Multiple Data Stream measurement of UX in a work context

Mohit Yadav
Department of Design,
Indian Institute of Technology
Guwahati, India
mohit.yadav@iitg.ac.in

Torkil Clemmensen
Department of IT Management
Copenhagen Business School,
Howitzvej 60 DK-2000
Frederiksberg, Denmark
Tc.itm@cbs.dk

Abstract
In this paper we discuss the emergence of a redefined human work interaction design environment due to Internet of Things. The change in paradigm challenges designers to re-think the category of the user/worker to include their trusted IT devices/cognitive objects while designing for work environment. We present a theoretical proposition to understand the new user (as body, brain + cognitive object), and suggest an approach to capture the UX of the smart workplace. We present and discuss a pilot experiment where we integrate multiple (physiological, behavioral, environmental and IT processes) data-streams of UX in a work setting. This may give a holistic view of UX in the smart workplace.

Keywords
Affective Computing; Extended Mind; UX in Context; Internet of Things; Cognitive Objects

Introduction
In the near future, we will design our workplaces within highly ubiquitous and pervasive [13] and context aware [12] computing environments, hereafter called Internet of things (IoT) environments. This paper aims to identify novel techniques for how interaction design for pervasive and smart workplaces can ensure high quality usability and user experience for workers.

Human Work Interaction Design (HWID)

HWID research as done in IFIP TC 13.6 relates work analysis, design artifacts, and interaction design processes. Applying this framework to an empirical case may involve various analyses.

Work analysis of the organizational usefulness of the future design (analysis of meeting agendas and resumes, consultant reports, organizational content templates and policies, interviews with key individuals in the organization).

Interaction design include analysis of the individual usefulness of the future interaction design by creating conceptual models, that is, explicit ideas about how future users should interact with the new design, as well as ideation of fictive users.

Focus: The relation between work analysis and interaction design.

The motivation for this research is that the emergence of the IoT environment may redefine human work, interaction design, users and user experience. Our position in this paper is that one way to study pervasive and smart workplaces is to design and discuss ways to measure the UX of smart workplace, rather than start only from theoretical discussions.

By work we mean personal work rather than collaborative work practices in organizations, see e.g. [7], and by place we refer to space invested with strong cultural expectations to appropriate behavior, e.g. [8]. By 'smart' workplace we mean the use of personal, trusted computers and smartphones, or what can more general be called 'cognitive objects'. So when we talk about the worker as a user, we refer to the enculturated supersized mind [5], or extended mind [2], that is, the body, brain and trusted/dependent cognitive objects, in a workplace. Finally, the focus of this paper is on ways to capture the UX of the smart workplace. By UX we refer to the ISO standard [6], which gives the definition "a person's perceptions and responses that result from the use or anticipated use of a product, system or service". We replace 'person' with 'extended mind' and put emphasis on the IoT context.

In this paper we discuss a pilot experiment about working in an IoT (Internet of Things) environment. In the experiment we measured multiple data streams: physiological (GSR), Environmental (Sound, Light and Temp) and IT process data (memory usage) which was then imported to a common platform (Noldus) to explore the relations between human work and interaction design in an IoT environment.

Related Work

The extended mind we understand as body, brain plus cognitive objects. Möller, Roalter, and Kranz [9] defined a concept of Cognitive Objects as "physical artifacts embodied in an interaction which include sensors, actuators, communication and computation, to equally support humans and robotic systems in the task execution". These cognitive objects will play a key role in navigating human life in a future IoT environment.

The IoT environment we envisage much along the lines of an environment embedded with 'ambient intelligence'. Sadri [11] did a survey of ambient intelligence, which he defined as: "the vision of a future in which environments support the people inhabiting them. This envisaged environment is unobtrusive, interconnected, adaptable, dynamic, embedded, and intelligent." Furthermore, he looked at "several application areas of ambient intelligence, including the smart home, care of the elderly, healthcare, business and commerce, and leisure and tourism.", and then he "considered the role of affective computing and human emotions in ambient intelligence..." and "... considered different approaches to recognizing and classifying emotions, including self-reports, physiological metrics, seat and hand pressure sensors, and characteristics of speech acts". Forest, Oehme, Yaici, & Verchère-Morice [4] studied ambient intelligence and introduced the need for supporting "psycho-sociological awareness". However, we are not suggesting to measure every emotions in ambient intelligence or IoT environments, rather we suggest to limit the focus to measuring the emotions and more of the extended mind acting in such environments.

Smart Workplace Scenario

The user enters the workspace using her biometric identity.

This is recognized by the office system and the user is greeted with a personalized vocal message.

Based on the preferences the office environment (lights, temperature and sound) adjusts to suit the user's need.

The system recognizes the user and the work station is filled with environment for the users work.

Meanwhile the sensors in the room keep track of the user's movement and action to customize her environment.

As soon as the user keeps her trusted device on the interactive table, the table shows the wellbeing of the device and any other important information about the device for that particular day.

The work starts with holographic meetings and other communications.

The problem with working in IoT environments might be conceptualised as IT mediated interruptions of work. Addas and Pinsonneault [1] developed a "taxonomy of information technology interruptions and presents propositions that relate distinct interruption types and subtypes to individual performance in project environments". The potential negative force of IT disruptions are only enlarged when we focus on the extended mind, i.e., not only aim to protect body and brain, but also aim to protect trusted and relied upon cognitive objects against disruptions from the IoT environment.

Method

In this section we describe a pilot experiment setup which we used to study UX of the worker's extended minds: body, brain and cognitive object (Laptop in the present scenario), in an IoT environment. The primary aim of the setup was to collect various UX data streams: Physiological, Environmental, IT processes and behavioral data and integrate them on single platform for further analysis.

During the experiment the participants were asked to complete a set of tasks (IQ test, typing a mail, interacting with a Segway meeting robot, etc.). As the participants were completing the tasks, the environment was being constantly changed by increasing/decreasing light level, increasing/decreasing sound level and the interruptions by the robots. This was done to observe whether the interruptions in IoT *environment* affected the other data streams. Before the start and at the end of the experiment, the participants were asked to take the UCLA wellbeing test [10] to observe any change in the wellbeing. Each data stream measured during the experiment is described below.

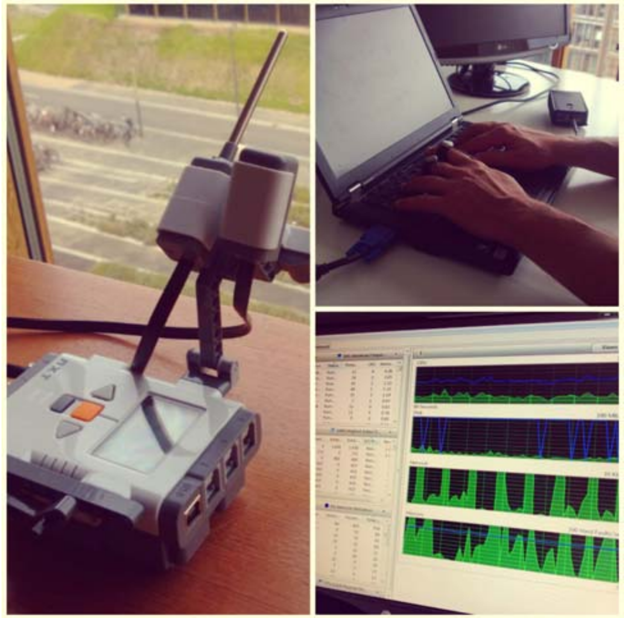

Figure 1. Measuring various data streams

Physiological Data Stream

The physiological data stream was chosen to study the effect of changes in IoT environment on the participant's physiological parameter. We decided to measure the stress level as a physiological parameter. It was measured using the Galvanic Skin Response (GSR) Sensor. GSR reading was preferred over HRV (Heart Rate Variability) sensor because the latter is more prone to distorted reading due to movement.

Environmental Data Stream
For measuring the IoT environment changes we measured the Light, Sound (dB) and Temperature (F) using the Lego Mind-storm NXt Data Logger. The measurements were done in live time using the Mind-storm Data Logger desktop application. We also noted the activities of a segway meeting robot and another robot (A Lego Mindstorm robot running on the floor).

IT Process Data Stream
The cognitive objects will play a key role in helping humans navigate in a technologically enhanced IoT environment. As an indicator of cognitive object stress, we measured the memory usage of individual applications and exported the value into csv format every 20 seconds. This was done using a simple script with the task list command in command prompt.

Behavioral Data Stream
In the complete experiment participant's visual and vocal cues are of key importance as they give us the feedback about the participant's feedback. To record these cues we used two GoPro Hero3 cameras capturing the visual, including screen behavior, and vocal cues.

Once all the data streams were collected we sought to integrate and import them onto a single platform to compare them and explore relations. We used Noldus Observer XT 11 to import all the data in the form of individual data streams for comparison.

Result
To measure the qualitative aspect of the experiment the following coding schemes were used to mark the events. The events were categorized into Disruption, Tasks and extended mind.

- Disruption (Start-Stop)
  - Lego robot disruption
  - Segway robot disruption
  - Light regulation disruption
- Tasks (Start-Stop)
  - IQ Tests
  - Communicating IQ results
  - Ran chrome browser
- Extended mind state (Mutually exclusive, Exhaustive)
  - GSR
  - Vocal cues
  - Laptop hardware
  - Laptop memory load

This coding scheme was used to mark and map out the various activities in the experiment.

Syncing the various data-streams demonstrated some interesting relations between the IT processes and the physiological parameters. However as this was a pre-flight-pilot experiment, we did not deduce concrete results.

Discussion
In this paper we discussed a pilot experiment about working in an IoT (Internet of Things) environment. We report on some initial testing out of a setup that allowed us to measure multiple data streams: physiological (GSR), Environmental (Sound, Light and Temp) and IT process data (memory usage). These were imported to a common platform (Noldus) to explore the relations between human work and interaction design in an IoT environment.

The main finding was that this can act as a way to qualitatively inspect and interpret relations between multiple data streams including video of behaviors, and might generate insights into HWID relations, see e.g. [3], in an IoT environment. The pilot experiment challenges what we mean by a worker's experience since we measure the stress load on cognitive objects on par with stress loads on body and brain and sync these to explore the UX in smart workplaces.

Among the limitations in this pilot study are the problems with syncing and integrating data streams. In particular, even when using equipment bought to work together (GSR and Noldus) syncing was not easy, and syncing with data streams from the Lego Mindstorm and to be done manually (by handclapping marks in the sound stream). Conceptually we did not do much in terms of work analysis but used a simple, but stressful, intelligence test as the task. This task was supposed to be very stressful but we could not see this in the data streams, and we wonder which personal work tasks could be more stressful, or if we need to switch to study collaborative work [7], or find a task that culturally fit to workplace computing [8]. We would also like to work with more trusted cognitive objects, and perhaps go beyond Møller et al [9]'s definition. Regarding the UX, our modification of UX “"an extended mind's perceptions and responses that result from the use or anticipated use of a product, system or service in an IOT context" might work, but we need to be more precise about ‘responses’ since we measured different kinds of stress. We never came around to measure “psycho-sociological awareness” [4].

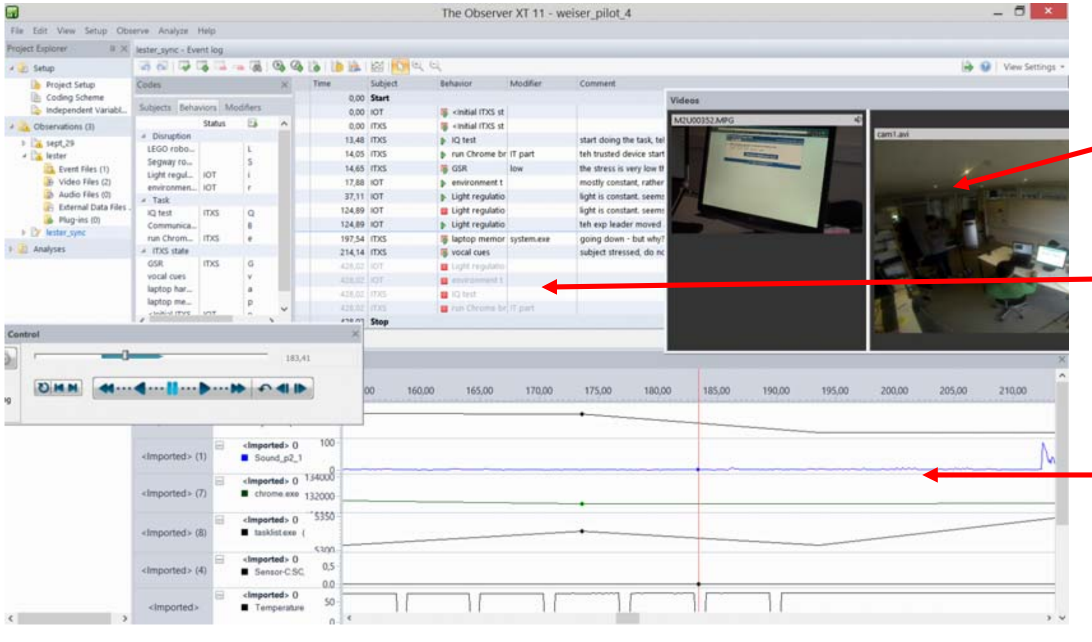

Figure 2. The analysis window

Future research includes developing a framework for IoT environment interruptions of the smart workplace, as a prerequisite for measuring UX of the smart workplace.

Conclusion

The experiment provided us the basic framework to do such experiment in the future. The main objective of integrating variable data streams on Noldus was achieved and additional data streams could be added for the next iteration of the experiment. However as this was just a pilot experiment no substantial results were obtained but the relation between wellbeing and age, processes with stress and others were noteworthy. The aim of the experiment was achieved and we believe that the insights achieved during the experiment would be useful in the future.

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