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| RESEARCH ARTICLE

E-WheelShare: An IoT-Based Bicycle Sharing System Prototype for University of Cebu

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| ABSTRACT

This study explores the implementation of an IoT-based bicycle-sharing system designed to promote sustainable transportation within the University of Cebu campuses. Recognizing the increasing demand for eco-friendly and efficient transportation options in educational institutions, this project integrates IoT technologies and cloud data analytics to manage and monitor bicycle availability, usage, and maintenance in real-time. The prototype provides a user-friendly solution accessible via a mobile application, allowing students and staff to locate, rent, and return bicycles easily. The research aims to assess the feasibility, usability, and impact of such a system in enhancing campus mobility, reducing carbon emissions, and fostering a healthier, more sustainable campus environment. Findings from this study will inform future developments in campus mobility solutions and contribute to the growing body of research on sustainable transportation in educational institutions.

| KEYWORDS

IoT-based bicycle sharing, sustainable campus transportation, cloud data analytics, smart mobility solution, sustainability, eco-friendly transport, real-time tracking, data-driven campus planning, electric bike monitoring, university of cebu

| ARTICLE INFORMATION

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1. Introduction

Efficient and sustainable transportation is an essential aspect of modern urban living, especially within educational institutions where daily commutes often involve short, repetitive trips across campus. However, campuses like the University of Cebu face challenges such as traffic congestion, insufficient parking spaces, and the environmental impact of motorized vehicles. With increasing awareness of sustainability and the need for eco-friendly solutions, developing innovative transportation alternatives has become a priority for educational institutions worldwide.

Existing research highlights the potential of bicycle-sharing systems as an effective solution for urban mobility, reducing carbon emissions, and promoting health and well-being. While commercial bike-sharing systems have gained traction in cities globally, there remains a lack of tailored solutions designed specifically for campus environments. Furthermore, advancements in Internet of Things (IoT) technology have enabled real-time tracking, usage analytics, and automated maintenance systems, making bike-sharing smarter and more efficient.

This study proposes an IoT-Based Bicycle Sharing System Prototype designed for the University of Cebu, aiming to address mobility challenges, reduce the campus's environmental footprint, and promote sustainability.

The specific research problem lies in the absence of a campus-focused, technology-driven transportation solution that caters to the unique needs of students and staff. By integrating IoT and data analytics, this project seeks to fill this gap and enhance campus mobility.

The structure of this paper includes a detailed review of related literature, the design and development of the proposed system, an evaluation of its feasibility, and an analysis of its impact on campus sustainability and transportation efficiency. This research aims to contribute to the advancement of sustainable campus development through innovative mobility solutions.

2. Literature Review

The shift towards sustainable transportation has gained significant momentum in recent years, driven by the need to address urban congestion, reduce carbon emissions, and promote healthier lifestyles. The integration of technology into transportation systems, particularly through the Internet of Things (IoT), has revolutionized traditional approaches to mobility.

Studies have shown that IoT-based solutions enhance the efficiency and user experience of bicycle-sharing systems. For example, Zhang et al. (2021) highlight the role of IoT in enabling real-time tracking of bicycles, optimizing bike distribution, and improving maintenance schedules. IoT sensors provide data on bike locations, usage patterns, and battery levels, allowing operators to make informed decisions about resource allocation.

Similarly, a study by Chen et al. (2020) demonstrated the effectiveness of IoT-powered e-bikes in urban areas, emphasizing how real-time data analytics reduces operational inefficiencies. These findings underscore the potential of IoT in addressing the specific needs of campus-based transportation systems.

While urban bicycle-sharing systems are well-documented, few studies focus on their implementation in educational institutions. A study by Liu et al. (2019) examined the benefits of campus-based bike-sharing programs, noting their ability to reduce reliance on motor vehicles, alleviate parking issues, and promote a culture of sustainability. However, challenges such as bike availability and maintenance remain unresolved in many systems.

Sustainability is a growing concern in higher education, with universities adopting initiatives to reduce their carbon footprint. According to a report by the International Sustainable Campus Network (ISCN, 2020), transportation accounts for a significant portion of campus emissions. Implementing bicycle-sharing systems aligns with global efforts to create greener campuses by offering low-emission transportation alternatives.

Research by Davis et al. (2018) highlighted the importance of user-friendly interfaces and mobile applications in ensuring the success of bike-sharing systems. Features such as easy bike reservations, seamless payment systems, and responsive customer support significantly influence user adoption rates.

A study by Gómez et al. (2022) explored the common challenges faced by bike-sharing systems, including theft, vandalism, and poor bike redistribution. The authors emphasized the role of technology, particularly IoT and data analytics, in addressing these issues by enhancing monitoring and optimizing operations.

3. Methodology

Research Design

The study employs a mixed-methods approach, combining quantitative data analysis and qualitative user feedback. The prototype development follows an iterative design methodology, integrating IoT technologies for real-time tracking and analytics.

Development Phases

1. System Design: A mobile application and IoT sensors were developed to enable bike tracking, renting, and returning. Cloud infrastructure was used for data analytics and storage.
2. Prototype Implementation: The system was piloted with a fleet of 10 bicycles equipped with IoT-enabled GPS trackers and locking mechanisms.
3. User Testing: Students and staff participated in a one-month trial, providing feedback through surveys and focus groups.

Data Collection

1. Quantitative Metrics: Data on bike usage frequency, duration, and distribution across campus were collected via IoT sensors.
2. Qualitative Feedback: User satisfaction surveys and focus group discussions gathered insights into usability and perceived benefits.

Analysis Methods

1. Descriptive statistics for usage data.

2. Sentiment analysis and thematic coding for user feedback.

4. Results and Discussion

Results
The system recorded 2,000 rides over a one-month trial period, demonstrating strong adoption among the target user base. The average ride duration of 12 minutes confirmed that the system effectively catered to short-distance trips across the campus, which aligns with the intended use case.

The fleet utilization rate of 85% indicates that most bicycles were actively used during the pilot period, showcasing the demand and practicality of the system. The peak usage times between 10:00 AM and 12:00 PM highlight the alignment with class schedules and campus activity patterns, providing insights for future optimization of bicycle distribution.
Moreover, the system contributed to a reduction of 0.8 tons of carbon emissions within a single month, reinforcing its potential to promote eco-friendly transportation on campus.

The pilot program demonstrated promising results. Key metrics are summarized in the table below:

Table 1. Quantitative Results

Metric	Value	Interpretation
Total Rides Conducted	2,000 rides	High adoption rate among students and staff.
Average Ride Duration	12 minutes	Suitable for short-distance campus trips.
Peak Usage Time	10:00 AM – 12:00 PM	Aligns with class schedules and campus activities.
Fleet Utilization Rate	85%	Effective resource allocation and high system usage.
Reduction in Carbon Emissions	0.8 tons/month	Significant environmental impact for a small fleet.

Qualitative Feedback
1. Positive Aspects:
    - Convenience and time savings were cited as major benefits.
    - Users appreciated the system's reliability and real-time updates.
2. Challenges Identified:
    - Some users reported difficulty in finding bicycles during peak hours.
    - Suggestions included increasing the fleet size and adding more docking stations.

Qualitative Findings
User feedback gathered through surveys and focus groups revealed a positive reception of the system. Participants highlighted the following key benefits:
- Convenience: Users appreciated the ease of locating, renting, and returning bicycles via the mobile app.
- Time Savings: The system reduced the time spent walking between distant campus locations.
- Health Benefits: Many users noted that cycling encouraged physical activity and improved their overall well-being.

However, several challenges were also identified:
- Bicycle Availability: Some users experienced difficulty in finding available bicycles during peak hours, particularly in high-demand areas.
- Fleet Size: The limited number of bicycles (10 units) occasionally led to unmet demand.
- Docking Station Locations: Suggestions were made to increase the number of docking stations to cover more areas within the campus.

Discussion
The findings indicate that an IoT-based bicycle-sharing system is both feasible and impactful in an educational setting. High utilization rates reflect strong user interest, while the environmental benefits align with the university's sustainability goals. Addressing operational challenges, such as peak-hour demand, could further enhance the system's effectiveness.

Interpretation of Findings

The pilot project validated the feasibility and effectiveness of the proposed system. The high adoption rate and positive feedback indicate strong acceptance among the university community. Additionally, the system's impact on reducing emissions and promoting active transportation aligns with the university's sustainability objectives.
Challenges such as bicycle availability and docking station coverage provide opportunities for improvement. By addressing these issues in future iterations, the system can enhance its usability and scalability, ensuring a more comprehensive solution for campus mobility.

5. Conclusion

The IoT-Based Bicycle Sharing System Prototype designed for the University of Cebu highlights the transformative potential of smart transportation solutions in educational institutions. By integrating IoT technology with sustainable mobility practices, the system has effectively addressed campus transportation challenges such as limited mobility options, congestion, and carbon emissions.

The pilot study demonstrated a significant positive impact, with high adoption rates and a reduction of 0.8 tons of carbon emissions within one month. It also improved campus connectivity, reduced reliance on motorized vehicles, and encouraged active lifestyles among students and staff. These outcomes align with broader institutional and global sustainability goals, showcasing the potential for scalable solutions in similar contexts.

However, the project also identified operational challenges, including limited bicycle availability during peak hours, insufficient fleet size, and the need for more docking stations. Addressing these issues will be crucial for enhancing user experience and supporting broader adoption.

This research not only validates the feasibility of IoT-powered bicycle-sharing systems for educational settings but also lays a foundation for future innovations. Advanced features like predictive maintenance, AI-driven demand forecasting, and integration with campus-wide sustainability initiatives can further enhance the system's efficiency and impact. Ultimately, this project represents a significant step toward fostering sustainable and technology-driven campus environments.

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