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Measuring human perceptions of urban landscape using machine learning: factors affecting perceived walkability of street-view image

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Abstract:

Studies utilizing street-view images for the impacts of the urban environment on the human qualitative perception of the city are currently on the rise. The research methodology includes analysis of characteristics of the urban environment based on the survey results of people's evaluation of the city relevant to specific criteria such as beauty, charm, and boring, measured with an absolute score. However, identifying features in the landscape that affect human perception of the walkability is imperative to the improvement of the urban construction environment. This study attempted to analyze which factor of the city significantly affects the score of perceived walkability. By using semantic segmentation, we extracted the ratio of each feature in the image and analyzed the features affecting the perceived walkability through machine learning. In this research, we particularly focused on finding the optimal machine learning method. The methodology proposed in this study contributes to the understanding of the factors of urban environments that affect semantic human perceptions.

For this study, we collected 196,624 street view images from roads in Jeonju City, South Korea by crawling the KAKAO street view data. Using these, Kim and Kang (2022) predict the perceived walkability score of whole images through deep learning, which is the dependent variable of this study. The mean of the score is -0.21, the minimum is -10.21, and the maximum is 7.52. A score that goes positive means that the perceived walkability of the scene is better; a score that goes negative means the opposite.

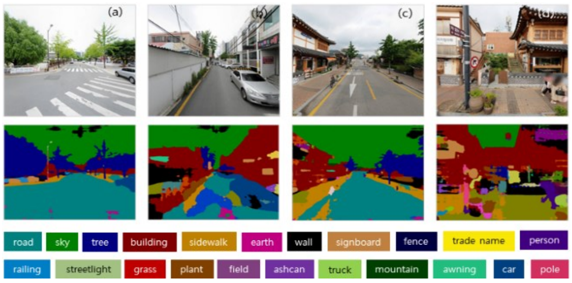

Figure 1. Example of semantic segmentation and 22 features, which are selected after pre-processing.

Semantic segmentation is the method that calculates the pixel ratio of each feature from the image. In this study, the ratio from Park et al. (2022), which used the segmentation method to get the ratio from street view images, is used as an independent variable of machine learning. ADE20K dataset is chosen as a training dataset, which has 150 features of indoor and outdoor scenes in Park et al. (2022). We only have the outdoor scene images and had to remove indoor and useless undetected features for the accuracy of the machine learning. Therefore, we removed features that over 90% of the 196,624 data that segmentation ratio is 0, and after pre-processing there are 22 features left (road, sky, tree, building, sidewalk, car, wall, signboard, fence, earth, pole, railing, streetlights, grass, plant, field, ashcan, truck, mountain, awning, trade name, person) (Figure 1). The range of segmentation ratio is 0 to 1.

As previously mentioned, we compared 8 machine learning methods (multiple linear regression (MLR), Lasso regression, Ridge regression, ElasticNet regression, XGBoost, Random Forest (RF), Support Vector regression (SVR), and Artificial

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Neural Network (ANN)) and considered the coefficient and feature importance of best model to explain the relationship between semantic segmentation features and predicted score of perceived walkability. Table 1 shows that SVR performed the best based on the MSE, MAE, R^2 scores, which are measurements of regression performance. Figure 2 shows the coefficients and feature importance of SVR.

	MLR	Ridge	LASSO	Elastic	XGB	RF	SVR	ANN
MSE	0.6580	0.6580	0.6637	0.6657	0.6768	0.5285	0.4697	0.7869
MAE	0.5916	0.5916	0.5939	0.5947	0.5958	0.5320	0.4982	
R^2	0.6303	0.6303	0.6271	0.3891	0.3798	0.5492	0.6106	

Table 1. Results of machine learning models. The best model in this paper is SVR.

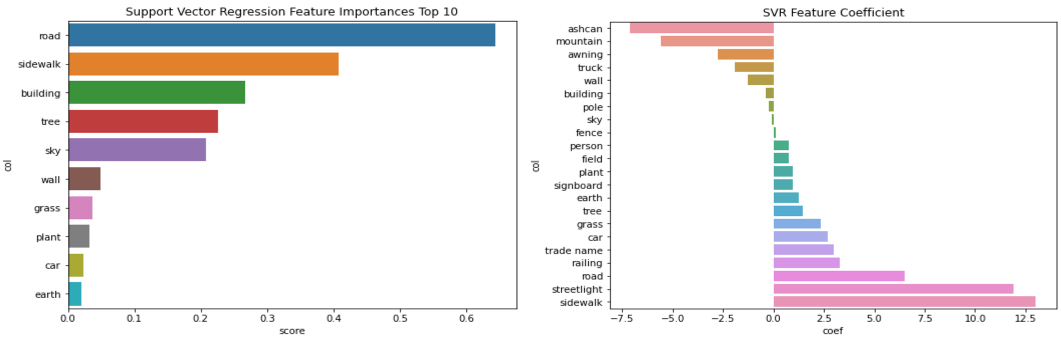

Figure 2. Feature importance graph (left), coefficient of SVR (right).

From Figure 2, the road, sidewalk, and building are the most important and effective feature of the perceived walkability score, which is the obvious result that factors such as road and sidewalk affect walking. Also, the result shows the greenery features (tree, sky, grass, and plant) are effective factors. In the feature coefficient graph, we noticed the sidewalk and road work positively to the score, but the building and wall show negative coefficient. This can be interpreted that the area of this study is an old city, and therefore the high ratio of buildings and walls in the scene means that area is a backward part of the city. Another interesting result is that sky and mountain work negatively on the walkability score. The same reason for building and wall, the study area is a provincial city and the image we collected was from in the city and around the city. Around the city, there are plenty of bare grounds, so that can be analyzed the high ratio of sky and mountain, which means that the area is not appropriate for walking.

In this paper, we showed the relationship between outdoor features and perceived walkability score by comparing 8 machine learning models and extracting the best models' feature importance and coefficient. The result of the comparison, SVR is chosen to show which feature affected the scores of perceived walkability and how it works. This work proved that qualitative data can be explained by machine learning methods and it will help the understanding of how people feel about the walking environment. Also, this work shows how each factor of the city influenced the perceived walkability score by using machine learning.

The limit of this work is that although we show relations by machine learning, the results can be understood as part of common sense. To make improvements in our future work, handling the outlier of data or a number of features will be helpful to improve the evaluation score and see more details. Also, setting the quantile perceived walkability score as a dependent variable can be helpful to see a change in each feature coefficient. The semantic segmentation ratio can be replaced by an image by analyzing the object detection so that image can be the independent variable.

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References

Kim. J. Y. and Kang. Y. O., 2022, Development of a Deep Learning Model to Predict the Qualitative Evaluation of a Walking Environment based on Street View Images, Journal of Korean Society for Geospatial Information Science, 30(2), 45-56

Park. J. Y., Kang. Y. O., and Kim. J. Y., 2022, Development of Walkability Evaluation Index Using Streetview Image and Semantic Segmentation, Journal of the Korean Cartographic Association, 22(1), 53-68

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