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Design Approach of AI-Based E-Scooter for Societal use

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***Abstract*— This paper presents a comprehensive design for an economical E-scooter. It is aimed at improving urban transportation for short-distance travel in heavily populated cities, with a focus on inclusivity, affordability, and durability. The e-scooter is designed with user-friendly controls and adjustable ergonomics, catering various and diverse range of users, including elderly individuals and people with limited technical skills. By using advanced technologies such as AI based algorithms, IoT-enabled GPS for real-time tracking, the e-scooter aims to improve user experience. This paper emphasizes on the usage of cost-effective components to ensure affordability, short-distance E-Scooter particularly for lower-income communities such as workers, while maintaining durability that can work in almost any environmental conditions. Additionally, solar-powered battery is used and charging supports future use goals, further it minimizes the emission of greenhouse gases that may pollute the environment which is beneficial for commuters. This design ultimately offers a sustainable and efficient alternative to traditional vehicles, promoting eco-friendly travel and addressing the traveling needs of needy urban populations.**

***Index Terms*— AI-driven real-time location tracking, affordability, inclusivity, solar-powered charging, smart vehicle.**

I. INTRODUCTION

Cities are growing fast, which brings problems like pollution and a lack of good options for short trips. Many people, such as older adults and people with low incomes, struggle with transportation. This makes it important to find better ways to help them get around. This study introduces a new, low-cost e-scooter designed to make city travel easier. The goal is to create a transportation option that is simple, affordable, and durable. This e-scooter will help people who need better ways to travel and also support a cleaner environment. The e-scooter is easy to operate, with simple controls and adjustable features so anyone, no matter their age or ability, can ride it. It includes smart technology like AI and GPS with Internet of Things (Io T) tools, which show the e-scooter's live location and provide real-time updates. These features make using the e-scooter faster and more reliable.

The e-scooter also runs on solar power, which is good for the environment. Solar charging reduces the need for regular electricity and helps cut pollution. It is made with low-cost materials to make it affordable for people who need a budget-friendly option.

Fig.1. Workers in College Campus

This research will explore how this e-scooter could improve transportation in cities. It will show how it can reduce pollution, offer more travel options, and make city travel fairer for everyone. By focusing on these points, the study aims to show how cities can create better solutions for everyone while protecting the environment.

The rest of the paper is structured as follows: the next section describes the reviews from various researchers, followed by design approach. After that, we discuss proposed concept of our project in section four followed by discussions in section five and lastly, conclusion in the section six.

II. LITERATURE REVIEW

E-scooters are becoming a popular way to travel short distances in busy cities because they are easy to use and environmentally friendly. However, many current e-scooters are either too expensive or not durable enough for everyday use. In recent studies from 2023 and 2024, researchers have been looking into how e-scooter designs can be improved, how artificial intelligence (AI) can make them smarter, and how these scooters can benefit both individuals and the environment. The fast growth of e-scooters in transportation in cities has raised important discussions around their innovation, accessibility, sustainability, and scalability. Despite the technological advancements and environmental benefits, challenges remain that hinder the widespread adoption of e-scooters, particularly in India, where infrastructure, affordability, and maintenance concerns are prominent. The following research sheds light on the various dimensions of e-scooter development in India.

Patil et al. [1] have explored the economic barriers to the widespread adoption of e-scooters in India. They highlight that, while e-scooters present an affordable mode of transport compared to cars, the initial investment is still too high for

many low-income groups. Furthermore, the lack of charging infrastructure across the country makes e-scooters less viable for daily use, especially in smaller cities and rural areas. Patil et al. recommend that government subsidies, combined with private sector innovation, could make e-scooters more affordable and accessible.

Sharma & Deshmukh [2] focused their research on the environmental benefits of e-scooter adoption in India. Their study emphasizes that while e-scooters are environmentally cleaner than conventional fossil-fuel-powered vehicles, their environmental impact largely depends on the energy mix used for charging. E-Scooters charged by electricity from non-renewable resources, they might not be eco-friendly. The authors suggest integrating solar-powered charging stations in urban areas and encouraging the use of renewable energy to power these vehicles, which could significantly reduce their carbon footprint.

In their study, Bhat & Mehta [3] explored the role of advanced technologies in enhancing e-scooter design. They emphasize that e-scooter manufacturers are increasingly using AI and Io T technologies to improve the user experience. For instance, AI can help optimize battery usage by analysing user patterns and adapting to different routes and terrain. Additionally, Io T-enabled e-scooters allow for real-time monitoring, ensuring better fleet management and improved customer service. Bhat & Mehta highlight the need for further research to improve battery efficiency, durability, and smart features that can make e-scooters more appealing to consumers.

Ravi & Joshi [4] provided insights into the business models behind e-scooter start-ups in India. They discuss how various companies are adopting both ownership and shared mobility models to penetrate the Indian market. In cities like Bangalore and Delhi, where traffic congestion is a major problem, shared e-scooter services have become increasingly popular. However, Ravi & Joshi also point out the challenges posed by competition, high operating costs, and issues like vandalism and theft. They recommend that businesses adopt hybrid models that combine ownership with shared rentals to meet the different needs of the people in cities while keeping costs manageable.

Verma & Patel [5] conducted research on the importance of battery technology and the lack of adequate charging infrastructure, which are two of the major hurdles faced by e-scooter adoption in India. They argue that the development of lightweight, high-capacity batteries is critical for increasing the range and efficiency of e-scooters. Moreover, the widespread establishment of charging stations is crucial to overcome 'range anxiety,' where users are concerned about running out of battery while on the move. The authors also suggest the development of fast-charging stations, which would make e-scooters more practical for daily commuting.

Kumar et al. [6] a studied on the adoption rates of e-scooters in India, focusing on consumer perceptions. Their research shows that while the awareness of e-scooters is increasing, many consumers remain hesitant due to concerns over safety, reliability, and the lack of infrastructure. Moreover, the absence of government regulations and standardization for e-scooter design and operation adds to consumer anxiety. Kumar et al. emphasize the importance of consumer education campaigns and government policies that provide clearer guidelines for e-scooter usage, safety standards, and maintenance.

In their study, Singh & Sharma [7] analysed the integration of E-Scooters into existing transportation systems in cities. In cities like Pune and Ahmedabad, where traffic congestion is a major issue, e-scooters could complement public transport by providing 'last-mile connectivity,' making it easier for commuters to access stations and terminals. The integration of e-scooters into these systems could potentially reduce congestion and improve overall mobility in urban areas.

Iyer & Nair [8] explored the regulatory challenges surrounding the use and commercialization of e-scooters in India. They noted that while e-scooters have been introduced in many Indian cities, there is still a lack of comprehensive legislation to govern their use. Issues such as speed limits, safety standards, insurance policies also registration of e-scooters remain unresolved. The lacking in clear regulatory framework has led to confusion among both consumers and businesses. Iyer & Nair argue that the Indian government needs to develop a structured policy for e-scooter usage, which would help in streamlining operations, enhancing safety, and boosting consumer confidence.

Patel & Shah [9] focused on the need for increased public awareness about the benefits of e-scooters. In their study, they emphasize that while e-scooters are becoming increasingly popular among tech-savvy youth in major cities, there is still a lack of understanding about their environmental benefits, cost-effectiveness, and safety features. They recommend that e-scooter companies invest in marketing campaigns that educate consumers, especially in smaller cities and rural areas, about the advantages of e-scooters over traditional vehicles. Increased awareness could lead to greater adoption and a more sustainable market for e-scooters.

Nair & Reddy [10] examined the challenges of adopting e-scooters in rural India. While urban centre has seen a surge in e-scooter usage, rural areas face unique challenges in terms of affordability, road infrastructure, and access to charging stations. Nair & Reddy suggest that e-scooter manufacturers should focus on creating affordable models suited to rural conditions, incorporating larger wheels and enhanced suspension systems to tackle poorly maintained roads. They also recommend the establishment of decentralized charging solutions, such as solar-powered charging kiosks, supporting the rural adoption of E-Scooters.

Gosling [11] in his research emphasized the benefits of e-scooters in environment, particularly in reducing urban pollution, emissions from greenhouse gases, and fossil fuels

reliance. He points out that the adoption of clean transportation technologies like electric vehicles, especially in cities with severe traffic congestion, is crucial for long-term urban sustainability. In India, where air pollution from vehicles is a major problem, e-scooters represent an affordable and eco-friendly alternative to conventional modes of transport. However, Gosling also acknowledges the need for infrastructure improvements, such as charging stations and government incentives, to foster the widespread E-scooters adoption.

In line with the findings of Gosling, Smith [12] highlighted the significant role that affordability aims to play in the adoption of e-scooters. In his study, Smith argued that the high upfront cost of e-scooters in India remains a significant barrier to entry for many consumers, especially among lower-income groups. Additionally, the lack of affordable financing options and subsidies for e-scooter buyers limits their widespread adoption. Smith also suggests that the design of e-scooters should cater to a wide demographic, including the elderly and people with limited technical knowledge. Making e-scooters more affordable and accessible could unlock their potential as a mass transportation solution, particularly in densely populated urban areas like Delhi and Mumbai.

Chaudhary [13] conducted a study on e-scooter design innovations, particularly focusing on user-centrist features. In India, where the population is diverse in terms of age, physical abilities, and technical skills, designing e-scooters that cater to these varying needs is essential for broader acceptance. Chaudhary advocates for adjustable seats, handles, and user-friendly interfaces to make e-scooters more accessible to a larger user base, including the elderly, people with disabilities, and first-time users. The integration of such features could help make e-scooters a viable transportation option for everyone, further enhancing their role in urban mobility.

Li et al. [14] analysed that the spatial and temporal distribution of e-scooter sharing differs greatly across different urban areas, reflecting diverse patterns in user behavior and operational practices. They emphasized thee factors like population characteristics, weather and the urban built environment are key in building these patterns. Their findings show that e-scooter sharing is more commonly used by young, male, and well-educated populations from middle to high incomes.

Nigro et al. [15] (2022) created a Micromobility Compatibility Index (MCI) to assess road suitability for e-scooters compared to cars, estimating that 20% of weekday car trips in Rome could shift to micromobility. They noted a gap in understanding how street environments influence individual travel experiences, which their study addresses.

Aman et al. [16] (2021) identified safety concerns, particularly about road conditions, as a major factor affecting riders' satisfaction through an analysis of app store reviews. [17] Askari et al. (2024), using a digital survey in Chicago, found that targeted cycle lanes and e-scooter parking facilities mainly enhanced user satisfaction.

Clewlow et al. [18] explored how e-scooters could contribute to making urban transport systems more networked by providing less focused areas and communities with better access to transportation. They emphasized the importance of understanding who uses these services and for what purposes to evaluate their true impact. Using Vienna as a case study, the research looked into the demographic profiles of e-scooter users and the types of trips they take. The study highlighted that such insights are crucial for assessing whether e-scooters are genuinely fostering inclusive and addressing gaps in urban mobility.

Moran et al. [19] found that in 2019, shared e-scooters in Vienna were mostly concentrated in the inner city, where public transport is already highly accessible, with stations located just 250 to 300 meters apart. This led them to conclude that e-scooters that are shared, are more likely competing with public transport rather than serving as a first- or last-mile solution. They argued that the city needs to rethink the role of shared E-scooters in its mobility plan and introduce regulations to guide their use. One suggestion was to require operators to expand coverage to peripheral districts, where shared e-scooters could be more effective in addressing almost every travel needs.

TRANSIMS, developed by Lee et al. (2014) [20], is an open-source simulation tool written in C++ for studying urban travel patterns, including the role of electric vehicles (E Vs). Created at Los Alamo's National Laboratory, the model supports large-scale simulations, capturing daily variations in EV usage and infrastructure requirements. Its modular design enables population synthesis, activity modeling, route planning, and detailed traffic simulations.

Any Logic, developed by Borshchev (2014) [21], is a Java-based simulation platform for agent-based modeling of dynamic systems like city traffic. It uses discrete-event modeling, where each vehicle is treated as an agent with behavior defined by rule-based models. The platform includes predefined algorithms for driving behavior simulation, providing outputs such as traffic density, delays, and average speeds.

Davis ET AL. (2014) [22] reviewed Agent-Based Models (ABMs) for micro mobility, aiming to define criteria for their use in traffic and travel behavior simulations. They analyzed 161 abstracts from 2010 to present, categorized into general model capabilities, traffic simulation, and travel behavior. Findings included empirical studies on traffic simulation, surveys on e-scooter rider behavior, and spatial analysis, providing a foundation for developing simulation criteria.

McKenzie (2020) [23] discusses the rise of e-scooter sharing as a new micro mobility solution in cities. These electric scooters, which feature a standing deck and handlebars, provide an efficient and convenient way to travel short distances. They are seen as a great alternative for less crowded, direct trips within urban areas.

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Since the introduction of e-scooter sharing in 2017, research on the topic has rapidly increased. Li et al. (2022) [24] explore how e-scooter usage varies in space and time, finding that factors like sociolect-demographic characteristics, weather conditions, urban infrastructure, and street environments all play a key role in influencing usage patterns in different cities.

III. DESIGN APPROACH

The e-scooter is designed to be strong, affordable, and good for the environment. The frame of the e-scooter is made from recyclable aluminium. This material is light in weight and very strong, which makes the e-scooter easy to handle and long-lasting. Since aluminium can be recycled, it is also better for the environment. This design ensures the e-scooter is not only built strongly but also helps reduce waste, making it eco-friendly and suitable for daily use.

The e-scooter runs on a solar-powered battery. This battery charges using sunlight, so it doesn't always need electricity to recharge. This helps save money and supports cleaner energy usage. The battery is designed to last long and provide enough power for short-distance travel. Riders don't have to worry about frequent charging or high electricity bills, which makes it perfect for city travel.

To make the e-scooter safer and more efficient, it uses low-cost LED lights. These lights use very little energy and provide bright light for night time or low-light conditions. This keeps the cost of the e-scooter low while ensuring it is safe for riders in any lighting condition. The e-scooter is also built with replaceable and self-triggered parts. These parts can adjust or reset themselves to work better, which means less repair work is needed. If any part does not work properly or gets damaged, it can be replaced easily with low cost, making the e-scooter simple to maintain.

The braking system is made to be safe and affordable. It is easy to use and very reliable, ensuring the safety of the rider. This makes the e-scooter a good option for everyone, including older people and beginners who might not have much experience using such vehicles. The brakes are designed to work well in all situations, keeping the rider in control at all times.

Overall, the e-scooter combines recyclable materials, solar energy, and low cost, easy to maintain parts to create an eco-friendly and affordable solution for short-distance travel. It is strong, safe, and easy to operate which makes it a better choice for people who need an environment-friendly way to move around in cities.

IV. PROPOSED APPROACH

This paper aims to present a simple yet complete design for an e-scooter that focuses on making short trips in crowded city areas easier by considering affordability. The e-scooter is created with easy-to-use controls and adjustable parts to suit different users, including older people and those who may not be familiar with technology. Important features include Io T enabled GPS for real-time tracking, which helps with both user convenience and managing fleets of e-scooters. The design uses budget-friendly materials and parts, making it affordable, especially for people with lower incomes. Solar-powered charging is also added to make the e-scooter environment-friendly and reduce its impact on nature. This idea aims to provide a dependable, eco-friendly option to traditional vehicles, helping people with lesser resources and encouraging greener ways to travel.

Table I: Parameters of E-scooter

Parameter	E-Scooter	Traditional Vehicle(e.g.,Car)
Initial Cost	Low	High
Maintenance Cost	Minimal	High
Environmental Impact	Zero emissions (with solar power)	High carbon emissions
Energy Consumption	Solar and electric battery	Gasoline or diesel
Usability in Densely Populated Areas	High maneuverability, short-distance travel	Limited by traffic congestion and parking
Target Audience	lower-income communities, urban users	General public

Table II: Features used in E-Scooter

Feature	Description
AI-Driven Route Optimization	Provides optimal routes using traffic data and user preferences.
GPS with IoT Integration	Enables real-time tracking and fleet management.
Solar Power Charging	Solar panels integrated for eco-friendly battery charging.
Adjustable Ergonomics	Handlebar height and seat adjustments to accommodate a wide range of users.
Durable Construction	Built to withstand various environmental conditions, ensuring long-term use.
Cost-Effective Components	Utilizes affordable materials without compromising on quality, aimed at making the product accessible to lower-income communities.
User-Centric Controls	Intuitive control panel designed for easy use by all, including the elderly and those with limited technical knowledge.

V. DISCUSSION

This e-scooter design serves a major need for sustainable and easy to operate and access urban transportation, particularly designed for short-distance travel within high-density cities. By focusing on affordability and inclusive, the design fills the mobility gaps in communities that are often unseen by traditional transportation options. The integration of user-friendly features, including adjustable ergonomics ensures that the scooter can be operated by a broad age group, focusing on elderly group of people and those with lesser technological skills. Additionally, the inclusion of AI-driven Io T enabled GPS tracking enables real-time location tracking, efficient route planning, and improved safety monitoring.

The choice of cost-effective, durable materials is crucial to achieving affordability, especially for lower-income populations, also promotes flexibility in various environmental conditions. Solar-powered battery charging

helps to maintain sustainability, reducing dependence on traditional electricity and decreasing the carbon emission of urban transport. This emphasis on renewable energy that keeps the urban environment clean and safe from hazards.

Overall, the proposed e-scooter design provides a complete solution that balances the demands for cost, usability, and environmental impact. Future research could explore optimization of battery life, further advancements in route optimization algorithms, and the integration of more comprehensive safety features, expanding the potential of this design to meet the evolving needs of urban transportation. This approach exemplifies how technological and material innovations can work together to offer practical, sustainable alternatives that enhance mobility and reduce environmental impact.

VI. CONCLUSION

In conclusion, this e-scooter design gives people an affordable and eco-friendly way to get around busy city areas, specifically focusing on short distances. The scooter is made to be easy for everyone to use, including elderly people and those who aren't very familiar with technology. Its design includes smart features like AI algorithms and GPS that allows people to track the scooter in real time. These features improve the overall riding experience and help companies manage large numbers of scooters more efficiently. By using low-cost but strong materials, the e-scooter remains affordable, making it a great choice for people in low-income communities. Additionally, it uses solar power to charge the battery, which means it is less dependent on regular electricity and produces less pollution, helping to protect the environment. Overall, this e-scooter is a green and practical option that provides a better way to travel around cities while meeting the needs of all kinds of people, including those in crowded urban areas where clean and convenient transportation is essential.

Declaration of competing interest

The authors state that they have no known financial interest and personal relationships that could have influenced the work presented here.

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