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Urban Spaces Smartification: A Pathway to Improved Walkability

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ABSTRACT: The use of urban streets as an element of urban life is jeopardized today, particularly In rising metropolises such as Tehran, due to the rapid rise in automobile ownership, population expansion, ineffective transit systems, poor quality urban architecture, and other challenges. On the other hand, there are various potential to efficiently drive urban growth toward sustainability in an era of digitalization, artificial intelligence and the Internet of Things. It implemented that the use of new urban technologies is looking for methods and incentives to encourage today's citizens to walk more. This research attempts to address the question "does smartification of urban spaces significant impact on walkability"? This paper examines the effect of smartification defined as the incorporation of digital technologies and IOT solutions on walkability in urban spaces. By analyzing design of pedestrian path with various smart initiatives, such as gamification, pedestrian-friendly infrastructure, and digital solutions, this study seeks to understand how these innovations contribute to creating more walkable environments. This study used a quantitative approach to test its assumptions, and SPSS software and a questionnaire were used to examine the data that was gathered. Additionally, Friedman's test and the single population mean test (t-test) were employed to evaluate the research assumptions. The study's findings indicate that smart buildings can enhance pedestrian circulation in the studied location (Farahzadi Blvd., Shahrak Gharb). The findings suggest that smartification can significantly enhance walkability by improving safety, social interaction, and pleasurability in user experience. Additionally, from the perspective of users, smartification has the most influence on the comfort factor that promotes walking.

Keywords: *Walkability, Smartification, Urban Spaces, ICT*

INTRODUCTION

ICT is developing at an accelerated rate, which has fundamental consequences on how cities are laid up spatially, alters urban lifestyles and forms, and makes it difficult to forecast the future (Yousefi and Dadashpoor 2020; Ben-Elia and Zhen 2018; Al-Ghamdi and Al-Harigi 2015). Furthermore, future neighborhood developments must adhere to fundamental urban design principles like walkability, dense development, and mixed use (Lehmann 2016; Al-Thani et al. 2018). Walkability is the appeal of an area for walking; a particular site's essential features offer easy walking without unnecessary turns and excessive effort (Mihelič et al., 2015).

On the other hand, encouraging pedestrians should be the next course of action if the streets are not attractive enough. It will be challenging for residents to stroll around the streets (Ghalambor & Farzadi, 2018). This makes it necessary to research how ICT and changes in walkability in cities interact Walkability refers to the ease with which individuals can navigate urban spaces on foot, encompassing factors such as safety, accessibility, and connectivity.

This paper aims to explore the relationship between the smartification of urban spaces and walkability, providing insights into how technological advancements can foster pedestrian-friendly environments.

Literature Review

Walkability criteria

Walking is an environmentally friendly mode of transport and, at the same time, a viable alternative of transport for shorter routes in an urban environment (Rosi et al., 2021). Walkability means the ability to walk. According to Litman (2003), walkability can be measured through various indicators, including street connectivity, land use diversity, and safety perceptions. In the academic

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literature, walkability is frequently defined by reference to such factors as safety, security, economy, and convenience of traveling by foot. In the context of the debate on urban planning, walk-ability is seen as the need to facilitate citizens to move and develop (Jamei et al., 2021), and thus to provide a "quality of a place" (Eckermann et al., 2015), or a user-friendly built environment (Ewing & Handy, 2009). These more detailed insights comply with our definition of walkability According to Turon et al., (2017), transport should be comfort (Rosi et al., 2021). Based on the recent years researches, the most significant of the theoretical literature's criteria, which can be applied in designing walkable urban spaces as follow:

- Social interaction: The presence of all social classes, genders, and ages together creates a unique combination in a pedestrian-oriented urban setting, which is an effective component. One could argue that no specific group owns the sidewalk (Darvishi & Masoumi, 2014).
- Pleasurability and vibrancy: the variety of different activities creates vibrancy for different groups and invites them to participate in pedestrian spaces (Ghalambor & Farzadi, 2018). One of the characteristics of being on the sidewalk is high mobility and unpredictability. Therefore, any factor that prevents users from reaching their desires and creates limitations for them will cause dissatisfaction with the space and eventually not welcoming the space (Rahmani & Safari. 2015).
- Comfort: indicators affecting the desirability of urban sidewalks that affect the criteria well-being and comfort are: 1) Ease of access to the sidewalk from other parts of the city 2) Lighting, 3) Use of different flooring, 4) Facilities available on the pedestrian path (Alshammari, 2022; Akbarzadeh & Ahmadi, 2016).
- Safety: Safety and Security is very important in the continuation of the presence of citizens in the urban space. Aspects of security on the sidewalk include the legibility of the space, the absence of hidden corners, lighting at night, the use of sidewalks at night, and active presence. Mentioned people in the city and being seen in space (Pakzad, 2013).
- Aesthetics: Organizing pedestrian mobility spaces is one of the effective tools to improve the landscape and beautify the city, proper design should promote three elements: intimacy, identity and attractiveness in these spaces (Alshammari, 2022; Mehdizadeh, 2000).
- sense of belonging to a place: The sense of belonging to a place can be described as an emotional relationship between a person and a place. An emotional link that people value that place as a place to return to. In fact, the feeling of belonging to a place is an indicator through which one can measure the degree of distinctiveness of that place for people compared to other places.

ICT and Its Impact on Walkability

Smart cities utilize technology to improve urban services and enhance residents' quality of life. The term "smartification" encompasses various initiatives such as smart traffic management systems, pedestrian navigation applications, and sensor-based infrastructure (Caragliu et al., 2011). so, Smartification is the process of adding technology to everyday objects, has the potential to significantly impact our interactions with the environment. These technologies aim to optimize urban mobility and enhance the overall user experience.

There are many reasons why cities should be redesigned and continuously evolved into smarter ones. ICT may affect walkability in two general ways: First; technology as a problem that reduces walkability by transferring functions to the virtual world, and second; technology as a solution; a tool for strengthening walkability (Hankel et al. 2018).

The use of ICT devices (smartphones, computers, etc.) leads to the flexibility of urban nodes. In other words, citizens continue to use urban nodes, but their usage changes to leisure activities (Wang et al., 2015). In this way, Urban designers should be able to use the potential of technological tools to enhance interactions in public spaces at the same time of following the principles of good design (Abdel-Aziz et al., 2016).

Main design elements of smart pedestrian urban space

According to the conducted studies, the main elements that are examined and designed in this research for the smartness of the sidewalk are:

1) Smart pavement: one of the important components in the attractiveness of urban spaces, especially sidewalks, is their flooring design. But urban flooring has a role in addition to the vitality and attractiveness of urban spaces, the participation of citizens in changing the environment and creating beauty. And it is the floorings that play a role in making the city smarter by producing new experiences such as light, sound, movement, etc via technologies. (Dadgar, 2017).

2) Smart walls and facades: The implementation of smart urban facades through the interactive change of light and sound and videowall has been evaluated as effective in the formation of behavioral setting in urban spaces (Hashemi & Ghalambordezfooly, 2021).

3) Smart lighting: In general, the main advantage of smart lighting is in its ability to harmonize with the environment and user conditions, in such a way that it tries to coordinate itself with what it should be at every moment. This coordination causes the user to find a special feeling for lighting (Adelvand, 2018).

4) Smart furniture and amenities: The design and use of smart technologies in urban furniture will be effective directly and indirectly in improving the level of sustainability and social welfare of citizens (jafarnejad & Naeini, 2020).

Theoretical framework

the discussion on walking in the smart city needs to take many factors into consideration including, but not limited to, sidewalks (length, width, material used, continuity, ease of use, presence of obstacles, accessibility to adjacent uses from the sidewalk, etc.), connectivity nodes with nearby uses, land use strategies (presence of mixed use and other essential focal points to ease everyday functions), type

of urban design for the street itself, comfort and ease of walking, visual aspects, enhancements and impairment during walking, sound, acoustics and noise levels during the walking journey, the overall leisure of the experience itself, and also congestion points and traffic junctures that may hinder the walking process.

As mentioned before, this research suggests that the concepts of walking and walkability in the smart urban spaces are defined by reference to the following four main design elements: (1) Urban Furniture; (2) Flooring and pavement pedestrian path; (3) Walls and Facads; and (4) Lighting of path. Smart city ICT enhanced solutions, such as Gamification tools, Smart pavements, Smart lighters etc. suggesting the better mobility. Finally, walking in smart urban spaces ones acts as a connector between the synergies of urban space and urban life (La Rocca, 2009). Figure 1 shows this conceptual framework.

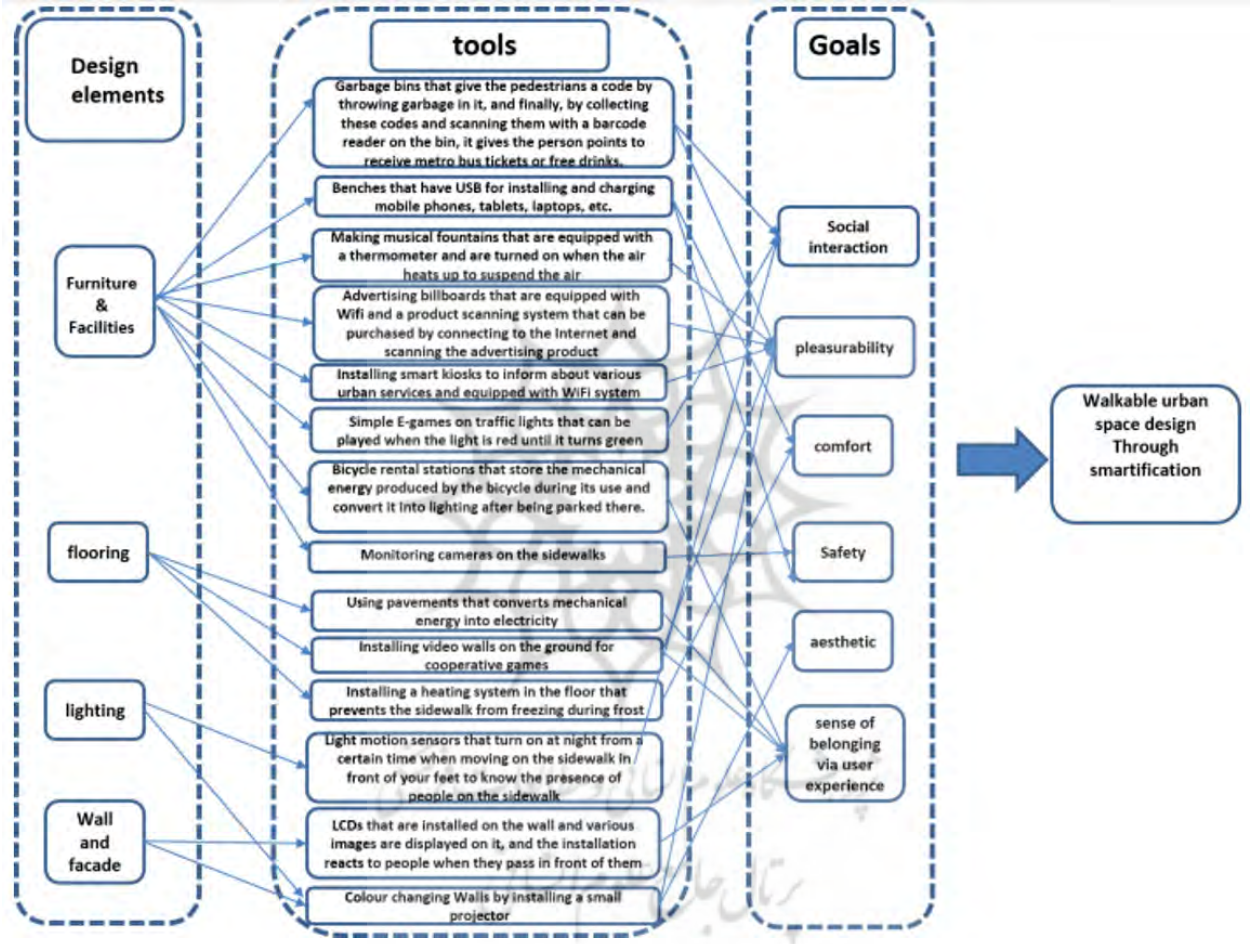

Fig.1: research conceptual model

MATERIALS AND METHODS

Research Methodology

The applied research group is where this study belongs. This study used a descriptive-analytical research design, and the data was gathered using two approaches: field interviews with local residents and library research.

This study employs a quantitative data analysis. Data were collected from urban areas implementing smart initiatives aimed at improving walkability. Surveys were conducted among residents to assess their perceptions of walkability after smartification efforts. Additionally, case study of Farahzadi Boulevard was analyzed to identify successful strategies. The questionnaire was designed based on research conceptual model. The statistical population for this case study is pedestrians in the surrounding area of Farahzadi Boulevard in West Tehran. A random sampling technique is used, and the estimated sample size using Cochran's formula is 384 persons. Additionally, SPSS software and the data gathered via the questionnaire were utilized to assess the research hypothesis. The Friedman test and the t-test were employed to evaluate the research assumptions.

Case Study

The case study is selected based on the availability of previous walkability studies in Iran.

"Shahrak Gharb" is a neighborhood in the northwest of Tehran, situated in the Tehran municipality's second district. A group of American engineers designed this neighborhood in 1340 with the intention of creating a contemporary Tehran. Because the planning pattern in this area is comparable to American patterns, it was given the name Shahrak Gharb. Due to its contemporary planning, broad, uniform avenues, low population density in comparison to other Tehran neighborhoods, welfare and medical amenities, villa homes, and convenient access to the city's main thoroughfares, this neighborhood is among the most valuable residential regions. (Fig. 2)

Also, the path of Farahzadi Boulevard in Shahrak Gharb neighborhood, due to the existence of diverse and attractive activities for walking trips, high social potential and traction, as well as the width of the sidewalks, can be a good choice for designing a walkable and smart urban space.

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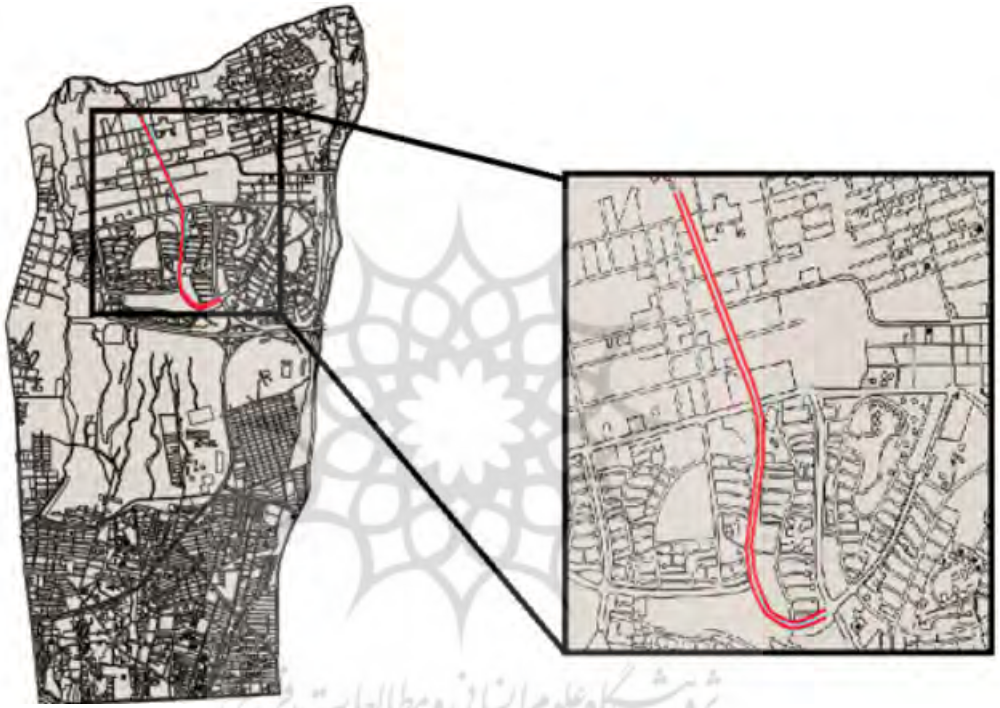

Fig. 2: The case study location in Shahrak Gharb neighborhood of Tehran

Fig. 3: Pictures of Farahzadi Blvd sidewalk which shows the high potential of social interaction and becoming an urban space.

RESULTS AND DISCUSSIONS

In order to answer the main question of the research "Is there a significant relationship between smartness and pedestrianized urban space or not?" The results of the T test presented in Table 5 are used. In the one-sample mean test, the null hypothesis and the opposite hypothesis (claimed hypothesis) are defined as follows.

smartification does not affect pedestrian-oriented urban spaces: H_(0)

smartification has an impact on pedestrian-oriented urban spaces: H_1

The results presented in Table 1 show that, considering that the probability value of the t statistic for the total index of smartness is 0.000, it can be said that at the confidence level of 95%, the hypothesis H1 was confirmed, in other words, smartness on pedestrian urban spaces. Circuit is effective and considering that at the 95% confidence level, the upper limit and lower limit are positive, it can be said that smartification has a positive effect on pedestrian urban spaces. At the same time, the results show that according to the t statistic, the significance level of all smartness indicators is less than 5%. In all six indicators, at the confidence level of 95%, the upper limit and the lower limit of each are positive, it can be said that smartification through all six indicators has a positive effect on walkable urban spaces. According to the above, the hypothesis can be confirmed at the confidence level of 95%.

Table 1. One sample T test results

	T	df	Sig(2-tailed)	Mean difference	at the 95% confidence interval of difference	
					lower	upper
Total smartification index	39.388	199	0	0.964	0.9161	1.0126
Belonging index	29.894	199	0	1.24	0.1582	1.3218
pleasurability index	36.21	199	0	1.119	1.0582	1.1801
Aesthetic index	21.689	199	0	0.833	0.7568	0.9082
Safety index	12.797	199	0	0.578	0.4885	0.6665
Index of comfort	3.299	199	0	0.235	0.0945	0.3755
Social interaction index	24.188	199	0	1.108	1.0172	1.1978

In order to achieve the design strategy, the results of the Friedman test presented in Table 2 and Table 3 are used to determine the priority in the design. Table 2 shows the number of observations, the value of the chi-square statistic, the degree of freedom and the significance level, respectively. Because the significance level is less than 5%, the null hypothesis is rejected and the claim of the same ranking of intelligence indicators is not accepted at the 95% confidence level.

Table 3 is a descriptive statistic that shows the average ranks of each index. The smaller the average ranks, the more important that indicator is. Considering that the "Belonging Index" has the lowest average, it has a better position in the field of intelligence. In general, among the six indicators, "comfort index" has the highest importance and "belongingness index" has the lowest importance.

Table 2: Statistical of Friedman's test

Number	*384*
Chi-square statistic (2χ)	*229.648*
df	*5*
Significance level (sig)	*0*

Table 3: Mean ranks

Sense of belonging	*4.39*
pleasurability	*4.22*
Aesthetic	*3.29*
Safety	*2.68*
Comfort	*2.35*
Social interaction	*4.08*

The findings suggest that the smartification of urban spaces plays a significant role in enhancing walkability of urban space. By leveraging technology to improve safety, comfort, and social interaction, urban designers can create environments that encourage walking as a primary mode of mobility. Based on this research result one of the primary benefits of smartification is enhanced safety for pedestrians. This result confirms the claim of previous research. In Barcelona, for example, the implementation of smart traffic signals has led to a 30% decrease in pedestrian injuries (City of Barcelona, 2020). In Singapore, the use of mobile apps that offer accessible route options for individuals with disabilities has improved overall walkability (Singapore Land Transport Authority, 2021). Also, in case of pleasurability index, smart amenities—such as benches with charging stations—has contributed to a more enjoyable walking experience. Case studies indicate that cities investing in pedestrian-friendly infrastructure see increased foot traffic and community engagement (Gehl, 2019).

CONCLUSION

This study aims to discover impact of smartification in urban spaces on walkability. This paper serves as a foundational exploration of how smartification influences walkability in urban areas, highlighting benefits while emphasizing the need for continued research in this evolving field. The smartification of urban spaces presents significant opportunities for enhancing walkability. As cities continue to evolve, integrating technology into urban planning will be essential for creating sustainable and pedestrian-friendly environments. Future research should focus on long-term impacts of smart initiatives on walkability and explore strategies for overcoming existing barriers.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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