

## **1. Problem Statement**

### **1.1. Historical Introduction**

One of the first devices ever to measure a person's pulse rate, the often associated rubric of vital measuring, was the lie detector. John Larson was credited the invention of the lie detector in 1921. The lie detector revolutionized history by using multiple sensors, such as pulse rate sensors and respiration rate sensors, in a single system. Half a Century later, Polar released the first ever wireless heart rate monitor in 1982. Though touted as wireless, there was no wireless communication interface; it simply did not require wires to give instantaneous measurements of pulse rate. Since then, fitness trackers, such as Fitbit and Garmin, have evolved considerably, introducing more activity measurements, better ways of viewing data, and more accurate or convenient measurement techniques.

From the first lie detector model to the latest Fitbit vital measuring watch, these vital measurement devices share a core philosophy of purpose. All of these devices examine obvious and easy to measure characteristics of physical bodies to determine obtuse and difficult to quantify measurements. The original lie detector took the measurements of pulse rate and respiration to determine the elusive quality of honesty. Modern fitness wearables take even more physical statistics into account and yield helpful insight into subtle categories such as injury recovery, exhaustion levels, and fitness progress tracking.

Modern health tracking wearables now exist in abundance; however, at public sporting events, interference prevents the use of the fitness trackers from monitoring the health of players in the game. Zotikon overcomes and shines in these situations by making use of a different wireless interfacing protocol. Zotikon devices connect with advanced techniques that improves its communication in environments laden with interference, increases its range and reliability, and even lowers power consumption in many situations. This allows coaches to easily communicate with and monitor an entire team's worth of Zotikon devices simultaneously and accurately in many different environments and situations. From an indoor basketball game surrounded by thousands of fans on interfering devices to an expansive soccer field where players are great distances away, Zotikon is equipped and ready to meet any challenge.

### **1.2. Market and Competitive Product Analysis**

Zotikon would primarily be used by competitive athletes or teams to monitor their health as they train for anything from high school competitions to the Olympics. The National Collegiate Athletic Association (NCAA) reports that there are over 460,000 college athletes competing in 24 different sports every year [3]. The US Bureau of Labor Statistics reported in 2014 that there were 13,700 professional athletes in the United States [1]. Five hundred and fifty-eight athletes were chosen to represent the US in the 2016 Olympics [2]. With so many athletes trying to gain a competitive edge, there is a high demand for health monitoring systems to improve athletic training regimens.

Currently, the wearable health monitoring device market is composed of individual wearable systems and team-based wearable systems. Team-based wearable systems are designed to monitor multiple athletes simultaneously and display those readings to a training staff. The monitoring devices in team-based systems are usually designed to be easily concealable under a jersey to allow them to be worn during NCAA competition events. Polar offers a team-based system with wearable chest straps that relay the heart rate of the athlete back to a tablet for the trainer to watch in real-time. Polar uses Bluetooth to connect its athlete-worn devices to the tablet. It also has software to send the data saved during the training session or game back to a desktop whenever the trainer chooses. The use of Bluetooth in Polar athlete-worn devices limits the range at which trainers can receive the heart rate data reliably. Polar also

has limited software to support a user friendly experience. The software they use to export data simply takes a screenshot and saves it as a PDF, which forces the training staff to manually enter the data into another program to be able to process the raw data. Polar charges more money for any other software to help process data.

Individual wearable systems are designed to monitor a single athlete and, in more recent years, have become heavily integrated with wristwatches, which makes it impossible to conceal them for competition activities. Garmin offers three series of devices in the individual wearable market with heartrate measuring capability — Forerunner®, fēnix®, and vivoactive®. These devices cost \$200 for the simplest models and \$900 for the most advanced models. Garmin also provides a well-developed software platform for viewing the sensor data post-activity that includes heart rate data, step tracking, and a variety of Global Positioning Satellite (GPS)-based measurements that are targeted for the running community. However, the software is limited because it is only for post-activity analysis and only supports input from a single athlete. The wearable device comes in a wristwatch, which means athletes could not wear it during NCAA competitions.

The Zotikon system is configurable for team-based and individual monitoring in real-time. The Zotikon system communicates with a highly-robust, software-defined radio, which eliminates the connectivity issues in Polar team-based devices. The software platform offered with Zotikon outperforms the software provided by Polar by allowing easy data exports in common formats. In order to be compliant with NCAA rules that stipulate any wearables must be concealable under the athlete's uniform, the athlete-worn monitoring device in the Zotikon system is a small chest strap unit. Since Zotikon is targeted towards sporting events that occur in an enclosed area, GPS is not a feature that is beneficial to include to compete with Garmin products that target the running community. From an interview with a member of the training staff at Mississippi State University, step counters are also not useful since it is easy to generate false measurements. While Zotikon targets the team-based market by improving functionality compared to other vendors, its flexibility and design allow it to compete in individual markets as well.

### **1.3. Concise Problem Statement**

Professional trainers for competitive athletes continually seek to improve athlete performance during training and competition but lack the ability to conveniently and accurately monitor the essential performance indicators or a method to analyze performances post-exercise. Zotikon provides real-time monitoring of those indicators and communicates them through a robust network to trainers to allow for advanced, adaptive workouts and finely-tuned recovery periods and, upon completion of the exercise, the information is available in common data formats for further analysis.

The Zotikon system performs these monitoring functions with an athlete-worn device and communicates them real-time to a trainer's station where members of a training staff can carefully monitor the athletes' performances. The athlete-worn device collects the essential performance indicators — heart rate and movement data. Collection of the indicators persists regardless of sweat or physical contact. Because this system is designed for use on common athletic courts and fields, the athlete-worn devices communicate nearly line-of-sight with the trainer's station over the required distance for common courts and fields and withstand the harsh electromagnetic interference (EMI) that exists in sporting arenas. Due to a mesh networking backbone, the devices are able to communicate much farther if enough devices are present in the transmission path. The system at the trainer's station allows real-time access to all the performance indicators on each player being monitored and includes algorithms to assist with player performance analysis and overstress warnings. It also allows the training staff to export the data from an event to common data formats for post-processing analysis.

#### **1.4. Implications of Success**

Zotikon enables coaches from many disciplines to more personally and precisely train athletes. Coaches can see athletes' real-time physical performance data and adjust coaching accordingly. Zotikon records this data to provide an overview of the athlete or team's performance over time. If a player is injured or falls ill, causing his or her performance to drop during recovery, coaches can use Zotikon to maximize an athlete's improvement while limiting the athlete to a safe level of activity. For example, an athlete might have recently recovered from a severely sprained ankle. Inability to train may have caused the athlete's physical fitness level to suffer. A coach would compare the player's heart rate and movement data, which reflect fitness, before the injury to data collected after the injury and aim to bring the player back to pre-injury fitness while also allowing the coach to record recovery time. During this process, the coach would see when the athlete becomes unsustainably exhausted, allowing the coach to give tactical breaks as needed to improve fitness recovery times.

This functionality has the ability to impact the performance of athletes everywhere. A successful launch of Zotikon would see use of the system within both college and professional sports leagues. With the information provided by the Zotikon system, athletes will be able to push their bodies to the limit. If an athlete knows the limit, proper training and exercises can raise those limits. Athletes could see the progress of their fitness over time. In turn, this would produce athletes with a skill level never before seen by previous generations of athletes.

## References:

- [1] Bls.gov. (2017). Athletes and Sports Competitors : Occupational Outlook Handbook: : U.S. Bureau of Labor Statistics. [online] Available at: <https://www.bls.gov/ooh/entertainment-and-sports/athletes-and-sports-competitors.htm#tab-6> [Accessed 5 Sep. 2017].
- [2] Team USA. (2017). Meet Team USA. [online] Available at: <http://www.teamusa.org/road-to-rio-2016/team-usa/athletes> [Accessed 5 Sep. 2017].
- [3] NCAA.org - The Official Site of the NCAA. (2017). Student-Athletes. [online] Available at: <http://www.ncaa.org/student-athletes> [Accessed 5 Sep. 2017].
- [4] Polygraphia.ca - Polygraph Examination Service. (2011). The Polygraph History. [online] Available at: [http://www.polygraphia.ca/polygraph\\_history.html](http://www.polygraphia.ca/polygraph_history.html) [Accessed 31 Aug. 2017].