

SMART BIKING AND TRADITIONAL BIKING

Radosław WOLNIAK^{1*}, Wies GREBSKI²

¹ Silesian University of Technology, Organization and Management Department, Economics and Informatics Institute; rwolniak@polsl.pl, ORCID: 0000-0003-0317-9811

² Penn State Hazleton, Pennsylvania State University, wvg3@psu.edu, ORCID: 0000-0002-4684-7608

* Correspondence author

Purpose: The purpose of this publication is to present the most important features with which the smart biking is characterized.

Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

Findings: Smart biking is a transformative approach that integrates modern technology and innovative solutions into urban transportation, revolutionizing cycling as a mode of travel in smart cities. By merging traditional cycling with cutting-edge advancements, smart biking enhances the overall cycling experience, focusing on safety, connectivity, and community engagement. This concept aligns seamlessly with the core principles of smart cities, emphasizing data-driven planning, environmental sustainability, and seamless integration with public transportation to create a bike-friendly urban environment. The development of dedicated bike lanes, cycle tracks, and bike-sharing systems showcases the smart city's commitment to improving cycling infrastructure and encouraging its adoption as a preferred mode of transportation. By providing real-time information and mobile apps, smart biking empowers cyclists to efficiently plan their routes, while advanced safety features and IoT technology enhance cyclist safety on the roads. Furthermore, smart biking fosters a sense of community among cyclists through social platforms, promoting an active and engaged cycling community.

Originality/value: Detailed analysis of all subjects related to the problems connected with the smart biking in smart city.

Keywords: smart biking, smart city, quality of life, biking, smart mobility.

Category of the paper: literature review.

1. Introduction

The smart city concept aims to utilize modern technologies and innovative solutions to enhance the quality of life in urban areas, improving their efficiency and sustainability (Herdiyah, 2023). Smart city initiatives encompass various domains, one of which is smart

mobility (Jonek-Kowalska, Wolniak, 2021, 2022; Jonek-Kowalska et al., 2022; Kordel, Wolniak, 2021, Orzeł, Wolniak, 2021, 2022, 2023; Rosak-Szyrocka et al., 2023; Gajdzik et al., 2023; Ponomarenko et al., 2016; Stawiarska et al., 2020, 2021; Stecuła, Wolniak, 2022; Olkiewicz et al., 2021). Smart mobility holds particular importance in modern cities, as it facilitates the organization of transportation systems in a contemporary manner.

Smart biking exemplifies smart mobility in a smart city, showcasing how technology and innovative solutions are applied to transform urban transportation and make it more efficient, sustainable, and accessible. Smart biking is seamlessly integrated into the city's overall transportation ecosystem. It complements existing public transportation systems, providing first and last-mile connectivity solutions. Cyclists can easily combine biking with buses, trains, and other transit options, promoting a multi-modal approach to commuting.

The purpose of this publication is to present the most important features with which the smart biking approach is characterized.

2. Smart biking

Cycling has always been a popular mode of transportation, a great form of exercise, and an environmentally-friendly way to get around. In recent years, the world has witnessed a technological revolution that has impacted every aspect of our lives, and cycling is no exception. The emergence of the "Smart Biking" concept has brought together the traditional joys of cycling with cutting-edge technology, creating a new and exciting experience for cyclists.

The heart of the smart biking concept lies in the development of smart bikes. These bicycles are equipped with advanced sensors, microprocessors, and connectivity features that make them much more than just two-wheeled vehicles. Smart bikes are designed to gather and analyze data, communicate with other devices, and provide enhanced functionalities to both the rider and the environment. Smart bikes come with built-in navigation systems and GPS trackers. Riders can set their destinations through a mobile app or directly on the bike's interface. The bike's GPS provides real-time navigation, suggesting the best routes, avoiding traffic, and even indicating points of interest like bike-friendly cafes or parks. This feature is particularly useful for urban commuters and long-distance cyclists who want to explore new routes (Rahman, Dura, 2022).

Safety is a primary concern for cyclists, especially when sharing the road with motor vehicles. Smart bikes incorporate various safety features like proximity sensors, collision detection, and automatic brake systems. Proximity sensors warn the rider of nearby vehicles or obstacles, while collision detection can automatically apply the brakes in emergency situations. These technologies significantly reduce the risk of accidents and enhance the overall safety of

cycling (Wolniak, 2016; Czerwińska-Lubszczyk et al., 2022; Drozd, Wolniak, 2021; Gajdzik, Wolniak, 2021, 2022; Gębczyńska, Wolniak, 2018, 2023; Grabowska et al., 2019, 2020, 2021). Smart biking encourages a healthy lifestyle by integrating fitness tracking functionalities. Built-in sensors can monitor the rider's heart rate, calorie expenditure, distance covered, and other vital health metrics. This data is then synced to the rider's smartphone or fitness app, allowing them to keep track of their progress, set goals, and make improvements in their fitness routine (Prajeesh, Pillai, 2022).

Electric bikes, or e-bikes, are becoming increasingly popular, and smart biking takes e-bikes to the next level. Smart e-bikes offer various modes of power assistance that can be adjusted based on the rider's preference or the terrain. For instance, the bike can automatically increase assistance when climbing a hill and reduce it on flat roads to conserve battery power. This efficient energy management maximizes the bike's range and minimizes environmental impact.

Smart biking fosters a sense of community among cyclists. Dedicated mobile apps and social platforms allow riders to connect with each other, share experiences, plan group rides, and even compete in virtual cycling events. This social aspect of smart biking not only makes the experience more enjoyable but also motivates cyclists to stay active and engaged. Smart bikes can be equipped with environmental sensors to collect data on air quality, temperature, humidity, and more. By crowdsourcing this data from a fleet of smart bikes, city planners and environmental agencies can gain valuable insights to improve urban planning, optimize cycling infrastructure, and make cities more sustainable and bike-friendly (Boichuk, 2020).

Smart bikes are equipped with self-diagnostic systems that monitor the bike's performance and condition. They can detect potential issues such as tire pressure, chain wear, or brake problems and notify the rider in real-time. This proactive approach to maintenance ensures that the bike is always in top shape and minimizes the risk of breakdowns during rides (Ku et al., 2022).

The smart biking concept represents an exciting fusion of technology and traditional cycling, enhancing the overall experience for riders and promoting cycling as a viable transportation option (Sułkowski, Wolniak, 2015, 2016, 2018; Wolniak, Skotnicka-Zasadzień, 2008, 2010, 2014, 2018, 2019, 2022; Wolniak, 2011, 2013, 2014, 2016, 2017, 2018, 2019, 2020, 2021, 2022; Gajdzik, Wolniak, 2023; Wolniak, 2013, 2016; Hys, Wolniak, 2018). With the integration of navigation, safety features, fitness tracking, and environmental data collection, smart bikes are transforming the way we ride, making it safer, more enjoyable, and environmentally responsible. As technology continues to advance, the future of smart biking holds even more promising possibilities for cyclists worldwide (Benevolo et al., 2016).

Smart biking leverages technology to offer real-time information to cyclists. Dedicated mobile apps and smart devices provide access to updated route information, weather conditions, traffic updates, and even available bike-sharing options. This real-time data empowers cyclists to make informed decisions and plan their rides efficiently. Also smart biking promotes

eco-friendly transportation within the smart city. By encouraging cycling as a preferred mode of transport, it reduces carbon emissions, traffic congestion, and the overall environmental impact of commuting. This aligns with the smart city's goals of promoting sustainable practices and reducing its carbon footprint (Kunyska et al., 2023).

It can be said, that smart biking prioritizes cyclist safety through the integration of advanced technologies. Smart bikes can be equipped with collision detection systems, proximity sensors, and automatic braking features, enhancing the safety of riders. Additionally, smart biking infrastructure may include well-lit bike lanes and smart traffic signals that respond to cyclists' presence, further improving safety on the roads. Also those initiatives collect valuable data on cycling patterns, usage, and demand. This data is used for data-driven planning and decision-making. City authorities can analyze the data to identify popular cycling routes, areas with high demand for bike-sharing, and opportunities for improving cycling infrastructure to better serve the community (Orlowski, Romanowska, 2019).

Smart biking fosters community engagement among cyclists. Dedicated social platforms and apps allow riders to connect, share experiences, plan group rides, and participate in cycling events. This sense of community helps promote smart biking and encourages more people to adopt cycling as a mode of transportation. The concept of smart biking contributes to improved public health within the smart city. By encouraging more people to bike, it promotes an active lifestyle and helps combat sedentary behaviors. This, in turn, can lead to reduced healthcare costs and improved overall well-being for residents.

Bike-sharing systems are an integral part of smart mobility in a smart city. These systems are integrated with other transportation options and are equipped with technology for easy access, payment, and tracking. Smart bike-sharing enables convenient, affordable, and flexible transportation for residents and visitors alike.

Smart bike-sharing systems are innovative and technology-driven solutions that provide convenient and flexible access to bicycles for short-term use. These systems are designed to enhance urban mobility, reduce traffic congestion, promote sustainability, and offer an alternative mode of transportation in smart cities and urban areas. Smart bike-sharing systems typically involve the following key features and components: Smart bike-sharing systems consist of automated bike stations strategically located throughout the city. These stations are equipped with docking points that securely hold the bikes when they are not in use. Users can easily rent and return bikes at these stations.

Users can access the bike-sharing system through mobile apps or interactive kiosks placed at the bike stations. The mobile app provides information about station locations, bike availability, and real-time data on nearby bikes. Smart bike-sharing systems offer a contactless rental process. Users can unlock a bike by scanning a QR code or using a mobile app. This allows for quick and easy access to the bikes without the need for physical keys or cards.

Each bike in a smart bike-sharing system is equipped with GPS tracking and connectivity features. This enables operators to monitor the location of bikes in real-time, manage bike distribution, and collect valuable data on bike usage patterns. Smart bikes have built-in smart locking mechanisms. Once a user completes their ride, they can securely lock the bike at any available docking point within a designated station. Smart bike-sharing systems offer integrated payment systems that allow users to pay for their bike rentals through the mobile app using credit/debit cards or digital wallets. The mobile app and kiosks have user-friendly interfaces that provide clear instructions for renting and returning bikes. Users can also view their rental history and track their riding statistics. The mobile app provides real-time information about bike availability at each station, helping users find nearby bikes and plan their rides efficiently.

Smart bike-sharing systems are often integrated with public transit networks, providing a seamless and convenient option for users to combine cycling with other transportation modes, such as buses and trains. By encouraging cycling and reducing the reliance on motorized vehicles, smart bike-sharing systems contribute to a greener and more sustainable urban environment, promoting cleaner air and reduced carbon emissions.

3. Smart city and smart biking

The smart city concept and smart biking are interrelated in numerous ways, as both aim to utilize technology to improve urban living and transportation. The integration of smart city infrastructure and initiatives has a significant impact on the development and promotion of smart biking. Smart cities prioritize the creation of cycling-friendly infrastructure, including dedicated bike lanes, cycle tracks, and bike-sharing systems. These infrastructure developments encourage more people to choose biking as a viable mode of transportation. Smart biking initiatives benefit from the smart city's commitment to expanding and enhancing cycling infrastructure, making it safer and more convenient for cyclists to navigate through urban areas.

Also smart cities offer real-time information to residents, including cyclists, through various channels like mobile apps, digital displays, and smart kiosks. Smart biking takes advantage of this connectivity by providing cyclists with up-to-date information on bike lane availability, road closures, weather conditions, and potential hazards. Having access to such information enables cyclists to plan their routes more efficiently and stay informed about any changes in the city's infrastructure (Tahmasseby, 2022).

Smart cities often implement bike-sharing programs, where commuters can easily rent bikes for short trips. These bike-sharing systems are integrated into the city's overall transportation network, offering a seamless connection between various modes of transport like buses, trains, and even ride-sharing services. Smart biking benefits from this interconnectedness, making it easier for people to incorporate cycling into their daily commutes and travel.

The Internet of Things (IoT) plays a crucial role in smart biking. Smart city infrastructure can be equipped with sensors and connected devices that enhance cyclist safety. For instance, IoT-enabled traffic signals can detect approaching cyclists and adjust signal timings accordingly, reducing the risk of accidents. Additionally, smart streetlights can illuminate bike lanes and paths as cyclists pass by, improving visibility and safety during nighttime rides.

Smart cities leverage data analytics to make informed decisions about urban planning and transportation. This data-driven approach extends to smart biking, where information collected from bike-sharing systems, cycling patterns, and traffic flow can inform the expansion of bike lanes, the placement of bike racks, and the optimization of cycling routes. This data-driven planning ensures that smart biking initiatives align with the actual needs and preferences of cyclists (Dudycz, Piatkowski, 2018).

Smart biking aligns with the smart city's focus on environmental sustainability. By promoting cycling as a green and eco-friendly mode of transportation, smart cities aim to reduce traffic congestion and lower carbon emissions. As a result, cities invest in smart biking initiatives to incentivize residents to choose cycling over traditional motorized vehicles, contributing to a cleaner and greener urban environment. Smart cities encourage multi-modal transportation, where different modes of transit seamlessly connect and complement each other. Smart biking fits perfectly into this framework, offering a convenient first and last-mile solution for public transportation users. Cyclists can easily combine biking with buses, trains, or subways, reducing the reliance on private cars and contributing to a more efficient urban transportation ecosystem (Wawre et al., 2022)

Smart cities create an environment that fosters and supports the growth of smart biking initiatives, while smart biking contributes to the overall goals of a sustainable, efficient, and interconnected urban landscape. By embracing the smart biking concept, cities can promote healthier lifestyles, reduce traffic congestion, and improve the overall quality of life for their residents.

Table 1 highlights the relationship between smart cities and smart biking, showcasing how various factors associated with smart cities positively impact and promote the concept of smart biking.

Table 1.
Relationship between smart city and smart biking

Smart City factors	Smart Biking
Cycling Infrastructure	Development of dedicated bike lanes, cycle tracks, and bike-sharing systems to promote cycling as a preferred mode of transport.
Real-time Information	Provision of up-to-date data on bike lane availability, road closures, weather conditions, and potential hazards to aid cyclists in route planning.
Bike-sharing and Connectivity	Integration of bike-sharing programs with other transportation modes, offering a seamless connection between cycling and public transit options.
IoT for Safer Riding	Utilization of IoT-enabled sensors and devices to enhance cyclist safety, such as smart traffic signals and illuminated bike lanes.

Cont. table 1.

Data-Driven Planning	Data analytics to inform urban planning decisions related to cycling infrastructure expansion, bike rack placement, and route optimization.
Environmental Sustainability	Promotion of cycling as an eco-friendly and sustainable transportation option to reduce traffic congestion and carbon emissions.
Integration with Public Transportation	Encouragement of multi-modal transportation, where cycling complements public transit, providing a first and last-mile solution.

Source: (Ploeger, Oldenziel, 2020; Tahmasseby, 2022; Rahman, Dura, 2022; Prajeesh, Pillai, 2022; Boichuk, 2020; Benevolo et al., 2016; Kunytska et al., 2023; Christensen, 2020; Langer et al., 2021).

4. Smart biking and traditional biking

Traditional biking planning typically focuses on providing basic bike lanes and paths, which may lack proper connectivity and safety measures. Cyclists often rely on paper maps or limited online resources for route selection, without access to real-time data and mobile apps for updated route information and weather conditions. Safety measures in traditional biking planning might be limited, and cyclists often have to adhere to general road rules without the support of advanced safety features (Simonofski et al., 2023).

Regarding environmental impact, traditional biking does contribute to reduced emissions, but planning may not prioritize environmental benefits as a core objective. Data utilization in traditional biking planning is limited, with minimal use of data analytics and Internet of Things (IoT) technology for urban planning and optimizing biking routes. Integration with public transportation is often not well-developed in traditional biking planning, with limited connections and lack of seamless integration between biking and other transportation modes.

On the other hand, smart biking takes a more technologically advanced and environmentally conscious approach. It focuses on creating dedicated and connected bike lanes with smart technology integration for enhanced safety, including features like illuminated lanes and smart traffic signals. Smart biking planning utilizes real-time data and mobile apps to provide cyclists with updated route information, weather conditions, and road closures, making route planning more efficient and convenient. Safety in smart biking is improved through advanced features such as collision detection, proximity sensors, and automatic brakes, all designed to protect cyclists. Smart biking actively promotes environmental consciousness, encouraging cycling as a key component of green and sustainable urban transportation (Christensen, 2020).

Data-driven planning is a hallmark of smart biking, utilizing data analytics and IoT to optimize biking routes, identify high-demand areas, and make informed decisions for urban planning. Smart biking seamlessly integrates with public transportation, providing first and last-mile solutions for commuters and integrating bike-sharing systems (Kim, Hall, 2023).

Technological integration is a significant aspect of smart biking, where smart bikes with built-in GPS, fitness tracking, and connectivity features enhance the overall biking experience. The smart biking concept also fosters community engagement through social platforms, cycling

events, and crowdsourcing data to continuously improve biking initiatives (Wolniak, Sułkowski, 2015, 2016; Wolniak, Grebski, 2018; Wolniak et al., 2019, 2020; Wolniak, Habek, 2015, 2016; Wolniak, Skotnicka, 2011; Wolniak, Jonek-Kowalska, 2021; 2022). Lastly, smart biking incorporates self-diagnostic systems that monitor bike performance and notify riders of maintenance needs in real-time, ensuring that bikes are always in top condition for safe and enjoyable rides (Langer et al., 2021; Sen, 2022).

In table 2 there is a comparison between traditional biking planning and smart biking.

Table 2.
Comparison between traditional biking and smart biking

Aspect	Traditional Biking Planning	Smart Biking
Infrastructure	Focus on basic bike lanes and paths, often lacking connectivity and safety measures.	Emphasis on dedicated and connected bike lanes, incorporating smart technology for enhanced safety (e.g., illuminated lanes, smart traffic signals).
Route Planning	Relies on paper maps or limited online resources for route selection.	Utilizes real-time data and mobile apps to access updated route information, weather conditions, and road closures.
Safety Measures	May lack specific safety measures, and cyclists rely on general road rules.	Equipped with advanced safety features like collision detection, proximity sensors, and automatic brakes for enhanced rider protection.
Environmental Impact	Traditional biking contributes to reduced emissions, but planning may not prioritize environmental benefits.	Encourages cycling as a key component of green and sustainable urban transportation, actively promoting environmental consciousness.
Data Utilization	Limited use of data for planning and decision-making.	Utilizes data analytics and IoT for data-driven urban planning, optimizing biking routes, and identifying high-demand areas.
Public Transportation Integration	Limited integration with public transit systems, may not be well-connected.	Seamlessly integrates with public transportation, providing first and last-mile solutions for commuters, and integrated bike-sharing systems.
Technological Integration	Relies on traditional biking equipment without much technology integration.	Incorporates smart bikes with built-in GPS, fitness tracking, and connectivity features for a more enhanced biking experience.
Community Engagement	May have limited community involvement in planning and infrastructure development.	Encourages community engagement through social platforms, cycling events, and crowdsourcing data to improve biking initiatives.
Maintenance and Monitoring	Relies on periodic maintenance without real-time monitoring capabilities.	Equipped with self-diagnostic systems that monitor bike performance and notify riders of maintenance needs in real-time.

Source: (Ploeger, Oldenziel, 2020; Tahmasseby, 2022; Rahman, Dura, 2022; Prajeesh, Pillai, 2022; Boichuk, 2020; Benevolo et al., 2016; Kuniytska et al., 2023; Christensen, 2020; Langer et al., 2021).

5. Conclusion

The concept of smart biking exemplifies the integration of modern technology and innovative solutions into urban transportation, making cycling a more efficient, sustainable, and accessible mode of travel in smart cities. By combining traditional cycling with cutting-edge advancements, smart biking enhances the overall experience for cyclists, promoting

safety, connectivity, and community engagement. Smart biking benefits from the core principles of smart cities, where data-driven planning, environmental sustainability, and seamless integration with public transportation play crucial roles in shaping a bike-friendly urban environment. The development of dedicated bike lanes, cycle tracks, and bike-sharing systems reflects the smart city's commitment to improving cycling infrastructure and encouraging its use as a preferred mode of transportation.

The use of real-time information and mobile apps in smart biking empowers cyclists to plan their routes more efficiently, while advanced safety features and IoT technology enhance cyclist safety on the roads. Moreover, smart biking fosters a sense of community among cyclists through social platforms, promoting an active and engaged cycling community. In contrast, traditional biking planning may lack the technological advancements and data-driven approach that smart biking embodies. Basic bike lanes and limited integration with public transit might hinder the convenience and appeal of traditional biking.

The smart biking concept represents a remarkable fusion of technology and traditional cycling, presenting an exciting future for urban transportation. As smart cities continue to prioritize sustainability and technological advancements, smart biking will play an increasingly significant role in promoting healthier lifestyles, reducing traffic congestion, and contributing to a greener and more efficient urban landscape. By embracing smart biking initiatives, cities can build a brighter, more sustainable future for cyclists and urban residents alike.

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