GlideX : An IoT based Bicycle Rental System

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***Abstract*—With the rising concerns about urban congestion, pollution, and the need for sustainable transportation, cycle-sharing systems have emerged as a popular and eco-friendly solution in urban areas. The GlideX proposed in this paper addresses these challenges by harnessing the power of IoT and integrating advanced sensor technologies to provide a smart and efficient cycle rental service. The core of GlideX is a development board, a versatile and powerful platform that enables seamless communication between the cycles and a central server. This intelligent bicycle is designed by integrating various sensors for real-time monitoring of the cycle's orientation and movement, the actuator for the locking system, providing a reliable and efficient way to secure the cycle when not in use and for detecting the status of the cycle's odometer. This smart bicycle creates a comprehensive and intelligent system that not only facilitates smooth rentals but also enhances the overall safety and reliability of the cycle-rental service. The GlideX bicycle rental system represents a significant step towards revolutionizing urban mobility. The implemented Glidex is tested to verify the various features and screenshots of the results are presented. By prioritizing sustainability, technology integration and community engagement, this initiative will transform the way people commute in urban areas, promoting a greener and healthier future.**

***Index Terms*—Internet of Things, GPS, Gyroscope, bicycle, GlideX.**

I. Introduction

With the rising concerns about urban congestion, pollution, and the need for sustainable transportation, cycle-sharing systems have emerged as a popular and eco-friendly solution in urban areas. The success of such systems hinges on effective monitoring, secure locking mechanisms, and seamless user experiences. An e-bike startup company [1] developed a bicycle that allows the user to use an electric bicycle to traverse the city. It states that their bicycles can travel up to 60kms on full charge. It is required to charge this bicycle based on the time taken to reach the destination. [2] Coo Rides is a revolutionary bicycle-sharing company headquartered in Mumbai, is rapidly transforming urban transportation across India. Operating in over 10 cities, their robust network of accessible and affordable bicycles offers a convenient and eco-friendly commuting solution. [3] Onn Bikes is a Hyderabad-based motorbike-sharing startup that operates in over 3 cities across India. Onn-Bikes uses petroleum for the operation of its product, which increases the cost of usage. In addition, this product might experience mechanical issues which increases maintenance cost. In this paper, an ecofriendly and pollution free bicycle referred as Glidex is proposed. GlideX is developed to address the challenges being experienced for the usage of bicycles in urban areas by harnessing the power of IoT and integrating advanced sensor technologies to provide a smart and efficient cycle rental service. GlideX is dsigned such that the charges for using this bicycle will be based on the distance travelled which allows for cheaper and more cost-efficient means of transport.

Fig.1 presents the overview of Glides. The core of GlideX is a development board, a versatile and powerful platform that enables seamless communication between the cycles and a central server. The incorporation of the gyroscope allows for real-time monitoring of the cycle's orientation and movement, providing valuable data for both users and operators. Additionally, the GPS module ensures accurate location tracking, enhancing the security and traceability of rented cycles. To ensure user-friendly and secure operations, GlideX uses a hall sensor for detecting the status of the cycle's odometer. The servo motor acts as the actuator for the locking system, providing a reliable and efficient way to secure the cycle when not in use. This combination of sensors and actuators creates a comprehensive and intelligent system that not only facilitates smooth rentals but also enhances the overall safety and reliability of the cycle-rental service.

To facilitate data exchange, GlideX employs a combination of communication protocols tailored to different aspects of the system. HTTP is utilized for the website interface, enabling users to access and interact with the rental service. Actuator commands and sensor values are transmitted using HTTP, ensuring reliable and efficient operation.

The system's connectivity relies on WIFI for local communication, allowing cycles to connect to nearby access points for real-time updates and commands. The GPS functionality is enabled through satellite communication, utilizing the NEO6M GPS module to provide accurate location data for each cycle in real-time. This multi-protocol approach ensures that GlideX operates across diverse urban environments, offering an easy cycle-rental experience to users while optimizing the overall system efficiency. In this paper, we present the design, implementation, and evaluation of GlideX, showcasing its effectiveness in real-world scenarios and in achieving a comprehensive cycle-rental system.

The organization of this paper is as follows. Section II presents the construction details and specifications of various

modules used in the development of the Glidex prototype. Section III presents the features and technologies used in the prototype. The implementation of Glidex is presented in Section IV. The results obtained by testing the prototype to verify the features are presented in Section V. Conclusions are presented in Section VI.

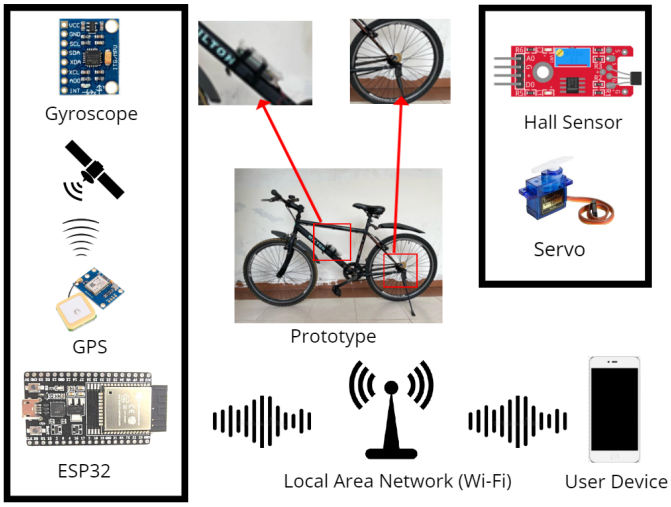

Fig. 1. Glidex Overview

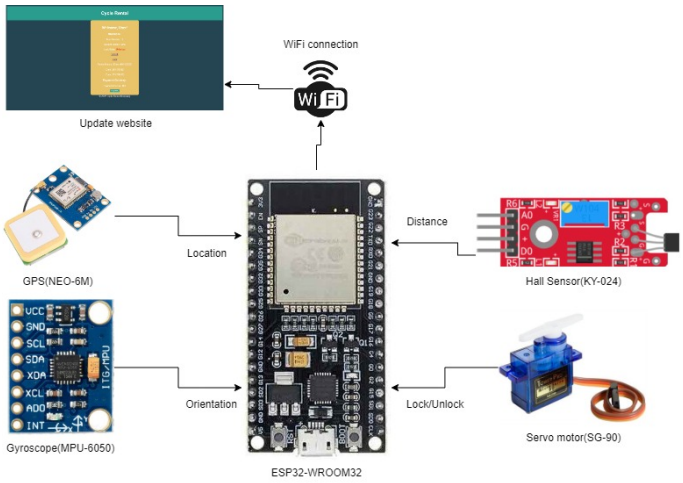

Fig. 2. Block Diagram

II. Construction

The construction of the GlideX IoT-based cycle rental system involves the integration of several key hardware modules, each serving a specific purpose to ensure the system's functionality and reliability. Fig.2 shows the block diagram of an IoT end device to be designed, employing the appropriate sensors and actuators, for attaching to the bicycle. This IoT end node converts the convectional bicycle to Glidex to meet the required challenges being identified for using in urban areas for sustainable and ecofreindly transportation. The features of all modules selected in the development of this proposed Glidex are explained briefly in the following subsections.

The brains of GlideX is the ESP32 microcontroller, a powerful and versatile platform that serves as the central processing unit for the entire system. The ESP32 facilitates communication with various sensors, actuators, and the central server, coordinating the flow of data and commands.

The MPU6050 gyroscope plays a crucial role in real-time monitoring of the cycle's orientation and movement. Integrated into the system, it relays valuable data related to the orientation of the cycle to the administrators, enhancing the overall safety and user experience.

For accurate location tracking and enhanced security, GlideX integrates the NEO6M GPS module. This module communicates with satellites, providing real-time location data that is essential for tracking the cycles, ensuring their security, and enabling users to locate and rent cycles conveniently.

A. Software

- HTTP: HTTP protocol is used for communication between the clients and web servers. In ESP-32 local website, HTTP is used to enable the ESP -32 to act as a websever that is accessible by clients on the local network. The ESP-32 web server is created by using the Arduino IDE programming environment. The web server is a mobile responsive and can be accessed with any device that is connected to the browser on the same local network. The contents of the webserver hosted on the ESP-32 locally can be controlled by the device connected and modified accordingly. The ESP-32 web server can be created using the ESP32WebServer library. The ESP-32 web server can serve HTML pages from the file system. You can also create a HTTPS web server on the ESP-32 using the Arduino core.

- WiFi: ESP-32 acts as a Wi-Fi station, as an access point or both. ESP-32 is set up as an access point using the Arduino IDE programming environment. The ESP-32 creats its own WiFi network and nearby Wi-Fi devices can connect to it.

- Arduino IDE: The Arduino IDE, or Integrated Development Environment, is a user-friendly software application designed for programming Arduino microcontrollers, a popular open-source electronics platform. It features a simple code editor with syntax highlighting, a built-in compiler for code translation, and an easy-to-use upload tool for loading code onto Arduino boards. Over the years it has also been made compatible with boards like Espressif (ESP) and Teensy to name a few and has been made compatible with languages like CSS and HTML for small scale website design and implementation. The IDE includes a Serial Monitor for real-time communication with the board, a library management system for code reuse, and integrated

examples for learning and reference. Compatible with Windows, macOS, and Linux, the Arduino IDE fosters a supportive community, making it accessible for enthusiasts and professionals to create a variety of interactive and programmable projects.

B. Hardware

- The ESP32 module is a versatile and powerful microcontroller widely used in the field of IoT (Internet of Things). Developed by Espressif Systems, the ESP32 integrates a dual-core processor, Wi-Fi, and Bluetooth connectivity, making it suitable for a diverse range of applications. It includes 3 UART, 3 SPI and 2 I2C interfaces with are responsible for the working of modules like gyroscopes, GPS etc. With its low power consumption, high computing capacity, and support for various communication protocols, the ESP32 excels in projects involving wireless connectivity and sensor integration. It is popular for building smart devices, home automation systems, and IoT prototypes. The ESP32's ease of use, ample features, and robust community support contribute to its widespread adoption among electronics enthusiasts and developers for creating innovative and connected projects.
- The KY-024 Hall Sensor is a small module designed to detect the presence of magnetic fields. It incorporates a Hall effect sensor that produces a voltage output proportional to the strength and polarity of an external magnetic field. When exposed to a magnetic field, the sensor generates a voltage signal, and this change in voltage can be measured to determine the characteristics of the surrounding magnetic field. The KY-024 is commonly utilized in electronic projects where the detection of magnetic presence or changes is crucial. Applications include proximity sensing, speed detection in rotational devices or to measure the distance travelled by a rotating object like a wheel for example, which is a perfect application for our project.

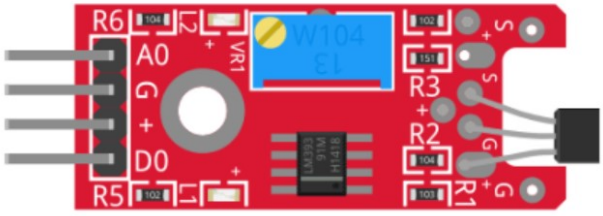

Fig. 3. KY-024 Hall Sensor

- The NEO-6M GPS module is a compact and efficient device designed to provide accurate global positioning system (GPS) data for electronic projects. Equipped with the u-blox NEO-6M GPS chipset, this module communicates with satellites to determine its precise geographic location, altitude, and time information. It receives signals from multiple satellites simultaneously, enhancing its accuracy. The NEO-6M typically communicates with a microcontroller through a serial interface that is, the UART pins, transmitting NMEA (National Marine Electronics Association) standard sentences containing the GPS data. Commonly used in applications such as navigation systems, tracking devices, and location-aware projects, the NEO-6M GPS module simplifies the integration of accurate positioning capabilities into various electronic projects.

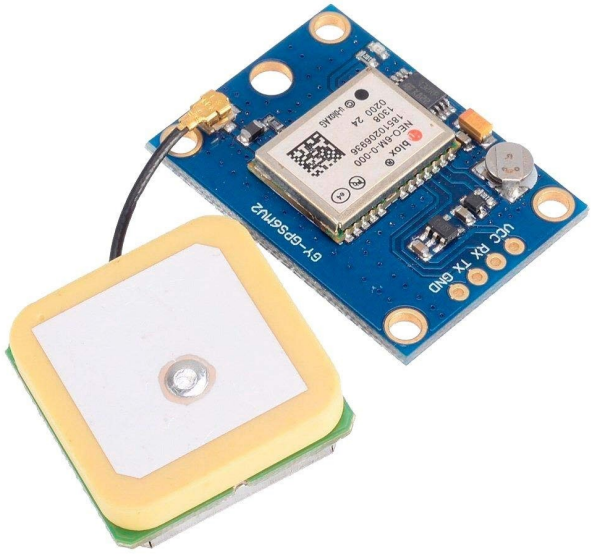

Fig. 4. NEO-6M GPS Module

- The SG-90 module refers to the SG90 micro servo, a compact motorized device designed for precise control of angular positions. Typically utilized in robotics and other motion control applications, the SG-90 servo features a small form factor, lightweight design, and is known for its affordability. The module consists of a DC motor, gears, and a feedback control system, allowing it to move to and hold specific angular positions based on the signals it receives. We use this feature of the servo motor to make a lock mechanism for the cycle by holding a specific angle for both the lock and unlock modes.

Fig. 5. Servo motor

- The MPU-6050 module is a compact and widely-used motion tracking device that combines a three-axis gyroscope and a three-axis accelerometer on a single integrated circuit. Manufactured by InvenSense, the MPU-6050 is commonly employed for measuring and processing orientation, acceleration, and angular velocity in electronic projects. This module is particularly valuable in applications such as robotics, drones, and motion-sensitive devices, where precise orientation tracking is essential. Its small form factor, low power consumption, and digital communication interface, often through I2C, make it a popular choice for hobbyists and professionals alike seeking reliable motion sensing capabilities in their projects.

Fig. 6. MPU 6050 Module

III. Implementation

GlideX employs a multi-protocol approach to ensure coordinated communication between the central server, and user interfaces.

HTTP is utilized for the website interface, allowing users to interact with the system and retrieve relevant information. Actuator commands, responsible for controlling the servo motor and locking mechanism, are transmitted via HTTP. Sensor values, such as gyroscope, GPS data, and hall sensor are also communicated through HTTP, providing real-time feedback to the central server.

WIFI connectivity is leveraged for local communication, enabling cycles to connect to nearby access points. This facilitates real-time updates, commands, and data exchange between the cycles and the central server, enhancing the system's responsiveness.

The GPS functionality is enabled through satellite communication. The NEO6M GPS module communicates with satellites to provide accurate location data for each cycle in real-time, to enable traceability of the rental service.

Fig. 7. Product form of Prototype

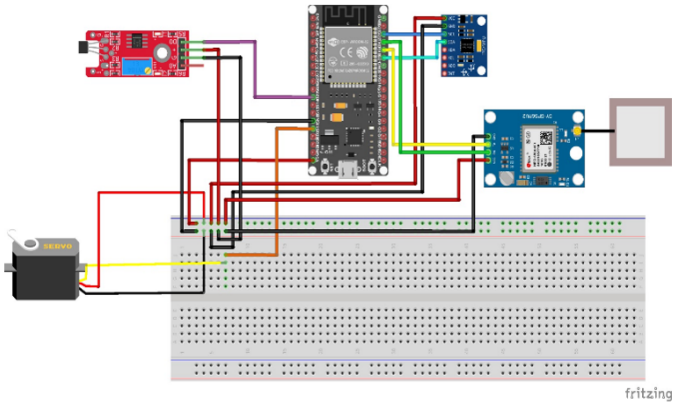

Fig. 8. The Circuit Diagram

IV. Results

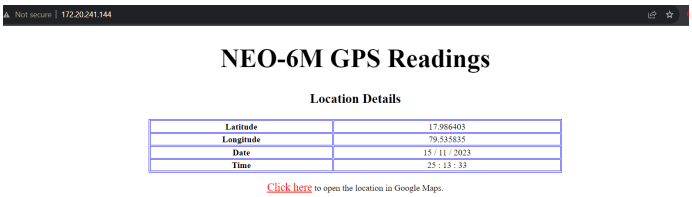

Fig. 9. GPS Readings on website

In the above figure, we can observe the part of our website that displays the GPS Data i.e, the longitude, latitude, date and time. There is also a hyperlink right below it, that redirects the administrator to the live location using google maps.

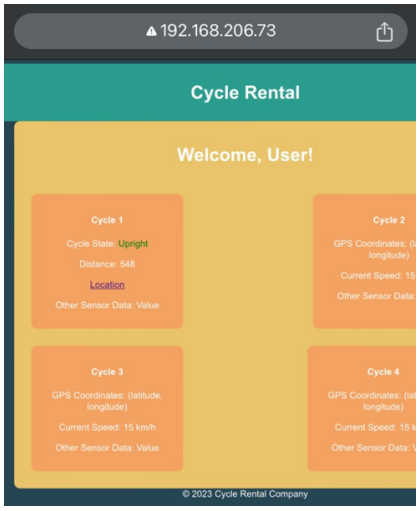

Fig. 10. Distance from Department to Gate

From Fig.10 we can see the different parameters calculated by the sensors, after a test ride was done by our team , starting from our department, to the main gate of our campus.

Fig. 11. Location of main gate

The location information, obtained through our on-board GPS module, is accessible to administrators via our website, as illustrated in Fig.11

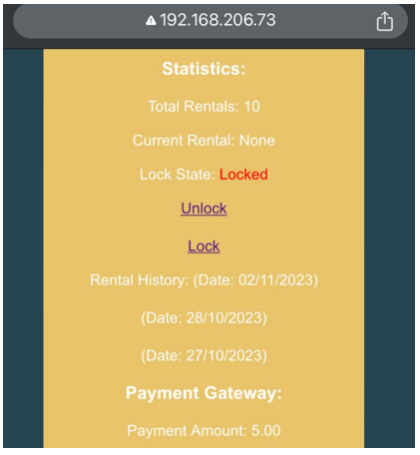

Fig. 12. User Dashboard

We examine the user dashboard on our website, enabling users to manage the bicycle lock both before and after renting. Additionally, users can review their rental history and the calculated fare for the current ride from Fig.12

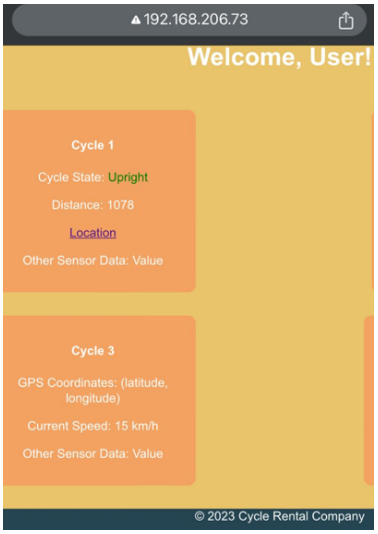

Fig. 13. Distance back to Department from Gate

Fig.13 displays the post-ride data relayed from the main gate to the department.

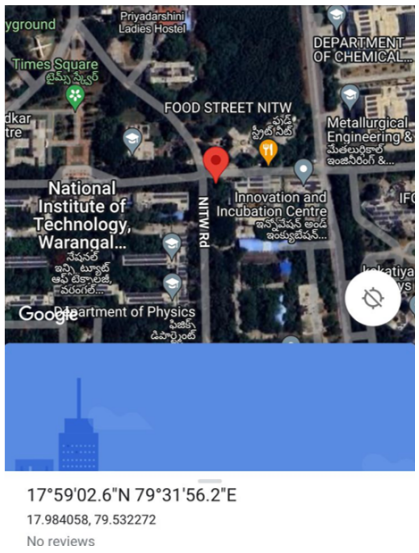

Fig. 14. Location of Department

Fig.14 displays the location information upon reaching back from our test ride from the department to the main gate and back.

V. Future Scope

1) Use industry grade sensors, to output accurate values.
2) Implement a more secure locking system for the bicycle.
3) Increase the compactness of the system.
4) Electrify the cycle to improve convenience of the user.
5) Provide docking systems, for ease of use and charging convenience.

VI. Conclusion

The GlideX bicycle rental system represents a significant step towards revolutionizing urban mobility. By prioritizing sustainability, technology, integration and community engagement, this initiative will transform the way people commute in urban areas, promoting a greener and healthier future

In summary, GlideX rental system lies in their ability to reimagine urban transportation, making it more ecofriendly, efficient, and accessible, ultimately transforming the way we experience and navigate cities.

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