Tian Yu Fan, Piyusha Kundu, Vishnu Penubarthi, and Daniel Ramirez

Ms. Curran

Section P STEM II

February 22, 2018

**Background & Market Research**

The proposed product is an assistive device for clients with difficulty remembering their walking aid, specifically those suffering from dementia. The product will utilize location tracking technology to emit a discreet warning when the client moves outside of a specified range of the walking aid for a specified duration. If the client fails to reclaim the walker within a specified time interval of the first warning being activated, a secondary notification will be sent to a specified other; this could be a staff member of an assisted living facility or a trusted associate. This system will afford the prospective clients greater safety and mobility despite their condition without infringing upon their independence.

Dementia is a condition found in 6.6% of adults between the ages of 65 and 99, a figure which can only be expected to increase as developing nations see elderly populations exploding (Jansen et al., 2005). Patients exhibit a range of diverse and often progressively worsening symptoms, the most common of which include disorientation, memory loss, depression, and personality changes (Mayo Clinic Staff, 2017). These symptoms, in conjunction with prescribed medications, increase patients’ risk of falls and other physical injuries; in fact, a deterioration in gait stability and muscle strength is also associated with dementia (Heerema, 2018). There is therefore a need to promote responsible amounts of physical activity in the daily routine of patients with dementia while taking additional safety precautions cognizant of their condition. However, traditional caretaking services may be insufficient to ensure the patient’s well-being, and may well even be unwanted. A device which could facilitate the locomotion of patients with dementia without depending on another person would not only provide them with increased self-sufficiency, but would significantly improve their health and longevity.

The primary technical challenge presented by the problem is that of determining the spatial or temporal conditions under which the device should send a warning. Bluetooth systems are frequently used in establishing relative location networks between multiple devices; this technology is extremely prevalent in wearable technology such as wireless headsets and fitness devices ("Radio Versions," n.d.). Active RFID tracking is a commonly employed technique in asset management which provides accurate locations of objects within a range of 60-300 feet using minimal energy, but due to the high cost of RFID readers it is practical only in large-scale operations (Smiley, 2017). Ultra-wideband (UWB) location is a relatively recent development in positioning technology, offering measurements accurate within 10 cm. However, these systems are extremely costly and most applications require the installation of numerous anchor devices throughout the area of interest ("Pozyx Ready to Range Kit," n.d.). The prohibitive cost of RFID and UWB tracking, in addition to the modest scale of the engineering problem, indicate that Bluetooth communication will be the most viable means of detecting the proximity of the client to the walker. This proximity data can then be evaluated over a period of time by the receiving device to determine whether a warning must be emitted.

Bluetooth-based location tracking systems comprise a beacon, usually a small unit which continually produces a low-energy signal that can be picked up by a nearby receiver. As signal strength is inversely proportional of the square of the distance from the transmitter, however, the uncertainty of measurement can increase drastically; while readings are highly accurate within short ranges, distances of 10 m or more can result in uncertainties of up to 5 m. Additionally, Bluetooth signals are transmitted via low-frequency radio waves, which may encounter interference from walls and other physical obstructions. The implementation of this technology to the engineering problem does not necessitate ranges greater than 5 m, but many measurements will take place indoors, suggesting that physical interference may be a formidable obstacle. The potential inaccuracy of the resulting measurements can, however, be mitigated by calculating average distances over fixed intervals of time: averages over periods of 0.5-1 s have shown far greater accuracy than instantaneous measurements (Faragher & Harle, 2014). The implementation of short-range Bluetooth proximity measurements calculated in this manner will yield sufficiently accurate data to fulfill the technical requirements of the proposed device.

The physical apparatus will comprise two units, located on the walking aid and with the client, respectively. While the construction of the devices is subject to significant variation, there are some important physical and functional requirements: the devices must be discreet, unobtrusive, durable, and capable of reliably and efficaciously performing the intended function. Bluetooth beacons are in many ways ideal for this application in their compactness and durability; beacons are frequently as small as a coin and contain batteries lasting upwards of 1-2 years (NewAndSmart, n.d.). The associated warning system of the device, however, must be successful in capturing the attention of the client and delivering a clear reminder. An audible alarm would be a clear warning, but may not comply with the discretion requested by the client. Vibrotactile notification is an inconspicuous and inexpensive alternative, but prototyping may reveal that it is lacking in its ability to capture the user’s attention. A simpler option would be to configure notifications to be sent to a caretaker charged with ensuring the safety of the client, but this approach may be impractical depending on the caretaker’s flexibility, and may be undesirable if the client seeks greater independence. The efficacy of each of these options, or any combination thereof, must be evaluated during product development and prototyping before selecting a concrete approach.

**Existing Devices**

*Table 1: Trakkies product description and analysis.*

|  |  |
| --- | --- |
|  | Device 1 |
| Device Name | Trakkies |
| Description | A bluetooth-based device which allows users to attach Trakkies to a bunch of devices to setup a relative network. When you might forget one thing in the morning, it will sense that the devices are getting farther away from each other and send you an alert message. |
| Limitations of Device | This device costs a lot of money to make and seems to only work if the user has multiple devices that they are using. In the case of the client, might not be optimal for a client to single device system |
| Citation/Link (APA) | M. (2015, July 23). Trakkies – A Multifunctional Microcomputer For Your Things. Retrieved February 17, 2018, from https://thegadgetflow.com/portfolio/trakkies-a-multifunctional-microcomputer-for-your-things/ |

*Table 2: Alert System and Cadence Walker product description and analysis.*

|  |  |
| --- | --- |
|  | Device 2 |
| Device Name | Alert System and Cadence Walker |
| Description | A system, mostly comprised of a receiver, a microcontroller, and a speedometer, records the time usage, distance travelled, and cadence of a user’s walker. The device will also notify the user when they move to an unsafe distance from the walker. |
| Limitations of Device | The total manufacturing cost of this device is $199.42; on the market, the user would have to purchase it at an even higher price. The device fails to directly contact the caregiver if the user is too far from their walker. The device cannot be easily found and purchased on the internet. |
| Citation/Link (APA) | O’Connell, R. (2013). *Alert system and cadence walker*. Retrieved from http://bmedesign.engr.wisc.edu/projects/file/?fid=2731 |

*Table 3: TITI Bluetooth Key Finder product description and analysis.*

|  |  |
| --- | --- |
|  | Device 3 |
| Device Name | TITI Bluetooth Key Finder |
| Description | A small object which can fit into wallets or on keychains that connects to the manufacturer’s corresponding app, from which a user can track a missing device, identify its last resting place, or trigger an audible alert to help locate it. |
| Limitations of Device | The app seems to have no built-in functionality to send warnings at a certain distance or after a specified duration of time. The device costs only $13.99, but it may be difficult to customize the functions of the app. Some Amazon reviews indicate that the sound from the device is insufficient over larger distances. |
| Citation/Link (APA) | TITI Bluetooth Key Finder, Phone Finder, Wallet Locator, Key Tracker for Apple iOS and Android Phone Tablet. (n.d.). Retrieved from http://www.titifinder.com/product/titi-bluetooth-tracker-phone-finder-key-finder-wallet-locator-for-ios-android-phone-tablet/ |

*Table 4: Bluetooth Tile product description and analysis.*

|  |  |
| --- | --- |
|  | Device 4 |
| Device Name | Tile |
| Description | A device that uses bluetooth connection to a cellular device to find and locate lost items. The small object has a location where it attaches to a key-fob or other items that are likely to be lost. Clients can press the Tile object twice to make the lost device ring (even if on silent). The device is easy to use and directly connects to an app; the app can run in the background and will located the exact time and place the client had the item. The tile app also connects users to a network of people. |
| Limitations of | The device only finds lost items. It will not alert the user if it they walk away from an item. A one-pack item is available for $19.99, but cheaper versions may exist. |
| Citation/Link (APA) | Find your keys, wallet & phone with Tile’s app and bluetooth tracker device | tile. Retrieved from <https://www.thetileapp.com/en-us/> |

**References**

Alzheimer’s Association. (n.d.). What is dementia? Retrieved February 23, 2018, from alz.org website: https://www.alz.org/what-is-dementia.asp

Avvel International. (n.d.). iBeacon Bluetooth low energy BLE 4.0 proximity device. Retrieved February 23, 2018, from https://www.amazon.com/iBeacon-Bluetooth-Energy-Proximity-Device/dp/B00JEGXITG

Faragher, R., Harle, R., "An Analysis of the Accuracy of Bluetooth Low Energy for Indoor Positioning Applications," *Proceedings of the 27th International Technical Meeting of The Satellite Division of the Institute of Navigation (ION GNSS+ 2014)*, Tampa, Florida, September 2014, pp. 201-210.

Heerema, E. (2018, February 12). Common causes of falls in people with dementia. Retrieved February 23, 2018, from Very Well website: https://www.verywell.com/causes-of-falls-in-people-with-dementia-98558

Intro to Robotics. (2013, November 20). Types of sensors for target detection and tracking. Retrieved February 23, 2018, from https://www.intorobotics.com/types-sensors-target-detection-tracking/

Jansen, A., van Hout, H., van Marwijk, H., Nijpels, G., de Bruijne, M., Bosmans, J., . . . Stalman, W. (2005, December). *Cost-effectiveness of case-management by district nurses among primary informal caregivers of older adults with dementia symptoms and the older adults who receive informal care: Design of a randomized controlled trial* (Research Report No. ISCRTN83135728). Retrieved from BMC Public Health website: https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-5-133

JokerDAS. (2015, October 15). Bluetooth proximity PC lock. Retrieved February 23, 2018, from http://www.instructables.com/id/Bluetooth-Proximity-PC-Lock/

Jones, S. (n.d.). Alerting devices. Retrieved February 23, 2018, from https://www.healthyhearing.com/help/assistive-listening-devices/alerting-devices

Mayo Clinic Staff. (2017, August 2). Dementia. Retrieved February 23, 2018, from Mayo Clinic website: https://www.mayoclinic.org/diseases-conditions/dementia/symptoms-causes/syc-20352013

NewAndSmart. (n.d.). NaamaSmart iBeacon Bluetooth LE 4.0 Slim Design Fully Programmable EDDYSTONE Compatible, Works with Android and iOS WHITE. Retrieved February 23, 2018, from https://www.amazon.com/NaamaSmart-Bluetooth-Programmable-EDDYSTONE-Compatible/dp/B074T4G64B/ref=sr\_1\_4?s=electronics&ie=UTF8&qid=1519331818&sr=1-4&keywords=iBeacon

Pozyx Ready to Range Kit. (n.d.). Retrieved from https://www.pozyx.io/store/detail/1

Radio Versions. (n.d.). Retrieved from https://www.bluetooth.com/bluetooth-technology/radio-versions

Smiley, S. (2017, July 10). Active RFID vs. Passive RFID. Retrieved from https://blog.atlasrfidstore.com/active-rfid-vs-passive-rfid

Srinivasan, P., Antonia, S., Rekha, A., & Anbarasu. (2014, March). *Locate misplaced objects! GPS-GSM-Bluetooth enabled tracking*. Retrieved from IJCTT Journal website: http://ijcttjournal.org/Volume9/number-1/IJCTT-V9P103.pdf

Stan. (2013, December 27). How to connect an Arduino Uno to an Android phone via Bluetooth. Retrieved February 23, 2018, from http://42bots.com/tutorials/how-to-connect-arduino-uno-to-android-phone-via-bluetooth/