PhD Research proposal

Jun Yang

Mobile:+358449723619

E-mail:jun.1.yang@aalto.fi

Exploration for an effective workflow in urban analysis through artificial intelligence: evaluating and advising walkability under machine learning models

Abstract

Walkability is an essential indicator to measure how friendly a road is for pedestrians. Walkable neighbourhoods not only encourage interaction between citizens but also enhance wellbeing in cities. Though studies related to walkability have been conducted in the last few decades, there is neither a clear definition of what is relevant to walkability nor standardized instruments to assess it. To be specific, the quantitative methods used for assessing walkability often fail to understand the reality of actual space in consequence of utilizing indicators of low relevance. While the ethnographic approach might reveal the perception of a particular space, it is rather time-consuming and difficult to carry out a generalization which can be applied to other locations. Furthermore, the efficiency or accuracy of the measurement for walkability is often unknown for the lack of validation. According to the problems mentioned above, the research intends to achieve the following goals. 1) to redefine weighted indicators correlated to walkability by conducting surveys and analyzing relevant data with clustering methods; 2) to construct a program to evaluate walkability through training data with classification methods and to provide advice for enhancing walkability in districts with low-walkable level through training dataset containing samples with a high degree of walkability. 3) to validate the program by applying it to concrete case studies and conducting expert interviews in Finland. The significance of the research is to create an evaluator program which presents the walkability in both micro and macro scale effectively and precisely to assist the decision-maker to recognize the potential benefits or risks in specific urban areas.

1.Background and topicality of the study

1.1 Street as a fundamental element in cities since ancient

Before the motor vehicle era, most of the cities in the world were reliant on pedestrian systems, which ensured picturesque public life. Nevertheless, when the vehicular manufacture was initiated around a century ago, countless cities have experienced a striking conversion of pedestrian-street-based urban systems into widened roads occupied by motor vehicles in the urban fabric. Tracing back over half a century, researchers had already realized that streets are crucial elements in cities to support public life. In the 1950s, Kevin Lynch, an American urban planner and author, mentioned the importance of urban streets, which are considered as the skeleton of the city image. (Lynch, 1975) Furthermore, under Jane Jacobs´ description, streets are not a simple instrument offering a connection between places, but also carrying the communication of public life. (Jacobs, 1961) Following that, as the pioneer of public space research, Jan Gehl has also devoted himself to advancing street space by evaluating the complexity of architectural facades, the speed limits and so on. (Gehl and Svarre, 2013) Those predecessors have verified that streets play an irreplaceable role for cities.

1.2 Impact of Walkability

Recently, many researchers have commenced appreciating walkability and they have also figured out how walkability has a significant effect on various aspects of our society. For instance, Jeff Seck, an American city planner, mentioned how a walkable region is able to promote an increasing value of a property, stimulating the economy and strengthening public health. (Speck, 2013) More significantly, in some research, the neighbourhood with low walkability has been linked to obesity among locals. (Colley *et al.*, 2019) (Hoehner *et al.*, 2011) Despite the fact that high walkability has the advantage to improve city life, it is vital to accelerate public awareness of its importance under the current inactive lifestyle. As an example, individuals nowadays are constantly surrounded by computers and smartphones, which has formed a sedentary life killing a considerable number of citizens yearly. (Biddle *et al.*, 2016) (Barreto, 2013) Walking, as an affordable and effective activity, was profoundly demonstrated to reduce risks of chronic disease and has a positive impact on public health. (Diehr and Hirsch, 2010) For these reasons, it is essential to explore a

more effective approach to indicate walkability for the purpose of constructing more walkable urban space.

2. Challenges and unprecedented opportunities

2.1 Hindrance of promoting walkability in practice

In spite of knowing the significance of walkability in urban regions, there is fierce resistance preventing its implementation in practice due to an unclear definition of walkability and non-evidence-based hypothesis. (Moura, Cambra and Gonçalves, 2017) There are two main instruments for evaluating walkability in cities. First, indicators which are believed to be related to walkability are utilized to calculate walkability under GIS, which leads to two problems. 1) The indicators used in GIS alone have limitations in depicting the attributes in actual streetscape owing to lack of three-dimensional perception. (Lee and Talen, 2014) 2) There is no standardized utility of experience-based indicators (Lefebvre-Ropars and Morency, 2018) in consequence of the uncertain correlation indicators and walkability, which leads to challenges in generalizing guidelines for city planners. The second is a qualitative approach, which may include a survey, a semi-structured interview or observation. For instance, by observation and interview, Appleyard and Lintell revealed how a difference in traffic capacity affects social life on the streets. (Appleyard and Lintell, 1972) While a qualitative way can describe an obvious characteristic of street space, it is time- and resource-intensive and can be only applied to a fairly small area. (Kelly *et al.*, 2011) In addition to the challenge of assessment methods, decision makers tend to believe walking can take care of itself (Litman, 2003), which leads to unawareness of the importance of walkability. On the ground of the situation mentioned above, it is urgent to explore an innovative instrument not only to assess walkability in a more accurate and efficient manner but also to have competence in convincing and guiding the decision makers to enhance walkability in urban space. In order to pursue the goal, two questions will be submitted. First, what indicators are the most correlated to walkability and which approach can be used to find out the most representative indicator? Second, how to present walkability based not only on quantitative indicators but also on perceptible attributes in real space?

2.2 A tendency for utilizing artificial intelligence in various fields

Artificial intelligence(AI) has emerged widely in various fields in recent years, as well as interdisciplinarity between AI and urban planning has turned a tendency. Not only the fields like face recognition and natural language processing benefit from using artificial neural networks (ANN), it also becomes possible to conduct research on public space preference through machine learning. (*Plaza Life Revisited*, no date) Last few years, there is an inclination of utilizing AI in urban-related studies. By way of illustration, a British team has invented a deep learning framework called Facelift to rank scenes in urban areas based on the aesthetic aspects and provide a possibility to generate transformed beautiful scenes on the existing street views. (Joglekar *et al.*, 2020) Another study has employed ANN to rank urban images on six perceptual attributes, based on which the images will receive different scores. (Dubey *et al.*, 2016) Yet, the utility of AI in urban planning is not prevailing, in the context of the development of big data, the use of AI may make more contributions to urban spatial analysis. For possessing the incomparable capacity to memorize data, the computational technique may provide an opportunity to reveal underlying laws from tens of thousands of street samples. So following the reasons above, the third question is how to utilize AI in walkability research and how to validate the effectiveness and reliability of a program created to assess walkability?

3. Research Objective

To answer the research questions mentioned earlier, the objective will be divided into three sections. The initial phase is to discover and redefine the indicators of walkability in order to seek evidence of what indicators are strongly linked to walkability. The findings then will be used as guidelines for the second phase that aims to construct a computer program containing two components to evaluate walkability and provide advice to a district with low walkability respectively. The purpose of this phase is to explore an innovative approach to represent walkability in multiple perspectives with attributes. Lastly, it is important to validate the efficiency and accuracy of the constructed computer program, so it can be applied to a practical process of urban analysis and be further developed in the future. The implication of the study is to present the degree of walkability in a randomly selected location when data is available, so it enables decision makers to

focus on solving more critical problems to improve the urban environment than spending a massive amount of time on sites visiting and investigating spaces in person.

4. Research methodology

The research methodology includes data collection, data analysis, program construction and validation. In data collection, an image-based survey in the research area will be conducted to gather the general public views on walkability and indicators of walkability selected from empirical evidence will be linked to available datasets. To reveal relationships between different indicators and walkability, survey results and dataset will be compared utilising principal components analysis (PCA). According to the results from PCA, a program will be established to understand the attributes involved in the walkability for the purpose of walkability grading and advising by employing different types of machine learning methods. Ultimately, the program will be tested under case studies based on real or virtual three-dimensional urban space in Finland and expert interviews may be involved to validate the efficiency and accuracy of the complete workflow.

4.1 data preparation and data analysis

The initial stage in research includes literature reviews and data collection. The literature reviews consist of theoretical, empirical and methodological literature. (Flick, 2014). Theoretical literature helps understand the role of walkability in a macroscopic scale in cities and how it has developed in the past. By reading empirical literature, walkability indicators will be distilled to find out their correlation to walkability. In order to conduct the research in a step-by-step manner, methodological literature will act as a guideline in the construction of the entire workflow, so the final goal can be pursued. Data collection includes two parts. Image data will mainly rely on images from Google Street View with coordinates, which will be used in a survey to obtain opinions of walkability from the public. The aim of the public survey is to gather people's views of their residing city as widely as possible, so it can be used as a reference to compare to the indicators selected from the empirical literature. Other types of data which represent indicators will be gathered through Statistics Finland or from local municipalities.

Data analysis aims to reveal the correlation between indicators and walkability by utilising PCA and semantic segmentation tools. PCA is a powerful data analysis tool to find correlation between attributes. (Bloomer and Rehm, 2014) Simultaneously, the image data used in the survey will be analyzed by applying semantic segmentation tools, which is used to detect objects with boundaries in images. Similarly, under PCA a correlation between walkability and labels in the images can be also found. With those analyses, it is possible to redefine the indicators which have a significant impact on walkability.

4.2 Program construction

According to the results from the previous step, it is possible to construct a program consisting of two components which not only evaluate walkability by offering a score to a randomly selected location where data are available but also supply advice to the neighbourhood with low walkability. Based on the degree of correlation between indicators and walkability, the first component will return a single score through calculating values of each relevant indicator from the dataset and labels from image respectively. Subsequently, an aggregate score will be generated to represent the walkability in that selected location. For providing advice to areas with low walkability, a separate ANN as the second component will learn the collected image data which receive high scores in walkability from first components. After a certain amount of the accumulation of sample study, the second ANN might possess the ability to create a proposal for promoting walkability on random street space. Generative adversarial networks might be used to train this neural network model, as it has been proven to hold impressive performance of generating images. (Karras *et al.*, 2017)

4.3 Evaluating the efficiency and accuracy

To validate the efficiency and accuracy of the program output, it will be tested under randomly selected virtual or real streetscape in Finland. Simultaneously, semi-structured interviews with experts might be conducted to evaluate how well the program can facilitate city planners to analyze walkability compared to the conventional procedure, so the advice gathered from the interview can be used for the further development of the program.

Reference

Appleyard, D. and Lintell, M. (1972) 'The Environmental Quality of City Streets: The Residents' Viewpoint', *Journal of the American Institute of Planners*, 38(2), pp. 84–101.

Barreto, P. de S. (2013) 'Why are we failing to promote physical activity globally?', *Bulletin of the World Health Organization*, 91(6), pp. 390–390A.

Biddle, S. J. H. *et al.* (2016) 'Too much sitting and all-cause mortality: is there a causal link?', *BMC public health*, 16, p. 635.

Bloomer, C. and Rehm, G. (2014) 'Using Principal Component Analysis to Find Correlations and Patterns at Diamond Light Source', in. JACoW, Geneva, Switzerland. doi: 10.18429/JACOW-IPAC2014-THPME188.

Colley, R. C. *et al.* (2019) 'An examination of the associations between walkable neighbourhoods and obesity and self-rated health in Canadians', *Health reports / Statistics Canada, Canadian Centre for Health Information = Rapports sur la sante / Statistique Canada, Centre canadien d'information sur la sante*, 30(9), pp. 14–24.

Diehr, P. and Hirsch, C. (2010) 'Health benefits of increased walking for sedentary, generally healthy older adults: using longitudinal data to approximate an intervention trial', *The journals of gerontology. Series A, Biological sciences and medical sciences*, 65(9), pp. 982–989.

Dubey, A. *et al.* (2016) 'Deep Learning the City: Quantifying Urban Perception at a Global Scale', in *Computer Vision – ECCV 2016*. Springer International Publishing, pp. 196–212.

Flick, U. (2014) *Introduction to Qualitative Research*. SAGE Publications, Limited.

Gehl, J. and Svarre, B. (2013) *How to Study Public Life*. Island Press.

Hoehner, C. M. *et al.* (2011) 'Association between neighborhood walkability, cardiorespiratory fitness and body-mass index', *Social science & medicine*, 73(12), pp. 1707–1716.

Jacobs, J. (1961) 'Jane Jacobs', *The Death and Life of Great American Cities*. Available at: http://www.academia.edu/download/58736355/5816-15512-1-PB20190328-113674-17px9eh.pdf.

Joglekar, S. *et al.* (2020) 'FaceLift: a transparent deep learning framework to beautify urban scenes', *Royal Society open science*, 7(1), p. 190987.

Karras, T. *et al.* (2017) 'Progressive Growing of GANs for Improved Quality, Stability, and Variation', *arXiv [cs.NE]*. Available at: http://arxiv.org/abs/1710.10196.

Kelly, C. E. *et al.* (2011) 'A comparison of three methods for assessing the walkability of the pedestrian environment', *Journal of Transport Geography*, 19(6), pp. 1500–1508.

Lee, S. and Talen, E. (2014) 'Measuring Walkability: A Note on Auditing Methods', *Journal of Urban Design*, 19(3), pp. 368–388.

Lefebvre-Ropars, G. and Morency, C. (2018) 'Walkability: which measure to choose, where to

measure it, and how?', *Transportation research record*, 2672(35), pp. 139–150.

Litman, T. A. (2003) 'Economic Value of Walkability', *Transportation Research Record: Journal of the Transportation Research Board*, pp. 3–11. doi: 10.3141/1828-01.

Lynch, K. (1975) 'The Image Of The City, Massachusetts Institute Of Technology Cambridge'. The MIT Press, Massachusetts.

Moura, F., Cambra, P. and Gonçalves, A. B. (2017) 'Measuring walkability for distinct pedestrian groups with a participatory assessment method: A case study in Lisbon', *Landscape and urban planning*, 157, pp. 282–296.

Plaza Life Revisited (no date). Available at: https://www.swagroup.com/idea/plaza-life-revisited/ (Accessed: 23 October 2020).

Speck, J. (2013) *Walkable city: How downtown can save America, one step at a time*. macmillan.