KHATIB & ALAMI

SMART URBAN TRANSPORT

A Whitepaper on Enhancing Micro-Mobility Safety with Artificial Intelligence Solutions

April 2024

EXECUTIVE SUMMARY

The increasing popularity of micro-mobility, specifically electric scooters, has opened up new opportunities for urban transportation, offering alternatives to traditional car-centric models. However, this surge has brought to light important safety issues, which requires innovative solutions to ensure the smooth integration of micro-mobility into urban landscapes.

This whitepaper delves into the challenges and potential solutions focusing on thesafety concerns surrounding micro-mobility, particularly electric scooters. The paper provides actionable insights into how cities can leverage artificial intelligence (AI) to improve the safety of riders and pedestrians by developing more effective regulations and infrastructure to support micro-mobility growth while minimizing risks. Addressing these safety concerns head-on can create a more sustainable and efficient urban transportation system that benefits all community members.

Governments and city planners are seeking a comprehensive guide for the seamless integration of micro mobility into the existing transportation network. This whitepaper aims to provide insights and highlight best practices, serving as a roadmap for sustainable urban development. By prioritizing safety, accessibility, and leveraging cutting-edge technologies, the recommendations outlined in this document aim to create a blueprint for a more inclusive and interconnected urban environment.

THE PROBLEM

Micro-mobility safety dilemma
Urban transportation systems that prioritize cars have resulted in negative outcomes such as traffic congestion, air pollution, and noise, significantly impact the quality of life in cities. In response to these challenges, city planners have implemented measures to discourage excessive car use while promoting alternative modes such as walking, cycling, and public transport. In this context, the emergence of shared electric bikes and scooters has marked a positive shift in urban transport dynamics.

Electric scooters have recently been integrated into micro-mobility, which has given rise to a safety dilemma marked by escalating concerns, accidents, and conflicts. Despite their convenience for short trips in urban areas, electric scooters have led to conflicts with pedestrians, cyclists, and vehicles, introducing a series of safety concerns and divided opinions on their regulations.

SPEED DISPARITIES AND INFRASTRUCTURE CHALLENGES

The speed differences between various transportation modes can lead to potential conflicts and safety challenges. For instance, e-scooters and pedestrians, with notably different speeds, face increased chances of interactions and collisions. Narrow Sidewalks exacerbate maneuvering difficulties, heightening the risk of collisions with pedestrians who lack protective gear like helmets. On on-road facilities, significant differences between e-scooters and motorized vehicles become evident, raising concerns about the vulnerability of e-scooter riders who lack the protective body provided by cars or motorcycles. This renders them more susceptible to severe injuries in collisions. Notably, 36% of reported e-scooter injuries occur on streets, double the percentage on sidewalks (17%). The severity and frequency of conflicts and collisions correlate with infrastructure components, such as intersections, where cyclists often experience collisions.

THE IMPACT OF MIS-PARKED E-SCOOTERS ON SAFETY

The increasing use of electric bikes and scooters worldwide has led to the introduction of two primary sharing approaches, docked and dockless systems. Although the dockless system is convenient, it poses several safety challenges, particularly in urban settings where e-scooters are often miss-parked. This exacerbates the risk of single collisions and compromises cycling and pedestrian infrastructure. Moreover, conflicts between e-scooters and mis-parked units in transport facilities highlight the need for a comprehensive strategy. Statistics revealed that 16% of e-scooters are miss-parked, causing 6% to block pedestrians' territories and resulting in parking violations.

These safety concerns impact various stakeholders, including pedestrians, e-scooter riders, and other road users, thereby undermining overall safety and comfort. Moreover, these concerns extend beyond transportation systems, influencing broader aspects of urban life.

OVERLOADING AND SIDEWALK MISUSE

Issues such as overloading e-scooters with passengers and riding on sidewalks without distinguishing between the pavement and the sidewalk contribute to safety risks. Overloaded e-scooters can lead to rollover accidents, causing injuries to both the driver and passengers. Riding on sidewalks without proper visibility can result in collisions with pedestrians or vehicles coming from blind spots. It is important to be aware of these risks and take necessary precautions while using e-scooters to ensure the safety of everyone on the road.

NIGHTTIME VISIBILITY CHALLENGES

The relatively small size of e-scooters compared to bikes may reduce their visibility at night, raising safety concerns for all road users.

HIGH-SPEED AND MANEUVERING CHALLENGES

The navigation maneuvers performed by riders to avoid potential collisions at high speeds may further increase the chances of losing balance and single accidents, especially in harsh weather conditions.

It is crucial to promptly devise a comprehensive solution for micro-mobility safety.
Failure to do socould lead to a surge in accidents, increased injuries, and negative impacts on public opinion and regulatory measures. Additionally, a declining comfort and acceptance of micro-mobility may hinder its stable integration into existing transport systems, impeding its full potential realization. Addressing this problem requires mitigating safety risks and establishing a framework that fosters sustainable and secure micro-mobility within urban landscapes

THE HISTORY

The current issue of safety in micro-mobility can be traced back to the problems that exist within car-centric urban transportation systems. To address these challenges, alternatives like active and non-motorized transportation modes were introduced, which were initially praised for their positive effects on urban transportation systems. Micro-mobility solutions were seen as promising alternatives, providing benefits such as reduced environmental impacts, physical activity promotion, and traffic congestion mitigation. However, the rapid rise of electric scooters equipped with electric motors brought forth new challenges.

Due to the absence of standardized sharing systems and clear regulations various cities had to create ad-hoc policies for micro-mobility. Non-compliance with these policies resulted in fines, which reflected the initial struggles to establish a cohesive framework for micro-mobility. The issues became more pronounced with the misuse of electric scooters, such as carrying more passengers than allowed resulting in collisions with pedestrians. This highlighted the need for solutions to regulate electric scooter usage and improve safety, as sidewalks, originally designed for pedestrians, became hotspots for accidents.

The culmination of these developments underscored the urgency of addressing the safety issues associated with micro-mobility. This historical journey sets the stage for exploring innovative solutions and advancements in technology that can mitigate the challenges faced by electric scooters, ensuring a safer and more harmonious integration within urban transport ecosystems.

THE SOLUTION

AI-Powered Solutions for Micro-Mobility Safety Enhancement

This whitepaper proposes solutions that leverage the integration of Artificial Intelligence to enhance the safety of electric scooters in urban environments. These solutions address vital scenarios contributing to collisions and conflicts between electric scooters and pedestrians. By integrating cutting-edge AI models, smart devices, and real-time data collection mechanisms, we aim to mitigate accidents and create a secure micro-mobility landscape, ensuring the seamless coexistence of e-scooters with pedestrians, cyclists, and other road users.

1. AI System for Real-Time Driving Focus
Developing an AI system capable of real-time data collection to assess an electric scooter driver's focus during travel is crucial. While this addresses safety concerns, it has limitations in distinguishing between different types of roads. Nonetheless, this system is foundational for enhancing driver awareness and reducing potential accidents.

2. Noise Generation Device
A device generating varying intensity noises based on the driving speed can be a solution to prevent collisions between electric scooters and pedestrians. However, this device only utilizes the power of the electric scooter and cannot distinguish the number of riders. This innovative safety feature adds an auditory dimension to alert pedestrians, contributing to overall safety on shared pathways.

3. Multifunctional Helmet and AI System:
A multifunctional helmet worn by electric scooter drivers coupled with an AI system to collect real-time accident data, including speeding and helmet non-compliance, has already been developed. However, this AI system relies solely on data collected from the helmet, making it unsuitable for shared scooter services where helmets are frequently lost. Furthermore, the data is collected based on a single person, so it cannot account for multi-person boarding situations. Despite these limitations, this solution provides insights into individual rider behavior, offering a tailored approach to safety.

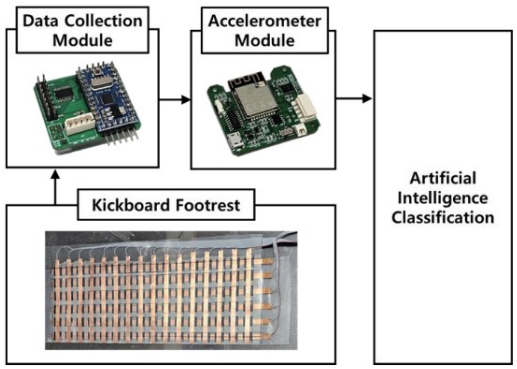
4. Geofencing for semi-dockless e-scooters:
A potential solution to tackle the problem of dockless sharing systems could be to assign more defined virtual areas, such as geofencing, for parking in various transport facilities. These measures could be seen as a semi-dockless system that may assist in designing secure infrastructure for e-scooters and other commuters.

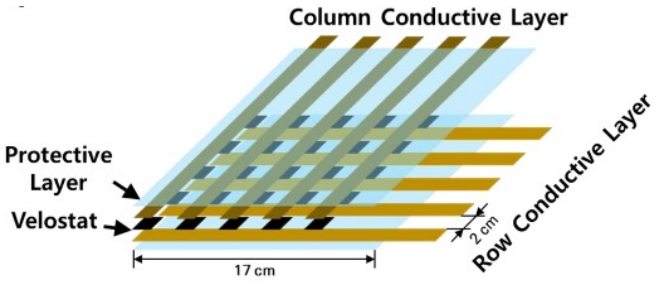
5. Object Surveillance via Surveillance Cameras:
The development of an AI system utilizing surveillance cameras to recognize objects addresses the need to identify illegal activities by e-scooter riders. While limited to areas with cameras and the questionability of being able to locate sidewalk areas, this solution targets key safety aspects such as multi-person driving and adherence to helmet-wearing regulations, enhancing overall safety.

6. Real-time Data Collection Module for Sidewalk Safety:
Developing a module for real-time data collection from electric scooters and generating an AI model helps prevent accidents caused by sidewalk driving and identify the number of riders. This solution directly addresses one of the most common scenarios leading to accidents, enhancing safety on sidewalks and shared spaces.

7. Footrest and Data-Collection Module with AI Integration:

The innovative solution combines a footrest with force-sensitive sensor layers, a data-collection module, and an accelerometer module to address sidewalk driving and overloading issues. The footrest generates an electric signal based on the pressure applied by the driver during boarding, which is sent to the data-collection module for analysis. The data-collection module uses AI models to identify accident factors from the accelerometer and data-collection modules, significantly reducing common safety risks associated with electric scooters.

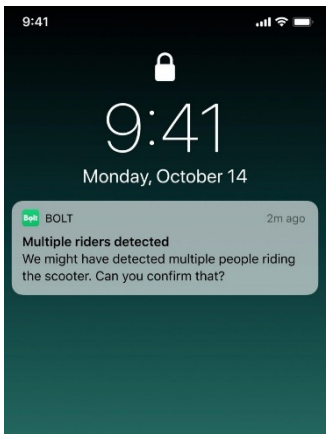




The footrest is made of Velostat, a force-sensitive material, to obtain the rider's pressure information. The data-collection module receives this electrical signal as an analog multiplexer and an Arduino process.

The accelerometer module has a printed circuit board with an accelerometer and a Wi-Fi wireless communication module. The Wi-Fi wireless communication module receives data output from each sensor and transmits it to the terminal via UDP communication.

The footrest is attached to the e-scooter, and the rider receives data on their smartphone when using it. The data collected is transmitted to an artificial intelligence server, allowing the user to check whether multiple people are riding or the scooter is driving on the sidewalk in the current state. Once the smartphone app detects tandem riding, the user is sent a push notification on their app.



The footrest and data-collection module collect data for different numbers of people boarding an electric scooter and different positions. Meanwhile, driving data for electric scooters on paved roads and sidewalks is collected with the accelerometer module. Other data sent on the app includes the Cognitive Reaction Test, designed to combat intoxicated riding, and the Skid Braking Prevention System, designed to prevent dangerous riding behaviors like fast riding and drifting.

THE BENEFITS

Leveraging AI for Micro-Mobility Safety and Seamless Urban Integration

Adopting AI-powered solutions for micro-mobility is critical for cities to enhance the overall safety of urban transportation and promote a more sustainable and efficient way of getting around cities. Adopting the recommended solutions offers many benefits, drives positive change in urban mobility, and brings many advantages.

1. Enhanced Safety for Riders and Pedestrians:
Integrating AI in micro-mobility systems significantly reduces accidents and injuries. This creates a secure environment for all transportation network users, especially electric scooters and pedestrians, and improves safety in shared spaces.

2. Increased Rider Awareness:
AI technology enables riders to receive real-time updates on traffic patterns, weather conditions, and potential hazards, enhancing their decision-making and promoting efficient urban traffic flow. This promotes responsible and sustainable use of micro-mobility options, fostering a harmonious coexistence between different modes of transportation in the city.

3. Auditory Safety Measures:
AI technology can enhance the safety and accessibility of micro-mobility options by providing auditory safety measures for riders, such as alerts for approaching vehicles or potential collisions. This makes micro-mobility more attractive and reliable for urban residents, enhancing their safety and accessibility.

4. Tailored Safety Insights:
AI can also provide personalized safety insights to riders based on their specific riding habits and preferences. By analyzing data on route choices, speed, and frequency of rides, AI can help riders improve their safety practices while using micro-mobility options, empowering them to make informed decisions that prioritize their safety and contribute to a more sustainable and secure transportation environment in the city.

5. Effective Dockless System Management
AI technology can enhance the management of dockless systems by providing real-time data on bike and scooter availability, usage patterns, and maintenance needs. This optimizes vehicle distribution to high-demand areas, ensuring safe and well-maintained vehicles. This not only enhances the user experience but also reduces clutter and improves safety on city streets. AI-powered dockless system management also promotes the sustainable and responsible operation of micro-mobility services.

6. Improved Surveillance and Regulation
AI can help authorities identify safety concerns, enforce traffic laws, and prevent vehicle misuse by analyzing vehicle movements and rider behavior. This enhanced oversight can ensure micro-mobility services comply with regulations, contributing to a safer and more efficient transportation system. AI has the potential to revolutionize urban management and regulation, promoting sustainability and user-friendliness.

7. Sidewalk Safety Enhancement
Real-time data collection modules for sidewalk safety can prevent accidents caused by sidewalk driving and identify riders. This data can be used to implement targeted safety measures and infrastructure improvements, such as designated lanes for micro-mobility vehicles or increased signage. By leveraging AI technology, cities can create a pedestrian-friendly environment and reduce accidents involving micro-mobility services, maximizing benefits while minimizing negative impacts on urban spaces.

8. Innovative Overloading Prevention:
The footrest and data-collection module with AI integration also tackles overloading issues, significantly reducing common safety risks. This technology can monitor the weight and distribution of riders on micro-mobility vehicles, alerting both users and operators if the vehicle is overloaded.

9. Advanced Cognitive Reaction Tests:
Integrating cognitive reaction tests into the app combats intoxicated riding, enhancing overall safety. This feature requires users to complete a quick test before unlocking a vehicle, ensuring they are in a clear state of mind to operate it safely. By promoting responsible behavior, cities can further reduce accidents and injuries related to micro-mobility services.

10. Prevention of Dangerous Riding Behaviors:
The Skid Braking Prevention System, featured in the app, prevents dangerous riding behaviors like fast riding and drifting, promoting responsible micro-mobility practices.
This system uses sensors to detect when a rider is engaging in risky behavior and automatically applies the brakes to prevent accidents.

WHERE TO LOOK FOR SOLUTIONS

Governments and city planners can explore solutions offered by well-established technology providers with a track record in AI and micro-mobility safety when seeking AI-powered solutions for micro-mobility safety. They can also attend or organize conferences and expos focused on urban innovation to discover the latest advancements in micro-mobility safety solutions. They can also engage in community forums and discussions within the micro-mobility sector to learn about real-world experiences and recommendations from industry professionals.
Solutions can also be found in collaborating with local urban planning authorities actively implementing smart city initiatives, as they may provide valuable insights and recommendations.

CONSIDERATIONS FOR VENDOR SELECTION

- **Expertise in Artificial Intelligence:**
Assess the vendor's expertise in developing and implementing AI solutions, particularly in micro-mobility safety.
- **Proven Track Record:**
Look for vendors with a proven track record of successful implementations and positive outcomes in similar urban environments.
- **Customization Capabilities:**
Evaluate the vendor's ability to customize solutions to meet the unique challenges and requirements of your specific urban setting.
- **Scalability and Future-Readiness:**
Ensure the chosen solutions are scalable and capable of adapting to future developments in micro-mobility and AI technologies.
- **Collaboration with Stakeholders:**
Choose a vendor willing to collaborate closely with local authorities, urban planners, and other stakeholders to ensure seamless integration into existing systems.

To ensure successful and sustainable implementations, stakeholders can make informed decisions when selecting vendors for AI-powered micro-mobility safety solutions by considering these important factors.

NAVIGATING THE FUTURE OF MICRO-MOBILITY WITH AI INTEGRATION

In the ever-evolving urban transportation landscape, Artificial Intelligence (AI) integration emerges as a beacon of hope for mitigating safety concerns associated with micro-mobility. As AI technology continually monitors and analyzes data, cities gain the capacity to proactively address potential safety challenges, ushering in a new era of optimized micro-mobility services. The potential for AI to revolutionize how cities approach safety in micro-mobility signals a transformative shift toward a more efficient and harmonious coexistence among diverse modes of transportation.

Exploring the Technological Horizon

Behind the scenes of these advancements, AI models, particularly those utilizing the versatile Keras open-source library, play a pivotal role. Leveraging Python as a programming language, Keras interfaces seamlessly with various artificial neural network frameworks, including TensorFlow, PyTorch, JAX, PlaidML, Theano, and Microsoft cognitive toolkits. The AI model is meticulously trained with diverse boarding and road-driving data, laying the foundation for a sophisticated understanding of micro-mobility scenarios.

Challenges and Future Frontiers

However, the journey toward comprehensive micro-mobility safety solutions is still ongoing. Collecting and training data under a more extensive array of conditions, including diverse driving situations (rainy, snowy, etc.) and passenger characteristics (height, weight, foot size, gender, etc.), is imperative to avoid overfitting and enhance the AI's reliability. Recognizing that safety issues stem from multifaceted factors such as drunk driving and illegal parking, there lies an opportunity to develop a system that can holistically address these challenges. The goal is to continually refine and expand our understanding, contributing to the stable integration of electric scooters as an innovative and globally recognized mode of mobility.

An Ongoing Commitment to Safety and Innovation

Integrating AI into micro-mobility safety solutions is not a static achievement but a continuous commitment to refinement, adaptation, and innovation. The potential for transformative advancements remains boundless as cities navigate the future of micro-mobility with AI as a guiding force. The open road ahead invites collaborative efforts, diverse perspectives, and a shared dedication to creating safer, smarter, and more sustainable urban transportation ecosystems.

ABOUT THE WRITER

Dr. Houssam al Masri, Smart City Design Lead with 30+ years of experience, has managed broadband communication networks and smart city infrastructure projects. He was the Smart City Design Senior Project Manager at Khatib & Alami and led the master planning of the Jeddah Central Development Smart City project in Saudi Arabia.

Houssam managed telecommunication projects such as Smart Cities and Solutions, Smart Buildings and Smart Homes, Fiber to Homes, and Broadband Access in the MENA region. As a senior project manager for Alpinada Telematics, he increased market share by winning and completing various projects in Saudi Arabia and the UAE. Houssam holds a PhD in Computer Engineering from MIT and has been Chairman of the Smart City Opt. and App Committee in FiberConnect Council MENA since 2019. He is a member of the ESRI GIS community professionals, IEEE IT Society, and the Green Buildings Association. Houssam is also a member of the ISO Smart City Technical Committee.

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ABOUT THE COMPANY

Khatib & Alami (K&A) is an international multidisciplinary consultancy comprising architects, engineers, planners, and other specialists. We have vast experience working at the forefront of fast-changing urban environments, with a deep understanding of delivering complex and significant projects within agreed timeframes and budgets.

K&A was founded more than 50 years ago by two university professors who shared the same vision: to create an organization through which talent could thrive, built on the foundations of professional excellence, integrity, and social responsibility. While today, K&A employs more than 6,000 experts in more than 30 international offices, our people are the custodians of these values. We are driven by curiosity, with a firm belief in the importance of delivering exceptional quality to make a positive and sustainable contribution to the communities in which we work.