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# The Role of Autonomous Cars on Development of Smart Urban Space

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**Abstract**

The process of developing smart urban space as one of the most important challenges of contemporary society has started a new expansion with the arrival of autonomous cars as an effective and transformative factor. This article examines the essential and influential role of autonomous cars in the development of smart urban space. Therefore first, the concept of smart urban space as a comprehensive system that takes advantage of population gathering, information and communication technology, and intelligent management is examined. Then the issue of autonomous cars, which as one of the advanced technologies in the field of transportation, play a very important role in the development of smart urban space, are introduced. These cars have the ability to provide new solutions for traffic problems, creating trouble and improving urban security. Among the important components identified in the role of these cars, it can be mentioned that increasing productivity and reducing travel time, creating smart public transportation networks, and supporting sustainable and green movement in cities. Then, focusing on various components of the urban environment including transportation, traffic, safety and infrastructure, the role of autonomous cars in improving and optimizing these components is analyzed. This analysis includes examining positive effects such as reducing traffic and travel time, increasing safety and improving

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access to public services. Finally, in this study, the components and analyzes necessary to identify the effective indicators of the role of autonomous cars in the development of smart urban space have been introduced. Therefore, it was shown that autonomous cars in the urban form were combined in three groups of principles, which include the impact on urbanization, influence on road infrastructure, and influence at the level.

**Keywords**: autonomous car, smart urban space, urban space

## 1. Introduction

In recent decades, with the advancement of technology and the introduction of autonomous cars into transportation field, the concept of smart cities as a new approach in urban space management has been highly regarded. As one of the great developments in this field, autonomous cars have the ability to provide new solutions to improve traffic, safety and sustainability in cities. In this regard, evaluating and analyzing the role of these cars in the development of smart urban space and identifying indicators affecting this role is a fundamental and necessary matter that has attracted the attention of researchers and decision makers in the field of urban planning (Julian, 2023). In this research, we investigate the role of autonomous cars in the development of smart urban space. By reviewing the existing literature and providing detailed analysis, we try to identify and evaluate the essential and effective factors on this role. Also, in this research, it is tried to examine the positive and negative effects of the presence of autonomous cars on traffic, safety, environment and the development of smart cities.

Hence, in recent decades, a significant increase in the number of vehicles worldwide is clearly evident. Approximately, the number of vehicles in 2015 reached about 1.3 billion vehicles, most of which were passenger vehicles. This growth is projected to double by the end of the 2020s or early 2030s as the upward trend continues. In the meantime, the presence of driverless cars or autonomous vehicles (AV) has been raised as an important topic of discussion in various forums as well as for governments and universities. The focus of more research is on the technical aspects of this technology, and its effects on urban spaces and the future of people's mobility have been less investigated. In other words, autonomous cars combined with sharing are likely to dramatically change the face of individual transportation and urban space over the next three decades. Research shows that autonomous car technology is developing and advancing rapidly. It is predicted that by 2040-2050, fully autonomous cars will enter the market in the world's largest cities. However, technical, political, legal, and economic issues related to this technology are still being discussed globaly. The presence of autonomous cars does not only affect people's daily trips, but its effects on the appearance and shape of cities can also be seen. Therefore, the effects of autonomous car technology on urban space and its architecture should also be investigated and analyzed (Abrar, 2020).

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This article examines the problems of introducing autonomous cars and its effects on urban form and architecture. Due to the rapid development of this technology, the changes made to cities and their spaces will be irreversible. Therefore, it is very important to know the consequences of the implementation of autonomous cars and prevent its negative developments. However, for now, the interrelationship between autonomous vehicles and the urban space and the corresponding urban infrastructure and platform should be explored in a more coordinated and bidirectional way. Cities are now facing many changes in their spatial structure and architecture after centuries of their initial structure. In this regard, long-term construction and urban development activities are considered as one of the most important stages of physical-spatial changes in the city. Changes in the urban spatial structure, especially in the development of trade, tourism, recreation and changes in urban infrastructure have had significant effects on the urban space. These changes were created and benefited by the increasing population and construction needs (Kili et al., 2018).

Much of the nature of the emergence of autonomous cars, whether this is an evolution or a revolution in the urban space, will gradually and soon become clear. But without a doubt, this technological progress is a revolution in the history of modernity. The long-term impact of this development on our daily lives, the safety of our citizens, and the environments in which we live and work, on our streets and in our metropolises, will redefine our society, and this impact will be greater than any other technology which has appeared before.

It is clear that the literature supporting autonomous vehicles is essential for smart and sustainable development. This research is one of the first efforts in the field of investigating the adaptation components of the texture and spatial structure of cities on the traffic and use of autonomous cars. It explains the effects of this technology on the urban space, the environment, sustainable urban development, the livability of streets and passages, the improvement of the urban landscape and visual factors, the effects on neighborhoods and different urban areas, and their mutual effects on each other. Until now, most of the studies have focused on the production and technical performance of autonomous cars, or their environmental or economic aspects have been researched at the level of the cars' performance. In this research, an attempt has been made to examine the way cars travel and the adaptation of the spatial structure and texture of cities, and to highlight the importance of street redesign in localities and the comfort of users, which has been neglected in previous researches.

In short, this research emphasizes that innovation, from the point of view of the possibility of using this emerging technology in existing cities or new cities, has important and extensive effects, including the well-being and comfort of users, improving the livelihood of city residents, affecting the quality of life, and is based on the dimensions of sustainable

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development. This research aims to help achieve these components and provide solutions for better and more effective management of urban space and transportation in cities.

## 2- Theoretical framework

### 2-1- Theoretical definition of autonomous car

Theoretical basis related to autonomous cars are often based on legal definitions and technical concepts. For example, Section 8 of the Nevada State Code of 1988 defines an autonomous vehicle as a motorized vehicle that uses artificial intelligence, sensors, and a global positioning system to drive itself without the intervention of a human operator. This definition provides a basic basis for knowing the autonomous car and emphasizes its importance in determining the limits and characteristics of this type of vehicle. A autonomous car is known as a type of car equipped with an artificial intelligence system that allows moving between two places without the intervention of the driver. This concept is the basis on which driverless cars are seen as an example of technological advancement in the field of transportation. In this model, the main role of the human driver is in driving as recognizing and determining the destination, while artificial intelligence systems and sensors are used to control and manage driving operations. These theoretical concepts show that the autonomous car is not only a means of transportation, but also a representative of technological advances in the field of automobile manufacturing, which offers more facilities for the comfort and safety of passengers. In addition, these basic definitions emphasize the importance of more detailed analysis of the various effects and impacts of this technology in the field of urban space and transportation.

### 2-2- urban space

Urban space generally reproduces the general order of the human world (Rob Carrier), if we want to clarify the concept of urban space without imposing aesthetic criteria, we must consider all examples of the space between buildings in cities and other places as urban space. This space is geometrically surrounded by various symbols. It is only the revelation of its geometric features and aesthetic qualities that allows us to consciously consider the outer open space as an urban space. The two fundamental elements in this field are street and square (Jean-Pierre) More urban spaces inside or around cities are places specific to the social life of citizens, which include green and civil spaces, sidewalks, squares, and playgrounds. The use of these spaces is numerous and includes: traffic, recreation, play, meeting, etc. On the other hand, urban space as a platform for social functions plays a prominent role in facilitating these functions and campaigns related to it, which appear in the form of institutions, organizations, etc., and facilitates relationships and refines social construction. Since the urban space, by interfering in the facilitation and refinement of social construction,

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is generally involved with social strategies and sometimes strengthens, consolidates or weakens them, therefore it has a social role due to the generality, certainty and repetition of its effects. (Khazaei, 2015, Bagh Mohammadi and Salavarzizadeh, 2019: 94, Garg & Praliya 922: 2021)

**2-3- Components of urban space and their qualities**

In the last two decades, various theorists at the global level have addressed the components of urban spaces and examined their role, effectiveness and quality from various dimensions. Among the different dimensions and contexts of urban space quality, three functional, experiential-aesthetic and environmental components are deduced as the shaping forces of urban space.

According to karmona (2003), on the one hand, the functional components include the provision of movement and easy and convenient access to attractive and focal urban centers, and on the other hand, they include other functions such as passive recreation, watching various events, etc. To guarantee the vitality and richness of the spatial experience of the city. Also, the experimental-aesthetic components deal with the perceptual, cognitive perceptions and environmental preferences of people in front of the routes as an urban space and finally, the environmental components in its micro dimensions including categories such as: micro climate regulation of urban spaces (sun, air flow, wind, shading, etc.) and in its macro dimensions, it has been concerned with environmental sustainability such as balance in the environment, reduction of pollutants and cleanliness of the environment, etc. (Mohammadi et al.: 2013)

In the following, based on time precedence, the most important indicators of the quality of urban space are discussed according to functional, experimental-aesthetic and environmental components from the point of view of theorists.

Table 1. Opinions of experts on the components of urban space and their qualities

| theorists | Functional component | Experimental-aesthetic component | Environmental component |
|---|---|---|---|
| Jane Jacobs 1961 | The priority of order of activities over visual order, mixed use, permeability, possibility of monitoring and care, variety and wealth of activities | Attention to the element of the street, the possibility of social mixing, wealth of activities, flexible spaces | - |
| Cullen 1961 | Creating connections between elements of the | Personal perceptions, relative aesthetics, order | - |

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| | physical environment such as trees, landscapes, buildings and urban traffic, functional connections | and sequential views, environmental grace | |
| Kevin Lynch 1983 | Adaptability, access, control and supervision, efficiency, justice | vitality of life, meaningfull | Biological vitality |
| Violich 1983 | | readability of the environment, freedom of choice, different urban forms, the possibility of social life, listening to the past (reading cultural heritage) | Attention to local-regional links |
| Wilkinson 1983 | Selectivity, evoking a sense of mastery | Balancing and calming human dynamics, the ability to create social relationships, a sense of self-fulfillment | Communicate with nature |
| Transic 1986 | maintaining movement sequence (communication) | Enclosure of spaces, continuity of edges, control to axes of vision and perspectives, combination of inside and outside. | - |
| Green 1992 | Performance includes: access and communication, diversity of users, security | Order includes: doing, clarity, consistency Identity includes: center of unity, personality Attractiveness includes: scale, visual fit, functionality, vitality, harmony | Climatic comfort |
| **theorists** | **Functional component** | **Experimental-aesthetic component** | **Environmental component** |
| Tibbalds 1992 | Mixed use, attention to the needs of all groups, flexibility, growth and | attention to places more than buildings, learning from the past and | Climatic comfort of pedestrians |

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|---|---|---|---|
| | gradual changes, attention to pedestrians | respecting the existing context, human scale, legibility | |
| Brian Goody 1993 | Permeability, flexibility, measured and controlled growth and development | Vitality, harmony with the existing platform, diversity, human scale, possibility of personalization, readability, wealth | - |
| Planning Advisory Committee London 1993 | Safety, use and mixed activities, existence of public spaces and special spaces, ease of movement on foot and on horseback | Appropriate structure, legibility and identity, visual wealth, human scale and compactness of the city fabric, optimal urban management. | cleanliness |
| Prime Minister's Special Urban Design Force 1994 | Responding to local characteristics and needs, the relevance of plans to the conditions of the local world | Restoring plans to adapt to ongoing future developments, and strengthening ties to the past | attention to the natural and artificial background of designs |
| Architecture and Artifact Environment Commission 2000 | Adaptability, diversity, freedom of movement | Readability, character, continuity, quality of public space | |
| **theorists** | **Functional component** | **Experimental-aesthetic component** | **Environmental component** |
| Frank 2001 | Distance, security, cost, time, convenience | Values and attitudes, environmental pleasant, personal habits | - |
| Sorkin 2002 | Functional mixing, cavalry-pedestrian movement system | Circular neighborhood, preservation of edges, control of view and landscape, centrality of public places, native architecture, privacy, beauty | Greenness, sustainability |

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|---|---|---|---|
| Can 2004 | Public ownership, access, interaction of space facilities | - | - |
| Handi 2006 | Density and intensity, mixed use, street connectivity, regional structure | Scale of the route, three-dimensional space, aesthetic quality, pleasantness and attractiveness of the place | Shade percentage at noon |
| Varna 2014 | Public ownership, control, physical composition | Enlivening (vitality), decency (Induction of social behavior) | - |
| Cremona 2003 2010 | Providing easy and appropriate movement and access to attractive and focal centers, passive recreation, watching various events, safety and security | Perceptual, cognitive and environmental preferences of people in front of routes as urban space, vitality, richness of experience, public space and urban landscape | In micro dimensions of micro regulation of the climate of urban spaces (sun, air flow, wind, shading, etc.) and in macro dimensions of environmental sustainability, such as balance in the environment, reduction of pollutants and cleanliness of the environment, etc. |
| Habibi 1999 | Diversity, safety, security, neighborhood, compatibility | Conductor and guidance, memorable, social role, differentiation and personality, legibility, temporal and spatial continuity, spatial contrast, milestones, detail design, pause places, human scale, flexibility | Weather conditions, road cleanliness |
| **theorists** | **Functional component** | **Experimental-aesthetic** | **Environmental** |

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| | | component | component |
|---|---|---|---|
| Golkar 1379 | Quality of behavioral camps (compatibility of activity, time, space)<br>Quality of urban form compatibility with uses, pedestrian and bicycle network<br>Safety quality of the environment for activities<br>Quality of security of the environment for activities | Quality of the physical-spatial environment (objective environment)<br>Quality of perceptual-sensory environment (perceptual environment)<br>Quality of the perceptual-mental environment (cognitive environment)<br>Quality of mental landscape (spatial and temporal) | |
| Pakzad 1383 | Active and permanent presence of users in the space and social interaction of citizens | Sense of belonging, recognition of people's spiritual and psychological needs and their reflection in public spaces | |
| Behzadfar et al. 2018 | Mixing of uses, flexibility, access, permeability, walkability | Vitality, readability, scale, variety | |
| Zekavat et al. 2015 | Behavioral accommodation, mixing function and activity, facilitating access, functional diversity, fit and confinement, permeability, physical diversity,<br>Safety and security, inclusiveness, flexibility and adaptability | Background and recognition of aspect, transparency, legibility, visualization, vitality, sense of belonging, collective memories, sense of place, sense of time, sensory richness, identification and identity, urban tourism, night life, livability | |

**2-4- Effect of autonomous cars on the city structure**

Autonomous cars can be one of the biggest and most powerful challenges to influence the structure of cities. While the excitement and attraction of autonomous cars is well known to the general public, many cities are still not ready for what impact smart cars will have on

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their urban development and future, and many urban development organizations do not know the effects that autonomous cars will have on infrastructure. They have not considered the tax structure, safety and traffic equipment, and even real estate. In the future, the impact of technology on distance, speed and urban development will be determined. This means that they will change and many of them will be unpredictable. Some of these items are given in the table below.

Table 2. Impact of autonomous cars on the city structure

| Effective factors | Special characteristic | Sample | |
|---|---|---|---|
| Reducing the need for parking | One of the most important effects autonomous cars on the urban structure is reducing the need for parking. Many cities generate a large amount of their revenue each year through parking fees and other parking fines. | San Francisco alone generates about 132 million dollars annually through parking. In America, cars spend 95% of their time in urban areas in park mode | Autonomous cars also reduce the need for parking permits and other costs of having a parking space. |
| Reduce wasted time | One of the biggest complaints and concerns of local travelers who go to cities every day is wasting their time. | Autonomous car technology will meet the needs of millions of Americans and people in other countries to improve their livelihoods. | They will be able to devote their time to other activities instead of losing their time that is mostly spent commuting. |
| Public transportation | For decades, urban planners have hoped to define a point-to-point, low-density transportation system without the costs that traditional transportation systems | | Autonomous cars can have a significant impact on the public transport fleet |

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| | currently incur. | | |
| Changing urban transport policies | Autonomous cars can have different and significant effects on city performance and income generation | It will be noticeable in small cities and suburbs where public transportation is inadequately provided. | Transportation systems consisting of autonomous cars are not efficient and cheap enough to be available as bus lines at all times. Experts also believe that the privatization of public services should not be rushed and the security of this system should be guaranteed first |

**2-5- Benefits of autonomous vehicles a set of measures to reduce traffic**

Regulating the use of urban transportation and encouraging car sharing companies to purchase autonomous vehicles in bulk and changing their service delivery model will help achieve a fundamental improvement in the traffic situation, including factors specific to the urban environment. However, the costs of this type of improvement may turn into other problems. AV can have a different impact on urban forms depending on the type and form of ownership. From the point of view of technological, legal and economic changes, it is the first and the simplest scenario in which a simple car is replaced by an autonomous car. From the point of view of urbanization, the scope of this study shows the need to promote the introduction of the second scenario, which eliminates the private ownership of vehicles and in turn reduces their number. One of the negative consequences of the introduction of AV is the change of urban infrastructure in order to meet the requirements of AV. Transport infrastructure tools should be redesigned with the possibility of greater adaptability and reuse with other functions.

Therefore, based on the theoretical theory presented and researchers' opinions, the development of autonomous cars are classified as described in Table 3:

Table 3. Research theory literature

| Row | Title | Year | Researcher | Research method | Goals | Results |
|---|---|---|---|---|---|---|
| 1 | Environmental impacts of | 2022 | ÓscarSilva, RubénCordera | Qualitative | Concept of environmental effects relates | Due to the lack of study of some of the environmental results |

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| | autonomous vehicles: A review of the scientific literature | | | | to many aspects of air pollution, this paper aims to review and present the findings and shortcomings of current research with a broader perspective. | of AVs, it is not possible to draw accurate conclusions about their overall impact, and calls for more comprehensive studies that allow the identification of all necessary measures to achieve a sustainable future. |
| 2 | Impact of Driverless Vehicles on Urban Environment and Future Mobility | 2020 | SerioAgriestibFaustoBreviaPaoloGandini | Descriptive-survey | Purpose of this research is to focus on the way this technology can affect our urban environments and create a basis for policy change at multiple levels. | Planners, policy makers and car manufacturers and other new stakeholders must take a comprehensive and multidisciplinary approach in understanding and evaluating the impact of this technology on our lives and cities. |
| 3 | Impact of Automated Vehicles on Urban Form | 2022 | | | | |
| 4 | Smart cars, smart cities and smart sharing: The changing nature of public urban spaces on streets, | 2020 | Celen Pasalar | Descriptive - library | How these three socio-economic and technological changes may affect the current and future use of urban public space | This chapter addresses the fundamental changes brought about by intelligent vehicles or autonomous AVs. Smart city technologies; And business models and technologies related |