HARVESTING TECHNICAL NOTE

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2022

Haptic Proximity System Research & Development

Summary

Research into the use of haptic feedback technology and proximity sensors with a view to development of a custom-built prototype Haptic Feedback Proximity System. Haptic technology allows worn or held devices to give tactile feedback to the wearer through sensations, typically vibration. Two possible approaches were explored, and several technologies were investigated to assure operational parameters would be met. The findings of this research will provide a pathway for the development of the technology into a prototype Haptic Proximity System. The recommended approach is to assemble pre-built wearable devices and beacons. Then, a custom application will be created allowing the provision of haptic feedback to the workers through the device when within range of the beacons.

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Introduction

This report details research on currently available haptic technology and proximity sensors with the goal of designing a functional feedback system for workers on the landing.

Two possible options for creating a full solution were explored, within commercial and scientific frameworks. The first option, a pre-built solution, included commercial wearable haptic technology (such as Apple Watch and Fitbit).

The second option, a custom-built solution, incorporated haptic technology engineered into a wearable device. Individual beacons capable of sending signals to our potential wearable application and device are listed with information regarding their durability and ranges.

Compatible Software Development Kits (SDK) were considered to allow connection between the wearable receiver, application operating system and beacon signal.

The findings of this research will provide a pathway for the development of the technology into a prototype Haptic Proximity System. The recommended approach is to assemble pre-built wearable devices and beacons. Then, a custom application will be created allowing the provision of haptic feedback to the workers through the device when within range of the beacons.

Haptic Feedback Technology

Haptics allow worn or held devices to give tactile feedback through sensations, typically vibration. It can create effects such as force, weight, strain, pressure, or alertness. To provide haptic feedback to workers, we need to consider how the technology will connect to the user. We can exclude touch feedback on device screens and held devices on equipment. These types of haptic delivery would be unsuitable to the workers due to task changes required in the work environment. Options for worn technology were investigated further owing to the ability to seamlessly fit into a dynamic, fast-paced workplace. The list of potential technologies is contingent on the dependencies, capabilities, and alignment to the proposed purpose.

Pre-Built Smart Haptic Devices

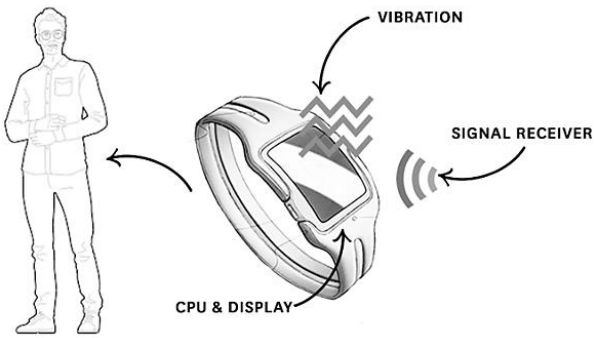

Figure 1. Smart Wrist Band with Haptic Capability

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Table 1 shows the available smart watches and smart devices with haptic programming. There is also an option to use a smart phone, attached to the worker via a waterproof strap-on arm case.

Table 1. Smart watches and smart devices with haptic programming.

Name	Type	Link	Industry	Battery Life	Waterproof	
Fitbit Charge 4	Smart Wrist Band	https://www.fitbit.com/nz/home	Varied Industries	Up to 7-days	Resistant to 50m wear	
Apple Watch Series 4 or 5	Smart Wrist Band	https://www.apple.com/nz/watch/	Varied Industries	Up to 18-hours	Resistant to 50m wear	
Galaxy Watch / Fit	Smart Wrist Band	https://www.samsung.com/nz/wearables/galaxy-fit-r370/SM-R370NZKAXNZ/	Varied Industries	Up to 7-days	Water-resistant and dustproof based on the IP67 Rating, which tests submersion in fresh water up to 1m for up to 30 minutes.	
WearWorks, Way Band	Smart Wrist Band	https://www.wear.works/	Navigation			
NFC Ring	Smart Ring	https://nfcring.com/#what-is-the-nfc-ring	Varied Industries			

Custom Build Haptic Device Components

The following section explores the option to coordinate a group of functioning pre-built parts as a complete system. The parts required include the following:

(i) Haptic device / driver
(ii) CPU (computer)
(iii) Operating system, and
(iv) Display.

Initially, we researched the haptics element of the custom build.

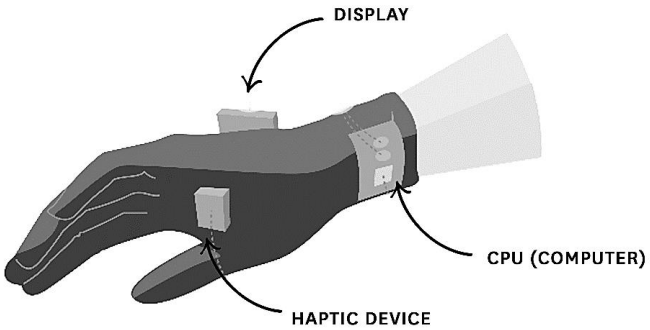

Figure 2. Custom Build Haptic System Example

Haptic Gloves and Suits (Device Component)

Haptic gloves and suits (Table 2) are primarily used for Virtual Reality equipment and applications as a means of enhancing experiences. Such experiences include entertainment and training across varied industries (such as medical, military, and automotive). It is not feasible to employ such devices in the proposed custom build as they will likely require a large computer within proximity, or mounted sensors to one spot. This decreases the area where the technology will work to a few metres, which is not effective in typical harvesting conditions. Appropriate glove or suit technology must be connected to its own CPU with Bluetooth (or similar signal) and be able to run the proposed custom software.

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Table 2. Available haptic gloves and suits.

Name	Type	Link	Industry	
Go Touch VR	Gloves	https://www.gotouchvr.com/	VR Training	
VR GLUV	Gloves	https://www.vrgluv.com/	VR Training	
Haptx	Gloves	https://haptx.com/technology/	Virtual Reality	
Plexus	Gloves	http://plexus.im/	Virtual Reality	
Sense Glove	Gloves	https://www.senseglove.com/	Robotics	
Stretch Sense	Gloves	https://stretchsense.com/	VR Varied Industry	
Be Bop Sensors	Gloves	https://bebopsensors.com/	VR Varied Industry	
Dexta Robotics	Gloves	https://www.dextarobotics.com/en-us	Varied Industries	
Avatar VR	Gloves	https://avatarvr.es/	Business Solutions	
Hi5 VR Glove	Gloves	https://hi5vrglove.com/	Business Solutions	
Manus VR (Prime Series)	Gloves	https://manus-vr.com/prime-haptic-gloves/	Mocap	
VMG 35 Plus Haptic Glove	Gloves	https://www.vrealities.com/products/data-gloves/vmg-30-plus	Prototyping	
Teslasuit	Full Body Suit	https://teslasuit.io/the-suit/	Mocap	
B Haptics Tact Suit	Full Body Suit	https://www.bhaptics.com/tactsuit/	VR Arcade Gaming	
Hardlight VR Suit	Full Body Suit	https://www.kickstarter.com/projects/morgansinko/hardlight-vr-suit-dont-just-play-the-game-feel-it	VR Arcade Gaming	
Force Dimension	Varied	https://www.forcedimension.com/company/about	Medical Tech	

Haptic Drivers (Device Component)

The below haptic drivers and device parts can be used in unison with other technology and materials to create a custom haptic technology solution.

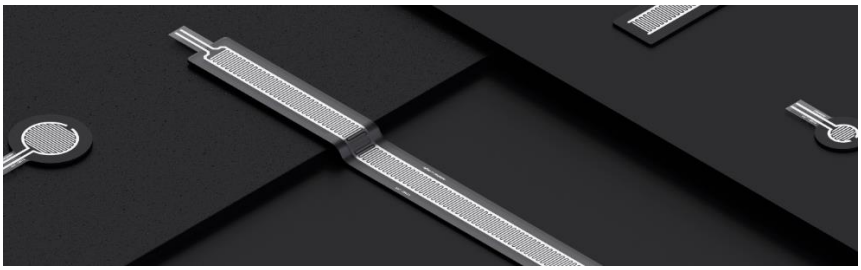

Figure 3. Haptic Driver Example

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Table 3. Available haptic drivers.

Name	Type	Link	Industry	
TDK Haptics, Power Hap	Haptic Drivers	https://www.digikey.co.nz/en/product-highlight/t/tdk/haptics	Build Component	
Immersion Haptic	Haptic Drivers	https://www.immersion.com/haptic-experience/	Build Component	
Nidec Haptic Devices	Haptic Drivers	https://www.nidec.com/en/corporate/about/business/haptic-devices/	Build Component	
Nanoport / Nanomagnetics	Haptic Drivers	https://nanoport.io/haptics/	Build Component	
Tacterion	Haptic Drivers	https://www.tacterion.com/	Varied Industries	
Novasentis Kemi	Wearables	https://www.novasentis.com/	Varied Industries	
Boreas Technologies	Haptic Drivers	https://www.boreas.ca/	Build Component	
Tactile Telerobot	Robotics	https://www.shadowrobot.com/telerobots/	Prototyping	
ESTEC	Robotics	https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Telerobotics_Haptics_Laboratory	Prototyping	
Haptics for Telesurgery	Robotics	http://www.brl.ac.uk/research/researchthemes/medicalrobotics/hapticsfortele-surgery.aspx	Medical Tech	
Ultra-Leap	Ultra-haptics	https://www.ultraleap.com/haptics/	Varied Industries	
Foldaway	Grip	http://www.foldaway-haptics.com/haptics/index.html	VR Varied Industry	
Taclim	Limbs	https://taclim.cerevo.com/en/	Virtual Reality	
Tactical Haptics	Motion Controller	https://tacticalhaptics.com/products/	VR Arcade Gaming	

Beacon Technology (Proximity Sensor Systems)

Beacons are small radio transmitters with their own unique ID that can be read by other devices. They consist of three parts: (1) batteries, (2) CPU, and (3) radio. Beacons use BLE 4.0 (Bluetooth Low Energy) – a type of signal that needs less power allowing the beacons to run undisturbed for long periods. There are many types of beacons available for mobile wearable use, indoor use and industrial outdoor. The beacons listed below are industrial outdoor beacons.

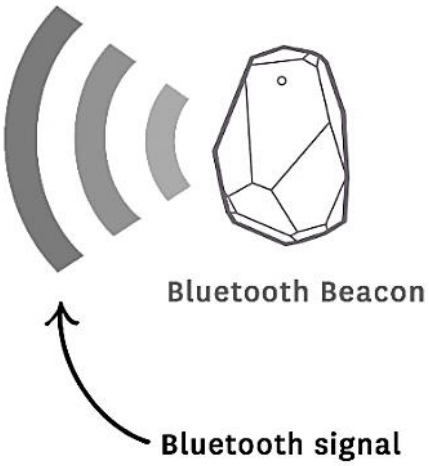

Figure 4. Bluetooth Beacon

Table 4 shows a list of outdoor, weatherproof beacons with both short- and long-range capabilities.

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Table 4. Available Bluetooth beacon hardware.

Name	Type	Link	Range	Battery Life	Waterproof	
Estimote	Bluetooth Beacon	https://estimote.com/		4-5 years	Waterproof enclosure, made from silicone	
Beaconstac	Bluetooth Beacon	https://www.beaconstac.com/	0.15-80m	Up to 2 years	Designed to withstand most conditions - wind, water, temperature, and dust.	
Kontakt	Bluetooth Beacon	https://kontakt.io/blog/launching-new-toughbeacon-designed-outdoor-use/		5 – 7 Weeks	Shatter-resistant, waterproof up to 10m, anti-static, UV-resistant	
BlueUp	Bluetooth Beacon	https://www.blueupbeacons.com/index.php?page=forte	0.5-100m	11 months to 8 years (24/7 at ambient temperature)	Protection IP65/NEMA4, outdoor weatherproof enclosure, and special battery for extreme conditions	
Quuppa LD-7L Locator	Bluetooth Beacon	https://quuppa.com/quuppa-ld-7l/	150m and 'accurate results at close distances'		Durable, dust and waterproof casing with IP65 classification	
Piper	Bluetooth Beacon	https://www.pipernetworks.com/outdoor-indoor-beacon/	Up to 45m	Up to 5 years	IP65 rated weather resistant casing	
Gimbal	Bluetooth Beacon	https://store.gimbal.com/collections/beacons/products/s22	Up to 50m	Up to 4 years		
Aruba	Bluetooth Beacon	https://www.arubanetworks.com/products/location-services/aruba-beacons/	Up to 60m (Maximum signal range depends on the physical environment)	Up to 4 years	IP67 rated outdoor case with magnetic brackets for mounting	
BLE 4.0 / 5.1 Tags	Bluetooth Beacon	https://www.infsoft.com/technology/transmitter-hardware/ble-40-51-tags				

Beacon Signal Software Development Kits

Compatible beacon software development kits (SDKs) that could connect the wearable app and the beacon were collated (Table 5).

Table 5. Available Bluetooth beacon signal software development kits.

Name	Type	Link	Industry	
Apple iBeacon	SDK	https://developer.apple.com/ibeacon/	Varied Industries	
Google Eddystone	SDK	https://developers.google.com/beacons/eddystone	Varied Industries	
Infsoft	SDK	https://www.infsoft.com/technology/positioning-technologies/bluetooth-low-energy-beacons	Varied Industries	
Quuppa	SDK	https://quuppa.com/	Varied Industries	

Potential Custom Build Solution

The research into haptic and beacon technology has illuminated the step-by-step process to build a working system:

i. Purchase a Bluetooth haptic device connected with a compatible operating system for the chosen beacon.
ii. Create an application that links to the hardware, be it wearable or not.
iii. Ensure the application can 'read' beacon signals and IDs (multiple) with a compatible SDK to send haptic feedback to the user through the device it runs on. Applications will need to know when the beacon is triggered by any device, not just the device the user is currently wearing.
iv. Beacons will be setup to appropriate signal ranges for the equipment or environment they are in.

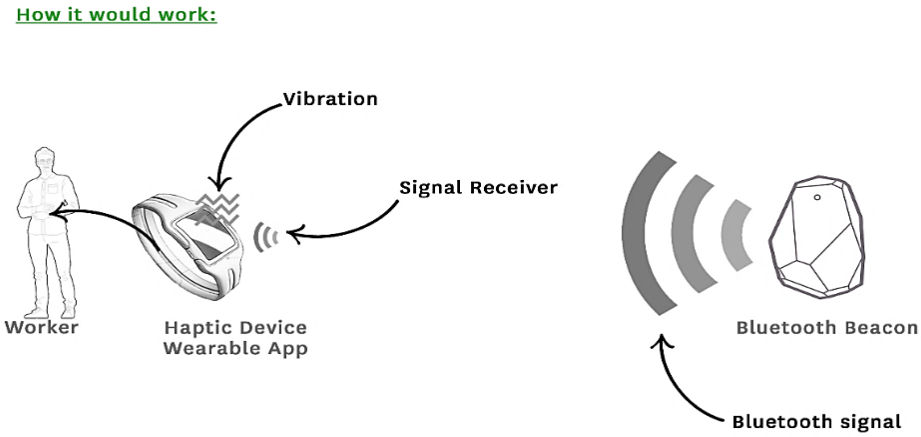

Figure 5. Potential configuration

Challenges

There are a few challenges. The specific operational use is uncommon and therefore there will be several unknown parameters necessitating the need to pivot depending on the capabilities of the technology available. For example, the Human Factors team is confident that there are existing outdoor beacons that are reliable, long lasting, and weatherproof. There is lower confidence that there will be a wearable device with an acceptable amount of reliability compared to the beacon.

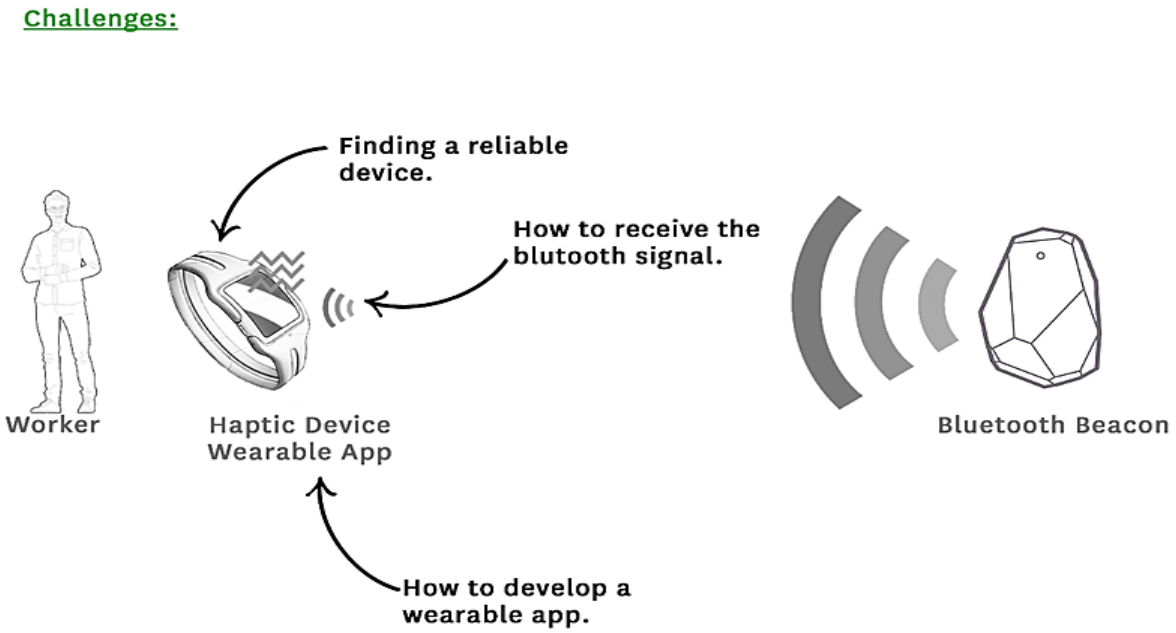

Figure 6. Potential challenges

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Suggested Technology

The technology detailed below looks to be the most likely to work together compatibly to exploring the Proximity Alert System idea further. These components will need to be connected via a custom created software.

FitBit Charge 4 Smart Watch	Beaconstac Beacon	Google Eddystone SDK

**Note: Fitbit has its own operating system, there may be a case where the operating system isn't compatible with the beacon SDK, in which we need to switch to a different smart watch.*

Next Steps

The next step is to prove the pre-existing hardware custom build approach is feasible by purchasing the equipment and building the software to link the Fitbit to the beacons. If successful, it is our aim to trial this system on a forestry landing to investigate durability, identify any issues from the environment, and gather user feedback.

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