Paper Review Group #1

1. Finding Common Ground: A Survey of Capacitive Sensing in Human-Computer Interaction

This paper is a review of the existing research that has been published in ACM and IEEE for Capacitive Sensing technology for the HCI field. This paper provides unified semantics to describe the systems studied in the previous works. This paper aims to categorize capacitive sensing applications and to clarify the boundaries and limitations of the capacitive technologies. The paper also discusses of the state of the research as it was when the paper was published (2017) and what would be some possible future research advancements.
First, this paper introduces a general taxonomy. The paper differentiates active (the user triggers the sensing, more precise) and passive capacitive sensing (external fields trigger the sensing, less precise), and describes different capacitive sensing methods for both active and passive sensing, which they call "operating modes": loading, shunt, transmit, receive, intrabody coupling. The different modes involve that the human and the system have different roles. These different roles allow to create diverse applications. For example, loading mode is used for touchscreens and receive mode for gesture recognition.
The capacitive sensing research is not always providing details of the technologies used for making their device. Thus, this paper aims to provide semantics and guidelines for improving the reproducibility. The researchers describe features to be mentioned, such as identifying the type of capacitive sensing (active or passive), the operating mode mentioned above, but also information about hardware, sensor frequency, software used, etc. The researchers also discussed about the necessity to get close-to-reality experiments as the lab settings do not necessarily represent the real world settings. The paper explores the feasibility and outcome of research that has been done outside of the HCI domain (e.g. electro-optics crystal) which could be used in the field to address the current issues (e.g. energy, noise, etc.). The paper explores different areas of use for capacitive sensing and describes the main findings. For instance, for gesture recognition, researchers were able to detect grisp, grasp, or different body poses. This paper is a very good presentation and overview of the research that's been done for capacitive sensing. The paper describes well the main techniques used, and the authors have made use of multiple references to illustrate the different application domains.

2. Gesturewrist and Gesturepad: Unobtrusive Wearable Interaction Devices

This paper presents two wearable devices Gesturewrist and Gesturepad which use capacitive technology. The first wearable is an enhanced watch that is able to recognize the arm movements and hand gestures. The second device is a sensor system that is placed behind clothes — so that it is not intrusive and socially acceptable. With Gesturepad a user can trigger actions by touching the piece of clothing where the sensor is underlying.
First, Gesturewrist is an enhanced watch but its technology could be integrated in a smartwatch in the future. The device possesses a transmitter electrode and receiver electrodes and an accelerometer. The device can measure the changes associated with the hand gestures, by observing the shape of the user's wrist. In total, the researchers defined 6 different gestures that could be used.
Second, Gesturepad is a piece of material that can have multiple configurations which allow different interaction features: communication with other devices, prevention of touch from other people, signal reception from Gesturewrist. The users can touch or slide on their cloth to trigger the interaction.

Although the paper proposes some basic interactions for the two devices such as being able to control music or presentations, the main focus of the paper is on the technology and the different interactions that are possible with the devices. Something really interesting is the emphasis on wearable communication. Although the technology is very innovative, the researcher are, for this project, already focused on the user and discussed how non invasive the technology is. This is extremely relevant as this is one of the major UX issues for wearable technology.

3. Bodyprint: Biometric User Identification on Mobile Devices Using the Capacitive Touch Screen to Scan Body Parts

In this paper, the researchers present a novel concept for identifying a user on their phone. This work, which was published when the fingerprint sensors for phones were not yet popular, is exploring new ways to enhance security on a mobile device. The main contributions are that using their technology is affordable and secure. The researchers do not implement extra sensors to the phone but make use of the capacitive touchscreen.

The system recognizes users' specific body parts (palms, fist, fingers, or ears). A person could then access to sensitive information (folder) or actions (calls). The researchers also worked on a two-persons authentication mode. The implemented system is called Bodyprint. The users, by touching the screen with their body, provide a 2D capacitive map. On this map, the distance, the distance of the body part is expressed from black (nothing is detected) to white (something is touching the screen). As the sensor used is the capacitive screen, we could think that the resolution would not allow to recognize specific users. However, thanks to the algorithms that go along with the mapping, the researchers were able to build a recognition system. The recognition system involves having 1) a preprocessing system to get the best frames out of the sensor, 2) a classification algorithm to detect the different body parts, and 3) an identification system that, thanks to a previously built dataset, will be able to recognize the body parts and identify or not a user. The implemented algorithm provides a very good accuracy (more than 95%).

This technology is very innovative and this paper focuses on the possibility of running the technology on a smartphone. However, I found that the paper is lacking of a good related work section. For instance, the researchers claim that they could reach a very good accuracy when they tested their technology, but I found that studies worked on exploring the racial differences in hand shapes [1][2]. This paper does not provide information about the diversity of the users. Some interesting stress tests would for example include having twins trying to unlock each other's device. An other interesting point that is, according to me, relevant, is the fact that the identification process uses a dataset that regroups users' body parts map samples. First, if this technology would come to be on the market, it could raise privacy issues. Second, the researchers do not mention the time taken to identify a user. This technology is aimed to be user-centered for it's practicality. Thus, the recognition should be quick enough to ensure that it is convenient.

4. CapAuth: Identifying and Differentiating User Handprints On Commodity Capacitive Touchscreens

CapAuth is an enhancement of Bodyprint, a system that allows to identify users through using the capacitive screen of a smartphone. CapAuth focuses on palm recognition at a certain angle, generating 2D images when the user is touching the screen. The researchers worked on improving thee performance of the previously proposed technology, on authenticating users and on identifying users. The researchers also stressed the recognition of the handprints having users with hand moisture. This paper details the different classifiers used by the team to implement the technology and they reach a good recognition (>95%) using machine learning (SVM). However, they highlight that secure applications could not use this technology because it usually requires an accuracy >99.9%. This paper proposes different application domains for the usage of the technology such as multi-user applications, recreation, or parental control. The technology is not convenient because it requires to have a strict positioning of the hands, and the researchers even trained a binary classifier to identify good and bad positioning. The challenges for CapAuth are the same as the ones mentioned for Bodyprint. However, in this paper, the researchers highlighted that the technology was not necessarily perfect for large group of users and security. They also discussed the fact that environmental conditions could lead the system not to work correctly.

References

1. Wilder, H. H. (1904). Racial differences in palm and sole configuration. American anthropologist, 6(2), 244-293.
2. Wilder, H. H. (1922). Racial differences in palm and sole configuration. Palm and sole prints of Japanese and Chinese. American journal of physical anthropology, 5(2), 143-206.