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Skinput: Advance Input Technology

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ABSTRACT

In this paper we are describing about the new input sensing technology that is skinput. Skin put technology enabled device acts as an input interface. It provides a new input technique based on bio-acoustic sensing that allows the skin to be used as a finger input surface. This also allows the body to be annexed as an input surface without the need for the skin to be invasively instrumented with sensors, tracking markers, or other items.

KEYWORD: *Skin put, Bio-acoustic, Finger, Pico-Projector, Palm, Proprioception.*

I. INTRODUCTION

Skin put is a technology which uses the surface of the skin as an input device. Our skin produces natural and distinct mechanical vibrations when tapped at different places. However, skin is fundamentally different from conventional, off-body touch surfaces. As skin is stretchable, it allows for additional input modalities, such as pulling, pressing and squeezing. This increases the input space for on-skin interactions and enables more varied forms of interaction, for instance more varied gestures. This opens up a new interaction space, which is largely unexplored. We aim to contribute to the systematic understanding of skin as an input modality and of its specific capabilities. To start with, we focus on input on the upper limb (i.e. upper arm, forearm, hand and fingers), for this is the most frequently used location. Devices with significant computational power and capabilities can now be easily carried on our bodies. Appropriating the human body as an input device is appealing not only because we have roughly two square meters of external surface area, but also because much of it is easily accessible by our hands (e.g., arms, upper legs, torso). In this paper, we present our work on Skinput – a method that allows the body to be appropriated for finger input using a novel, non-invasive, wearable bio-acoustic sensor.

II. THEORATICAL REVIEW

Skin put using touch on palm or hand surface. : As computing becomes more mobile, there is an increasing need to develop more advanced input tools and methods. Screens are smaller, cameras are more ubiquitous, and touch technology is everywhere. Yet entering text, choosing graphics entities, performing drag-and-drop, and so on are still difficult. One real struggle in dealing with small screens is surface area. Current mobile-devices screens have enough clarity that you can detect tiny objects, even as presbyopia set in. Skinput combines simple bio-acoustic sensor and some sophisticated machine learning to enable people to use their finger or forearms as touch pads. It has been, found that different types of finger taps on different parts of the hand and forearm produce unique acoustic signatures as per the study conducted by Carnegie Mellon University Machine learning parses the features into a unique interpretation of the different taps. Skinput gives new meaning to the term "touch typing."

Figure 1: Skinput uses bio-acoustic sensor and sophisticated machine learning to turn the human palm into a touch pad.

More than touch : Skin is fundamentally different from off body touch surfaces, opening up a new and largely unexplored interaction space. We investigate characteristics of the various skin-specific input modalities, analyze what kinds of gestures are performed on skin, and study what are preferred input locations.. As skin is stretchable, it allows for additional input modalities, such as pulling, pressing and squeezing. This increases the input space for on-skin interactions and enables more varied forms of interaction, for instance more varied gestures.

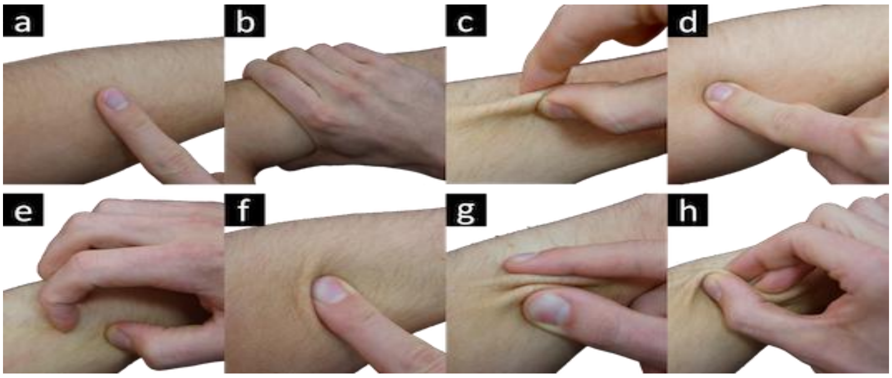

Figure 2: Input modalities: (a) touch, (b) grab, (c) pull, (d) press, (e) scratch, (f) shear, (g) squeeze and (h) twist.

The flexible nature of skin affords not only touching, but also pulling, shearing, squeezing, and twisting. Skin is capable of sensing various levels of contact force, which enables pressing. Lastly, the physiological properties of the touching finger or hand further add to the expressiveness, touch can be performed with the fingernails, resulting in scratching, or the full hand can enclose another body part resulting in grabbing. The resulting set of eight modalities as shown in Figure 2. It was derived from established modalities of conventional touch interfaces and from results of studies on the biomechanics of skin. These modalities are ranging from on-surface interaction to intense skin deformations. More complex gestures, e.g. rubbing or shaking, can be performed by using these basic input modalities. Note that these modalities are defined from a user perspective and not from a technology-centered one.

III. PRINCIPLE

The principle on which this technology works is bio-acoustic. Whenever there is a finger taps on the skin, the impact creates acoustic signals, which can be captured by a bio-acoustic sensing device. Some amount of energy is lost to the external environment in the form of sound waves. Apart of the rest energy travels along the surface of the skin and the rest is transmitted inward till it's get reflected from the bone. Depending on the type of surface on which the disturbance is created, the amplitude of the wave varies. For example, on a soft surface (forearm) the amplitude is larger as compared to a hard surface (elbow) where the amplitude is smaller. In addition to the underneath surface, the amplitude of the wave also varies with the force of disturbance. Variations in bone density, size and the different filtering effects created by soft tissues and joints create distinct acoustic locations of signals, which are sensed, processed and classified by software. Interactive capabilities can be linked to different locations on the body. The average body surface area of an adult is 1.73 m^2, is 400 times greater than a touch-screen phone 0.004 m^2. Sailors and tattoo parlors have long seen opportunities for the body as a display. Skinput adds interactivity via a Pico-projector and vibration sensing tap an image projected on your arm, and the resulting arm vibrations control an application. [4]

IV. WORKING

Skin put uses acoustic information, to capture this information a wearable armband that is non-invasive and easily removable is employed. The Skin put sensor and the processing techniques used to segment, analyze, and classify bio-acoustic signals are studied in this section. The working is based on acoustic signals through density of tissues. Your tap on the arm translates through sensors into an instruction on a menu. The graphic display appears on your arm or hand, wherever the display is set up to be located, and from then on it's like using a cell phone. Arm is better, because the graphic display on your arm is about 200 times bigger. You can use Skinput to control devices you carry, like a dashboard setup. So in theory you can control your phone, your iPOD, etc, with one tap on your arm. It really does look impressive. [6]

Bio-Acoustics : When a finger taps the skin, several distinct forms of acoustic energy are produced. Some energy is radiated into the air as sound waves; this energy is not captured by the Skinput system. Among the acoustic energy transmitted through the arm, the most readily visible are transverse waves, created by the displacement of the skin from a finger impact as shown in Figure 4. When shot with a high-speed camera, these appear as ripples, which propagate outward from the point of contact. The amplitude of these ripples is correlated to both the tapping force and to the volume and compliance of soft tissues under the impact area. In general tapping on soft regions of the arm creates higher amplitude transverse waves than tapping on boney areas (e.g., wrist, palm, fingers), which have negligible compliance. [5] In addition to the energy that propagates on the surface of the arm, some energy is transmitted inward, toward the skeleton as shown Figure 5. These longitudinal (compressive) waves travel through the soft tissues of the arm, exciting the bone, which is much less deformable then the soft tissue but can respond to mechanical excitation by rotating and translating as a rigid body.

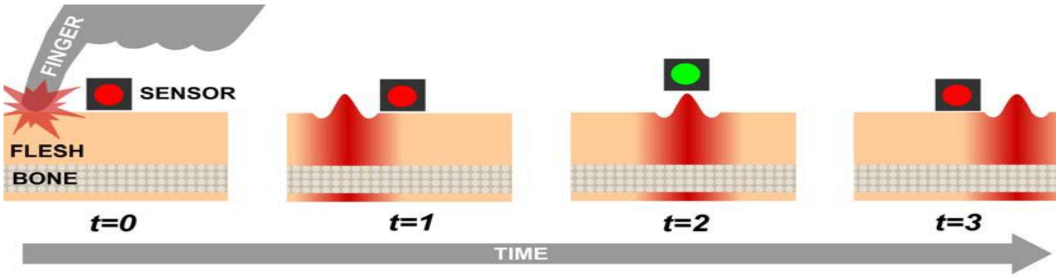

Figure 4: Transverse wave propagation: Finger impacts displace the skin, creating transverse waves (ripples). The sensor is activated as the wave passes underneath it.

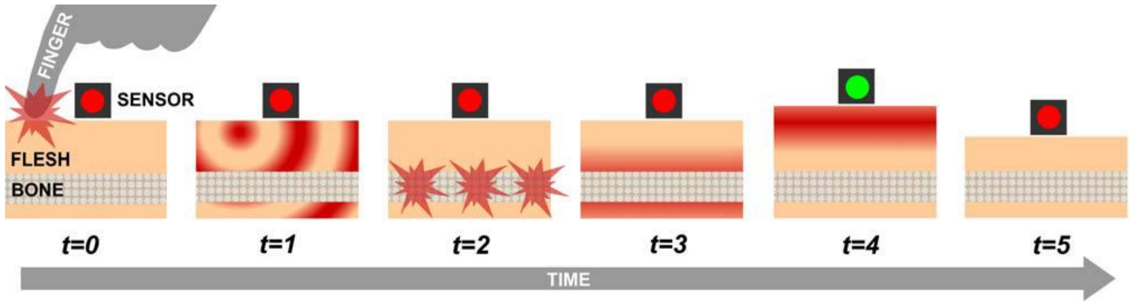

Figure 5: Longitudinal wave propagation: Finger impacts create longitudinal (compressive) waves that cause internal skeletal structures to vibrate. This, in turn, creates longitudinal waves that emanate outwards from the bone (along its entire length) toward the skin.

The two separate highlight forms of conduction transverse waves moving directly along the arm surface, and longitudinal waves moving into and out of the bone through soft tissues because these mechanisms carry energy at different frequencies and over different distances. Similarly, it is also believed that joints play an important role in making tapped locations acoustically distinct. Bones are held together by ligaments, and joints often include additional biological structures such as fluid cavities. This makes joints behave as acoustic filters. The design of a novel, wearable sensor for bio-acoustic signal acquisition as shown in following figure describes an analysis approach that enables our system to resolve the location of finger taps on the body. The robustness and limitations of the system has been assessed through user study. The broader space of bio-acoustic input been explored through prototype applications and additional experimentation

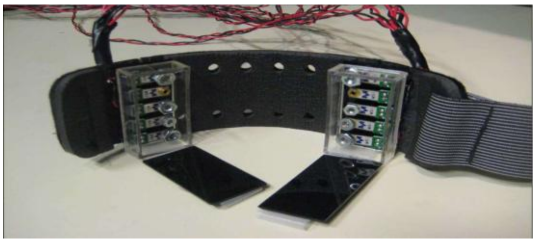

Figure 6: A wearable, bio-acoustic sensing array built into an armband. Sensing elements detect vibrations transmitted through the body. The two sensor packages shown above each contain five, specially weighted, cantilevered piezo films, responsive to a particular frequency range.

Armband : Final prototype, as shown in Figures 6 and 7, features two arrays of five sensing elements, incorporated into an armband form factor. Based on pilot data collection, we selected a different set of resonant frequencies for each sensor package as mentioned in Table 1. The upper sensor package was turned to be more sensitive to lower frequency signals, as these were more prevalent in fleshier areas. Conversely, lower sensor array was tuned to be sensitive to higher frequency signals, in order to capture signals transmitted through then denser bones. [5] In this prototype system, a Mackie Onyx 1200F audio interface was employed to digitally capture data from the ten sensors. This was connected via Fire wire to a conventional desktop computer, where a thin client written in C interfaced with the device using the Audio Stream Input/ Output (ASIO) protocol.

Figure 7. Prototype armband

.Upper array	25 Hz	27Hz	30Hz	38Hz	78Hz
Lower array	25Hz	27Hz	40Hz	44Hz	64Hz

Table 1: Resonant frequencies of elements in the two sensor packages

Each channel was sampled at 5.5 kHz, a sampling rate that would be considered too low for speech or environmental audio, but was able to represent the relevant spectrum of frequencies transmitted through the arm. This reduced sample rate makes this technique readily portable to embedded processors. For eg, the ATmega168 processor employed by the Arduino platform can sample analog readings at 77kHz with no loss of precision, and could therefore provide the full sampling power required for Skinput 55kHz total . Data was then sent from thin client over a local socket to primary application, written in Java. This program performs three key functions. First, it provided a live visualization of the data from ten sensors, which was useful in identifying acoustic features as shown in the following figure. Second, it segmented inputs from the data stream into independent instances i.e. taps. Third, it classified these input instances. The audio stream was segmented into individual taps using an absolute exponential average of all ten channels as shown in figure 8, red waveform. When an intensity threshold was exceeded as figure 8, upper blue line, the program recorded the timestamp as a potential start of a tap. If the intensity did not fall below a second, independent “closing” threshold as in figure 8, lower purple line between 100ms and 700ms after the onset crossing a duration found to be the common for finger impacts, the event was discarded. If start and end crossings were detected that satisfied these criteria, the acoustic data in that period i.e. plus a 60ms buffer on either end was considered an input event as in figure 8, vertical green regions. Although simple, this heuristic proved to be highly robust, mainly due to the extreme noise suppression provided by our sensing approach.

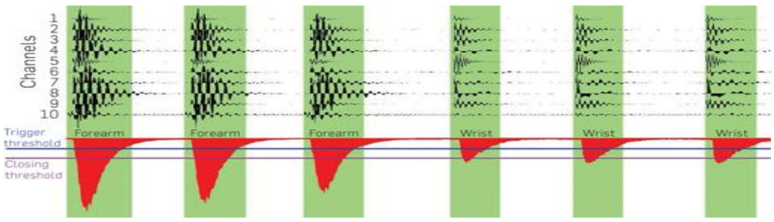

Figure 8: ten channels of acoustic data generated by three finger taps on the forearm, followed by three taps on the wrist. The exponential average of the channels is shown in red. Segmented input windows are highlighted in green. Note how different sensing elements are actuated by the two locations.

Experiments and Discussing: In this section the results and experiments conducted by Carnegie Mellon University on arm as well as the fore-arms is discussed.

Fingers (Five Locations): One set of gestures tested had participants tapping on the tips of each of their five fingers. The fingers offer interesting affordances that make them compelling to appropriate for input. Foremost, they provide clearly discrete interaction points, which are even already well-named. In addition to five finger tips, there are 14 knuckles five major, nine minor, which, taken together, could offer 19 readily identifiable input locations on the fingers alone Second, exceptional finger to finger dexterity, as demonstrated when counted by tapping on our fingers. Finally, the fingers are linearly ordered, which is potentially useful for interfaces like number entry, magnitude control (e.g., volume), and menu selection. At the same time, fingers are among the most uniform appendages on the body, with all but the thumb sharing a similar skeletal and muscular structure. This drastically reduces acoustic variation and makes differentiating among them difficult.

Whole Arm (Five Locations): Another gesture set investigated the use of five input locations on the forearm and hand: arm, wrist, palm, thumb and middle finger as shown in figure 7. These locations was selected for two main reasons First, they are distinct and named parts of the body e.g. wrist these locations in three different conditions. One condition placed the sensor above the elbow, while another placed it below. This was incorporated into the experiment to measure the accuracy loss across this significant articulation point (the elbow). Additionally, participants repeated the lower placement condition in an eyes-free context: participants were told to close their eyes and face forward, both for training and testing. This condition was included to gauge how well users could target on-body input locations in an eyes-free context (e.g., driving).

Forearm (Ten Locations): Fifth and final experimental condition used ten locations on just the forearm as in figure 6 Not only was this a very high density of input locations unlike the whole-arm condition, but it also relied on an input surface the forearm with a high degree of physical uniformity unlike, e.g., the hand.

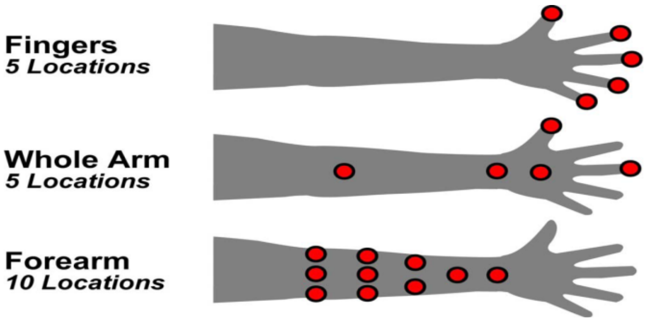

Figure 9. Figure 7: The three input location sets evaluated in the study. As per study conducted at Carnegie mellon university by Chris Harrison, Desney tan, Dan morris.

Now lets discuss the results of the above mention experiments .Five finger Despite multiple joint crossings and ~40cm of separation between the input targets and sensors, classification accuracy remained high for the five-finger condition, averaging 87.7% (SD=10.0%, chance=20%) across participants. with errors tending to be evenly distributed over the other digits. When classification was incorrect, the system believed the input to be an adjacent finger 60.5% of the time; only marginally above prior probability (40%). This suggests there are only limited acoustic continuities between the fingers. The only potential exception to this was in the case of the pinky, where the ring finger constituted 63.3% percent of the misclassifications.

Whole Arm

The below-elbow placement performed the best, posting a 95.5% (SD=5.1%, chance=20%) average accuracy. Moving the sensor above the elbow reduced accuracy to 88.3% (SD=7.8%, chance=20%), a drop of 7.2%. This is almost certainly related to the acoustic loss at the elbow joint and the additional 10cm of distance between the sensor and input targets. Figure 8 shows these results.

Forearm

Classification accuracy for the ten-location forearm condition stood at 81.5% (SD=10.5%, chance=10%), a surprisingly strong result for an input set The goal of this exercise was to explore the tradeoff between classification accuracy and number of input locations on the forearm, which represents a particularly valuable input surface for application designers.

Figure 9: Higher accuracies can be achieved by collapsing the ten input locations into groups. A-E and G were created using a design-centric strategy. F was created following analysis of per-location accuracy data. As per study conducted at Carnegie mellon university by Chris Harrison, Desney tan, Dan morris.

Feasibility of the given technology : Skin put is yet in its nurturing stage but when fully developed it can be used as an input for almost any electronic device. Through skin put we can play games with just the movement of our hands. This will introduce a totally new era of gaming.. At the same time, bodies have clear physical limitations; you get tired holding your arm still. Unless the goal is to get into better shape, such mundane factors impose real constraints on what interfaces you're likely to actually adopt. Piezoelectric sensors used to measure the deformation. Today, such sensors are commonly used as guitar pick-ups. Increasingly diverse and cheap sensing technologies make this a really exciting time for inventing new interactive systems further step is to flesh out the design space of alternatives, understand their trade-offs, and build theories. This exploration will require tools (and curricula) for rapidly and flexibly creating interfaces with rich sensing and machine learning.[4]

V. CONCLUSION

In this paper, we have presented the approach to appropriating the human body as an multi input surface where multiple acoustic sensors can be togetherly interfaced sensing multiple touches and impressions. It described a novel, wearable bio-acoustic sensing array built into an armband in order to detect and localize finger taps on the forearm and hand. Results from experiments have shown that our system performs very well for a series of gestures, even when the body is in motion. Additionally, it have presented initial results demonstrating other potential uses of our approach, which we hope to further explore in future work. These include single-hand, multi-hand gestures, taps with different parts of the finger, and differentiating between materials and objects. We conclude with descriptions of several prototype applications that demonstrate the rich design space we believe Skinput enables.

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