

Heart Rate Monitoring System

Section 1.1 – Project Intro

Health and fitness has become a substantial concern among the general populace over the past decade. With obesity rates on the rise, the resulting heart and health problems are trending in the same direction [1], [2]. People are realizing the importance of being fit and taking care of themselves. Almost daily, you are told that to be fit, stay well, stay healthy, but for the average user there is a lack of easily attainable health information. Heart rate is closely tied to cardiovascular diseases and other health problems [3]. Good feedback is critical to be able to accurately assess one's activity for the day, determining if they are meeting their health goals. The heart rate can also increase early diagnosis if there is a history that a doctor can look at. That is why the heart monitoring system is targeted to the average consumer desiring feedback on their daily health status as well as the fitness enthusiast who wants to accurately assess their training program.

The average consumer and fitness enthusiast have several overlapping requirements that are needed to have an effective product. The customers desire a product with a small form factor that is non-intrusive. One that is easy to use and has a simple user interface that allows for the data to be easily reviewed. Since smartphone applications are so prevalent in today's age, it is a given that an interface through a smartphone for the information is required. Then of course, being battery powered is key since portability is huge concern when someone is physically active or training. These critical customer requirements are what drove the decisions for the form factor and features of the product.

The product is going to be in a watch form factor. This form is very appealing because of the small size and non-intrusiveness since it is an ordinary item to have while being active. The size, however, also creates new problems for fitting in the technology needed to satisfy all the requirements. The watch has to read in accurate heart rate data fairly quickly to be of use and then will send that information to the smartphone. The phone application will take care of the data processing and presentation, but the watch proves to be a challenge to provide reasonable battery life in the midst of all it is doing. Power management will be critical for the watch to perform well between telling time, monitoring heart rate, wirelessly communicating, and still staying within a reasonable size for the watch.

Section 1.2 – Technology Table

Product	Smart phone connectivity	Health monitoring	Backlit screen	Touch screen	Battery life	GPS	Social integration	Watch form factor	Rechargeable	Cost
Basis B1 [4]	BT	Yes	Yes	No	3-4 days	No	None	Yes	Yes	\$199
Casio G-Shock GB-6900 [5]	BT	No	Yes	No	2 years	No	None	Yes	No	\$180
Sony SmartWatch [6]	BT	No	Yes	Yes	3-4 days	No	None	Yes	Yes	\$130
Nike FuelBand [7]	BT	Yes	N/A	No	4 days	Yes	Little	Watch band	Yes	\$150
WIMM One [8]	BT & WI-FI	No	Yes	Yes	2 days	No	None	Yes	Yes	\$200
Fitbit Force [9]	BT	Yes	N/A	No	7-10 days	No	Yes	Watch band	Yes	\$130
Citizen Eco-drive Proximity [10]	BT	No	Yes	No	N/A	No	None	Yes	Solar powered	\$345
Pebble Smartwatch [11]	BT	Yes (with phone apps)	Yes	No	7 days	No	None	Yes	Yes	\$150
Martian Smartwatch [12]	BT	No	Yes	No	7 days	No	None	Yes	Yes	\$300
ConnecteDevice Cookoo Smartwatch [13]	BT	No	Yes	No	1 year	No	None	Yes	No	\$130

Section 1.3 – Technology Analysis

The project area of wearable technology, specifically in the smart watch and fitness band field, is still a relatively new market. Though they have existed for several years, it has not been until recently that products have begun to flood into the market. The commonality between all of them is that they connect to a mobile phone or similar device. Most projects focus on being an extension of the user's phone with alerts and controls while few obtain health relevant data and even fewer do both. Ten projects were reviewed in the technology table (Section 1.2) and compared across a variety of features. All were quite similar and yet very distinct. There is not set design in the young market and that shows in the differences among the project. There has been no clear victor among the devices which seems to suggest that room still remains for a health monitoring watch that is accurate and incorporates a person's smartphone in a unique and exciting way.

Smart Phone Connectivity

Almost every device on the market allows connectivity with a smartphone via Bluetooth technology. This allows for syncing between propriety or store apps and the smart watch or band. Most of the products utilize Bluetooth 4.0, which is ultra low power. One product (WIMM One) also supports WI-FI connectivity, while this is not specifically between the phone and the product, it should still be mentioned as a unique feature.

Health Monitoring

Only about half of the reviewed products included any sort of fitness monitoring. This mostly included step counting through accelerometers for the Fitbit Force, Fuelband, and Pebble smart watch. Some products kept track of different movements and incorporated it into a more sophisticated tracking of movement in the form of counting stair steps. Few allowed for heart rate monitoring, which was done through an optical sensor. There are other technologies for sensing heart rate in the industry such as dry electrodes, which require physical contact with the skin, and noncontact sensors, but optical sensors are still the most common to be used [14]. This feature is what makes the Basis B1 product stand out among the crowd.

Backlit Screen

The only time that a product did not come with a backlit screen was when the product utilized an LED array to display information (Fitbit Force, Fuelband). Being able to see the screen or display when it is dark is a necessary and assumed feature in today's products.

Touch Screen

Some of the more innovative products include a capacitive touchscreen for the user interface. The ones that do not have a touch screen are either using the traditional buttons on a watch or are one of the bands. For a product to not have a touch screen is a slight step back in innovation. There are enough products out now with touch screens that are in a form factor that you put on your wrist, that if a product wants to lead the market, it will probably need a touch screen. This feature definitely sets the Sony smart watch and the WIMM One apart from the crowd. That being said, a touch screen still does not seem to be a deal breaker for the average consumer as long as the rest of the product is innovative itself.

Battery Life

The examined products typically ranged from 2 to 7 days on a single charge. A couple products had non-rechargeable batteries and could survive from a year to two years on a single coin cell. There was a single product (Citizen Eco-Drive Proximity) that was actually solar powered. This is unique among the realm of wearable technology and is definitely a feature that should be noted as state of the art.

GPS

Most products do not have GPS in the sense of within the product itself. Several of them can access the GPS from the phone and utilize the data through its connectivity. Only the Fuelband actually has an onboard GPS. This feature does not seem as important to consumers because it can just be obtained through a smartphone and is not necessarily a weakness for products that do not have it.

Social Integration

This is a unique feature among a couple of the reviewed products but most notably among the Fitbit Force. The social integration is the idea of having your fitness information available to be shared among your friends, creating a competitive dynamic to

keeping track of your activity. You can access your information in detail through an online account and see a history of your activity. This area is where the Nike Fuelband is lacking with only Facebook and Twitter integration. It is a weakness compared to the Fitbit as both products have similar target audiences and social integration has been a burgeoning desire among consumers.

Watch Form Factor

Most smart wearable technology comes in a watch form factor. The watch allows for an excellent carrier for smart technology. The majority of consumers still use watches and therefore provides an opportunity for innovative designs that do not draw attention. This provides the user with a discrete way of monitoring notifications and other information. If a product in this market does not tell time, it is at a severe disadvantage in today's technology.

Rechargeable

For the products that do not have a long battery life because of the amount of computing they are doing, there is the need to be rechargeable. This can solve power management problems, which would otherwise require a much bigger product to fit in the necessary batteries. It is slightly more inconvenient to have to charge the device but consumers have become accustomed to recharging products over the years with laptops, phones, etc.

Cost

The products that were reviewed in the technology table ranged in price from \$130 to \$345. The price seems to be more dependent upon the brand name of the product than the feature set. Oddly enough, the most expensive products are more like watches than wearable computing technology. Consumers seem willing to pay for an expensive product if it has the right feature set for them. The cheaper products are the ones that have a very specific purpose and not very many extra features. Which if you are looking for product with that specific purpose, it definitely puts the Fitbit Force and Fuelband at an advantage with their pricing.

Section 1.4 – Possible Design Requirements

Customer Requirement: Monitors heart rate.

1. Records the heart rate within 10% error of standard medical equipment
2. Heart rate information must be displayed in beats per minute
3. Heart rate information is recoded no fewer than 4 times per minute
4. Heart rate information will be obtained with optical IR sensors

Customer Requirement: Communicates with mobile device

5. Device will connect with a user's smartphone
6. Device will use BT low energy to connect with smartphone
7. Device will remain connected to smartphone without having to be repaired (excluding out of range and loss of power situations)
8. Device will update its time from the phone

Customer Requirement: Intuitive UI/user friendly

9. iPhone application on smartphone to interface with device
10. Device will have between 2-4 pushbuttons to change settings.
11. Buttons on device will have no more than 3 levels of directories
12. Device must implement an on/off switch
13. Application will contain a history of data for at least 3 days
14. Must have user documentation of at least 3 pages

Customer Requirement: Practical form factor

15. Device will be utilized as a wristwatch that also indicates the time of day
16. The display of the watch cannot exceed the dimensions 2.5" x 2" x 1"
17. Wristband must fit wrist sizes with circumference of 5" to 9"
18. Watch must not weigh more than 0.75 lbs.
19. Must have a backlit screen
20. Must have LCD screen
21. Must stay attached to user for at least 1 hour of jogging at a an average pace
22. Must be able to operate after exposure to -10 C to 65 C
23. Must be able to operate after being exposed to 15 drops of water on enclosure

Customer Requirement: Battery powered

24. Watch will last at least 24 hours on a single charge.
25. Watch will be rechargeable.
26. Watch will use micro USB connection to recharge.
27. Must be able obtain a full charge in under 3 hours
28. Watch indicates when it is fully charged

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