# GlideX: An IoT Based Bicycle Rental System

Lakshmi Boppana
*Department of Electronics and Communication Engineering, National Institute of Technology Warangal,*
Warangal, India

Seth Ranjan Chodagam
*Department of Electronics and Communication Engineering, National Institute of Technology Warangal,*
Warangal, India

Levin Joji Mathews
*Department of Electronics and Communication Engineering, National Institute of Technology Warangal,*
Warangal, India

Vishnu Murali Krishnan
*Department of Electronics and Communication Engineering National Institute of Technolog5y Warangal,*
Warangal, India

Indranil Abhay Athawle
*Department of Electronics and Communication Engineering National Institute of Technology Warangal,*
Warangal, India

2024 1st International Conference on Robotics, Engineering, Science, and Technology (RESTCON) | 979-8-3503-4884-2/24/$31.00 ©2024 IEEE | DOI: 10.1109/RESTCON60981.2024.10463563

***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. COO Rides [2], a revolutionary bicycle-sharing company headquartered in Mumbai, is rapidly transforming urban transportation across India. This company Operates in over 10 cities with their robust network of accessible and affordable bicycles and offers a convenient and eco-friendly commuting solution. ONN-Bikes [3] 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 the maintenance cost.

Smart Bicycle Monitoring and Finding System for Rider Safety [4] uses accelerometer to detect whether there has been a crash or the cycle has fallen down. This can be counterproductive as the cycle can generate a large force due to rough handling of the frame. The cycle also is designed to be operated using Bluetooth module which requires the presence of other users in the area to share location to the app in the situation of theft. The IoT end device to be attached to the bicycle is designed using the Nvidia Jetson Nano development board. This has more resources and might not be required for the bicycle. Smart Sharing Bicycle for a Sustainable City [5] provides a system using RFID to access cycles. This becomes complicated when the number of users becomes a large number. It also uses Bluetooth to communicate with a nearby cycles which can be dangerous in the event of theft of mobile phones. [6] uses NEO-6M module and is paired with a third party software using MQTT protocol. This gets triggered every 10 seconds and does not have a very accurate representation available as to where the tracker is located.

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 designed such that the charges for using this bicycle will be based on the distance travelled, providing a cheaper and more cost-efficient means of transport. Fig.1 presents the overview of Glidex. 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 the 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, while it is not being used. 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.

GlideX is designed by employing a combination of communication protocols tailored to different aspects of the system for facilitating data exchange. 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 all the features incorporated in its development are presented in Section V. The feature scope of the prototype is presented in Section VI. Finally, Conclusions are presented in Section VII.

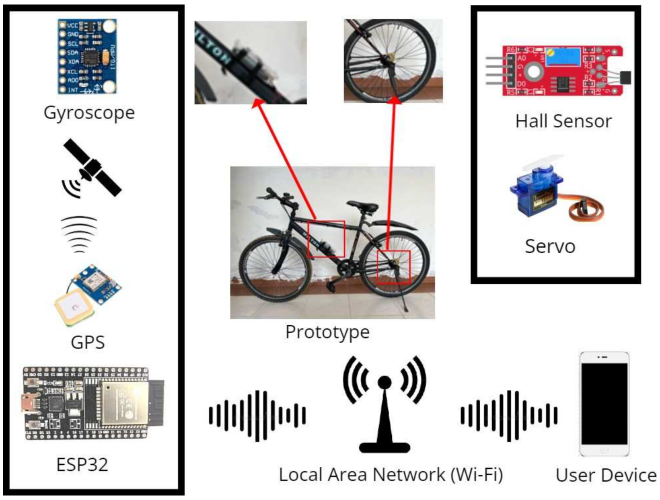


Fig. 1. Glidex Overview

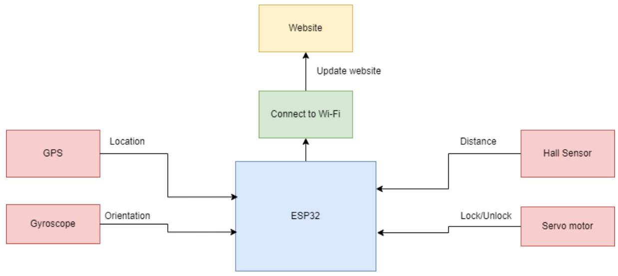


Fig. 2. Block Diagram

## II. Proposed Prototype Design

The construction of the GlideX, an 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. Fig.3 shows the circuit diagram of IoT end device designed for attaching to the bicycle. The features of all hardware and software modules selected in the development of this proposed Glidex are explained briefly in the following subsections.

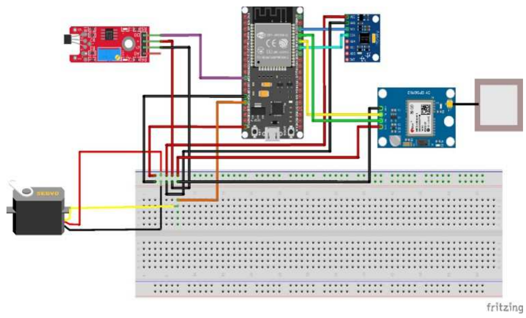


Fig. 3. Circuit Diagram

### A. Hardware Modules

- The ESP32 module shown in Fig.1, developed by Espressif Systems, is a versatile and powerful microcontroller widely used in the field of IoT (Internet of Things). The ESP32 integrates a dual-core processor, Wi-Fi, and Bluetooth protocols, making it suitable for a diverse range of applications. It is a low power and high computing power device with three UART, three SPI and two I2C ports for interfacing modules like gyroscopes and GPS.
- The KY-024 Hall Sensor shown in Fig.1 is a small module designed to detect the presence of magnetic fields. It is developed using 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. Applications of this module 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.

- The NEO-6M GPS module shown in Fig.1 is a compact and efficient device designed to provide accurate global positioning system (GPS) data. This module, designed using u-blox NEO-6M GPS chipset, 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 UART interface transmitting NMEA (National Marine Electronics Association) standard sentences containing the GPS data.
- Fig.4 shows the SG-90 module, a compact motorized device, designed for precise control of angular positions. This low cost and light weight module is preferred in robotics and other motion control applications as it is designed with small form factor and lightweight. 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. 4. Servo motor

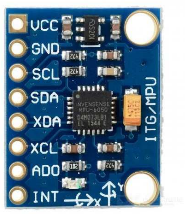


Fig. 5. Accelerometer and Gyro Sensor

- The MPU-6050 module shown in Fig.5 is a compact and widely-used Accelerometer and Gyro Sensor used for motion tracking device that combines a three-axis gyroscope and a three-axis accelerometer on a single integrated circuit. This sensor is commonly used for measuring and processing orientation, acceleration, and angular velocity. This module is particularly preferred 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 through I2C, make it a popular choice for reliable motion sensing.

### B. 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 web sever 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 web server 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 ESP32 WebServer 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 is configured as an access point using the Arduino IDE programming environment. The ESP-32 creates its own WiFi network and nearby Wi-Fi devices can connect to it.

- Arduino IDE: The Arduino Integrated Development Environment, is an 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.

### C. Flow Diagram

Fig.6 shows the flow diagram of the functionality of IoT end device developed for designing Glidex with various sensors, actuators and communication protocols, and capture data from sensors, and updates the website.

## III. Implementation

Fig.7 shows the implemented GlideX after attaching the controller, sensors and actuators to convert the conventional bicycle into an IoT based bicycle rental system. This Glidex is designed employing multi-protocol approach to ensure coordinated communication between the central server, and user interfaces. HTTP is utilized for the website interface,

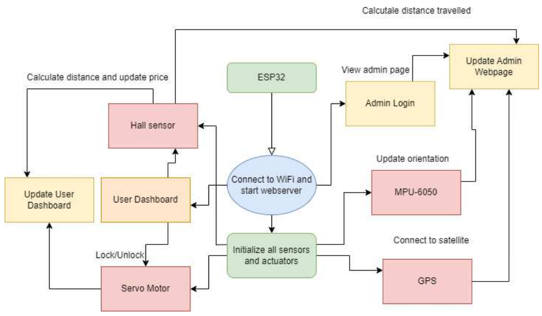


Fig. 6. Glidex:Flow Diagram

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 the 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. Glidex: Prototype

## IV. Results

The implemented Glidex is tested to verify various features incorporated to design a smart and efficient cycle rental System. Fig.8 presents the part of our website that displays the GPS data i.e, the longitude, latitude, date and time displayed on the website developed for maintaining the proposed Glidex. There is also a hyperlink right below it, that redirects the administrator to the live location using google maps. Fig.9 shows the distance travelled by the bicycle and the location captured by GPS module after a test ride was done by our team, starting from our ECE department to the main gate of our NITW campus. In addition, the sate of bicycle, whether it is upright or fallen, will also be shown in the website of the administrator. The location information

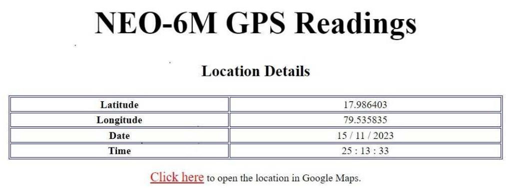


Fig. 8. GPS Readings on Website

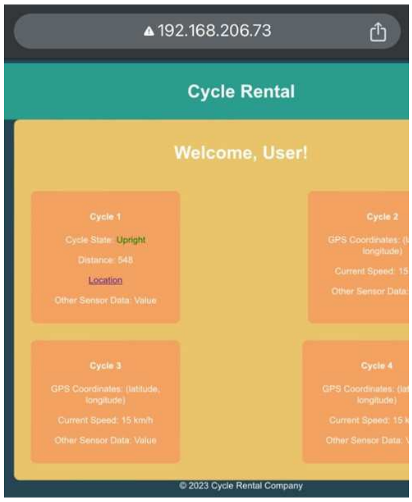


Fig. 9. Distance from Department to Gate

obtained through the on-board GPS module, is accessible to the administrators via website, as illustrated in Fig.10. The screenshot of the user dashboard on our website shown in Fig.11 presents the feature provided for 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. Fig.12 displays the location information of bicycle captured after our test rides from the main gate of NITW campus to E.C.E department. Fig.13 displays the post-ride data relayed while riding from the main gate of our institute to the department.

## 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.


Fig. 10. Location of main gate

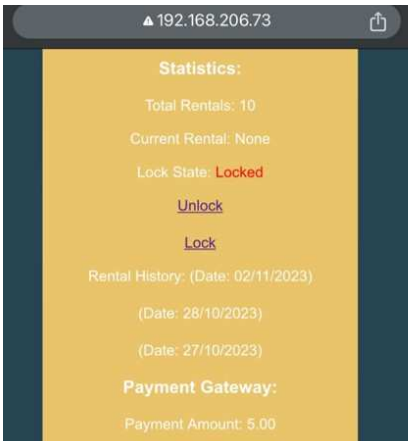


Fig. 11. User Dashboard

## VI. Conclusion

The smart bicycle presented in this paper 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. This 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 re-imagine urban transportation, making it more ecofriendly, efficient, and accessible, ultimately transforming the way we experience and navigate cities.

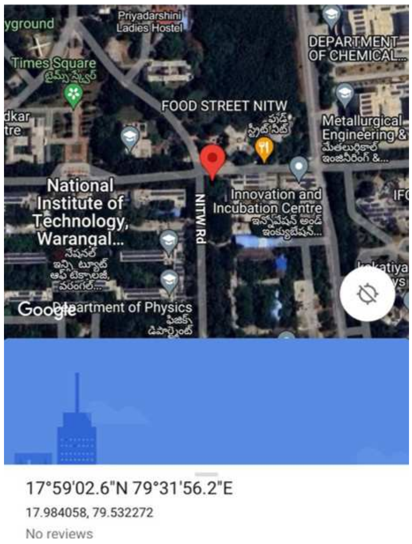


Fig. 12. Location of Department

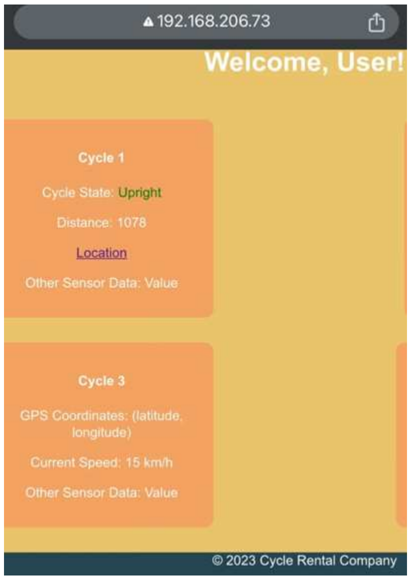


Fig. 13. Distance back to Department from Gate

## References

[1] “https://www.yulu.bike/” -Yulu Bikes’ Website
[2] “https://coorides.in/” -Coo Rides’ Website
[3] “https://www.onnbikes.com/” -Onn Bikes’ Website
[4] L. -W. Chen and C. -Y. Cho, ”BiLight: A Smart Bicycle Monitoring and Finding System for Rider Safety Based on IoT Technologies,” 2022 IEEE International Conference on Pervasive Computing and Communications Workshops and other Affiliated Events (PerCom Workshops), Pisa, Italy, 2022, pp. 100-102, doi: 10.1109/PerComWorkshops53856.2022.9767405.
[5] N. Sehrawat and S. Kaur, ”Smart Sharing Bicycle for a Sustainable City: An Application of IoT,” 2022 International Interdisciplinary Humanitarian Conference for Sustainability (IIHC), Bengaluru, India, 2022, pp. 887-891, doi: 10.1109/IIHC55949.2022.10060489.
[6] P. V. Crisgar, P. R. Wijaya, M. D. F. Pakpahan, E. Y. Syamsuddin and M. O. Hasanuddin, ”Hardware Design for IoT-Based Vehicle Tracking and Theft Detection System,” 2021 International Symposium on Electronics and Smart Devices (ISESD), Bandung, Indonesia, 2021, pp. 1-6, doi: 10.1109/ISESD53023.2021.9501601.