|| Volume 6 || Issue 6 || June 2021 || ISSN (Online) 2456-0774
INTERNATIONAL JOURNAL OF ADVANCE SCIENTIFIC RESEARCH
AND ENGINEERING TRENDS

IOT CONTROLLER FOR SMART BICYCLE

Akhilesh Nadkarni[1], Omkar Mudrale[2], Rashi Saraf[3,] Harshali Zodpe[4] Vishal Pansare[5]

Student, School of Electronics Communication, MIT World Peace University Pune, Maharashtra, India [1 2 3]

Associate Professor, School of Electronics Communication, MIT World Peace University Pune, Maharashtra, India[4]

Business Manager-Manufacturing IT Logicontechnosolutions Pvt.Ltd., Pune, Maharashtra, India[5]

anadkarni03@gmail.com[1], omudrale0953@gmail.com[2], rashisaraf2210@gmail.com[3] harshali.zodpe@mitwpu.edu.in[4], vishalpansare@logiconteh.com[5]

---------- ***----------

Abstract: **People purchase a bicycle for transportation, recreation or for keeping themselves fit. Technology has been used to manufacture smart bicycles, making the traditional bicycles inferior in terms of tracking various parameters. In order to overcome this, an IoT controller can be attached externally to a traditional bicycle making them smart! The system, which is budget friendly, provides various functionalities which is aimed to be presented through this paper. A smart lock is incorporated in order to lock/unlock the bicycle. The Hall Effect sensor module is used to measure the distance travelled and the calories burned through cycling is calculated using the algorithm devised. The bicycle's location can be tracked, and this is achieved using the GPS module which gives the real time positioning of the bicycle. Our system comes with an application which aims to provide the user a friendly interface in order to keep a track of the parameters like distance travelled, calories burned, real-time location of their bicycle. The ThingSpeak server is used as the cloud platform in order to store the data and to establish a communication between the Hardware and the Application.**

Keywords: *Traditional and smart bicycle; IoT; Hall Effect sensor; GPS; calories burned; Cloud platform*

----------***----------

I INTRODUCTION

Now-a-days, fitness plays a vital role in our life. When it comes to fitness, the bicycle is something which is very popular among all generations. Cycling increases stamina as well as strength. The traditional bicycle is quite popular as it is easy to ride, burns a good number of calories in less time, and is economical. The current era is of automation and smart accessories. People prefer using high tech gadgets over traditional gadgets with basic features. As people are getting more concerned about health and fitness these days, they have started using smart devices which track the number of calories burnt while exercising, amount of water intake, sleep cycle, their current location, and so much more. These modern-day requirements have given rise to the concept of a fitness bicycle or smart bicycle. These smart bicycles are sure to take over the traditional bicycles in the years to come. Researchers have worked upon automatic measurement systems for bicycles where they have developed smart bicycles using different microcontrollers. It provides features like measuring the speed and distance travelled by the bicycle, calculating the number of calories burned and equivalent fat loss occurring through cycling.[1] This system converts a regular bicycle into a double purpose bicycle which can be used for both travelling as well as for exercise purposes. Location tracking in various systems is done through various ways. GPS is used to track the current location of a vehicle or the device the module is attached to. In some projects using SQL and MATLAB GUI, the database of vehicles was displayed on a Webpage and then tracked through GPS. In some systems, own applications were built for the user and vehicle end. [2] Some companies have come up with smart bicycles that provide an app with different ringtones to alert cars and pedestrians. They also provide theft alarms and navigate streets along with tracking your cycling habit. The bicycle has numerous sensors placed on it such as a speed sensor and GPS module. Another company has launched smart road and mountain bicycles. It provides features like GPS tracking, distance covered and other fitness metrics.

Keeping in mind the health concerns and the technology requirements, the developed system is controllable through a Mobile App. The system can be externally attached to any bicycle to convert a simple bicycle into a smart one! Besides, the proposed system is far more economical as compared to the existing smart cycles as it is built using open source softwares and is affordable to all levels of society. The system is built entirely on the IoT domain. The controller used is NodeMCU ESP8266. The system uses ThingSpeak as the cloud platform for synchronization between the hardware and the mobile application. The location information along with Google Maps link is sent using IFTTT (messaging center) to the registered mobile number.

II LITERATURE REVIEW

Most bicycles designed for fitness purposes sold in the market are immobile that cannot be ridden outside, which is a drawback in some sense. [1] The smart bicycle is developed using MCS-51. Their system provides features like computing the rear wheel's speed and distance travelled by the bicycle, number of calories burned, and equivalent fat loss occurs through cycling. This system converts a fitness indoor bicycle into a double purpose bicycle which can be used for both travelling as well as for exercise purposes.

Tracking of vehicles is gaining importance in modern times. The system is advanced in technology and economical to use. [2] The system built is used to track the location and the parameters like location, speed, engine temperature and fuel level of various test vehicles from a centralized place for research and development purposes and data of those vehicles is stored on the server for analysis. Data collection is done using the Internet of Things (IoT). All the data is stored on the web server while vehicle location data is connected to Google maps where users can easily track their vehicle.

Keeping in mind the safety of the passengers in the school bus, and for the parents to keep a real-time track of the vehicle, the system proposed plays an important role. [3] It is based on Raspberry Pi. The database using MYSQL is displayed on the Webpage of the smartphone when the school bus will arrive. Whenever a vehicle theft occurs or an accident takes place, the system provides the vehicle's current location and speed to the vehicle owner's mobile.

The system has an application for the user and vehicle end. [4] GPS which is present in every smartphone gives the positioning of the vehicle and passengers can know the exact location of the vehicle. It is a very low-cost system since the cost is only the internet charges.

The calories burnt during an exercise helps in keeping a check on one's weight. [5] The system proposed counts calories based on the heartbeats, which in turn is calculated using a low-cost IR sensor. The IR sensor detects the blood flow changes of the index finger and thus measures the pulse rate. An amplifier is used to amplify the signals so that the heart rate can be measured properly. Some proposed formula has been used based on various parameters like Heart rate (in beats/minute), Weight (in kgs), Age (in years) Exercise duration time (in hours) to finally calculate the calories burned.

Internet of Things is a growing field and has been used in various applications. The same can be extended for the use of fitness tracking and security of the bicycle as well. [6] Arduino UNO is used in the system. The smart lock attached with the bicycle checks whether the bicycle is stolen or not. There are various states of the bicycle so this can be checked. It cannot be unlocked until the user enters the password on the partner android app. The heart rate sensor measures the pulse rate and thus the user can keep track of their health. A reed switch is used to measure the speed of the bicycle wheels. Stepper motor is used with the smart lock which enables it to move in both forward and backward directions. A local database is used by the app to store the ride activity data.

Vankhawks Valour has wifi bicycles which run in all parts of the world. They are not just smart but connected too. Various features are included like alarming the rider of any potential collision through slight vibration in the handles using ultrasonic sensor, motion prediction using accelerometers, gyroscopes, magnetometer, GPS receiver, speed sensors and blind-spot sensors, anti-theft alarm system through tracking of the in-built signature of the bike. They have developed an app which gives the real time information about the route being followed, the upcoming directions along with the traffic and the best route suggestions. The smartphone can be anchored on the front while riding the bicycle. If one does not want to do that, the bicycle handles have LED indicators which point left, right or even U-turn as per the directions suggested on the app. Moreover, a user can get his bike customised according to the frame size, colour and speed options before buying [7]. LeEcho smart bike is inbuilt with a 10cm touch screen docked on the frame. Various sensors are used to measure parameters like speed, barometric readings, and direction with a compass. Features like distance covered, duration of cycling and other fitness metrics are also calculated and stored. This smart bike provides voice communication with other smart bikes. A Snapdragon 410 processor handles all these functionalities smoothly [8]. Connected Cycles provide low-cost smart bicycles with various features like real time geolocation of the bikes, route history with details on the waypoints: distance, elevation, average speed, max speed, email alerts on unexpected usage, reports on monthly usage, list of trips enabling usage billing to end-customers, geofencing statistics: part of the fleet in zone / out of zone. Further features of the bicycle are- they are lightweight and of small size, support multiple input voltage range, backup battery, connectors, and adapters. They are the first ones to launch a SMART PEDAL that records speed, route, incline, and calories burned on every single bike trip [9]. Shoka Bell provides features like bell to alert cars and pedestrians; navigation, front light, theft/motion alert using an alarm, 200 hr battery backup. Their functionalities help a user keep track of their cycling rides and habits [10]. SITAEL S.P. A's ESB is the first real solution for e-bikes using IoT. This smart bike comes up with various features like anti-theft system, remote check and geolocation, crash detection, emergency calling, social activity, routes and remote diagnosis and support. The smartphone application supports these features and provides the user a very friendly interface [11]. Ridley, together with Byte Lab, developed a connected bike, which can monitor one's speed, location, acceleration, and other metrics. IoT is used for this smart bicycle with the potential to provide cyclist support in case of an accident or flat tire [12].

III PROPOSED SYSTEM MODEL

Block diagram consists of various sensors. Hall effect sensor and GPS are the input devices which are placed on the bicycle. These input devices collect all the data and send it to the Node MCU which the main controller of our system. Node MCU works on the signal received from the input devices and will do the required action. The processed data from the Node MCU is synchronized with the mobile app where user can easily access

all the data such as distance travelled, calorie burned, location information and can easily lock or unlock the bike.

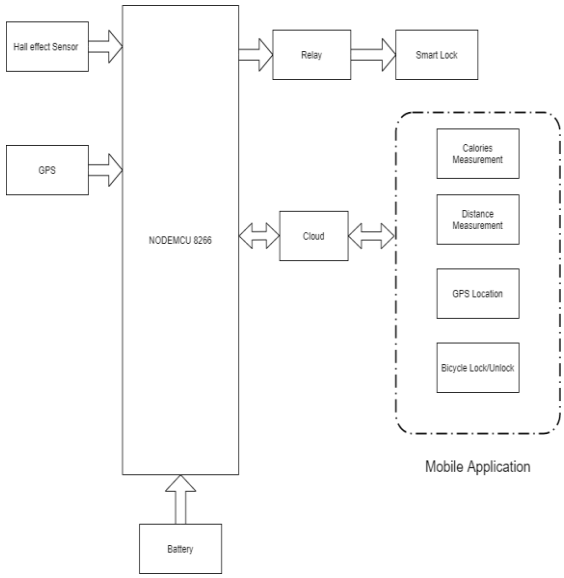

Fig.1 Block Diagram

Hall effect Sensor: This sensor is used to calculate the number of wheel rotations, by using below formula the distance covered by bicycle is calculated:

Distance Travel =Circumference of the wheel * No. of Rotations.

GPS: GPS is used to track the bike location.

Battery: It is used to supply power to various components.

Mobile App: User can easily access various functions through mobile app like: *Calorie measurement:* With the help of distance travel and the data obtained from the sensor, total calories burned are measured which will be shown on the Mobile App. *Distance Measurement:* Distance travelled by bicycle is shown on the Mobile App. *GPS Location*: User can easily track the bicycle location from the Smartphone. When he/she click on the location button on the App, an SMS containing the Google map link is sent on the registered mobile number. The link will redirect to the Google Maps where user can easily track the bicycle. This system is developed with the help of IFTTT and Thingspeak server. *Bicycle Lock/Unlock:* This can be done through Mobile App.

IV HARDWARE SOFTWARE REQUIREMENT

NodeMCU: NodeMCU often called esp8266 is open-source Lua based firmware and development board and is specially targeted for its IoT based applications. It includes firmware that runs on esp8266 Wi-Fi SoC from Espressif systems, and its hardware is based on the ESP-12 module which has Tensilica Xtensa 32-bit LX106 RISC microprocessor. NodeMCU supports RTOS. It operates at 80MHz to 160 MHz adjustable clock frequency. 128KB of RAM and 4MB of Flash memory which is used to store data and programs are specifications of NodeMCU. MCU stands for Microcontroller Unit - which really means it is a computer on a single chip. So NodeMCU also has high processing power with features of built-in Wi-Fi and can be easily powered with a basic Micro USB jack or VIN pin. UART, I2C and SPI are the communication protocols which are supported by NodeMCU.

Hall effect sensor: The proposed system uses the Hall effect module which is basically working on LM393 architecture. This module is a component that can detect the magnetic field using the Hall effect. This can detect the presence of an object or the proximity of a magnet which is the condition for our project. The built-in comparator of the module is used on its outputs so that it gives either digital (HIGH / LOW) or analog (0V-5V) signal, depending on the strength of the magnetic field. It is fast at detection and provides us with several wheel rotations in our project.

GPS Module: The system uses a GPS SIM28 module with an external antenna. SIMCom presents a high performance and reliable assisted GPS module-SIM28.

It has 16 channel GPS smart receivers. It has an ultra-low power GPS architecture. This is a standalone L1 frequency GPS module in a SMT type, and it is designed with the high sensitivity navigation engine, which allows you to achieve the industry's highest levels of sensitivity. It has High sensitivity (up to -152dBm typ) It has one of the best industry level accuracy, and Time-to-First Fix (TTFF) with lowest power consumption. It uses protocols like NMEA (National Marine Electronics Association) and PMTK (MediaTek proprietary data transfer protocol for GNSS) It has serial interfaces like UART, SPI and I2C. Antenna is a critical item for successful GPS reception in weak signal environments. So, the active antenna type using SMA connector is used. This antenna is used to access the real-time location of the bicycle.

12V Solenoid lock: This lock is widely used in projects or small applications. Basically, solenoids are electromagnets, they are made of a big coil of copper wire with an armature (a slug of metal) in the middle. 12V Solenoid lock works on 9-12V DC supply. It has a slug with slanted cut and a good mounting bracket. It can be called an electronic lock which is designed for a basic cabinet or door. The slug pulls and thus the door gets opened when the supply voltage mentioned above is given to the lock. No power is used in this stage. It is very easy to use, and it can be installed for automatic door lock systems like electric door lock with the mounting board. The proposed system uses this for smart lock/unlock of a bicycle with the help of a relay attached to it.

Relay: The electromechanical relay is used to protect circuit and component – with its expert solutions of power switching. It

accurately detects the occurrence of various faults like short-circuit, overload, etc. Their uses are typically related to managing and controlling devices – consisting of greater strength and power. The application incorporates diversified fields, including industries related to wireless technologies, aerospace industry, general aviation industry, and more. The striking attraction of Electromechanical Relay is that it is easy to use and highly economical in nature.

Arduino IDE is the open-source environment which makes it easy to develop or write code and upload it to the board. This software supports any Arduino board. NodeMCU ESP8266 has been used in this proposed system.It has more modern editor and it has more responsive interface it is provided with features like autocompletion, code navigation, and even a live debugger.

MIT Inventor: The App is built using MIT App Inventor. It is an online platform which is designed to teach computational thinking concepts through development of mobile applications. It is the platform made for students for their mini projects or final year project. This app helps students to create applications by dragging and dropping components into a design view and using a visual blocks language to program application behaviour. Components are core abstractions in MIT App Inventor The app build through MIT App Inventor is workable on every android phone.

V PROCEDURE

The microcontroller Node-MCU ESP8266 has Tensilica Xtensa 32-bit LX106 RISC micro- processor. It has an inbuilt Wi-Fi module, which helps the user to store the run time data to a cloud platform.The ThingSpeak server has been used as the cloud platform which acts as the medium of communication for our hardware and the smartphone application built using MIT App Inventor. Read and write API keys are used to connect the server with the microcontroller.

To start with, the user must go to the app and unlock the bicycle. As soon as the 'UNLOCK' button is clicked, the signal is received by the ThingSpeak server. The signal is then sent to the microcontroller, and further to the smart lock via the relay. The logic 1 is received by the lock, hence it gets unlocked. This happens over a span of 15 seconds.

Unlock: After getting unlocked, the Hall effect sensor and GPS module start recording values and keep sending this data to the server via NodeMCU continuously. As the user rides his/her bicycle, the no. of rotations keeps on increasing and the distance gets calculated. This has been further explained in detail below.

Distance Calculation: Hall effect sensor is used for the distance calculation. The working principle is shown in the below fig. Whenever a magnet comes in contact with a hall effect sensor, due to the magnetic field, the hall effect sensor module generates a signal. This signal is useful to count the number of wheel rotations. Magnet is placed on the rotating wheel while a hall effect sensor is placed on the stationary part of the bicycle. So, whenever a magnet comes in contact with the hall effect sensor a signal is generated that means the wheel completed one rotation.

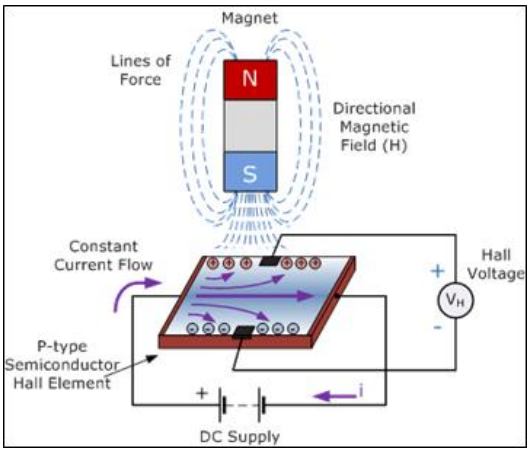

Fig.2 Hall effect sensor working principle.

Normal bicycle wheel has diameter of 622mm which is 0.622 meter. By using some calculations total distance covered by bicycle is calculated:

Total distance travelled by bicycle = No. of wheel rotations * Circumference of Circle

= No. of wheel rotations$* 2 * \pi * radius\ of\ circle(r)$

= No. of wheel rotations* 1.95 (meter).

By using all these calculations in the NodeMCU code the distance covered by bicycle is calculated.

Calorie Burned: The amount of calorie burn is calculated by an algorithm. After too much of research, with help of various data available on various sites an Algorithm is developed.[13] Below table is helpful for understanding that:

TABLE 1 Calorie burned Algorithm.

Distance	**Calorie Burned**
1 mile/1.6 km	48
3 mile/4.8km	143
5 mile/8 km	238
10 mile/16.1 km	476
15 mile/24.2 km	714
20 mile/32.2 km	953

Normal bicycle wheel has diameter of 622mm. So, bicycle will cover total distance of 1.95 meter in a single rotation. By using above table after travelling total distance of 1000 meters the

amount of calorie burned is around 30. So, using all this relations amount of calorie burned in a single wheel rotation is:

$$\frac{1.95}{1000} * 30 = 0.0585$$

By using all these calculations in the NodeMCU code the algorithm is developed.

Location tracking: To track the location of the bicycle, the GPS module comes into picture. The user gets the google map link through an SMS on the registered mobile number and is thus able to track the bicycle. This has been further explained in detail below:

As soon as the user clicks on the 'Location' button present beside the latitude and longitude on the app, the GPS receiver uses the data transmitted by the GPS satellites to collect and store the location of the bicycle. The GPS receiver collects data from at least 3-4 satellites.

The receiver receives a signal from each GPS satellite. The exact time when the signals are sent is transmitted by the satellite. The GPS can tell how far it is from each satellite by subtracting the time the signal was transmitted from the time it was received. At the moment they send their signals, the GPS receiver also knows the exact position in the sky of the satellites. So given the data of the GPS signals from the satellites and their exact position in the sky, the GPS receiver determines the location in all dimensions accurately. The below figure depicts the working of the GPS module.

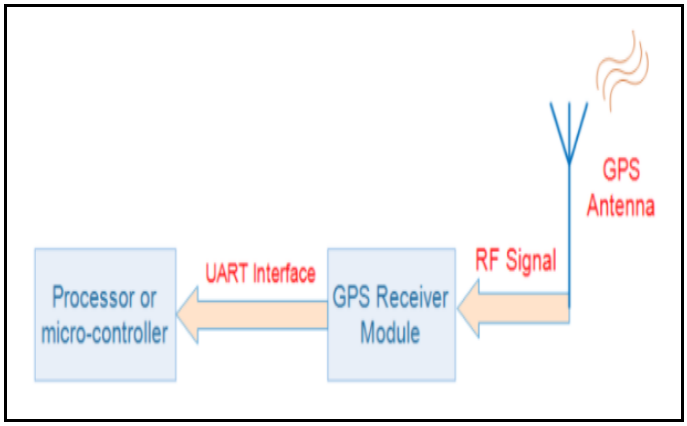

Fig 3 GPS working principle.

An SMS is sent to the user. This is done by an open-source site which is IFTTT which is used to connect different Mobile Apps together. When the user presses the location button on the app a trigger signal is generated. Due to this signal a message along with the Google maps link is sent to the registered mobile number given by the user. The link contained in the SMS leads the user to the google maps and thus helps the user easily track their bicycle.

Lock: The bicycle can be locked using the 'LOCK' button on the Application. As soon as it is clicked, the signal is received by the ThingSpeak server and using the logic 0 and the same procedure as mentioned for unlocking, the smart Lock gets activated and locks the bicycle.

VI RESULTS

After interfacing the hall effect sensor with the Node MCU the output data which is distance travelled by bicycle is observed on thingspeak server as shown in fig.4

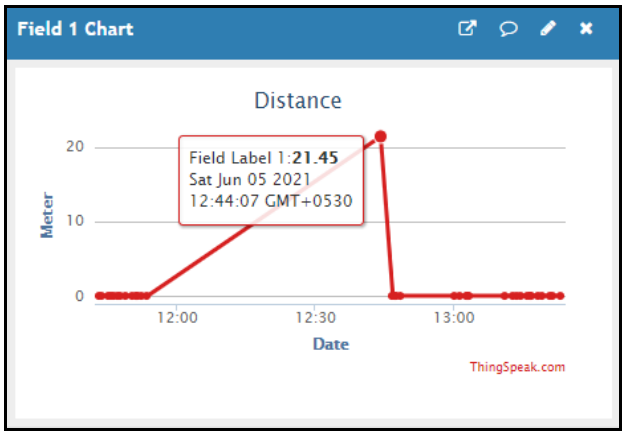

Fig 4 Hall effect sensor output on serial monitor

For real time location tracking the developed system is designed using the Thingspeak server, IFTTT which is used to send SMS. After testing the following results are obtained as shown in fig. and fig.6

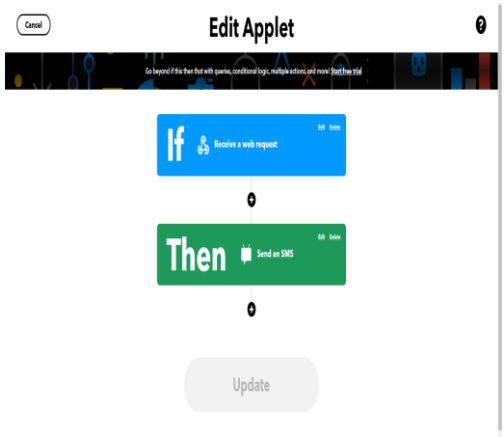

Fig 5 Applets for sending message.

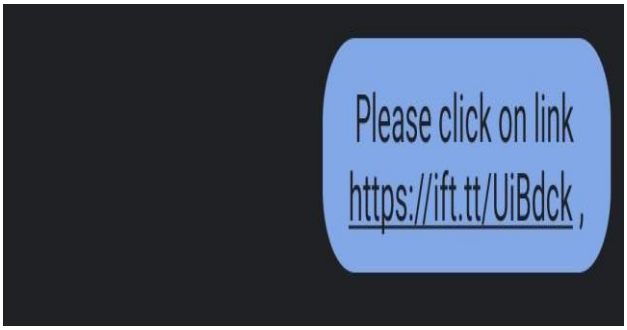

Fig. 6 Message to access location

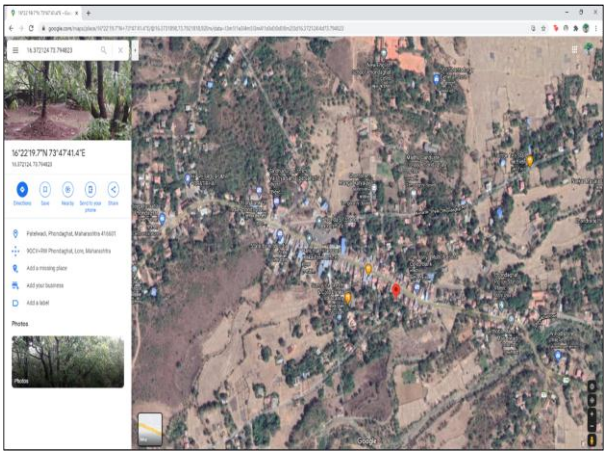

Fig.7 Location Google Maps

Location coordinates obtained from GPS module are as below:

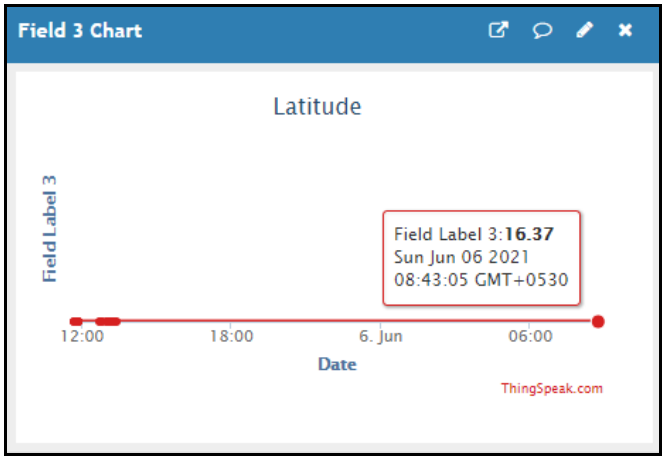

Fig.8 Value of Latitude on Thingspeak Server

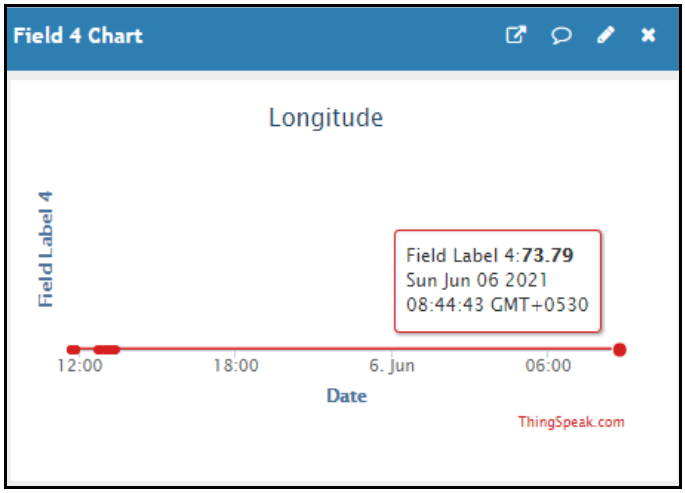

Fig.9 Value of Longitude on Thingspeak server

By using the calorie measurement algorithm, the below data is obtained on Thingspeak server which shows the number of calories burned by cycling.

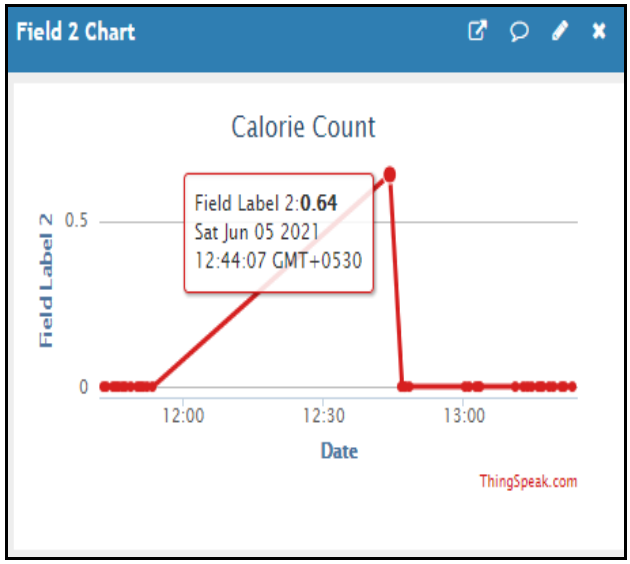

Fig.10 Calorie count on Thingspeak Server

The proposed System provides a feature of lock/unlock bicycle through Mobile App. The data transferred from Mobile App can be easily accessed through the Thingspeak server. The lock/unlock signal data sent by mobile app is shown below in fig.11.

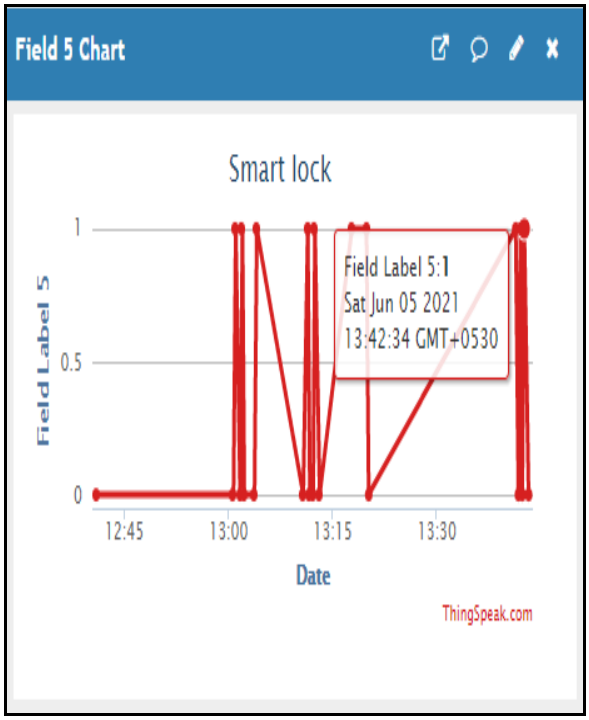

Fig.11 Smart lock signal

App development is completed using MIT App inventor. The synchronization between Mobile App and hardware is carried out by the Thingspeak server. All the parameters can be accessed using the mobile app as shown in below fig.

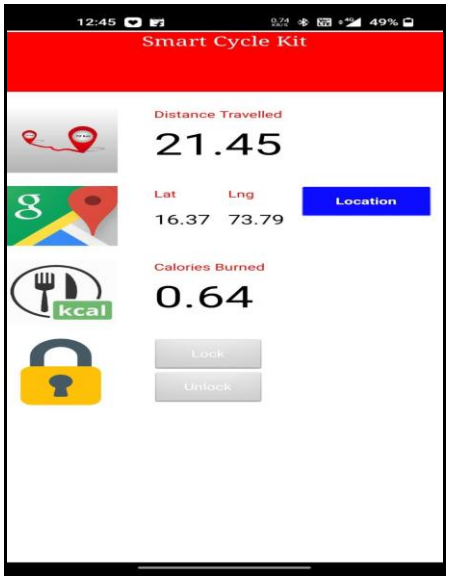

Fig.12 Smart Cycle App

VI CONCLUSION

The system is built keeping in mind all the aims and objectives. The traditional bicycle can be easily converted to a smart one with the help of our smart kit. The system is built using all the open source softwares and sites. So, it is economical as well as easy to use. The system involves communication between the hardware, Thingspeak server and the Mobile App. The bicycle with this smart kit can be used to travel from one location to another location. Also, it can be used to keep a track of the fitness measures which can prove to be useful to the user.

REFERENCES

[1] J. Y. Chen, Fuliang Wen, Chang Hua Lin and Deng-Fa Lin, "A new automatic measurement system for a bicycle," *IEEE International Conference on Mechatronics, 2005. ICM '05.*, 2005, pp. 514-519, doi: 10.1109/ICMECH.2005.1529311. URL:https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1529311&isnumber=32633

[2] M. Desai and A. Phadke, "Internet of Things based vehicle monitoring system," 2017 Fourteenth International Conference on Wireless and Optical Communications Networks (WOCN), 2017, pp. 1-3, doi: 10.1109/WOCN.2017.8065840.

[3]P. A. Shinde and Y. B. Mane, "Advanced vehicle monitoring and tracking system based on Raspberry Pi," 2015 IEEE 9th International Conference on Intelligent Systems and Control (ISCO), 2015, pp. 1-6, doi: 10.1109/ISCO.2015.7282250.

[4]https://www.researchgate.net/publication/323167379_An_IoT_Based_Approach_for_Very_Low_Cost_Real_Time_Vehicle_Tracking_System

[5]A Non Invasive Method for Calculating Calories Burned during Exercise using Heartbeat

[6]G. K. Reddy and K. L. Achari, "A non invasive method for calculating calories burned during exercise using heartbeat," 2015 IEEE 9th International Conference on Intelligent Systems and Control (ISCO), 2015, pp. 1-5, doi: 10.1109/ISCO.2015.7282249.

[7]https://www.kickstarter.com/projects/1931822269/vanhawks-valour-first-ever-connected-carbon-fibre

[8]https://www.theverge.com/ces/2017/1/3/14148308/leeco-android-smart-road-bike-mountain-bikeos-ces-2017

[9]https://connectedcycle.com/

[10]https://www.kickstarter.com/projects/dnlfls/shoka-bell-the-ultimate-city-cycling-tool

[11]https://www.sitael.com/internet-of-things/emobility/e-bike-management-system/#:~:text=ESB%20is%20the%20first%20e,of%20Education%2C%20University%20and%20Research.

[12]https://www.ridleys.com/

[13]https://caloriesburnedhq.com/calories-burned-biking/