1. PROBLEM AND MOTIVATION
Internet of Things (IoT) with smartphone technologies have vast applications in solving the problems of heart diseases in patients needing care. With wireless sensors and smart devices, the real-time physical status of heart patients can be identified by remote monitoring no matter where they are or what they are doing. The Electro-Cardio-Gram (ECG, and also called EKG), plays an important role in the monitoring, diagnosis and rescue of heart disease patients. The patient monitoring system can reduce the risk of infection and other complications. Furthermore, implementation of patient monitoring in hospitals might reduce various medical costs needed for monitoring in both personal and equipment, as well as in terms of installation maintenance [1]. Current research has been focused on heart rate monitoring systems, which do not adequately provide information or safety for elderly individuals prone to a stroke. The area of heart disease prediction using IoT is still understudied.

With the recent advances in mobile technologies, the cost of smartphones has decreased but their computational efficiencies have increased [2]. Smartphone-based heart disease detection and monitoring systems can function almost everywhere, since mobile phones are highly portable and already integrated into daily lives. We believe that the best way to reduce the number of risks due to abnormal ECG patterns is to use these systems to alert users when the possibility of abnormality increases.

To address the issue of heart rate monitoring using IoT, in this research, we propose a smartphone-based health monitoring system that can alert the user to abnormal ECG patterns. The smartphones are integrated with powerful sensors, such as accelerometers and navigation systems (e.g., GPS), that are used along with the AD8232 heart monitor device [3] to identify abnormalities in an ECG with user location information. Our system is useful for heart rate detection not only among the elderly but also has scope in identifying abnormal heart rate among children, physical rehabilitation patients, and even in individuals with autism. According to our research, we are the first to propose heart rate monitoring using low energy IoT devices along with a smartphone. Upon completion of this project our major contributions will be as follows:

(i) development of an IoT-based heart rate variability monitoring system for the elderly, which can warn users regarding a potential heart attack by identifying any abnormality in heart rate or ECG.
(ii) use of a built-in accelerometer and GPS of smartphone and ECG signal acquisition device to unobtrusively detect and monitor abnormality in heart rate.
(iii) use of signal classification techniques to classify normal heart rate from simulated abnormal heart rate.
(iv) Development of a Low-Energy (LE) Bluetooth network for communication between a smartphone and the ECG sensor.
(v) provide users, medical professionals and caregivers with highly personalized health feedback.

2. BACKGROUND AND RELATED WORK
Most of the proposed research for remote heart monitoring is based on body-worn sensors rather than embedded IoT sensors. Many researchers have talked about analytics that use the sensor data but few have discussed the use of IoT along with e-Health records that are becoming ubiquitous and can monitor a number of heart diseases. Koshti, et al., [4] implement a system which monitors the heart pulse of a patient. The authors monitor the ECG signal and heart beat through a laptop or personal computer wirelessly, which is difficult for real-time monitoring of a patient’s health status. In addition, it is difficult to collect heart rate data in any environment using the proposed system. In [5], the author proposes a system that recruits wearable sensors to measure various physiological parameters. Sensors transmit the gathered information to a gateway server through a Bluetooth connection. This system requires a physical infrastructure to monitor the user’s health. Our system is designed to address directly some of the shortcomings of the existing systems and yield good prediction results. Our proposed system not only capable of the sensing tasks but can also automatically connect to and exchange information with caregivers or loving persons through the Internet, significantly simplifying set up and administration tasks.

3. APPROACH AND UNIQUENESS
We divide our research into five steps: (i) using portable ECG acquisition device to check status of the heart of a patient and record the analog ECG signals, (ii) developing a LE communication module with less computation resulting in a low power consumption, (iii) collecting smartphone and ECG sensors’ data, (iv) evaluating the abnormality in heart rate by analyzing the ECG signals and smartphone sensors’ data, (v) providing more personalized health information for medical personnel or caregivers to aid with risk prediction, where each user can access only his personal data providing for privacy for the patients information. In the system, a smartphone of the user continuously recognizes the heart rate status by using the integrated data from ECG sensor’ and built-in smartphone sensors. While existing approaches are capable of detecting whether a subject is getting a stroke due to an abnormal heart rate, our proposed novel system predicts and attempts to prevent a risk of a heart attack by generating an alert message and combines a number of beneficial features without an infrastructure.

4. RESEARCH METHODOLOGY
The strength of our proposed architecture depends on existing wireless communication to maximize a patient’s freedom of movement at a low price. During the experimentation, the subject would be asked to wear the ECG sensor at a different location on the body and carry their smartphone in his/her pocket. The accelerometer of the smartphone is used to collect the 3-axis (x, y, and z) raw acceleration parameters and collect GPS data for location information. The AD8232 heart-rate monitor is used to...
measure the heart rate while the subject would be asked to perform four different types of activities: sitting, running, jumping, and exercising. The system is able to display ECG signals to the smartphone through a LE Bluetooth communication network. The ECG waveform is used to measure the heart rate variability. The heartbeat calculation is the major focus; the electrodes are simplified to three connections - one on the user’s right hand, one on the left hand, and one on the right leg. The data is processed in the smartphone to classify the abnormality in heart rate patterns. Though the system continuously monitors for ECG patterns and body accelerations, it only triggers a warning if the pattern reaches a threshold where the user might face a potential heart stroke. The proposed system enables an audio message and vibration to alert the subject and also to send a warning to the caregiver and loved ones. The system architecture of the proposed system is shown in Figure 1.

5. RESULTS AND CONTRIBUTIONS

For our preliminary results, we have developed a LE Bluetooth communication module between the smartphone and the ECG sensor. The data collection system provides a high rate of accuracy to distinguish between normal and abnormal ECG patterns. Our approach to signal classification is to build GMMs of signal trajectory densities in a Representation in Phase Space (RPS) and differentiate between signals. This is done in three steps. The first step, signal analysis, includes embedding the signals and estimating the time lag and dimension of the RPS. The second step is learning the GMMs for each signal class. The final step is signal classification, which is done with a Maximum Likelihood Estimator (MLE) technique. The ECG data collection process is shown in Figure 2. Here we use an instrumentation amplifier, which is a very first stage in an instrumentation system; it amplifies the ECG electrode output. A filter is used to reduce the noise level of the sensors’ output and sends the data to the smartphone through a LE Bluetooth communication module. An Arduino and a LE Bluetooth shield, bluefruit [6] are used to build a wireless module for communication. This module would convert signals into a digital format. The ECG signals from the heart rate monitor device are transferred to the smartphone through a myAdhoc communication network.

6. REFERENCES

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