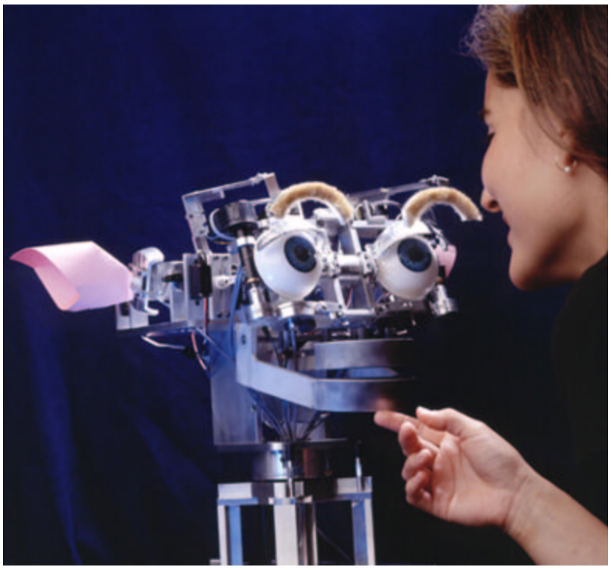

Figure 1: The robot Kismet.

2. Motion detection
3. Color analysis (areas of red, green, blue and yellow)

These basic perceptual inputs are combined with higher level influences. These include:

1. Attention System
2. Perception System
3. Behavior System
4. Motivation System
5. Motor System

2.1. Attention and Perception System

Kismet is equipped with a color stereo vision system. Through the motion detection system, Kismet may turn its head to a location where it detects motion. The weight of the movement can be influenced by the motivational and emotional state of the robot.

Perception stimuli are classified into *social* stimuli (people which move and have faces) and *non-social* stimuli (toys which move and are colorful). They satisfy the drive to be social, respectively to be stimulated by other things in the environment.

2.2. Motivation System

The motivation system consists of *drives* and *emotions*. There are three drives:

social drive need to interact with people

stimulation drive need to be stimulated by toys

fatigue drive need for rest

For each drive, there is a desired operation point. If not stimulated, the drive becomes under-stimulated. Excessive stimulation yields in a over-stimulated drive.

The robot's *emotions* consists of three dimensions:

arousal high, neutral or low

valence positive, neutral or negative

stance open, neutral or closed

2.3. Behavior System

The behavior system is organized into a loosely layered hierarchy as shown in Figure 2. At each level, only one strategy wins in a winner-take-all competition. The outcome then provokes an action in the motor system.

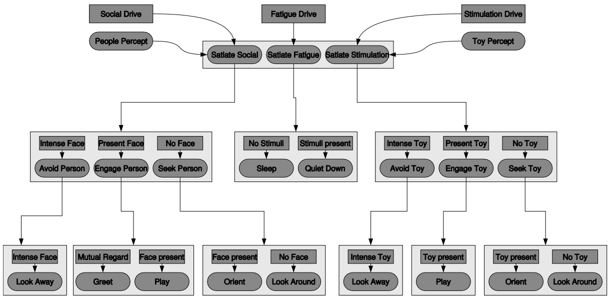

Figure 2: Kismet's behavior hierarchy. Only one behavior in a group is active at any given time.

2.4. Motor System

The motor system receives input both from the emotion system and the behavior system. Corresponding to the current emotional state, face expressions like fear, happiness, interest, sadness, surprise or calm are produced on the face. Other movements include the rotation of the head and movement of the neck and eyes. Kismet is also able to express emotions and drives with a human baby-like voice[3]

Four subsystems characterize the motor system:

1. motor skills system
2. the facial animation system
3. the expressive vocalization system
4. the oculo-motor system

[3] see `www.ai.mit.edu/projects/sociable/expressive-speech.htm` for a description and audio examples.

2.5. Social Responses

Kismet is able to express social responses of four types:

affective changing facial expression in response to stimulus quality and internal state.

exploratory visual search for desired stimuli, maintenance of mutual regard.

protective turn its head away from undesired stimuli.

regulatory biasing the care-giver to provide appropriate level of interaction, habituation to unchanging stimuli, generating behaviors in response to internal motivation.

3. Context awareness and social robots

While pervasive computing designers were apparently not working with scientists from the AI community in the past, it may be time to do so. It is critical to make those little devices as autonomous as possible - it won't be a matter of decades when every person will have wearable computers, head-mounted displays etc. Administrating these devices will just not be possible because of their sheer number.

The question is now how context-aware devices can benefit from the insights discussed above.

It seems that the relationship between a human and his pervasive computing devices could change: If in the past it was believed that computing devices have to do what they are told to, it may well be that in the future the user will engage in a social relationship with the intelligent device.

This kind of social engagement of the user with the device improves potentially the device-user binding and user experience, because communicating with the device will be more natural and intuitive than with common devices. It will also help people focus on their tasks and not on *how* they'll have to tell the device to accomplish them - the device will understand implicit communication and social context. The mobile phone won't ring in the concert anymore (unless it is angry with the user, that is).

4. Conclusion

After showing some problems of current pervasive computing devices, a research work of the MIT AI lab on social robots was presented.

It was showed then how a fusion of those two fields of research could lead to simpler, better maintainable, more autonomous, robust and efficient to use devices with a better user acceptance.

5. References

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