# Final Research Proposal, Project Charter
# Prosthetic Tactile Sensor With Force Feedback

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### Abstract

*This document is to expand the initial research aspects of tactile sensory implementation with durable materials, particularly the field of soft robotic applications in the aim to conceive a more applicable human response system.*

## 1. INTRODUCTION

The purpose of this research is to provide alternative responses, to better improve and achieve daily life tasks, for those of limitations due to a disability or disfigurement.

To explore and achieve the tasks of better design for a response feedback when grasping objects using tactile sensors, implemented in supportive wearable devices. This objective trends to meet requirements, where the ability to measure pressure or impulse over solid objects, physical interaction, with its environment to a reasonable scale.

Key concepts of this research steps through the ability to be durable, yet maintain accuracy giving the user the benefit of somewhat the sense of touch.

## 2. BACKGROUND

Key aspects when breaking down the system, to achieve this method include

- Applying Tactile Sensors to the latest designs of Soft Robotics
- Connecting current technologies, to be applied in more versatile solutions
- Ultimately achieve picking up an object with force response to provide the user with enough feedback that a safe and maintainable force is achieved

Currently there are many applications for force feedback of durable surfaces, specifically in the medical industry. Although many of these applications are already in practice, in daily use for automation deformation, and with sorting factories; there has yet to be a human interface designed to assist those whom had disabilities such as ALS, or amputees whom have suffered a loss of limbs.

The way in such the popularity of the force feedback devices have been studied from the early nineties with some early projects in the seventies to the current date, much of the recent development has been pushed in such the development over the last 10 years has expanded immensely. With companies from IEEE Spectrum, and the University of Tokyo, Professor Takao Someya Ph.D has achieved many developments which have implemented sensors with stretchable, bendable, and flexible properties to be as pliable as that of human skin.

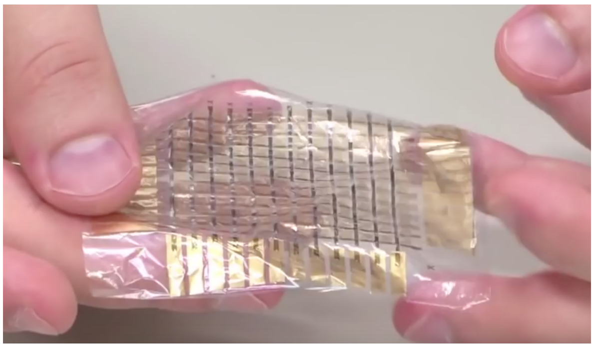

**Figure 1. Professor Takao Someya's E-Skin**

The development holds high regard for biomedical applications and is sought to achieve not only end user abilities for skin like responses, but also work done in surgery.

* *This work was not supported by any organization

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## 2.1. Research Questions

The purpose of this research is to achieve grip with response for safety purposes. The industry currently has many durable surface sensors of which have been applied in a vast number of ways, and some already have been applied even as skin, or feedback sensor of a finger for robotic delicacy to be applied in the medical field for automated surgery.

So to find what it is that is needed to be achieved the structure that is broken down is vital, not just in the technology, but due to the specific nature of human interface devices, aesthetics and ethics play a major part when development into daily like tasks and processes.

How can sensors be implemented in substances of thin, durable materials which can then be recognised as skin essentially to the naked eye. Can this be fitted with the smallest profile or even stick to the skin, but also be removable.

## 2.2. Design and Method

In order to get any useful response, many measurements over an area must be taken in different directions. Using thin film transistors printed on durable synthetic materials, provides many answers and is not only a viable option but also cheap and easy to handle, non toxic or harmful to the enviroment - aligning capacitors in a grid, and measuring the force over the general area as an average; then outputting the response as a scaled force. Including compensation for ghost force (skin stretching effecting force on other areas, e.g. when bending a finger pressure is exerted around the joint areas while expansions is observed over other areas. The elasticity of the skin provided by lines and wrinkles can give indication for these areas and there predictions.

Todays general tactile sensors are a majority of flex-ribbon circuits or an area of aligned transistors; however there are several other forms of measurement available including nano-composite cilia, which provides bi-directional response's for tasks that are subject to dependance on grip as well as direct force.

The materials structure may be stretched, folded, or even crumpled like paper, while maintaining integrity. The lightweight material may even stick and be removed from actual skin and in some cases remain unnoticeable gaining aesthetic apprasal.

# 3. SIGNIFICANCE OF RESEARCH

The skin like material with sensors response can be used for a variety of different applications, from health monitoring systems, to such of a more specific task of wearable medical instruments.

When implemented circuitry to an actuated movement, further analysis can be made as to how an object can be picked up when sorting; whether the target object is capable of being lifted safely.

A more specialised approach to the early stages of development in new sensory for potential human interfacing; giving back the sense of feeling, touch on skin for those with nerve damage or other precursive diseases such as, but not limited to ALS, RI, Cystic Fibrosis, any suppression of the sense.

The safety of picking up and holding simple objects securely

Adding the tactile devices to a user offers better measure and check the electrical activity of muscles, or even patients vitals.

## 3.1. Stakeholders

Many companies in California are developing systems which interface human input, e.g. Nevro is producing an IPG device called the HF-10, which is used to suppress chronic pain disorders in the lower back and legs region, via the T10 segment of the spine; and tapping in to the signal to produce a pulse like noise canceling, that suppresses the pain response given by the body. This technology is available today and you can get them for many applications, including things such as brain probes for more sever cases. Todays concepts are subject to user aesthetics and while some kids are happy with a Terminator or Iron man prosthetic others may prefer a more subtle approach for what they may find looks acceptable based on personal preference or others reactions

Robotiq (Force-Feedback) Constant Force Object Location Repeatable Force Weighing Stuff Hand Guiding

Qmed - Flexi ribbon Tactile sensor

Intech - Pneumatic Artificial Muscles

ipgLab - Smart tooth sensor

mdttag - IPG sensors

Atlas - Robotic arms with force feedback for medical industry and surgeries

The great part of this research is that there are many people with physical disabilities whom have limited options to improve quality of life at this stage. The stakeholders remain mostly in the medical industry with the ideals of developing affordable prosthetics for general public, however there are developments with DARPA and other weapon contractors for applications in combat and range situations with their exoskeleton projects and more.

### 3.2. Ethics

By the ability to measure and scale the force acting on the surface of different objects, correct force can be applied so not only machines can handle more gentle tasks, and be limited to safety deformations; but also response can be given to tasks that include pressure sensory not limited to a gas or liquid measurement.

### 3.3. Limitations

### 3.4. Timeline

## 4. PROJECT PLAN

### 4.1. Deliverables

Although the development has been around for decades for each field, implementation of the two has only recently began to be explored. Future development of this technology has the potential to be applied to many scenarios, both industrial and commercial. While there now are such robust designs and size limitations, there is confidence in the field form variety of applications to allow room to grow; more concise methods to be formed for feasible applicable devices.

One day not to far we can expect to see usage of these devices implemented in a direct response system By using IPG (implanted pulse generators) or Paddles a direct input output can be given from the users own nervous system almost matching the sense and movement of the original limb

By implementing different types of sensors into flexible substances, a response can be registered in a more durable manner; thus allowing the data to be interpreted in non-linear forms, mimicking the natural reaction to environments in a more general form.

What are the mechanics of the whole hand, directional force on knuckles, skin, muscles and for a start off to analyse a single finger

### 4.2. Outcomes

The scope of the project is to provide a measurable response via the force-feedback of the implemented durable surface tactile sensor in a prosthetic hand or response glove

Rather then designing an entire glove and implementing sensors throughout in many directions, then compensating for skin elasticity and joint directional force; this method of research is purely to test the implementation of a tactile response in a HID which has more of a practical approach.

Aesthetically pleasant, without having the negative public attraction What is socially acceptable at this stage? Not an eyesore- Something that a user can interact with to an acceptable standpoint can they put it on themselves in the morning? Provide useful response As the user continues to use the device becoming adaptive with the way in alerts are made, growing with the patient and learning common activities: yes this force is ok, no response needs to be given as the applied force is enough to engage with the object correctly

### 4.3. Results

Distortion Weight scale Compound elasticity Joint bends Object of interest shape or design (target to pick up or grip) Environmental aspects and Effect The ?Terminator? aesthetics (age group) Different ways people hold objects Natural positioning

Interference Positional sensors Ghost Force - skin stretch Influence from other skin surface area Other clean breaks Skin bending? - more/less sensitive?

While the main point of the device is to provide recognition for the user to know if he or she has grasped a cup which will not fall when lifted, or not use too much force when picking up a glass to break it; a fundamental aspect of the project is aesthetics and making a comfortable, low profile, and visually appealing device with least intrusion to the user.

By implementing just one finger, and using sensors to take measurement along the one axis of direction, then assessing the pressure force which in turn registers to a micro controller display output weather it is to produce A sound similar to that of the PDC on a car

A tightening band placed on a still intact part of the body to provide equal force as being applied

A Haptic or vibration response, where small shock pulses are given in similar adjustable frequencies to that of the PDC rather without the sound

OR eventually (out of this scope), direct implementation to the nervous system via IPG sensors giving the user full control of the system with low latency response

## 5. CONCLUSIONS

## APPENDIX

## ACKNOWLEDGMENT

## References