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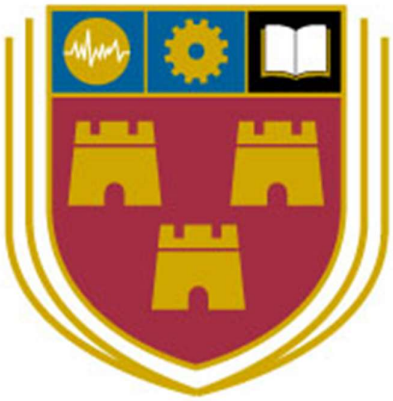

INSTITUTE of TECHNOLOGY CARLOW

At the Heart of South Leinster

Department of Computing & Networking.

Bachelor of Science (Hons) in Software DevelopmentCW238

Research Document.

Design and develop of a suitable activity monitor for Children with Autism.

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Abstract

The purpose of this project is to develop an application and accompanying wearable device that would enable parents, guardians, teachers, or care home workers to track the activity levels of children who suffer from autism spectrum disorders. The hope is that the use and adoption of this application would help improve the physical and over all health of such children.

The users of the app, who are intended to be use the app are mentioned above and it would allow then to monitors the children's activity levels. The metrics that will be measured will be the total number of steps, the number of calories they burned and the total distance they have walked.

The app will allow the user the easily store in the apps local database and access previous sessions data by searching for sessions with a specific name. Searching a name will also allow the user of the app to view the average of each of the recorded metrics for each child and will allow them to display this data in the form of various graphs which will give them a better visual representation of the activity data and allow them to view any progression made more easily.

There are an estimated 14,00 school aged children who suffer from ASD in Ireland, or around 1 in every 65 children in the country. This equates to a quite sizable group of children, who tend to be much less physically active than there normally developed peers, who could positively from the use of this application.

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Introduction.

The topic I have chosen for my Software Development Final Year Project is to design and develop a suitable activity monitor for Autistic children like a Fitbit. As mentioned in the project specification, a gap in our understanding exists about the relationship between the well-being of children with Autism and the amounts and types of exercise they undertake. The aim of this project is to research this topic and develop a device which would measure the activity levels for such children. This project will be undertaken in conjunction with the Health Sciences in IT Carlow, with Dr Sharon Kelly, who is heading the research into the area of wearable technologies for children with autism.

I have a 11-year-old brother with autism, so this project has a personal connection to me. Recently he has begun to take more of an interest into physical activity, having recently taken up soccer with a local u11 team and partaking in swimming lessons once a week. He also regularly makes comments on the number of calories he consumes and why he shouldn't eat another. Despite not really having any understanding of caloric intake and the physical exertion needed to burn of any excess calories consumed, he has shown that he is aware of his weight and the affect eating has on it. With his growing interest in sport and physical activity I feel as if this is a perfect choice for me

Areas covered in this report.

The report to follow contains:

- An overview of existing activity / fitness trackers on the market today, and the most popular of such devices.
- A list of technologies used in the development of such devices. This includes both the hardware (devices used to gather activity data) and the software(programming language, IDE) used in the development of these devices, as well as the benefits of each followed by my conclusion of which is best for use in the development of my project.
- Research into wearable technology in relation to kids with autism. This includes studies on the effect of wearing wearables on the physical activity levels of autistic kids and more.
- Research into the main challenges the development of such a device would face.

Activity Trackers.

An Overview:

"*An activity tracker is a type of electronic device that helps monitor some type of human activity, such as walking or running, sleep quality or heart rate. An activity tracker can be a smartwatch, or other small device linked to a local area network or otherwise connected to an IT system*"[Techopedia, 2021]

An activity tracker, or also known as Fitness Trackers, are devices or applications which are used for monitoring the wearers fitness related metrics such as the total distanced walk on a given day along with the numbers of steps the user took while walking or total caloric intake during a given day along with an estimated caloric usage. Other metrics monitored by these devices include heartrate / bpm, sleep quantity/quality. Primarily, these devices are smartwatches, which are synched, predominately wirelessly, to a smart phone where the wearers data is tracked and analysed.

Most Popular.

Fitness trackers and activity monitors have become increasing popular in recent years. Here are some of the big players that have emerged as the gold standard in the fitness tracker market.

Fitbit – Fitbit is an American consumer fitness electronics company. Probably the most popular fitness tracker on the market, Fitbit offers many different products ranging from smart watches to bracelets. As of 2019, Fitbit was the 5th largest wearable technology company in terms on shipments. Since its inception in 2007, they have sold more than 100 million devices and have 28 million regular users of their devices and the related software.

The key features of Fitbit devices:

- Sleep pattern tracking.
- Heart rate monitoring.
- Blood oxygen tracking.
- GPS tracking. (Rowden, 2021)

Garmin- A relatively new player in the wearable fitness tracker market, Garmin is an America multinational company founded in 1989. Specializing in GPS technology for automotive, aviation and marine activities. After beginning to develop technology for outdoor activities and sports, Garmin moved into the wearable technology for everyday consumers and now are competing with the likes of Apple and Fitbit. They are now one of the most prominent wearable technology companies with their range of wristwear technology aimed at activities such as running, swimming, golf, and cycling.

The key features of Garmin wearables are:

- Smart watch capabilities.
- Heart rate monitoring.
- Sync with Garmin Connect.
- Run tracking.
- Run tracking.
- Auto cycle detection.
- Body battery estimate. (ThreadCurve, 2020)

Apple Watch – The Apple watch was first released in 2015 and initially was designed to operate primarily in conjunction with the users iPhone, allowing the user to configure the watch to sync data with the iPhone's apps. It basically acts as a wearable extension of an iPhone on your wrist.

Apple then joined the activity tracker market with the launch of the Apple Health App. The Apple watch shows your activity levels in rings. A red ring tracks and displays how many calories your have burned in a day. A green ring tracks any exercise done that day, with an exercise being defined as any movement more intense than a brisk walk. The final blue ring is called the stand ring and it reminds the wearer of the device to stand up and move around if they have been sedentary for too long.

Other key features of the Apple Watch include:

- Long term activity trend tracking
- Workout tracking.
- Automatic workout detection.
- Ability to compete with friends.
- Fall detection for older wearers. (Mitroff, 2019)

Technologies:

Hardware:

To be able to function and gather the wearers activity data, wearable activity trackers require some must have hardware to function correctly. These include:

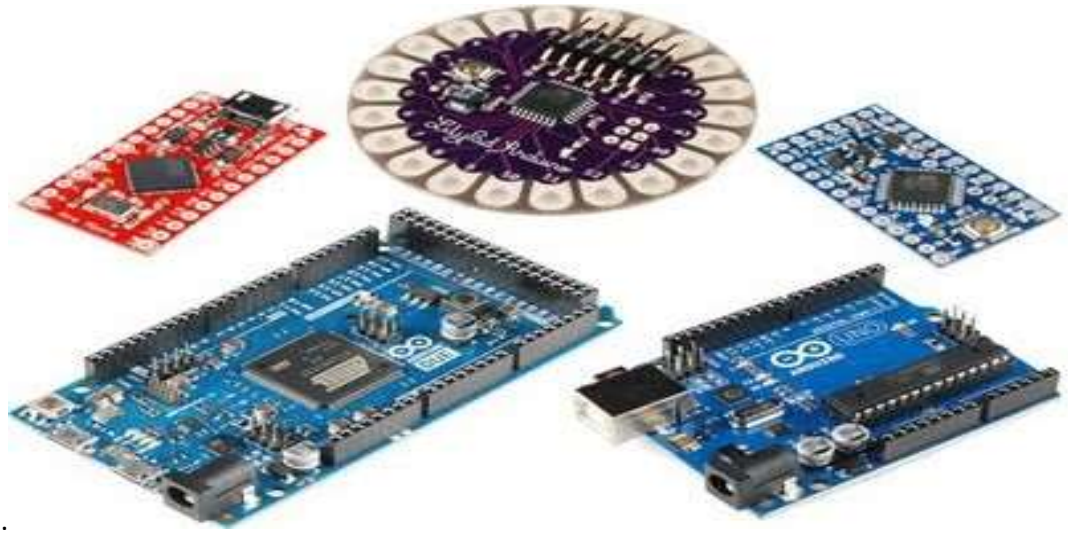
- **Accelerometers** – Accelerometers are designed to measure acceleration and track motion. It is primarily used to collect user data while cycling, running, walking, and swimming. The data collected includes speed, distance, cadence, calories burnt etc.
- **Gyroscopes** – A gyroscope is a device that uses the earths gravitational field to determine the orientation an object in space. They can be installed separately but in general they are used with in coordination with accelerometers.
- **Compasses** – A compass is used to determine an objects cardinal direction. Like gyroscopes, compasses can be installed individual but usually accompany the abovementioned hardware.
- **Micro-controller** - Microcontrollers are compressed microcomputers used to control embedded systems in robots, home appliances, automobiles, and a variety of other devices. Memory, peripherals, and, most crucially, a CPU are all included in a microcontroller.
- **Ambient light sensors** – As you can tell from the name, these pieces of hardware are used to detect the amount of light in the surrounding environment. They then automatically adjust the brightness of a devices display screen to avoid eye strain.

- **Bioimpedance Sensors** – These sensors are used to resistance of body tissues to even the smallest measure of electric current. They use this to gauge different physiological signals such as respiration rate, heart rate or galvanic skin response.
- **Barometric altimeter** – These are used to measure atmospheric pressure to determine the altitude the wearer is at. This can be used to assist in physical activities such as hiking and mountain climbing. (Pisuwala, n.d.)
- **Bluetooth** – Most fitness trackers use BLE, or Bluetooth low energy, to sync the activity data they have recorded to their accompanying app.

Conclusion.

In the context of my project, I have decided to use the following components to assembly the wearable device to track the activity data

1. 2. 3.



5. 4.

Figure 1. Types of Arduino boards

Microcontroller – The above figure shows the 5 main micro controller options available to me. They are as follows:

1. Arduino Red Board.
2. Arduino Lilypad.
3. Arduino Pro Mini.
4. Arduino UNO R3
5. Arduino Leonardo.

All the above have their own pros and cons, but I have chosen the Arduino Pro Mini. The pro mini microcontroller based on the ATmega328. It's designed to be permanently embedded into portable devices. It was a close call between using the Pro Mini or the Arduino Lilypad,

but I opted with the Pro Mini for its small weight, compact size, and low power consumption. Its low cost and its small and compact size make it perfect for my project.

Figure 2. MPU 6050

Accelerometers / Gyroscope – I have decided to go with the MPU-6050 as it is the best suited for my project as it contains both the required accelerometer and gyroscope. It is a MEMS, which stands for Micro Electro-Mechanical system. It consists of a 3-axis accelerometer and a 3-axis gyroscope which are used to measure such features as velocity, orientation, and acceleration. Again, its small size if perfect for my project.

Figure 3. HC-06 Bluetooth module

Bluetooth – The wearable device will send the activity data gathered by the MPU 6050 to the application via Bluetooth. To do this I will use the HC-06 Bluetooth module. The HC-06 is very widely used with Arduino boards.

Figure 4. 3.7v LiPo Battery

Figure 5. LiPo Charger

Power Supply – The device will be powered using a 3.7v LiPo battery. These batteries are designed for use in electronic devices what require small amounts of power which makes it perfect for my project. In addition to the battery, I will also use a LiPo battery charger module which will allow the device to be recharge.

Software.

The next decision for me to make is what technologies I will use for the development of the software component of my project. These include which IDE I will use, which programming language I will code the project in, what database I will use for the back end of the application, and which is my target operating system.

Integrated Development Environment.

One of the main decisions to be made regarding the development of my project is to decide on which Integrated Development Environment to use. The project spec requires me develop my app for one of Android or iOS or Linux or Windows, and depending which operating system I choose, will determine which IDE I will use. The 3 main integrated development environments that came into consideration are as follows:

Android Studio:

Android Studio is the official integrated development environment for developing apps for Android Devices. It is based on IntelliJ's IDEA, the main integrated development environment for Java Virtual Machine languages. As well as IntelliJ's powerful code editor and developer tools, Android Studio offers even more futures that also enhance your productivity when building apps. (Developers, 2020)

These include, and are not limited to:

- A flexible Gradle-based build system
- A fast and feature-rich emulator
- A unified environment where you can develop for all Android devices
- Apply Changes to push code and resource changes to your running app without restarting your app
- Code templates and GitHub integration to help you build common app features and import sample code
- Extensive testing tools and frameworks
- Lint tools to catch performance, usability, version compatibility, and other problems
- C++ and NDK support
- Built-in support for Google Cloud Platform, making it easy to integrate Google Cloud Messaging and App Engine (Developers, 2020)

XCode

XCode is Apples proprietary integrated development environment that allows developers to build apps for iOS devices such as iPhone, iPad, and Apple Watch. It provides very useful tools to manage your entire application development workflow from creating your new app at the beginning, to testing it, optimization and finally, submitting your finished application to the Apple Store.

The XCode interface integrates code editing user interface design, asset management, testing and code debugging into a single workspace window.

This window reconfigures what content it displays as your work. This means that when you select a file in one area, the appropriate editor opens in the appropriate area. It also allows developer to focus on certain tasks by only displaying only what you need, such as just your source code or user interface layout. (Developers, 2016)

The benefits of using XCode as my IDE include:

- Helpful Assistant Editor to aid developers
- Smooth Navigation of project workflow.
- Easy application testing.
- Built in scheme feature.
- SwiftUI (Developers, 2020)

SwiftUI is apple proprietary programming language and all apps developed using it are native to iOS devices. One of its main selling points is the ease in which an app developed for one iOS device such as the iPhone, can be easily ported across to another iOS device such as a MacBook.

Xamarin

Xamarin is an open-source platform for building modern applications for Android, iOS, and Windows with .NET. It is an abstraction layer that manages communications of shared code with the underlying platform code. It enables developers to share, on average, 90% of their applications across multiple platforms. This allows developers to write all their business logic in a single programming language, or alternatively, reuse existing application code, while also achieving native performance, look and feel on each platform respectively.

Technically speaking, Xamarin is not an IDE, but rather a platform so I would be using Visual Studio, which has been my IDE of choice since beginning college back in 2018. As Xamarin is so widely used and is constantly growing in popularity there is a vast amount of documentation available to me if I choose to use the platform.

The key benefits of using Xamarin include:

- API integration.
- Useful compiled code.
- Community support.
- Shared code base.
- Cross platform app development. (Labs, 2017)

Conclusion.

After researching the options available to me, all three of the abovementioned integrated development environments have their own benefits. However, I have decided to begin development in Android Studio. This is based on having worked briefly with Android Studio

in the past along with having the most experience with the programming languages it is compatible with, both Java and C++ .

Programming Language & Operating Systems.

The next decision to be made is which programming language(s) I will use for development. This decision was very much dependant on which integrated development environment I have chosen. As I have decided to use Android Studio, the choices regarding which programming language to use are listed below:

C++ :

Like Java, C++ is another general purpose, object-orientated programming language. It was developed by Bjarne Stroustrup of Bell Labs in 1979. C++ is compatible with C, being capable of compiling 99% of programs written in C without changing a single line of code. However, C++ is more well-structured and safer language than C. (Thompson, 2021)

Although Apple and Google champion specific programming languages for mobile development (Swift for Apple's iOS, and Java for Googles Android), C++ provides an alternative route for developing mobile apps. Last year, Android Studio added support for the Native Development Kit (NDK) so that developers could use C/C++ in their Java Apps. (Bolton, 2016)

Using C++ for app development has the following benefits:

- Faster code.
- Smaller memory footprint (Bolton, 2016)
- Re-usability
- No warm-up time when compiling (Bolton, 2016)

Java

Java is an absolute must know for developing an Android App compatible with wearable devices. It is operated by Oracle and was created in 1995. Java is the official language of android development and many of Androids APIs are written in Java. Java is the probably the most common option for building modern hight performance mobile applications. (Admin, 2021)

Java's development of wearable technology and devices has become a main players in the wearable market. Googles Android Wear OS is compatible with most wearable devices, even the Apple watch and other iOS devices. This kind of flexibility has meant that those who develop applications for Android Wearables in Java have become in very high demand.

The benefits of using Java include:

- Easy to learn and use
- Compatible Platforms
- Community supports for developers
- Powerful development tools
- Open-sourced programming language.

- Object-Orientated. (Admin, 2021)

All the above benefits have meant, according to State of Developer Nation report by Slashdata, that the number of Java developers worldwide has now exceeded 8 million, with an estimated 500,000 new developers expected to join the workforce yearly.

Kotlin

Kotlin is a general purpose, free, open source, programming language initially designed for the Java Virtual Machine and Android. It combines object-orientated and functional programming features (Heller, 2020)

Kotlin is fast becoming a favourite programming language of choice for android developers. Despite Java popularity as the go-to programming language for Android, Kotlin now offers a viable alternative. They key benefits of using Kotlin for Android Development are:

- Shorter and simpler code.
- Compatibility with Java.
- Null reference elimination.
- Solutions to Java's flaws.
- Cross platform development. (Developers, 2020)

While Java will remain the industry standard for Android app development, Kotlin will continue to grow in popularity and stature. Its impressive built-in features such as the null safety support and its ability to enable developers to build an app that can run on both iOS and android will mean that this rise in popularity will certainly continue.

Conclusion.

Despite C++ being my preferred language to code in and having more experience in it than other programming languages, my experience using Android Studio was in Java and the development of this project is a perfect opportunity to gain more exposure to Java, which is one of the most in demand programming languages in the world today. As well as this there is a huge number of online resources for android development in Java as it is the official language of android development. I will also be required to write some C++ code during my project as Arduino are programmed using C++.

Database and Backend

To complete this project, I will also require a backend database to store the activity data to be displayed on the app. There are three obvious database options that stood out to me immediately.

MySQL

MySQL is and open-sourced rational database management system used to create and manage databases. It uses a specific language to interact with the database, called standard query language, or SQL.

SQL can perform the following operations to the database:

- Data query – request specific information from the database.
- Data manipulation – This includes operations such as adding, deleting, creating, or updating data in the database.
- Data identity – Identifying or defining different data types. For example, changing a numerical value to an integer.
- Data access control. – MySQL provides data security which easily allows the user to control who can view or use any of the data stored in the database.

MySQL is perhaps the most widely used database software. It is extremely flexible and easy to use. It is very reliable, whether you are storing huge amounts of data or just using it for the back end of a college assignment, MySQL provides efficient and smooth data management. It also provides data security using both its Access Privilege System and User Account Management. All these factors have meant that MySQL has been the industry standard for years. (Boyett, 2021)

Firebase

The other option available to me is the Firebase Realtime Database. Firebase is a database hosted on a cloud platform. Data is stored in JSON format and is synchronized in real time to every client that is connected to it and remains available when your app goes offline. The Firebase Realtime Database can be accessed from both a mobile device or web browser directly and does not require an application server to host. It provides an Apple platform and both Android and JavaScript software development kits which allows users to develop cross-platform apps which share one real time database and provides automatic updates with the newest up to date data.

Data access control is governed by Firebases own language called Firebase Realtime Database Security Rules. This allows developers to define who has access to what data as well as how your stored data is defined along with when data can be read or written to. (Developers, 2021) The key advantages of Firebase Realtime Database are:

- Fast and safe data hosting.
- Reliable and extensive database.
- Google Analytics integration.
- Free multi-platform Firebase authentication.

SQLite.

Just like MySQL, SQLite is an open-source Rational Database Management System. SQLite is a self-contained database that does not require a server. This is also known as an embedded database because the database engine is integrated within the program.

The SQLite library is quite small compared to its alternatives and it stores data directly into a single file. SQLite is best suited for small, standalone development projects which do not require much scalability. The advantages of using SQLite are as follows:

- File-based

- Easy to set up and use
- Easily portable
- Uses standard SQL syntax with minor alterations (S, E., 2022.)

Conclusion.

Based on my research into all the above options and despite my previous experience working with MySQL, I have chosen to work with SQLite for my project. Its single file database structure, small disk storage and zero configuration and the fact that it is so like SQL make it a perfect fit for my app.

Wearable Technology for children with ASD.

Research & Studies:

"Wearable Technology has the potential to increase the quality of life, health, and wellness for kids with Autistic Spectrum Disorders (ASD) and their families". (Sumin Helen Koo, 2018)

However, there is a lack of research into wearable technology for kids with autism. Wearable technology could be used to this end through the unobtrusive monitoring of health conditions and factors. A 2014 study into ways to increase physical activity in ASD kids showed that regular physical exercise is extremely valuable for ASD kids, the same as it is for every man, woman, and child on earth. (Kate B. LaLonde, 2014)

However, most people with ASD do not exercise regularly. The study used walking (the number of steps taken) as the benchmark for physical activity as it is a good form of exercise while being one of the, if not the least strenuous as well as being easy to measure and quantify. The study also showed that goal setting and goal reinforcement had a positive effect in increasing walking (number of steps) in 1 in 5 of the studies participants. The participants of this study are older than the proposed age of the users of my activity tracker for this final year project, however, I believe that concept remains the same and the goal setting and goal reinforcement as crucial to the successfully adaption of the device and to be able to feel the full benefits of it. The study showed that participants were routinely able to walk the 10,000 steps goal during their 6-hour long school day without interrupting their everyday school activities. They do, however, point out that this was achieved by those activities were designed to facilitate meeting the goal of walking 10,000 steps, with the participants being given substantial amounts of time for walking. Children with ASD in other school settings, primary school for example, would have less discretionary time but would still have time at lunch and/or during activities such as PE and other extra-curricular activities. The inclusion of such activities would make this a more tenable options along with lowering the goal of 10,000 steps to suit the needs of a child with ASD in a primary school environment. (Kate B. LaLonde, 2014)

Another 2020 study was set up to determine to feasibility of a 12- week school-based Fitbit program for children with ASD. Out of 45 eligible participants, 42 (94%) opted to take part in

the study. The 42 participants of the study came from 3 high school classes and 3 middle school classes in a private school in central Florida. (Jeanette M. Garcia, 2021)

Children begin middle school at the age of 11 in America meaning that this study is a good source from research as my brother who will hopefully be the user of my device, is of middle school going age. Research has shown that consumer-based fitness trackers such as the Fitbit used in this study have been shown to be effective intervention approaches for children with ASD. Additionally, as noted in the previous study I have cited, evidence-based techniques such as goal setting and goal reinforcement can be used effectively with these devices to monitor physical activity in children with ASD.

Of the 3 middle school classes who took part, all of them noted that tracking steps was the most used function of the device, which reinforces the idea of encouraging them to be more physical active along with one class noting that their most enjoyable aspects of the device as the friendly competition with their classmates in reaching their set goals. Again, this will only increase adaption of the device. (Jeanette M. Garcia, 2021)

Challenges.

One of the main challenges faced when attempting to develop wearable technology for kids with ASD is the physical design of the device itself.

"The lack of understanding of user preferences and design factors has led to limited functions, problems with usability, and inappropriate designs" (Sumin Helen Koo, 2018)

Autistic kids are sometimes over sensitive to sensory information, this is known as hypersensitivity. Or the opposite can be there case meaning children with autism can under sensitive to sensory information. This is known as hyposensitivity. These conditions can provide a real obstacle when it comes to designing suitable wearable technology for children with autism.

Important design factors to take into consideration when attempting to develop such a device include:

- Safety.
- Data accuracy.
- Comfort.
- Flexibility.
- Portability.
- Durability.
- Price.
- Ease of use.
- Weight.
- Small and unnoticeable design. (Sumin Helen Koo, 2018)

When the mean and standard deviation was calculated for all the participants of the study was calculated, it ranked comfort as the most important design factor, which highlights the

effects of hypo and hypersensitivity on children with ASD. Comfort was then followed by data accuracy and durability. The 2018 study by Helen Koo Sumin et al also concluded that "*The most preferred item types of Wearable Technology for IASD (60%) and PASD (77.8%) were accessories such as watches, or bracelets followed by garments (IASD=6.7%; PASD=11.1%)*."

Other findings from the study which as very useful to my project are:

"IASD most preferred to use WT that could monitor body signals such as heartbeat and respiration (46.7%) , which is related to difficulties with monitoring or awareness of their own emotional state"

"About 47% of IASD and 44.4% of PASD preferred to have unnoticeable designs, important for long-term monitoring Wearable Technology"

"26% of IASD and 33% of PASD commented that they would prefer Wearable Technology that is made of flexible materials that are critical to comfort and unobtrusive designs"

"The majority of IASD (60%) and PASD (83.3%) preferred to receive the monitored data through smartphone apps due to their ease of downloads, ubiquity, and portability" (Sumin Helen Koo, 2018)

AutiSense.

Based on the findings of the research carried out Helen Koo Sumin and her colleagues, a prototype device called AutiSense was developed. As mentioned above, the study found that preferred wearable technology item type was an accessory such as glove. Therefore, the design chosen was a wearable fabric accessory which allowed the wearer to wear it everyday or easily take it off.

Initial designs included a fabric wristband and ring, however these designs proved too small to accurately gather data as they were easily affected by even the slightest of body movements. The final design was a thin well fitted glove. In accordance with the information gathered in the survey, the glove was coloured black to make the design unnoticeable, hard wires and electronics are replaced with stretchable and conductive fabric to make the device lightweight, thin cotton fabrics are used to provide the required flexibility. The galvanic skin response sensor used to measure the users sweat gland activity and pulse oximeter to measure heart rate were connected to the conductive thread the glove is made of to form electrical contact between the sensors, the microcontroller, and the fabrics.

The study also found that the preferred way to receive the data was for it to be displayed on a smartphone app. Therefore, the prototype device was designed to transmit the data wirelessly to a smartphone for display and analysis. (Sumin Helen Koo, 2018)

A survey was carried out after the trial of the prototype device and the results showed that the participants generally liked the device in terms of its functions, design, and data notification methods. The most liked aspect of the prototype was its lightweight, provided by the glove design of the device. On the other hand, the aspect that least satisfied the participants was the lack of a unique design. To satisfy this, the prototype designers would

have to make the design of the glove more unique while also remaining unnoticeable, which would prove difficult to achieve without changing the design of the device. (Sumin Helen Koo, 2018)

This study has proven to be an extremely valuable source of information for my project as it identified potential users of my device's preferred design features when it comes to wearable technology. It highlights what design factors are most important to the potential wearers of the device. However, the exact purpose of the device is not the same as the specification of my project, with Autisense designed to monitor such metrics as stress triggers whereas my device will be designed with in the aim to increase physical activity in children with ASD, I feel as if the design factors still carry weight and can be modified to suit my needs.

Conclusion.

From this research document we have discovered what an activity tracker is and what technologies they use, what technologies I will be using for the development of my project, such as the programming language, IDE, and backend. As mentioned earlier I have decided to use the Arduino Pro Mini as my device's microcontroller. It will use an MPU 6-Axis accelerometer and gyroscope to record changes in the X,Y, and Z axis of the device. The device will use Bluetooth Low Energy to send this data to the app, and it will be powered by a 3.3v Lithium Polymer Battery which can be charged using charger module. It was concluded that Java and Android Studio would be the programming language and IDE of choice for my project. This was decision was made with android being my target platform in mind and java being the official programming language for android development and the vast amount of documentation available to developers. Arduino IDE will also be required as I learned during my research that Arduinos are programmed using C++ and requires its own proprietary IDE to upload code onto Arduino boards. SQLite will be my database of choice for my project due to its ease of use and integration with android apps. Finally, from my research into existing attempts at devices like my project, such as AutiSense, I have concluded that the device will be best worn on the wrist of children using the device and the material of the wristband will be terry cloth, the same material that sweat bands are made from. Terry cloth contains properties that are perfect for design of this project such as a high rate of water absorption, heat resistant, quick drying, has excellent mechanical comfort and has an excellent surface texture (Jitendra Pratap Singh, 2017).

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