Evaluation Form – Technical Background Review

Student Name: _____

Project Advisor: _____

Team Name: _____

Team Members: _____

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_____ / 30 Technical Content

- Current state-of-the-art and commercial products
- Underlying technology
- Implementation of the technology
- Overall quality of the technical summary

_____ / 30 Use of Technical Reference Sources

- Appropriate number of sources (at least six)
- Sufficient number of source types (at least four)
- Quality of the sources
- Appropriate citations in body of text
- Reference list in proper format

_____ / 40 Effectiveness of Writing, Organization, and Development of Content

- Introductory paragraph
- Clear flow of information
- Organization
- Grammar, spelling, punctuation
- Style, readability, audience appropriateness, conformance to standards

_____ **/ 100 Total - Technical Review Paper**

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GPS Tracking Systems for Wearable Self-Defense Devices

Introduction

Wearable technology such as fitness trackers, smart watches, heart rate monitors, and global positioning system (GPS) tracking devices are becoming ever more popular in the consumer market as they provide users an opportunity for self-health management to ensure a healthier lifestyle. In fact, wearable technology was considered number 2 in the top 20 fitness trends for 2021 according to the Worldwide Survey of Fitness Trends [1]. Besides monitoring heart rates and tracking the users' daily activities such as step count and distance traveled, tracking devices provide an additional safety aspect by keeping track of people's real-time GPS coordinates. Obtaining accurate, real-time location-based information about the user requires a tracking system that is highly accurate, lightweight, and compact in a wearable device. This technical review briefly summarizes some commercially available GPS tracking systems designed for wearables, explains advances in the technology, and provides suggestions in its implementation in wearable self-defense devices.

Commercial Applications of Compact GPS Tracking Systems

Using a GPS-enabled wearable device to keep track of people's real-time GPS coordinates requires a highly accurate and compact GPS tracking module. A good horizontal positioning range for a GPS module is between zero to three meters [2]. At the top of the line is the NEO-6M GPS module offered by Swiss company u-blox that has a horizontal position accuracy of 2.5 m [3]. Additionally, the module boasts a compact size of 16 mm x 12 mm [3], fulfilling the compact requirement for a wearable device. This module is marketed at €43.31 ($50.05) [4].

Another competing module is the Grove GPS module by Seeed Studio. Like the NEO-6M, the Grove GPS also has a horizontal position accuracy of 2.5m [5]. The Grove GPS module is the cheaper option, marketed at $25.90, but it comes with a trade-off as it has larger dimensions at 40 mm x 20 mm [5], almost twice that of the NEO-6M.

Technology of GPS Tracking Systems

What is GPS?

The Global Navigation Satellite System (GNSS) comprises of at least 24 active satellites that supply geospatial positioning with worldwide courage 24 hours a day [6]. The GPS was the first GNSS

designed by the Department of Defense of the United States, initially released for military use, but they were made available for civilian use in the 1980s [7].

The GPS is differentiated into three main components, namely the user component, the space component, and the control component [6]. The user component consists of all GPS receivers [6]. With a GPS receiver, the user may identify their GPS coordinates (latitude, longitude, altitude) anywhere globally [6, 7].

The second component is the space component. This is where all the GPS satellites are arranged so that any GPS receiver can lock on to at least four satellites [6].

The last component is the control component. The control component consists of five control stations aligned carefully from each other around the world to monitor the performance and collect data from all of the GPS satellites [6].

How does the GPS work?

The GPS is a tracking system that assesses the signals of the GPS satellite network to triangulate its position [8]. GPS receivers use the process of trilateration to determine the user's location by computing the intersecting points of multiple satellite signals. To break this down, if the receiver acquires a GPS signal from only one satellite, the set of possible locations would be a spherical shell. When a second satellite signal is detected, the set of possible locations will narrow down to a 2-D circular intersection as a result of two spherical shells crossing. A third satellite signal will then further narrow down the possible set of locations to two intersecting points. The location of the receiver will be the closest point to the earth's surface. Therefore, a receiver must be locked on to at least three satellites to obtain its latitude and longitude [7]. With four or more satellites in view, the receiver can determine its altitude in addition to its latitude and longitude [7]. Generally, a GPS receiver will have four or more satellites in view [6], ensuring the accuracy of the GPS tracking system.

Improvements

Although the original concept for GPS tracking systems has largely remained unchanged, today's GPS receivers are extremely accurate due to powerful GPS position enhancement techniques, namely the differential GPS (DGPS) method [7]. The DGPS method uses a reference receiver located at a fixed, known location that calculates the difference it obtains between its measured position and its actual position and transmits the correction data to the nearest DGPS receiver [6]. This method is able to provide a highly accurate position within a range of a few millimeters to a meter [6]. It is, however, worth noting that the DGPS method requires an additional receiver and antenna in addition to the GPS receiver [7].

Implementation of GPS Tracking Systems in a Wearable Self-Defense Device

Due to the widespread use and high availability of GPS in wearable technology today, the implementation of GPS tracking systems in a wearable self-defense device would not be any different from a regular wearable such as a smart watch or a fitness tracker. However, careful consideration must still be taken when choosing the right GPS module for a wearable self-defense device. The GPS module must be lightweight and compact to ensure comfort for the user. It must also provide high GPS accuracy, preferably a GPS module with DGPS technology integrated, in the event of an emergency where the user needs to share their location. With this information, the product team must choose the most suitable GPS module for their device.

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