جامعة الأمير محمد بن فهد

PRINCE MOHAMMAD BIN FAHD UNIVERSITY

College of Engineering

Department of Mechanical Engineering

Fall - 2019

Senior Design Project Report

Design of Smart-Watch for Eating Tracking & Control

In partial fulfillment of the requirements for the Degree of Bachelor of Science in Mechanical Engineering

Team Members

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Abstract

There are no devices that tracks and quantifies food consumption. Inspired by the idea of fit-bit smart watches, we will be designing a smart watch prototype that will be to count and track eating bites. It will be relying on IMU sensors, a controller and vibration motors/ accelerometers to count the bites. Moreover, this project will be something towards proper health of the person wearing the watch since it would keep record of the food consumption and give statistics to see if a healthy routine is followed or not.

Acknowledgement

First of all, we would like to express our appreciation to our advisor Dr. Nassim Khaled for his continued support in our project and his sincere encouragement. Also, we express our sincere thanks to our professors in the faculty of Engineering for their expertise and guidance. We would like to extend our thanks and appreciation to Dr. Faramarz Djavanroodi, chair of the Mechanical Engineering Department at PMU, for his continuous encouragement and to believe in us and our abilities to carry out such a project that clearly tests us and challenges us to hone and use our gained knowledge through the year. Lastly, we thank our parents for the unceasing encouragement, support, and attention as because of their moral support we are able to stand tall at such a position.

List of Acronyms

x	**x-axis**
y	**y-axis**
z	**z-axis**
t	**Time**
T	**Period**
θ	**Angle**

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Chapter # 1: Introduction

1.1 Project Definition

This senior design project that we as a group will be after is to design a smart watch but with a peculiar feature that includes to properly track and control the eating habits. Since, there are many smart watches in the market that are extremely capable of performing some of the very state-of-the-art features like counting steps and also calories burnt while doing exercise, we intend to add our idea as well into smart-watches so that a person can keep track of his eating habits and food consumption by the movement of hand towards the mouth for taking a bite. This will lead to study of eating habits, eating routine and as well as the rate at which the person eats.

1.2 Project Objectives

Our project may seem like something that is aimed to do one thing which is to track eating but instead there are a couple of other relevant objectives that we plan to achieve which as well are:

(i) To track eating habits using a custom-built smart watch.

(ii) To measure the rate of which the person eats food or take bites.

(iii) To keep a record of eating habits that will be translated into a health tracking and metabolism.

1.3 Project Specifications

Our project will be based primary of a Gyro Sensor containing an IMU sensor which has a model number of MPU6050 as it will read the hand movement and periods between each bite while consuming food. As it transfers the values via I2C to Atmega328p a 32-pin Microcontroller having I2C ports to communicate with MPU6050. The calculation of counting specific hand movements for counting eating will be performed by MCU atmega328p as per designed algorithm using data from MPU6050 gyro sensor and will be sent to android phone application over the over

Bluetooth using connection between MCU atmega328p and Bluetooth module HC-05 via UART.

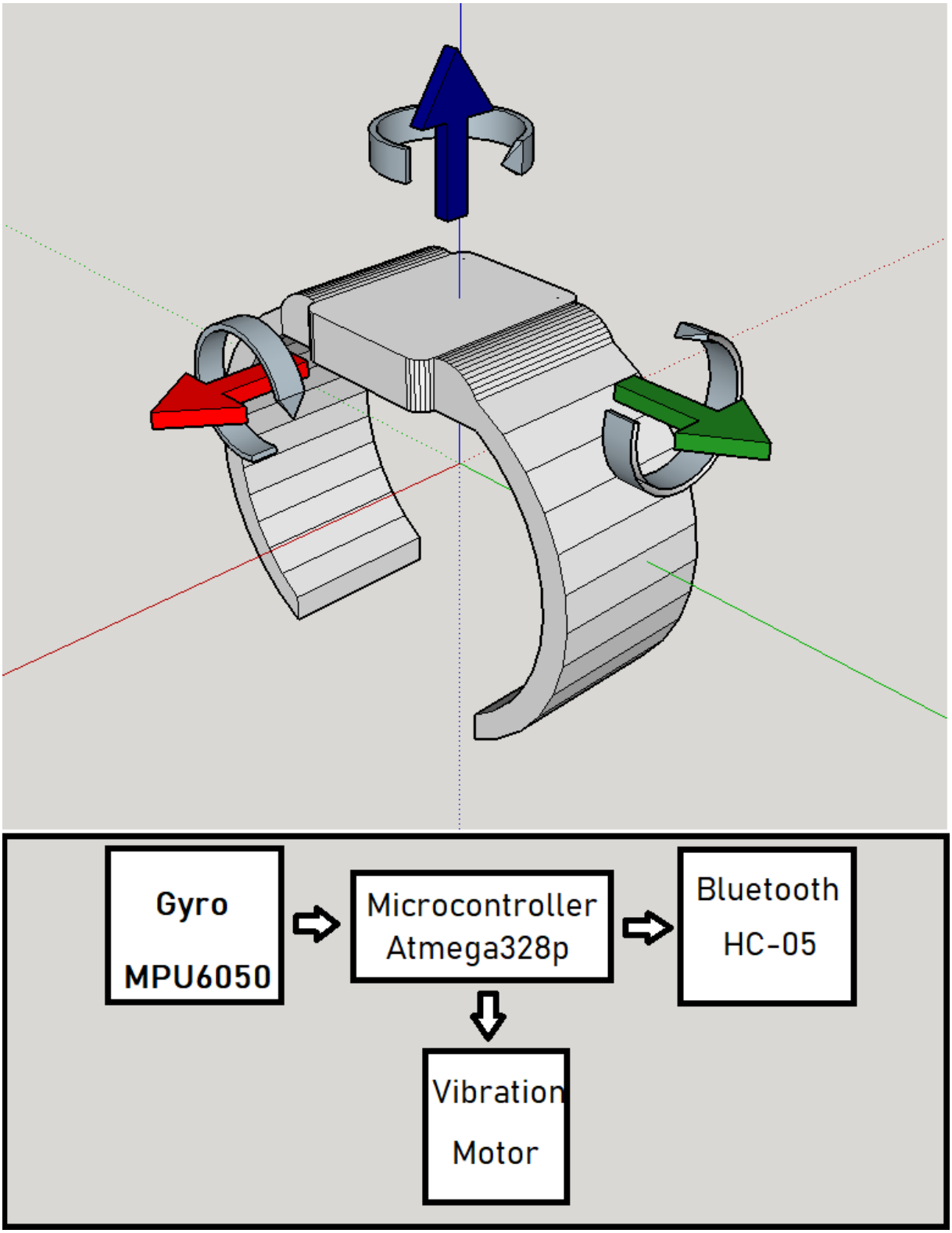


Figure # 1: S-Watch

1.4 Project Applications

Based on the idea and the vision behind our project, it can be said to have its application in a person's lifestyle where he/she would use it as something to facilitate himself or herself by living on the standards to maintain health. So, very dominantly, it will be used as a means to stay healthy, have a good diet with proper break in between each bite and to keep track of the food consumption to monitor metabolism.

Chapter # 2: Literature Review

2.1 Project Background

Wearable devices monitoring food intake through passive sensing is slowly emerging to complement self-reporting of users' caloric intake and eating behaviors. Though the ultimate goal for the passive sensing of eating is to become a reliable gold standard in dietary assessment, it is currently showing promise as a means of validating self-report measures. Continuous food-intake monitoring allows for the validation and refusal of users' reported data in order to obtain more reliable user information, resulting in more effective health intervention services. Recognizing the importance and strength of wearable sensors in food intake monitoring, there has been a variety of approaches proposed and studied in recent years [1].

2.2 Previous Work

In order to proceed with our project, we need to put in some kind of information related to the work that was relevantly done to our project in the past, would give us a range of creativity and an aspect to successfully continue with the idea that we hold dear to us as a group. Similarly, based on such a concern we looked into the past projects and researches or case studies that were conducted globally to provide some sort of reference to carry out our project and achieve the objectives that we have earlier defined.

First of all, let us look into the mHealth study by The University of North Carolina where they were donated Apple Watch Series-4 by Apple Inc. to finding the reasons for eating disorder. The Center of Excellence for Eating Disorders, part of the UNC School of Medicine's School of Psychiatry, handed out 1,000 donated Apple Watches in a connected health project to study genetic factors behind binge-eating disorder (BED) and bulimia nervosa (BN). Participants used the mHealth wearable to track eating and health habits over a 30-day span, then submit saliva and bacteria samples to digital diagnostics company uBiome for genetic analysis [2].

Secondly, fitness trackers and smartwatches are released to the consumer market every year. These devices are equipped with different sensors, algorithms, and accompanying mobile apps. With recent advances in mobile sensor technology,

privately collected physical activity data can be used as an addition to existing methods for health data collection in research. Furthermore, data collected from these devices have possible applications in patient diagnostics and treatment. With an increasing number of diverse brands, there is a need for an overview of device sensor support, as well as device applicability in research projects [3].

These previously done work has provided a sense of direction in order for our project to take a significant shape and progress. Because, the ideas seem relevant and advance as well in some scenarios to consider. However, it surely has provided a huge insight to the development of our project.

2.3 Comparative Work

For our team and the project, we are responsible to hold up our reputation as mechanical engineers in our institute and successfully pass out by achieving of the most important milestone of the whole degree plan, the senior year project. And, for that we have to ensure that the project we are pursuing as a team can be compared with the projects or some research work done in the past.

To begin with, we explore the use of gesture recognition on a wrist-worn smartwatch as an enabler of an automated eating activity (and diet monitoring) system. We show, using small-scale user studies, how it is possible to use the accelerometer and gyroscope data from a smartwatch to accurately separate eating episodes from similar non-eating activities, and to additionally identify the mode of eating (i.e., using a spoon, bare hands or chopsticks). Additionally, we investigate the likelihood of automatically triggering the smartwatch's camera to capture clear images of the food being consumed, for possible offline analysis to identify what (and how much) the user is eating. Our results show both the promise and challenges of this vision: while opportune moments for capturing such useful images almost always exist in an eating episode, significant further work is needed to both (a) correctly identify the appropriate instant when the camera should be triggered and (b) reliably identify the type of food via automated analyses of such images [4].

In a study, the researchers tracked the hand movements of 50 participants who labeled what they were doing with their hands at regular intervals for nearly 1,000 hours to create a database of common hand movements. Then, they were able to devise an algorithm that can discern with 95.2% accuracy the sometimes extremely subtle differences between 25 common hand movements, including washing your hands, washing utensils, scrolling on your phone, using a remote, and typing.

To capture such fine distinctions between movements, the researchers put the accelerometers into a high-speed mode that provided them with more granular information, which included orientation of the hand, movement patterns, and even some bio-acoustic information, which consists of micro-vibrations that propagate up the wearer's arm. Chris Harrison, the head of the Future Interfaces Group at Carnegie Mellon University and a co-author on the paper, says that this is almost like holding a stethoscope to your hand. A convolutional neural network, which is a type of machine learning algorithm, was able to find patterns using all this information and associate it with certain hand movements.

Harrison points to other, similarly context-aware applications. For instance, your watch could track when and for how long you're eating for an app that helps you track your calorie intake. Similarly, your watch could remind you to drink more water if it detects you haven't been drinking very much on a given day [5].

Since such works done in the past came out to be successful or under development stages, we as a group feel pretty confident to achieve something of that scale from the standard materials available in the market. Also, as a couple of these studies show that eat tracking is very crucial to monitor health, with our project advisor, Dr. Khaled, we think it can be achievable by following his guidance and help in every stage of progression.

Chapter # 3: System Design

3.1 Design Constraints and Design Methodology

3.1.1 : Geometrical Constraints:

The project our team aims at achieving has some very prominent geometrical constraints if looked into it from a different perspective, specifically in the view of watches and wearable gadgets for wrists. The watches of modern day are very small, portable and has components packed in a very precise manner and are of state-of-the-art technological advancements. However, compared to what we intend to achieve, the idea exists to be similar to these new and current type of smart watches but has a very bulky geometry to be worn on the human wrist. Also, the weight plays a concerning factor which is actually directly related to the accelerometer module.

3.1.2 : Sustainability:

As far as sustainability of our project is concerned, it has a very high chance of having a long-term future because in the current era we live in, many people rely on devices and gadgets which can help them save the trouble of performing tasks such as calorie intake, food eating habits, bite tracking, bite intervals and many more. So, it is safe to claim that this project could turn out to be a very durable one with the ease of providing health monitoring.

3.1.3 : Environmental Concern:

In terms of environmental concern, our project serves to be very environmentally friendly, since it does not produce any hydrocarbons that are harmful to human health as it will be a watch. Moreover, it is power by an in-built battery that does not consume a lot of resources to charging and powering it up and it works all on direct current principle. Similarly, due to it having very common parts, like plastic housing/ case and a rubber wrist strap, it poses no threat to the environment.

3.1.4 : Social Impact:

The food-tracking smart watch is of great importance to the majority of the society we live in nowadays since dependence on applications, electronic devices and gadgets is increased a lot, there remains a situation in which we have to consider in providing some sort of facilitation

and ease to the people in order to monitor their health by keeping track of how much they eat and in what manner they eat, because taking big bites and having no rest between each bite can affect the metabolism drastically.

3.1.5 : Economic:

Economically, if we look into the financial aspect of this project, it does serve to be in a fairly reasonable sum of money. Since, the accelerometer we purchased from the market was not very expensive and has a good built quality and the strap to be worn on the wrist is readily available in the market. Due to such attributes of our project, it can be very healthy on the economic scale.

3.1.6 : Safety:

Nowadays, almost every gadget, equipment or devices has to meet safety parameters and should avoid accidents like Samsung's cellphones which were a cause of poor battery and related parameters that caused it to explode. Similarly, keeping such incidents in mind, it has been made sure to keep safety parameters as our number one priority and inspect the vital parts for any concerns that could lead to unintended mishaps or incidents. Additionally, since the accelerometer module we are using does not even contain Lithium-Ion batteries (which are very efficient but dangerous) it is safe to say that our project is well within the safety code of operation and use.

3.1.7 : Ethics:

Every project is born with an idea from another project or it could even be a future recommendation and continuation of a project which has more to offer and deliver. On this information, ethically, this project was selected after conducting a brief research on how to produce something that could affect the human lifestyle in terms of their diet and health monitoring since most smart-watches already have tons of features and applications. Therefore, no app or watch has such a feature in which the number of bites is counted and bite intervals can be tracked because it can be directly related to the human metabolism according to which it can be determined what kind of a lifestyle an individual is up to.

3.2 Engineering Design Standards

Since our project contains components that are readily available in the market, as far as the engineering standards are concerned, they are dependent on the manufacturers producing such components. However, below is the list of components with their grade/ standards enlisted.

Components	***Engineering Standards***
Plastic Housing for Accelerometer Module	Polypropylene (Grade: 5)
Wrist Strap	Silicone Rubber (ASTM D2209)

Table # 1: Engineering Standards

3.3 Theory and Theoretical Calculations

Since the project prototype is based entirely on control systems and vibrations, the module used for the idea of our prototype consists of coding and to make sure the module works as we require it to, following lines of codes were written for execution.

As per manual observation

Testing of hand movement over graphs and observing the probability of eating poster. Tests were done using serial UART from Arduino Nano and gyro sensor. Based on observed coordinates we draw a code which accepts the coordinates as per logic mentioned in code.

After testing and real-time testing, we came across the final code which we are mentioning in below.

Code with Logic Implemented:

```
// I2Cdev and MPU6050 must be installed as libraries, or else the .cpp/.h files
// for both classes must be in the include path of your project
#include "I2Cdev.h"
#include "MPU6050.h"
// Arduino Wire library is required if I2Cdev I2CDEV_ARDUINO_WIRE implementation
// is used in I2Cdev.h
#if I2CDEV_IMPLEMENTATION == I2CDEV_ARDUINO_WIRE
    #include "Wire.h"
#endif
// class default I2C address is 0x68
```

```
// specific I2C addresses may be passed as a parameter here
// AD0 low = 0x68 (default for InvenSense evaluation board)
// AD0 high = 0x69
MPU6050 accelgyro;
//MPU6050 accelgyro(0x69); // <-- use for AD0 high
int count =0;
int16_t ax, ay, az;
int16_t gx, gy, gz;

#define OUTPUT_READABLE_ACCELGYRO
#define LED_PIN 13
bool blinkState = false;

void setup() {
    // join I2C bus (I2Cdev library doesn't do this automatically)
    #if I2CDEV_IMPLEMENTATION == I2CDEV_ARDUINO_WIRE
        Wire.begin();
    #elif I2CDEV_IMPLEMENTATION == I2CDEV_BUILTIN_FASTWIRE
        Fastwire::setup(400, true);
    #endif

    // initialize serial communication
    // (38400 chosen because it works as well at 8MHz as it does at 16MHz, but
    // it's really up to you depending on your project)
    Serial.begin(115200); //set as per our bluetooth baud

    // initialize device
    Serial.println("Initializing I2C devices...");
    accelgyro.initialize();

    // verify connection
    Serial.println("Testing device connections...");
    Serial.println(accelgyro.testConnection() ? "MPU6050 connection successful" : "MPU6050
connection failed");
```

```
    // configure Arduino LED pin for output
    pinMode(VibrationMotor, OUTPUT);
}

void loop() {
    // read raw accel/gyro measurements from device

    accelgyro.getRotation(&gx, &gy, &gz);

    #ifdef OUTPUT_READABLE_ACCELGYRO
        // display tab-separated accel/gyro x/y/z values
        Serial.print("a/g:\t");
        Serial.print(gx); Serial.print("\t");
        Serial.print(gy); Serial.print("\t");
        Serial.print(gz); Serial.println("\t");

    #endif

    if((ax > 1000) && (ay < 0) && (az >1000) ){ // main logic
      Serial.print("eat");
      count = count ++;
      }
      //When user eats more or equal to 40 than vibrate the watch.
      if(count => 40){

        digitalWrite(vibrationMotor,HIGH); //activate vibration motor
        delay(1000);
        count=0;
        }
        digitalWrite(vibrationMotor,LOW);


}
```

3.4 Product Subsystems and selection of Components

3.4.1 GyroSensor:

Selected same sensor with SMD packing to put into our circuit design and PCB design, using same operating circuit in our main circuit design

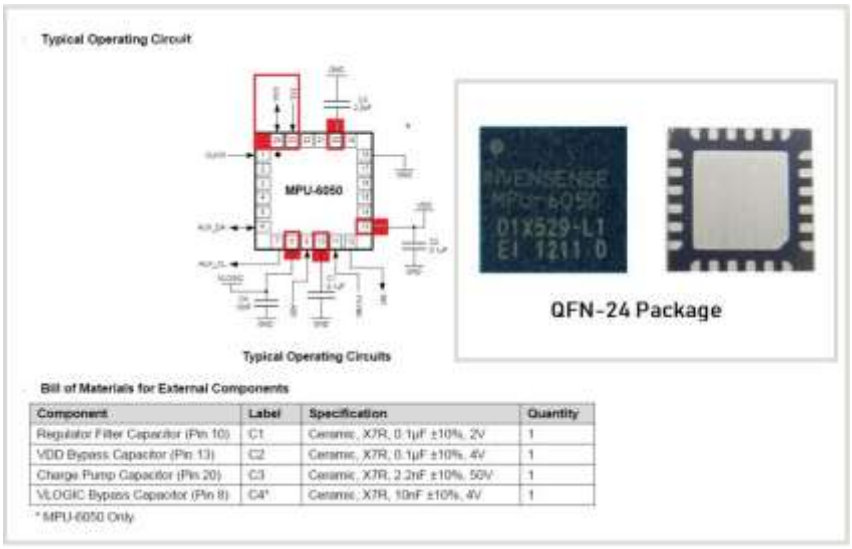


Figure # 2: MPU6050 gyro details

3.4.2 MicroController (MCU):

As per our requirement we needed a MCU to be reliable and having one I2C and one UART communication ports to work with Gyro Input via i2c and after processing calculation can send data to android app via Bluetooth.

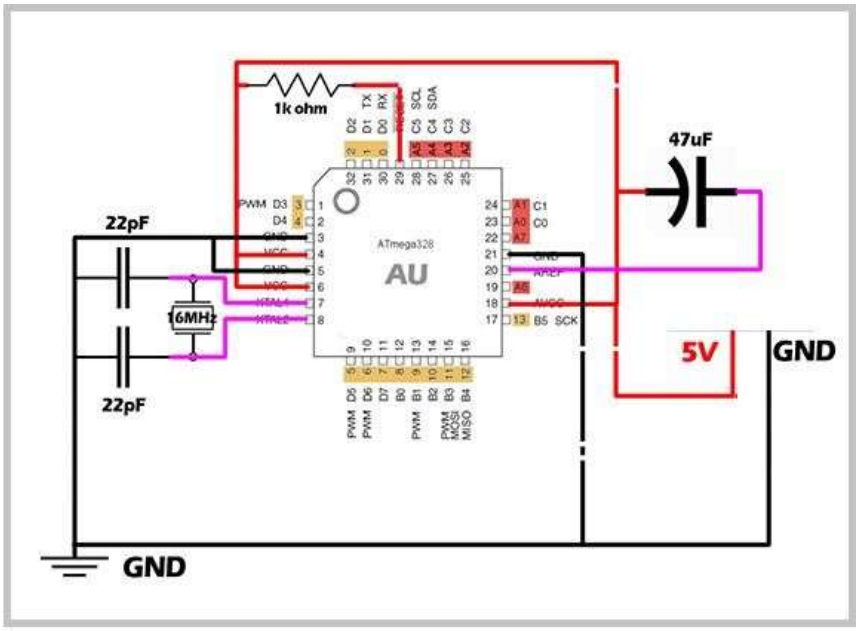


Figure # 3 Atmega328p Basic Circuit

3.4.2 Bluetooth (HC-05):

HC-05 is a bluetooth module works on SPP protocol ideal for this application it has UART interface to receive and transfer data, We are receive data from MCU to send eat counts to Application. And receiving Alerts from Android application based on our requirements.

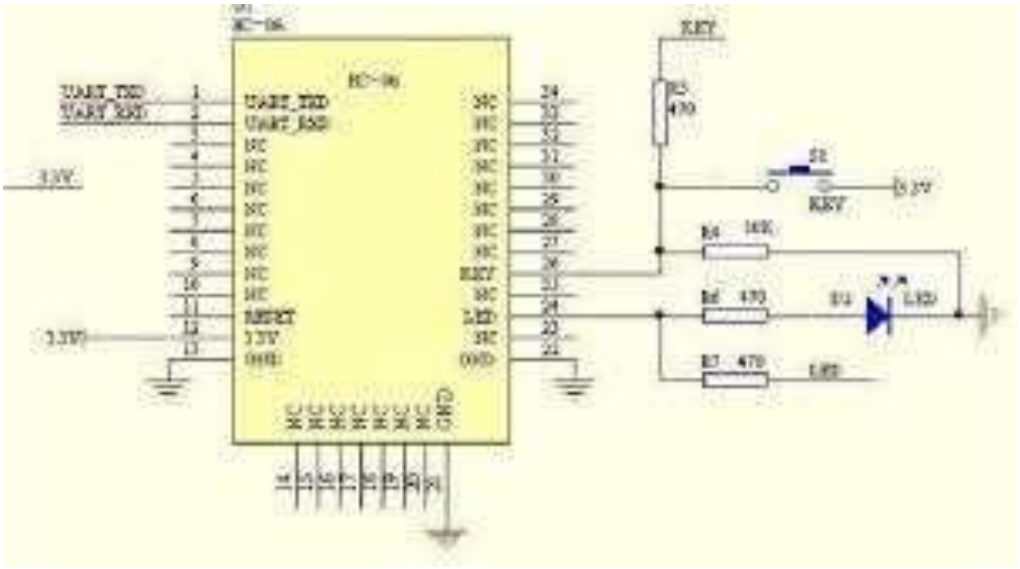


Figure # 4 HC-05 Basic Circuit

3.5 Manufacturing and Assembling (Implementation)

The process of manufacturing and Assembling started with design of Circuit and PCB design than 3dAnd then final product, Application was done on Android studio

3.5.1 Circuit design:

Circuit design was done using famous design tool Proteus Professional. We merged the basic circuits into on circuit to make it portable and fulfil our requirements.

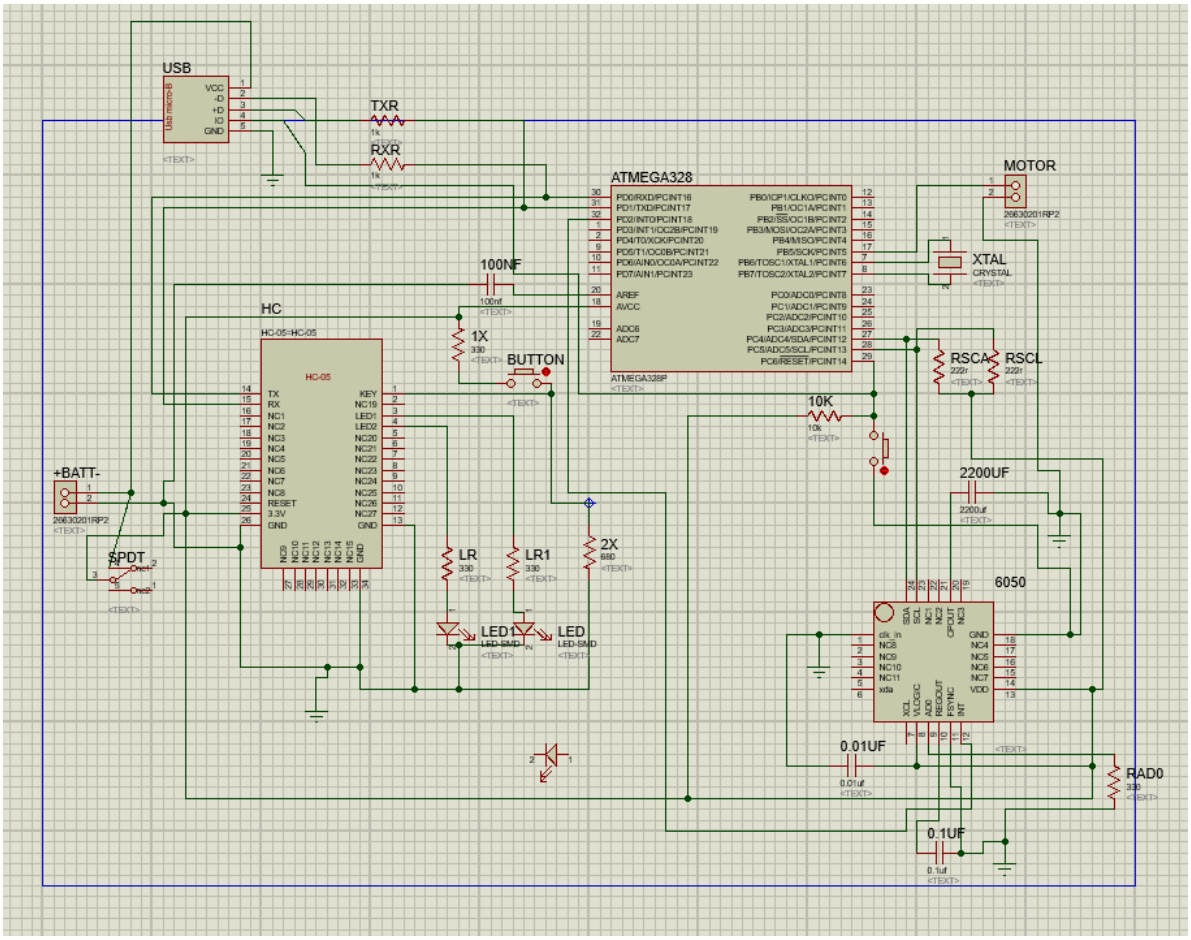
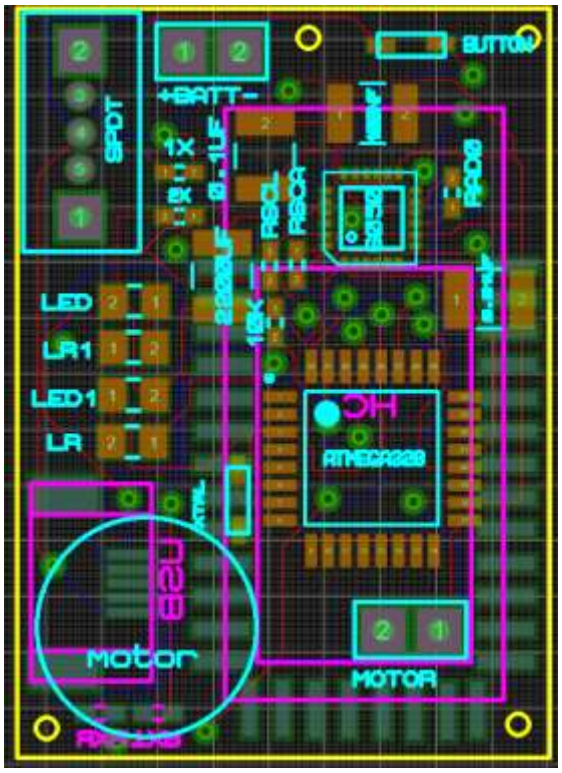


Figure # 5 Final Circuit

3.5.2 PCB Design:

The design tool proteus provide us designing of PCB based on our circuit using its subtool name ares. We used ares to design our PCB using exiting circuit design. Using SMD footprints we managed to shrink size a lot.



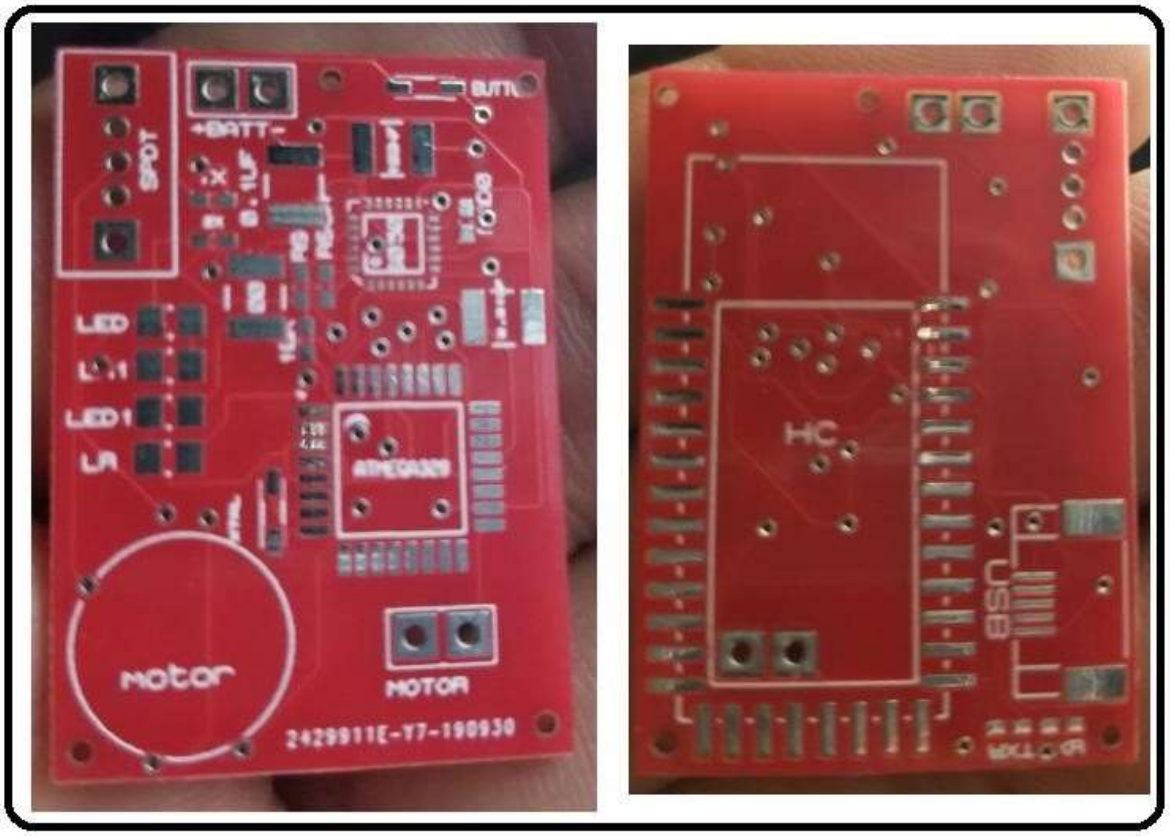


Figure # 6 Two Layer Final PCB

3.5.4 3D design of Watch:

After finishin the PCB we designed the 3D model of our device which should look like a normal watch and can be used in hand for effective use. Sketchup is a very simple tool to quick design 3d nodels which we used to design our design.

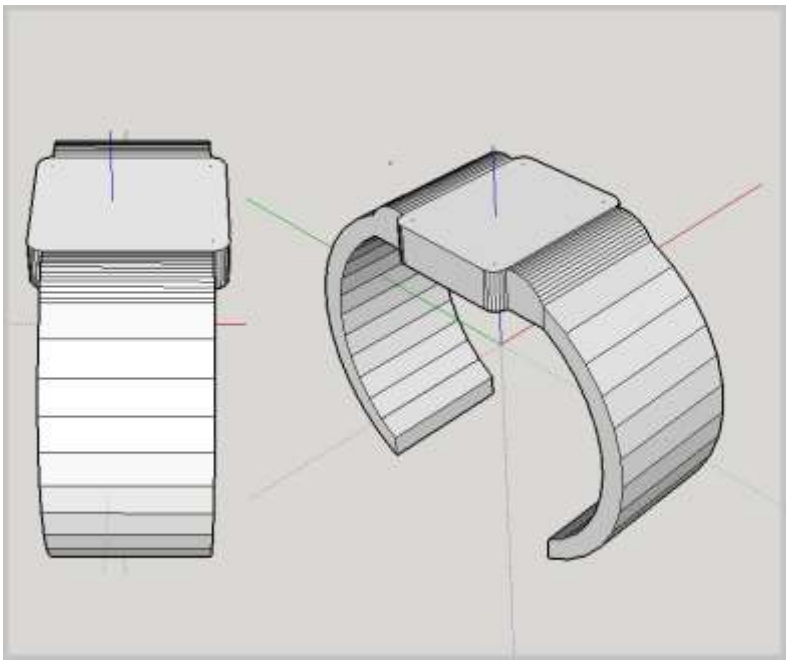


Figure # 7 Final 3d Model

3.5.5 Android Application Interface:

Chapter 4: System Testing and Analysis

4.1 Experimental Setup, Sensors and data acquisition system

4.1.1 : Bluetooth HC-05

In order to obtain the data recorded from the Arduino and microcontrollers which will be directly connected to the gyro sensors and vibration motors, a Bluetooth sensor is used to display the data. This data is displayed on a laptop or an android mobile phone application which can have a proper depiction of the waveforms and graphs that are produced in each axis as the person eats.

Moreover, the Bluetooth has following specifications;

Specifications:

- Serial Bluetooth module for Arduino and other microcontrollers
- Operating Voltage: 4V to 6V (Typically +5V)
- Operating Current: 30mA
- Range: <100m
- Works with Serial communication (USART) and TTL compatible
- Follows IEEE 802.15.1 standardized protocol
- Uses Frequency-Hopping Spread spectrum (FHSS)
- Can operate in Master, Slave or Master/Slave mode
- Can be easily interfaced with Laptop or Mobile phones with Bluetooth
- Supported baud rate: 9600,19200,38400,57600,115200,230400,460800

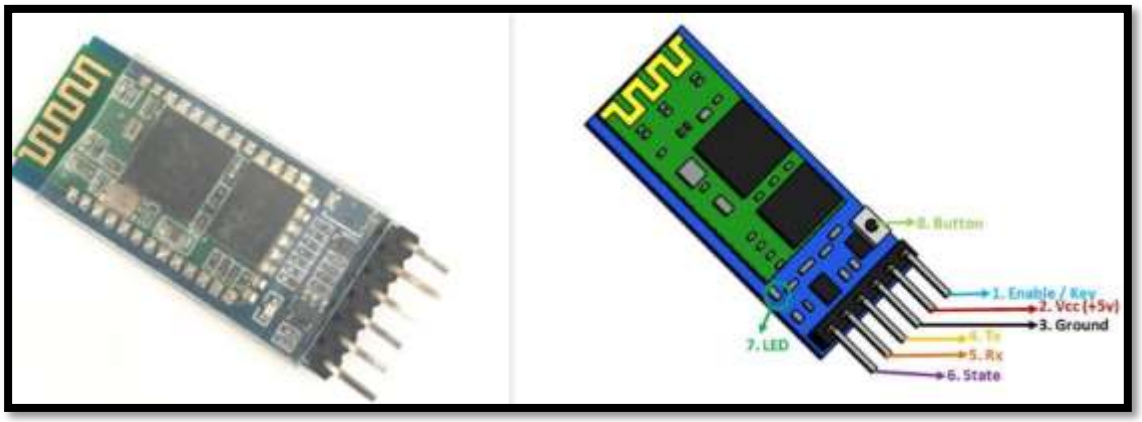


Figure # 8: Bluetooth HC-05

4.1.2 : Gyro MPU6050

In order to process al the physical data and record it, the gyro sensor plays a key role in transferring and recording vibrations in all three axes of movements. Since, the data from the gyro can be sensed directly and transferred to the application via the Bluetooth sensor.

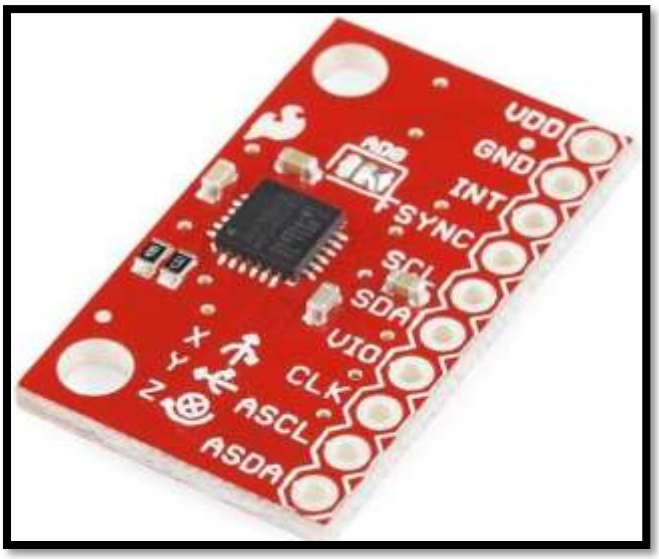


Figure # 9: Gyro MPU6050

Testing Parameters	
Bluetooth Sensor	**To connect to an android device for gathering data**
Gyro Sensor	**To record the vibrations and movements**

Table # 2: Testing Parameters

4.2 Results, Analysis and Discussion

Data obtained from the Bluetooth sensors were displayed in the following manner which also takes into consideration all the axes.

Accelerations at these axes are making most close relation for eating gesture.
+z -y and minor at +x these axes play vital role in defining this eating poster.

Gyro+MCU:

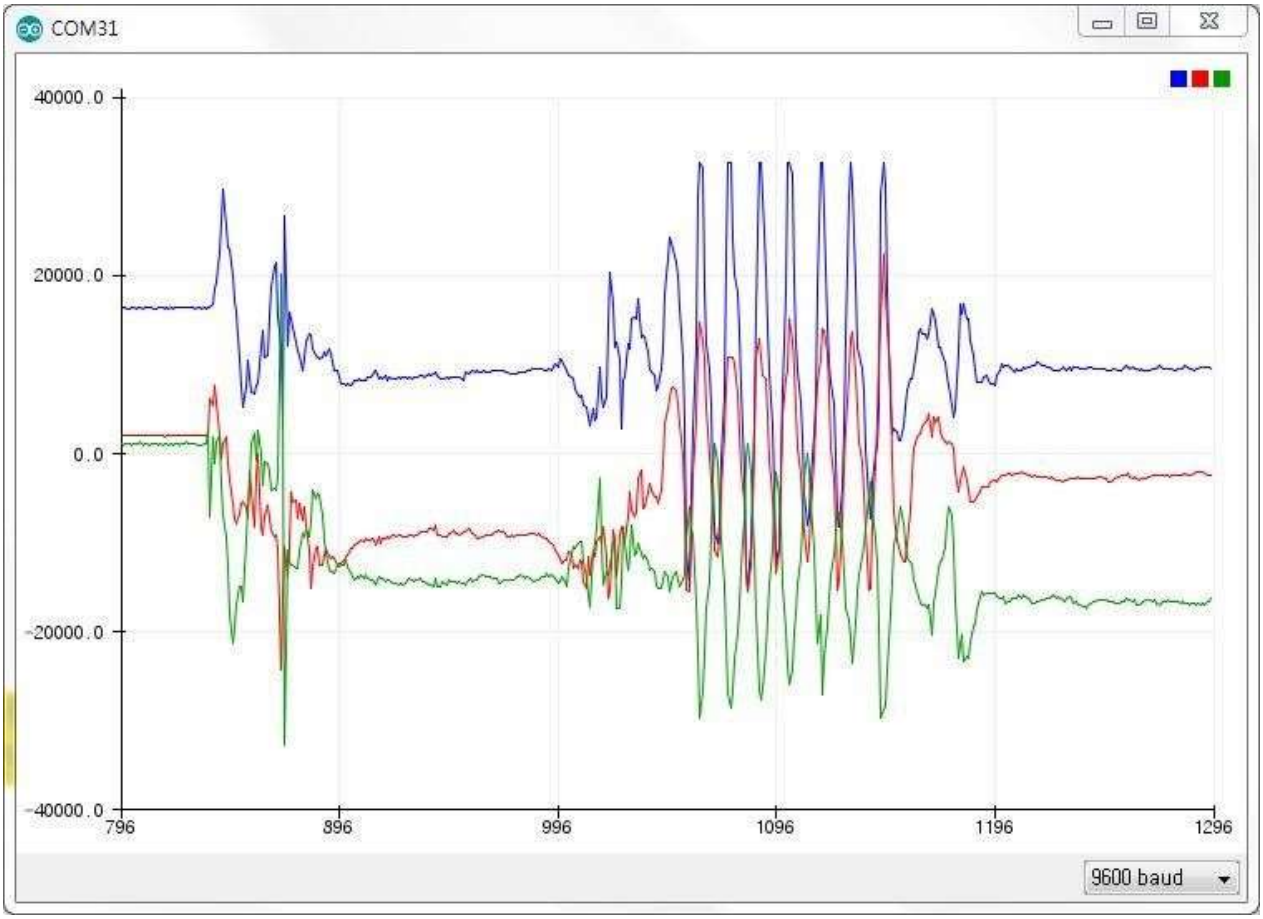


Figure # 10: Result of Movements in Waveform in all three Axes

Testing of hand movement over graphs and observing the probability of eating poster. Tests were done using serial UART from Arduino Nano and gyro sensor.

Chapter 5: Project Management

5.1 Project Plan

The project comprises of various tasks that are assigned to each group member in an equal manner, to ensure fairness between the members. Each member was given a specific task that needed to be completed within a certain amount of time.

The times and dates listed in the Gantt Chart were followed to ensure consistency and quality of the work done by the group members.

Table 3 displays the number of tasks done alongside with the number of days it took for that specific task to be completed.

S. No.	Tasks		Start	End	Duration
1	Ch. 1: Introduction		3/9/2019	6/9/2019	3 Days
2	Ch. 2: Literature Review	Project Background	7/9/2019	11/9/2019	4 Days
		Previous Work			
		Comparative Study			
3	Ch. 3: System Design	Design Constraints & Methodology	12/9/2019	17/9/2019	5 Days
		Engineering Design Standards			
		Theory & Theoretical Calculations			
		Product Subsystems & Component Selection			
		Manufacturing & Assembly			

4	Ch. 4: System Testing & Analysis	Experimental Setup, Sensors & Data	18/9/2019	22/9/2019	4 Days
		Results, Analysis & Discussion			
5	Ch. 5: Project Management	Contribution of Team Members	1/10/2019	6/10/2019	6 Days
		Project Execution Monitoring			
		Challenges & Decision Making			
		Project Bill of Materials & Budget			
6	Ch. 6: Project Analysis	Impact of Engineering Solution	10/10/2019	14/10/2019	4 Days
		Contemporary Issues Addressed			
7	Ch. 7: Conclusion & Recommendation	Conclusion	25/10/2019	29/10/2019	4 Days
		Future Recommendation			
8	Design of Prototype		1/11/2019	3/11/2019	3 Days
9	Parts Purchased		7/11/2019	10/11/2019	3 Days
10	Manufacturing		25/11/2019	30/11/2019	5 Days
11	Testing		1/12/2019	5/12/2019	5 Days

Table # 3: Tasks and their Duration

Table 4 identifies the team members responsible for their respected tasks.

S. No.	Task	Assigned Members
1	Introduction	Abdullah Al-Ghamdi
2	Literature Review	Obaid Alsubaie
3	System Design	Abdullah Al-Zabadin
4	Testing and Analysis	Abdullah Al-Ghamdi
5	Project Management	Turki Balhareth
6	Project Analysis	Abdullah Al-Zabadin
7	Conclusion and Recommendation	Abdullah Al-Ghamdi
8	Design	Ibrahim Al-Jarah
9	Parts Purchased	Obaid Alsubaie
10	Manufacturing	Turki Balhareth
11	Testing	Ibrahim Al-Jarah

Table # 4: Assigned Members for Each Task

5.2 Contribution of Team Members

Each member's contribution and their willingness to work was discussed in our first meeting as a team, and the tasks were divided and agreed upon by each member.

Table # 5 shows how much work each group member contributed, as a rough percentage.

S. No.	Tasks		Assigned Member	Contribution
1	Ch. 1: Introduction		Abdullah Al-Ghamdi	100%
2	Ch. 2: Literature Review	Project Background	Abdullah Al-Zabadin	33%
		Previous Work	Turki Balhareth	33%
		Comparative Study	Obaid Alsubaie	34%
3	Ch. 3: System Design	Design Constraints & Methodology	Turki Balhareth	20%

		Engineering Design Standards	Abdullah Al-Ghamdi	20%
		Theory & Theoretical Calculations	Turki Balhareth	20%
		Product Subsystems & Component Selection	Abdullah Al-Zabadin	20%
		Manufacturing & Assembly	Turki Balhareth	20%
4	Ch. 4: System Testing & Analysis	Experimental Setup, Sensors & Data	Abdullah Al-Ghamdi	40%
		Results, Analysis & Discussion	Abdullah Al-Zabadin	60%
5	Ch. 5: Project Management	Contribution of Team Members	Turki Balhareth, Obaid Alsubaie	100%
		Project Execution Monitoring		
		Challenges & Decision Making		
		Project Bill of Materials & Budget		
6	Ch. 6: Project Analysis	Impact of Engineering Solution	Abdullah Al-Zabadin	100%
		Contemporary Issues Addressed		
7	Ch. 7: Conclusion & Recommendation	Conclusion	Abdullah Al-Ghamdi	100%
		Future Recommendation		

8	Design of Prototype	Turki Balhareth	50%
		Ibrahim Al-Jarah	50%
9	Parts Purchased	Abdullah Al-Ghamdi	20%
		Obaid Alsubaie	30%
		Obaid Alsubaie	30%
		Ibrahim Al-Jarah	20%
10	Manufacturing	Obaid Alsubaie	60%
		Ibrahim Al-Jarah	40%
11	Testing	Ibrahim Al-Jarah	100%

Table # 5: Contribution of Tasks

5.3 Project Execution Monitoring

To ensure the continuous progress of the project, regular meetings between the group members, to discuss the next step, and between the group members and the advisor, to take approval for said step, needed to be done on a regular basis. In addition to these meeting, we were asked to hand in progress reports and perform a presentation to explain what we have done in the project till the date of the presentation. All the dates are listed in table 6 below

Activities and/or Events	Time and Date
Assessment Class	Once a week
Meeting with the group members	Weekly
Meeting with the Advisor	Bi-Weekly
Midterm Presentation	Once a week
Finishing Final Prototype	weekly
Test of the System	Bi-weekly
Final Submission of Report	Once a week
Final Presentation	Once a week

Table # 6: Dates of Activities and Events

5.4 Challenges and Decision Making

While working in developing our project to its final stages, we incurred some problems which effected the progress of our project and acted as a hurdle to overcome. However, after successions of different suggestions and review, they were eventually rectified. The problems we faced were some of the following:

5.4.1 : Equipment and Device Problems

- **Coding**

  As our project was purely based on the principle of control systems and mechanics all combined together, there was a minor hurdle in front of us which was to properly write the code for execution. Because, the microcontroller and other command unit we have reads code in several languages, which also stands true for Arduino as the Arduino board itself has a different coding language.

- **Axes in the Gyro Sensor**

  At the beginning of the project, we ran into a small problem of determining the axes for the movement as there were no proper labels to the direction of each of the axes. Therefore, in order to figure it out, several tests were performed to carefully mark each axis so we can code it accordingly.

5.4.2 : Testing & Safety Issues

Looking towards our project, we are confident to claim that our project had no testing and safety issues since the components and operation is very safe and works on D.C. source of the battery inside the gyro sensor. Moreover, it was extremely safe to handle and test to gather results as all the results were gathered and stored in a computer.

5.4.3 : Design Problems

The most basic design problems we faced were with the overall volume of the whole unit containing the gyro sensors, microcontrollers and Bluetooth sensor. Since, the unit was quite bulky and had a considerable weight to it, managing such an aspect was becoming a significant point where our project could have a flaw.

5.5 Project Bill of Materials & Budget

The table below illustrates the parts we purchased and the amount given to the third party for manufacturing some of the intricate parts for us. It includes the total amount spent in our project in Saudi Riyals (SAR).

Table 7 shows the amount of money paid for each part in Saudi Riyals (SAR).

Materials	**Cost (SAR)**
Microcontroller	530
Bluetooth Sensor	350
Gyro Sensor	310
Wrist Strap	390
Arduino Board	300
Total Sum	**1880**

Table # 7: Bill of Materials

Chapter 6: Project Analysis

6.1 Life-Long Learning

As senior students of our institution, we had to make sure to utilize all our knowledge and to challenge ourselves of how much have we learnt over the past few years. This also includes, that we had to undergo some of the difficulties we weren't ready to encounter but that is how we would be able to fight back strong and accomplish the goals we managed to set for over these three months of pure dedication and hard-work. Furthermore, it has and will refine us as a person because we gained the knowledge of how to lead as a team and completely abide by the timelines set for each task and with all due respect, it has been a extremely helpful for us now and in our future.

6.1.1 : Software Skills:

As mechanical engineers, the most basic platform to begin our designing starts from designing on computer-based software especially SolidWorks. Over the semesters we have earned the necessary skills to successfully design any prototype and simulate the conditions we would be planning to work in. Moreover, we also made use of MS excel to record data and illustrate them in a comprehensive graph which speaks better than words. Additionally, coding programs such as MATLAB and Arduino really gave us a new knowledge and skills to work into.

6.1.2 : Hardware Skills:

In order to conduct and perform experimental tests, we have managed to successfully made use of hardware equipment such as a gyro sensor and related application which records and displays the result in a waveform. These hardware devices were essential towards the successful accomplishment of the objectives we were working in.

6.1.3 : Time Management:

We had about three months of total time to complete the project, we really needed to manage our time in an efficient manner in order to be ahead of time for unpredicted difficulties and obstacles we might face. Thankfully, all group members were in close contact and everyone was on the same page when making decisions, which really helped with cutting time and utilizing it effectively.

6.1.4 : Project Management:

In achieving something of this big task as our project, we needed a proper plan and time management so every task can be accomplished in a timely fashion. It also shows us the properly managed teamwork among us all as a group because without proper communication, understanding, dedication and commitment with responsibility it was not possible to achieve the amount of goals set for us and our group.

6.2 Impact of Engineering Solutions

6.2.1 : Society:

The project we selected was already biased towards the betterment and facilitation of the society we are living in because if we notice, nowadays not many people pay attention to the meals they eat and the way they eat which directly effects their metabolism. So, our project/ prototype will act as that device which enables the people to be aware of their eating habits so they can lead a healthy lifestyle.

6.2.2 : Economy:

In terms of economical aspect, there is not a lot of to be spend in a project of this scale and level because most of the components and parts are readily available in the market and to utilize them properly, just a good information and knowledge is required in control systems and computer trickery as it all works based on coding and how well put together the whole unit is.

6.2.3 : Environment:

Environmentally looking towards our prototype, there is no threat towards the environment as the prototype does not produce any harmful by-products upon usage except of consuming a very little amount of electric power via batteries which are actually charged. Moreover, the whole material the unit is made of is degradable in a safe manner which has little to no effect on the environmental scale.

6.3 Contemporary Issues Addressed

Looking toward the past and then gazing towards the near future, we are almost confident enough to declare ourselves in which we have contributed towards the major society to utilize the natural environmental source to obtain something as precious as water for our basic necessities and especially thirst. However, not everything can be achieved in a perfect manner and there is always that one spot which can be troublesome and to address some in our opinion, we think that the project may need some optimization as it can sometimes note normal hand gestures for a mistake of eating. It can also be a problem if a smoker is wearing the watch as those gestures may also account into the eating habit. Therefore, overall our watch performs perfectly in the way we desire to completely be based on our objectives.

Chapter 7: Conclusion & Future Recommendations

7.1 Conclusion

In conclusion, our watch has been a very unique idea to execute since there are already watches in the market which do perform some of the functions related to health monitoring. But our proposed idea and objective focuses precisely on the fact of metabolism of an individual based on the way they eat or their eating habit which takes in account the bites and intervals between each bite of during a meal. And, we can successfully claim that our project has worked out nicely and serves the objectives very well.

7.2 Future Recommendations

As a future recommendation which can be looked into improving the overall prototype, there are some points which the watch could benefit from as a product for health monitoring. First of all, the watch's overall volume and dimensions should be reduced so it is easier and comfortable to wear. Secondly, it would be quite an added feature if there could be an option to add an image sensor in detecting the type of food being eaten which can already record the calories and then monitor the intake. And, finally, we can say that if the watch could easily be paired with an android device without additional coding or apps, it could be a very big yet a difficult step in refining this product.

8. References

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Appendix A: Progress Reports

SDP – MONTHLY MEETING REPORT

Department of Mechanical Engineering
Prince Mohammad bin Fahd University

SEMESTER:	FALL	ACADEMIC YEAR:	2019
PROJECT TITLE	Design of Smart-Watch for Eating Tracking & Control		
SUPERVISORS	Dr. Nassim Khaled		

Month: September & October

ID Number	Member Name
201502764	Abdullah Al-Ghamdi*
201402114	Abdullah Al-Zabadin
201601225	Turki Balhareth
201401253	Ibrahim Al-Jarah
201402660	Obaid Al-Subaie

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1.	Objectives and Abstract	Abdullah Zabadin	100%	N.K
2.	Acknowledgements	Turki Balhareth	100%	N.K
3.	Chapter # 1: Introduction	Abdullah Alghamdi*	100%	N.K
4.	Chapter # 2: Literature Review	Obaid & Ibrahim	100%	N.K

List the tasks planned for the month of ~~March~~ and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1.	Chapter # 3: Design Specification	Turki & Abdullah Alghamdi*
2.	Review Definition and Scope	Abdullah Zabadin
3.	Prepare Midterm Presentation	Obaid & Ibrahim
4.	Finalize Prototype	Obaid & Abdullah Alghamdi

Outcome f:
An understanding of professional and ethical responsibility.

Criteria	None (1)	Low (2)	Moderate (3)	High (4)
f1. Demonstrate an understanding of engineering professional and ethical standards in dealing with public safety and interest	Fails to Demonstrate an understanding of engineering professional and ethical standards in dealing with public safety and interest	Shows limited and less than adequate understanding of engineering professional and ethical standards in dealing with public safety and interest	Demonstrates satisfactory an understanding of engineering professional and ethical standards in dealing with public safety and interest	Understands appropriately and accurately the engineering professional and ethical standards in dealing with public safety and interest

Outcome d:
An ability to function on multidisciplinary teams.

Criteria	None (1)	Low (2)	Moderate (3)	High (4)
d1. Ability to develop team work plans and allocate resources and tasks	Fails to develop team work plans and allocate resources and tasks	Shows limited and less than adequate ability to develop team work plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Understands and applies proper and accurate team work plans and allocate resources and tasks
d2. Ability to participate and function effectively in team work projects	Fails to participate and function effectively in team work projects	Shows limited and less than adequate ability to participate and function effectively in team work projects	Demonstrates satisfactory ability to participate and function effectively in team work projects	Understands and participates properly and function effectively in team work projects
d3. Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	3. Understands and communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (d1)	Criteria (d2)	Criteria (d3)	Criteria (F1)
1	Abdullah Al-Ghamdi*	4	3	3	3
2	Abdullah Al-Zabadin	4	3	3	3
3	Turki Balhareth	4	3	3	3
4	Ibrahim Al-Jarah	4	3	3	3
5	Obaid Al-Subaie	4	3	3	3

Comments on individual members

Name	Comments
Abdullah Al-Ghamdi*	Great work. Prototype almost ready
Abdullah Al-Zabadin	Engaged team member.
Turki Balhareth	Engaged team member.
Ibrahim Al-Jarah	Engaged team member.
Obaid Al-Subaie	Engaged team member.

SDP – MONTHLY MEETING REPORT

Department of Mechanical Engineering
Prince Mohammad bin Fahd University

SEMESTER:	Fall Semester	ACADEMIC YEAR:	2019
PROJECT TITLE	Design of Smart Watch for Eating & Control		
SUPERVISORS	Dr. Nassim Khaled		

Month: October-2019

ID Number	Member Name
201502764	Abdullah Alghamdi*
201401224	Abdullah Alzabadin
201401253	Ibrahim Aljarah
201601225	Turki Balhareth
201402660	Obaid Alsubaie

List the tasks conducted this month and the team member assigned to conduct these tasks

#	Task description	Team member assigned	Progress 0%-100%	Delivery proof
1.	Chapter # 3: Design Specifications	Ibrahim & Obaid	100%	Nassim Khaled
2.	CAD Modelling	Turki	100%	Nassim Khaled
3.	Midterm Presentation	Abdullah Alghamdi	100%	Nassim Khaled
4.	Prototype Finalization	Abdullah Alzabadin	100%	Nassim Khaled

List the tasks planned for the month of November and the team member/s assigned to conduct these tasks

#	Task description	Team member/s assigned
1.	Performing Trial Runs and Experiments for Gathering Data	Turki & Obaid
2.	Chapter # 4: System Testing and Analysis	Abdullah Alzabadin & Abdullah Alghamdi
3.	Chapter 5 & 6: Project Management/ Project Analysis	Ibrahim & Obaid
4.	Finalizing Deliverables (Leather Book & Brochures)	Ibrahim & Turki
5.	Final Presentation	Abdullah Alzabadin & Abdullah Alghamdi

- **To be Filled by Project Supervisor and team leader:**
- **Please have your supervisor fill according to the criteria shown below**

Outcome f:

An understanding of professional and ethical responsibility.

Criteria	None (1)	Low (2)	Moderate (3)	High (4)
f1. Demonstrate an understanding of engineering professional and ethical standards in dealing with public safety and interest	Fails to Demonstrate an understanding of engineering professional and ethical standards in dealing with public safety and interest	Shows limited and less than adequate understanding of engineering professional and ethical standards in dealing with public safety and interest	Demonstrates satisfactory an understanding of engineering professional and ethical standards in dealing with public safety and interest	Understands appropriately and accurately the engineering professional and ethical standards in dealing with public safety and interest

Outcome d:

An ability to function on multidisciplinary teams.

Criteria	None (1)	Low (2)	Moderate (3)	High (4)
d1. Ability to develop team work plans and allocate resources and tasks	Fails to develop teamwork plans and allocate resources and tasks	Shows limited and less than adequate ability to develop teamwork plans and allocate resources and tasks	Demonstrates satisfactory ability to develop team work plans and allocate resources and tasks	Understands and applies proper and accurate teamwork plans and allocate resources and tasks
d2. Ability to participate and function effectively in team work projects	Fails to participate and function effectively in teamwork projects	Shows limited and less than adequate ability to participate and function effectively in teamwork projects	Demonstrates satisfactory ability to participate and function effectively in teamwork projects	Understands and participates properly and function effectively in teamwork projects
d3. Ability to communicate effectively with team members	Fails to communicate effectively with team members	Shows limited and less than adequate ability to communicate effectively with team members	Demonstrates satisfactory ability to communicate effectively with team members	3. Understands and communicates properly and effectively with team members

Indicate the extent to which you agree with the above statement, using a scale of 1-4 (1=None; 2=Low; 3=Moderate; 4=High)

#	Name	Criteria (d1)	Criteria (d2)	Criteria (d3)	Criteria (f1)
1	Abdullah Alghamdi*	4	4	4	4
2	Abdullah Alzabadin	4	4	4	4
3	Ibrahim Aljarah	4	4	4	4
4	Turki Balhareth	4	4	4	4
5	Obaid Alsubaie	4	4	4	4

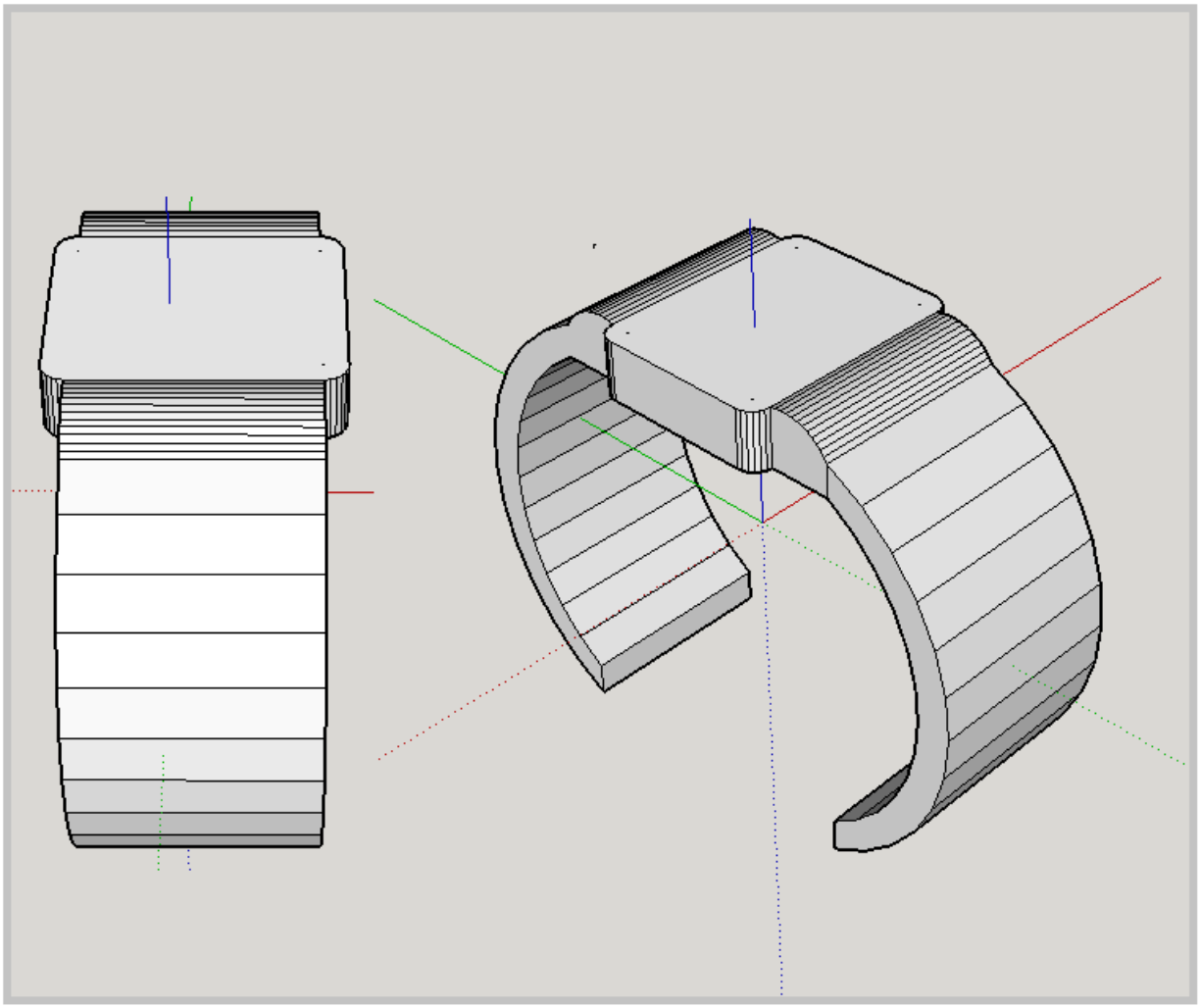
Comments on individual members

Name	Comments
Abdullah Alghamdi*	Prototype completed on time
Abdullah Alzabadin	// // // //
Ibrahim Aljarah	// // // //
Turki Balhareth	//
Obaid Alsubaie	//

Appendix B: Engineering Standards

Components	***Engineering Standards***
Plastic Housing for Accelerometer Module	Polypropylene (Grade: 5)
Wrist Strap	Silicone Rubber (ASTM D2209)
Bluetooth 2.0 AHRS	IEEE 802.15.1 3Mbps
Lithium Battery	UL 1642
Gyro Sensor	IEEE 2700-2017
Microcontroller	ISO-TS-16949

Appendix C: CAD Drawings and Bill of Materials



Appendix D: Prototype Picture

Appendix E: Operation Manual

To run the prototype, please follow these steps:

1. Make sure you wear the required safety equipment.
   - Remove all tools and unneeded items from the rotating parts.
2. Make sure you did the below step before turn the power on.:
   - Fill the water reservoir by enghug quantity of water as marked.
   - Wait until the water remains at the desired level.
   - Turn on the pump to start the circulate the water. (220-volt AC).
   - You need to have sensors; voltmeter and tachometer.
3. Turn on the motor (220-volt AC).
4. By using the variable, gradually, raise the speed by the radial button until you reach to the desired RPM

Appendix F: Gantt Chart