Development of Low Cost Monitoring Device for Individuals in Quarantine

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Abstract - *Coronavirus disease 2019 (abbreviated as COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARs-CoV-2). The disease was first identified in December 2019 in Wuhan, the capital of China's Hubei Province, and has since spread globally resulting in the ongoing coronavirus pandemic. As of November 1st 2020, more than 4 million cases of COVID-19 have been identified, resulting in the deaths of more than 250,000 people globally. Across the world, authorities have been calling for Social Distancing protocols in order to stop the spread of the virus. Since no vaccination or cure has been discovered yet, prevention is the only plausible solution to minimize its impact. In order to check for this, it has been required for people who have been infected or suspected of infection to remain in quarantine or self isolation for a particular amount of time. However it is difficult to ensure the execution of such orders due to multiple reasons. One of the reasons is the scarcity and expensiveness of a monitoring device. Currently monitoring devices cost more than 10,000 INR. This project proposes to make available a monitoring device with 10% of the current cost.*

Key Words: Geo-fencing, Social Distancing, GPS, GSM, Electronic Tagging

1. INTRODUCTION

The Case Fatality Rate (CFR) of COVID-19 has been estimated to be around 1-3%. The Basic Reproduction Number (R_o) has been estimated at 1.4-3.8. This number can be used to understand the number of cases one infected person shall generate. However, the disease can remain asymptomatic up to several days in which an infected person can infect many others. This implies that the virus possesses greater risk, not because of how virulent it is but because how contagious it is. Since this is a novel virus, humans are not immune to it. Therefore the entire human species is susceptible to it as per the latest research on the disease. Due to this, it can spread like a *wildfire*. Hence the only solution as of current time to mitigate the effects of the pandemic is by slowing the spread of the disease. Governments across the world have called for **Social Distancing** measures to be adopted by the common people along with other common sanitation techniques such as hand washing etc. Social Distancing helps flatten the curve (slows the rate of spreading) and makes sure that the health infrastructure can handle the pandemic. (Figure 2)

In order to slow the spread, people with travel history and perceived risk of contagiousness have been advised to keep themselves in self-isolation for many days. People who have been infected are also kept in quarantine. However it has been difficult to monitor if this directive is actually being implemented. A lot of people from different sections of the society have violated the issued isolation protocols putting the communities at risk. Currently the Police use mobile cell phone tracking to monitor this. **As mobile phones can be left at home while the person may still go out and violate the self isolation directive, it is not a very effective method of monitoring. Moreover, many people in India lack the financial means to possess a Smartphone.**

Since Electronic Tagging is highly costly, it hasn't been used either in the implementation of monitoring individuals under self-isolation or under quarantine. Electronic Tagging is defined as the attaching of electronic markers to people or goods for monitoring purposes, e.g. to track offenders under house arrest or to deter shoplifters. **Time and again, it has been used by health authorities also to mitigate pandemics.** Many countries, for example Bahrain has used watch like electronic devices to monitor the isolation
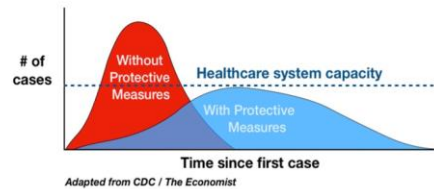
Figure 1: An Electronic Ankle Tag

Figure 2: Flatten the Curve

Electronic Ankle Tags (Figure 1) can cost more than 200$ in installation and up to 40$ a day in operating costs. Moreover Ankle Tags are majorly used for convicted felons in many countries. To check for mental health of people in isolation, our project uses a different approach than wearing the device than as an ankle tag. Our project uses a much cheaper device build on similar models that cuts cost significantly by up to 90 %. Since we have proposed to cut costs significantly, people who have financial difficulty in owning a Smartphone can be given the proposed device for monitoring purpose. Since the police have already been tracking people based on other technologies such as **geofencing**, or mobile app based tracking, it is known that tracking is legal for the authorities to monitor the pandemic. Hence this device is aimed at making tracking full proof, easier and cost effective.

The **Global Positioning System (GPS)** is a satellite based radio navigation system that provides geo-location and time information to a GPS receiver anywhere on or near earth where there is an unobstructed line of sight to four or more satellites. A **GSM module** or a **GPRS module** is a chip or circuit that is used to establish communication between a mobile device or a computing machine and a **GSM** or GPRS system.

2. PRODUCT DESCRIPTION

The Product uses easily available electronic components encased in plastic casing to implement successful monitoring of isolated individuals. The device may be worn on the wrist as a watch. A clothed layer preferably of cotton will be used to make sure that the device can be worn for weeks without causing skin irritation. However, since wearing of the product as a watch is not central to its functionality, it may be attached to the clothing, or any other convenient means of wearing the device can be thought of. The device may not be worn continuously 24x7. There may be a time window as determined by the authorities in which it may be required to be worn. For example, it could be taken off in the night time.

An **A7 Module** which is a GSM/GPRS+GPS module shall use the Global Positioning System to communicate the co-ordinates of the device to the microcontroller in real time. The microcontroller shall compute the conformation of allowed range of motion of the device. If the device is taken outside the allowable isolated zone, it shall trigger the authorities immediately through the A7's GSM/GPRS functionality. This will create a geo-fence like system and will ensure that no other form of data is collected. The real time location will not be monitored or recorded. A Boolean based algorithm will only check whether device is within the designated geo-fence or not in real time.
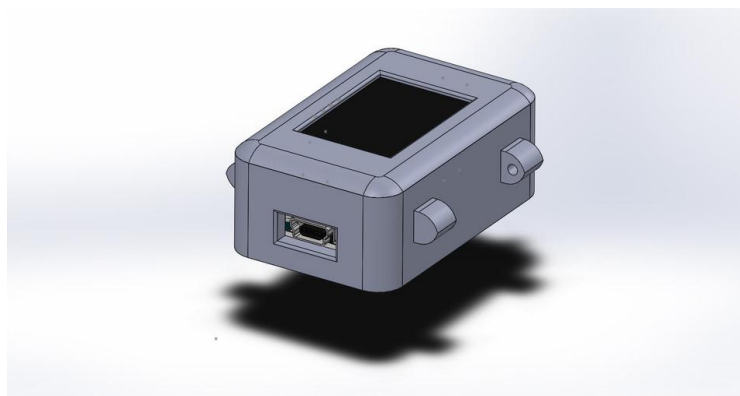

Figure 3: Sample Plastic Case – 3D File

If the device is broken, it shall stop communicating and this will trigger the authorities again. When communication shall be broken, this shall alert the authorities. **An android app shall be developed** for the authorities to monitor the status of the device continuously in real time, based on responses received from the device.
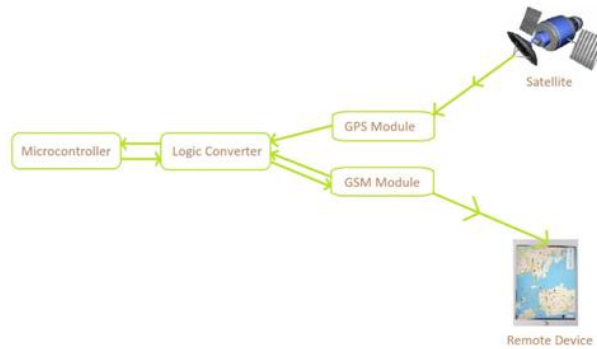

Figure 4: Schematic Diagram of the Device

The language C is generally used for programming such devices as it is compatible with this specific microcontroller. Code shall be written after a market survey. Talking to the authorities will give the team an idea on more specific requirements about the product, thereby guiding the code writing process. Simple modified GPS tracker code is easy to build and debug. The code shall be uploaded by **Atmel Studio**. Since this is just a proposal, much of the work in this domain in underway.

The following table discusses a pre cost analysis of the device.

Table 1: Parts - Cost Chart

S. No.	Item Name	Specification	Cost
1.	Atmega16	Microcontroller	176 INR
2.	A7 Module	GSM/GPRS + GPS	28 INR
3.	MAX232	Logic Converter	400 INR
4.	Battery	3.3 – 7.4V DC	250 INR
5.	Casing and Misc.	Plastic 3D Printed/ Custom Made	100 INR
		Total Price	954 INR approx

The manufacturing cost is planned to be kept minimal by incorporating the strength of undergrads by inspiring them to volunteer. This would serve multiple purposes. It would inculcate a sense of technological capability as well as contribution to the society. This would make them feel immensely satisfied and spark an interest for problem solving, and at the same time minimize the cost of manufacturing. It is obvious that the proposed device is significantly cheaper in manufacturing than commercially available similar devices.
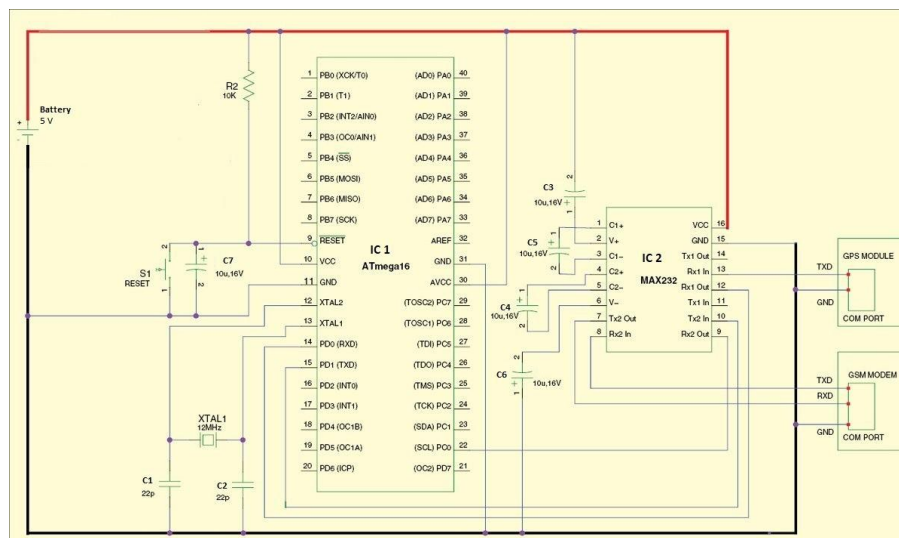
Figure 5: Circuit Diagram of Microprocessor

3. MANUFACTURING PROCESS

The proposed product cycle follows
1. **Planning** – Talking to the authorities about the requirements, and doing an analysis of the manufacturing process beforehand, so as to maintain supply to demand. Using powerful tools such as Gantt Charts to maintain a smooth process throughout.
2. **Procurement –** Procurements of necessary materials as per the order, from local electronics shop. This shall also increase the economic activity for MSME traders such as electronics parts shop owners.
3. **Manufacturing –** Assembly of the device as per the described specifications to meet its functionality.
4. **Distribution –** Installation of the device in individuals ordered for isolation and setting up of monitoring platform for the police and concerned health authorities.
5. **Service –** Providing handling and maintenance tutorials and acting as technical support for the operation of the device.

4. REQUIREMENT AND AVAILABILITY OF MATERIAL

All equipments that are needed to create a prototype for this device are available in any electronics shop in any city. The cost of the materials is the only cost that has been incorporated to determine the cost of the device, since the team is hoping to find volunteers for the manufacturing process.

5. LEGAL AND SOCIAL ASPECTS

Privacy is a major concern in the modern world with emerging technologies. The recent privacy issue with the government app "**Aarogya Setu**" as shown by ethical hacker **Elliot Anderson** illustrates how information can easily be leaked. In order to secure our users against privacy violations, we will use a Boolean-based algorithm, only to check whether the device has left the isolated zone or not. The device shall not collect any real time location data. It shall only check in real time if the device is within the **geo-fence** or not and accordingly alert the authorities. Moreover, no other data will be collected by the device.

This device is **not intended for use for all individuals** in a particular jurisdiction who have been directed to self-isolate. It is understandable that many individuals are conscious of the problem and are aware of the need to isolate, so it is needless to monitor them. However, as per the news, many individuals have violated the isolation directive, especially in the rural area. They have escaped from health authorities and put their communities at risk.

As per Section 2, of the Epidemic Diseases Act 1897, the authorities have the legal capability to temporarily implement measures such as monitoring individuals to prevent an outbreak. Any person not complying with the instruction of such authorities is said to have committed an offence punishable under section 188 of the Indian Penal Code (45 of 1860). Hence the police besides monitoring people in the current times (which they don't need to when there is no outbreak) have also arrested few individuals who have violated the directives putting communities at risk.

This makes it clear that the use of device may be legally permitted as per the agreement of concerned authorities without the need of a special legislation. So, after a risk evaluation, only those individuals, who are identified by the authorities as potential violators of isolation protocols, may be needed for monitoring.

However, in order to prevent social stigma and to address mental health issue for the individuals using the device, various measures can be adopted. It can be seen that the technology discussed in the proposal is the fundamental or central point approach in solving the monitoring problem. In the currently used cell phone tracking also, similar GPRS+GSM functionality is used. It is not needed that the device be worn as an ankle tag only. The device can replace high cost smart phones for individuals who don't possess phones. It can be worn as a watch, as authorities in Bahrain have done it. It can instead of being locked in the wrist, be carried in the pocket or be attached to the garment. Frequent counseling with the person wearing such device will help in addressing the issues of concern. Moreover, the use of device can be made compulsory by the authorities by virtue of power granted to them through the Epidemic Diseases Act, 2007. Donations of rations and medical supplies which are already underway could be used to leverage the use of such device.

With further work on this project, a low cost health monitoring digital watch could be introduced which could be a more holistic health package, working for both the individual as well as the community. Such a device will very likely have no stigma around it.

6. FURTHER WORK

The team is currently exploring more methods to reduce cost and time of manufacturing so that it can be distributed in hotspots to monitor population in real time, in order to keep a check on violations of social distancing protocols. Moreover, besides an improvised electronic ankle tag, we are working on making a commercially marketable product that meets all technical standards. This is necessary as current products that perform similar functions are quite expensive. We are also planning to study the possibilities of designing a multi-purpose wearable electronic device which may be able to monitor the health of the user through parameters such as pulse and temperature. Cost cutting in such devices can also be achieved through innovative and economic use of simpler parts and specific applications.

REFERENCES

[1]   Cost Effective GPS-GPRS Based Object Tracking System, K S Hasan, Abul Haque, Proceedings of the International Multi Conference of Engineers and Computer Scientists, Vol 1 IMECS 2009, March 18 – 20, 2009, Hong Kong

[2]   Bai Y, Yao L, Wei T, et al. Presumed Asymptomatic Carrier Transmission of COVID19. *JAMA.* Published online February 21, 2020. doi: https://10.1001/jama.2020.2565

[3]   Ying Liu, Albert A Gayle, Annelies Wilder-Smith, Joacim Rocklöv, The reproductive number of COVID-19 is higher compared to SARS coronavirus, *Journal of Travel Medicine*, Volume 27, Issue 2, March 2020, taaa021,

https://doi.org/10.1093/jtm/taaa021

[4]   Mobile App https://www.news18.com/news/tech/mohali-police-launches-covid-control-app-to-track-home-quarantined-people-2566929.html

[5]   200$ set up fee: https://equaljusticeunderlaw.org/thejusticereport/2018/6/12/electronic-monitoring

[6]   Bahrain's use of such device https://www.mobihealthnews.com/news/europe/bahrain-launches-electronic-bracelets-keep-track-active-covid-19-cases

[7]   Geofencing: https://whatis.techtarget.com/definition/geofencing

[8]   PDF File of the Epidemic Diseases Act, 1897

https://indiacode.nic.in/bitstream/123456789/10469/1/the_epidemic_diseases_act%2C_1897.pdf

[9]   An arrest made under EDA https://www.hindustantimes.com/gurugram/gurugram-man-escapes-after-testing-positive-for-covid-19-arrested-by-police/story-tWo9EjuYHOFlQWMc1qpAOJ.html

[10] People escaping https://scroll.in/pulse/956280/is-indians-lack-of-trust-in-public-healthcare-hurting-efforts-to-battle-coronavirus

[11]] Aarogya Setu Failure https://medium.com/@fs0c131y/aarogya-setu-the-story-of-a-failure-3a190a18e34

BIOGRAPHIES

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