Building a smart electric bicycle to solve problems faced in transport.

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Abstract - *In the Indian economy, transport plays a very fundamental role. India has made a lot of progress in terms of freight and public transport since independence. Many world-class achievements in aircraft, rail and road transport have been accomplished by India. Today there are more 6 million roads in India and more 25 million vehicles registered. Almost all modes of transportation consume fossil fuels which are rapidly depleting and also, they contribute to air and water contamination, both by combustion and through the refueling period, regardless of particular fuel intensity. Even today's relatively clean car can produce about 1 tonne of emissions over its lifetime. To solve this problem of excess use of fossil fuels people started to use bicycles as an alternative transport. But it's not feasible for the rider to travel long distances in a cycle in India which experiences persistent warm or high temperatures with average temperature of 24'C and going as high as 35-40'C during summer season. To face these challenges in the transport sector we are building a "Smart E-Bicycle".*

Key Words: Electric vehicles | IoT (Internet of things), Li-ion(Lithium Ion) battery | DC motor |

1. INTRODUCTION

Transport has always been one of the most in-demand resources for humans especially people living ur- ban areas. In this phase we are witnessing an exponential rise of people living in urban areas, by 2030 it is estimated that more than 5 billion people will be living urban area [1]. This will increase the demand for local transport and other trans- port facilities. This huge demand for transport facilities is not only causing problems like traffic jams, road congestion but also causing air pollution from vehicle emissions disturbing the environment in cities. In response to the problem's men- tioned so far, we are building a smart electric bicycle which uses electricity replacing petroleum-based vehicles. E-bikes are rapidly becoming in some European countries with de- veloped cycling cultures, appealing to both existing and new cyclists [2]. For example, in the Netherlands, sales of e-bikes equal or exceed those of conventional bikes in value one in ten bikes sold is an e-bike; and there are estimated to be over a million e-bikes in use in Europe [2]. Cycles are being used by people for a long time for fitness purposes [3], cycling is always regarded as one of the best exercises as it helps in burning calories and developing leg and arm muscles. These days there is a huge demand in smart fit- ness wearable's which monitors the performance of the user helping them to understand their progress. IoT is one of the most important areas of future technology and is gaining vast attention from a wide variety of industries Concept of IoT and AI has revolutionized how many physical systems are connected to the internet making communication easier be- tween many devices, sensors, actuators etc. For our project "Smart electric bicycle" we wish to embed many sensors and monitoring system for improving the rider experience.

2. LITERATURE SURVEY

Cycles are not one of the most used transport on roads in many countries due to less features offered by with which include.

1. Cycles are less user interactive than modern bikes and cars. In cars and bikes there are many things we can keep track of like speed, rpm fuel level, lights etc. This improves the rider experience.

2. Cycles don't have any rear-view mirrors; hence they are always vulnerable for accidents from rear of the vehicle hence not preferable for urban traffic. 3. There are many new gadgets coming up for fitness from bands to mobile apps. They record user data like location, heart- beat speed etc. There is a need to add these features to cycles too.

To face these requirements many researches are ongoing on making bicycle smarter and more interactive. Several projects demonstrate methods for gathering sensor real time data from cyclists. Dill and Gliebe used on board GPS for gathering data from cyclists [6]. IoT technology has transformed how people exercise by constantly capturing and distributing data that can be used to measure personal progress. The global smart fitness devices market is expected to reach 29.4 billion by 2025, according to a new report by Grand View Research, Inc. The smart fitness devices market has witnessed a rising demand. The link of wearable fitness trackers to the Internet would impact the everyday environment in the IoT period. Most people's lives are attributed to improved comfort and productivity in the execution of activities and tasks. There- fore, recognizing the variables that affect the intentions and behaviors of users to follow. An interesting and significant problem is using IoT- based wearable fitness trackers. Studies about using these kinds of technologies have been discussed several times over the past few decades since the proposal of TAM by Davis, et al [7]. People can easily access the inter- net in to browse the web, exchange data, and information in terms of real-time data refresh, using internet for multimedia content and information, services, projects, reading the lat- est news, using apps for social networking, and many other tasks [8]. Many apps will be introduced to fulfill the lives of people, with increased advances in cloud computing technology and the internet. Most advances in computer and

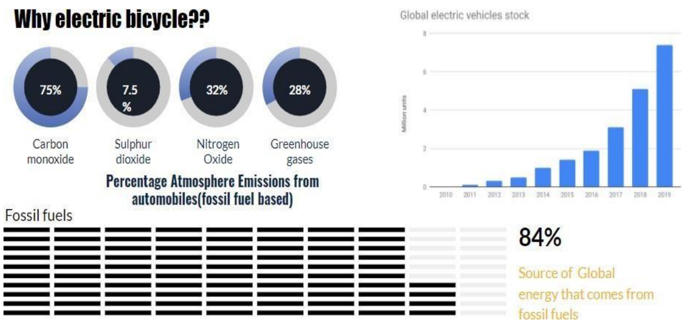

Fig -1: Factors supporting the need of electric cycle.

smart object enabling technologies and applications, including radio frequency recognition tags, sensors, actuators, PDAs, and smartphones, as well as cyberspace virtual objects, such as data and virtual desktops on the cloud. [9]

3. DESIGNING

3.1 Market Trends

After doing some literature survey on latest market trends in electric bikes. Classification of the basic components of used in an electric cycle. The table1 shows the different components and their types and placement methodology followed in design of various electric bi-cycle

Table -1: Market Trends

Sr no	Parameter	According to
1	Bicycle kit	Custom built Add on
2	Motor	Brushed DC motor Brushless DC motor
3	Motor assembly	Gear Hub Friction
4	Assist type	Full assist Half assist Half assist
5	Throttle	Twist throttle Thumb throttle Push button
6	Motor Placement	Front wheel Rear wheel Rear wheel
7	Battery Placement	Carriage Mounted Carriage Mounted

3.2 Prototype of the frame

Using the software **blender3D** we designed the prototype of the bicycle to consider various design parameters for adding the components efficiently. Figure 2 shows the complete design of the prototype.

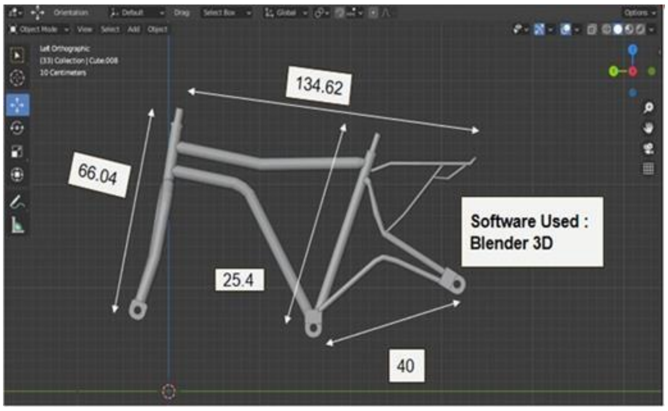

Fig -2: Used software blender 3D for designing of frame

3.3 Design of different parts

The BMS (Battery Management System), battery and rear obstacle sensors are mounted on the cycle carriage, and the engine is mounted on the rear wheel.

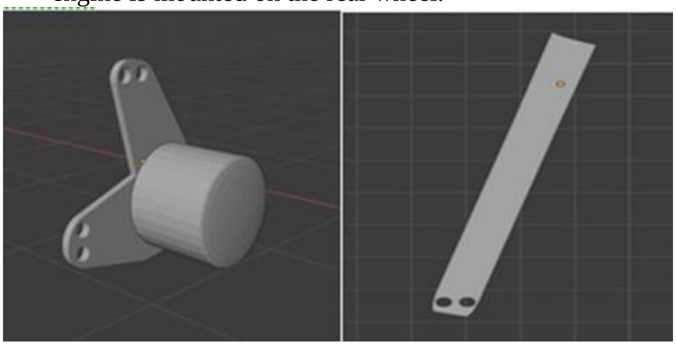

Fig -3: Extra support: length: 20-25cm Width: 5cm

A small chain is used to connect, its length is kept short to minimize the losses of the propulsion of the bicycle.

3.4 Architecture of the cycle

Figure 4 shows the architecture of the different project elements used. The LCD, the heartbeat sensor, the temperature humidity sensor is mounted on the handlebar, the rpm sensor is located in the wheel spokes, so that the rpm distance and speed cane counted. The BMS battery and rear obstacle sensors are mounted on the cycle carriage, and the engine is mounted on the rear wheel.

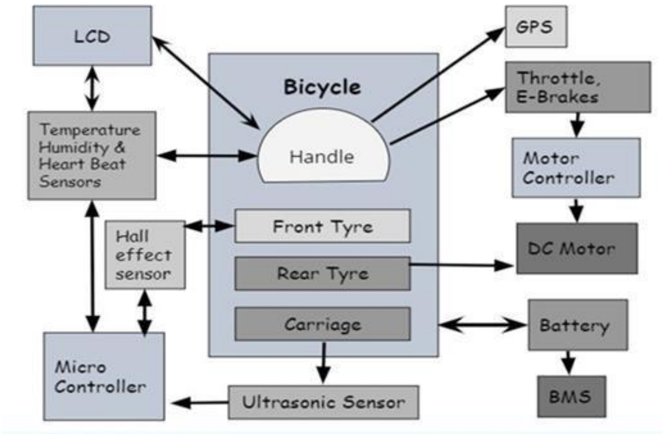

Fig -4: Architecture of the Cycle

4. MOTO R

Table 2 shows the parameters of the motor we are using for this project. Motor used is as shown in figure 5.

Table -2: Specifications of the motor

Parameter	Value
Operating Voltage	24 V DC
Motor Magnet Type	Permanent
Torque	22 Nm. i.e. approx. 225 Kg.cm
Maximum Current	approx. 13.4 to 19.2 A
of Teeth on Sprocket	9
Sprocket Chain Pitch	1/2" x 1/8"

Fig -5: Motor used for the cycle

Features of the motor:

•Electric motor with gear reduction produces more low-end torque than standard motor.

•This motor is capable of rotation in either the clock- wise or counterclockwise direction by reversing the motor's power wires.

•High power suitable for electric bicycles

5. SELECTION OF BATTERY

Power was a fundamental problem. We need to draw the power from the e-bike battery to satisfy the autonomy requirement, and this meant that battery protection was a crucial engineering requirement. We needed to select a suitable battery that would be able to power the cycle as well as be safe for operation.

5.1 Specification of battery

From table 2 the specifications of motor are:
Voltage: 24V Power: 350 W
Required voltage of the battery is 24V Power

$$350W \times 1hr = 350Whr$$

(Assuming Battery is 80% efficient)

$$350Whr \times 1.2 = 420Whr$$
$$420Whr/24V = 17.5AH$$

Battery should be at least 17.5 AH hence We will need a 24V 20Ah Battery for this project.

5.2 Type of the battery

For selection of the type of the battery a comparative study was done to identify the pros and cons of each battery type, figure 6 summarizes the study.

	Lead Acid	NiCd	NiMH	Li-ion
Capacity	2,000mAh	600mAh	1,000mAh	1,200mAh
Battery voltage	12V	7.2V	7.2V	7.2V
Energy per cycle	24Wh	4.5Wh	7.5Wh	8.6Wh
Number of cycles[4]	250	1,000	500	500
Battery cost (estimated)	330.22	330.22	462.3	660.44
Cost per kWh (SEk)	56.14	72.65	122.18	158.51

Fig -6: Comparative study of batteries

The battery type selected is Lithium-ion battery, which is considered to be the best among the available batteries according to the performance report obtained in comparative study on various batteries and other aspects like condense percentage and weight. This rating is placed by industries strictly based on the efficiency level and maximum durability.

6. ELECTRONICS

This cycle is equipped with many electronic components like sensors, actuators, micro controllers. For supplying them power through battery and for various applications we designed many electronic components.

6.1 Micro controller circuit

A microcontroller circuit was built for controlling of sensors, GPS, etc. also tested the interface of microcontroller and sensors. Only required number of DI, AI and PWM are added as required for this circuit.

6.2 Step-down circuit.

There was a need of 5V to power up the microcontroller and the battery gave an output of 24V. We needed to design a circuit which would convert 24V to 5V. Using NI Multisim the required circuit is designed as seen in figure7, the circuit was tested with a liner IC which converts 24V to 5V efficiently with a negligible drop in it. simulation the circuit in Multisim was done for betterment before building it for real application.

6.3 Selection of BMS

. Battery Management Systems are the main behind battery packs. They manage the output and pro- vide notifications on the status of the battery pack. They also provide critical safeguards to protect the batteries from damage. A BMS is essential for a Lithium-Ion battery system. This device manages a real-time control, manages SOC calculation, measures temperature and voltage of the battery pack. The choice of BMS determines the quality of the battery pack. Factors monitored and controlled by battery management systems include:

- Main power voltage of battery.
- Battery / cell voltage.
- Charging and discharge rates of battery.
- Temperature of the cells.
- Battery and each cell health.
- Coolant temperature and flow for air or liquid cooling.

As the need was for a Bluetooth BMS, after a long research I came to a conclusion to get a 7s BMS which supported 24V as shown in figure 8.

With built in short-circuit protection, SOH, SOC, overcharge protection, temperature sensor with auto cutoff. BMS comes in varieties 7s, 11s etc. as I had a requirement of 24V hence I selected the 7s one which will provide sufficient voltage and protection for the same.

6.4 Testing

The required follow ups in case of the following situations are given below

1. **Cycle shows power but motor does nothing.**

•Check that the e-brake lever is not damaged or engaged
•If engaged, this will keep the motor from operating.
•Check connection between the motor and controller.
•Disconnect both plugs and inspect the pins for damage or pulled out pins.
•Re-connect and re-test.

2. **Throttle troubleshooting**

•Check that the e-brake lever is not damaged or en- gaged. If engaged, this will keep the throttle from op- erating.

•Throttle may have become dis-connected or damaged.

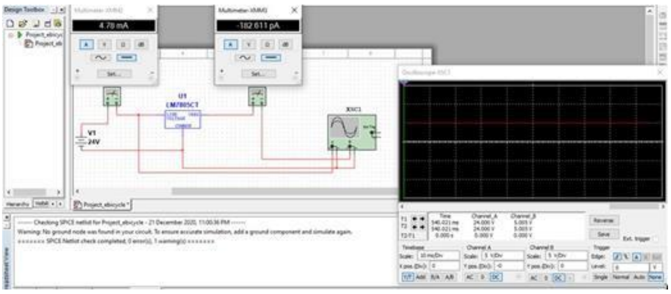

Fig -7: Step down circuit using multisim

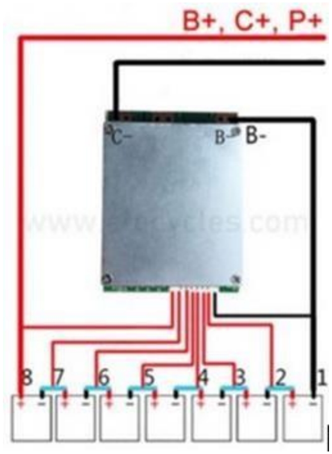

Fig -8: 7s-24V same port

•The throttle connector is the 3-pin connector usually with red, black and green wires.

•With a multi-meter you can test the pins for voltage:

•Black to red approx. 5V. Black to green should vary from 1-5V with throttle engagement.

•The throttles are reliable, and rarely cause issues unless damaged.

7. USE OF IOT

Throughout this project we have used several sensors for monitoring many parameters of a cycle while in motion. Using the microcontroller, it is necessary to program the sensors, for each sensor an algorithm needs to developed for making the sensors perform as per the application. Following are some of the features of the Bolt Wi-Fi module.

- Wi-Fi microcontroller module
- Robust communication
- Security
- Machine learning
- Scalability
- Alerts
- Mobile app development
- Global infrastructure
- Arduino compatibility

- Easily programmable

Steps taken to build a temperature monitoring system using Bolt IoT

1. Make all necessary connections of the temperature sensor with bolt
2. Give 5V power supply via battery or USB port of the laptop
3. Connect the Bolt IoT with an internet enabled hotspot
4. Open the Bolt IoT website to connect the device and program pins as shown in figure 9
5. Keep the circuit on and observe the result in the web-site as shown in figure 10.

For testing the setup of sensors, Arduino and Bolt IoT a simple temperature monitoring system is designed and tested. This ensures that the circuits are working and we use all the other sensors that are used in the bicycle.

Fig -9: Programming the pins of Bolt IoT on its website

Fig -10: Output of the temperature monitoring system

All the sensors are connected to the bike through microcontroller and Wi-Fi module, while the cycle is in use all these sensors for continuation monitoring of data, an LED display is mounted on the handlebar of the cycle so that the rider can see information like speed, heartbeat, temperature etc. Wi-Fi module can upload the data to the internet; this data can be obtained by the user from any smartphone or a computer. By this a rider can keep track of performance and progress for certain duration.

7. CALCULATION

7.1 No Load Speed Calculation.

Step 1: Length and speed of sprockets are the following:

Teeth on smaller sprocket (enter) (t1)	12
Teeth on larger sprocket (bicycle) (t2)	I8
Speed on smaller sprocket (N1)	400 rpm
Speed on larger sprocket (N2)	**?**

Step 2 : Using speed ratio formulae,

N 1 × t1 = N 2 × t2 N 2 = 287.46RPM

Step 3 :

Diameter of wheel	650 mm
Circumference of wheel	2072mm

Step 4:

Speed of the vehicle = speed of wheel X Circumference of wheel

287.56 × 2072 = 585930mm/min

593.83m/min 35.7km/hr

7.2 Range Estimation

On average, it’s been estimated that the average ebike battery will yield one 1 mile of travel for every 20 Wh of energy.

Motor specifications

Voltage: 24V Power: 350 W

Battery specifications

Voltage: 24V Amps: 20Ah

Capacity of Battery

24V × 20Ah = 480Wh

Range

480Wh/20Wh(per km) = 24miles(approx.)

In one charge our cycle is expected to travel 38km for typical 175-lb rider, on dry, flat, and paved roads, with tires properly inflated and no headwinds. Results may vary depending on conditions.

8. CONCLUSIONS

With a lot of research and trial error we have come up with a durable and low-cost E-bicycle which makes it easy for city people to travel. As pollution rate has risen hence this way of building an own DIY project would create a brighter and greener future ahead.

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