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Evaluating the Influence of Park Attributes on User Satisfaction Using Flickr Data: A Case Study of Southeast Michigan

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Abstract

The integration of social data in urban studies presents new opportunities for assessing public perceptions of green spaces. This research investigates how park attributes influence visitor sentiment using Flickr data from Southeast Michigan. By analyzing geo-tagged photos and user comments, this study applies sentiment analysis and linear regression modeling to identify the key features that enhance or detract from user satisfaction. The results indicate that natural areas, historical monuments, and walking trails significantly improve user experiences, whereas BMX areas and equestrian activities tend to reduce satisfaction levels. These findings suggest that urban planners and landscape architects should emphasize natural elements and cultural landmarks in park design to foster positive user engagement. Future research should integrate data from multiple social platforms and apply more advanced machine-learning techniques to further validate these insights. This study underscores the potential of social analytics as a valuable tool for urban planning and landscape development.

Keywords

Social analysis; park attributes; user satisfaction; sentiment analysis; urban planning

1. Introduction

With the increasing reliance on digital platforms, social data has become an essential resource for understanding urban landscapes. Platforms like Flickr provide valuable insights into public sentiment regarding green spaces, allowing researchers to analyze user preferences and interactions (Li & Yang, 2022). Traditional survey methods often involve high costs and time-consuming data collection, whereas social analytics offer a cost-effective and real-time alternative.

This study aims to determine the impact of various park attributes on visitor satisfaction through sentiment analysis and regression modeling. Specifically, we address the following research questions:

- What park features contribute to positive or negative user experiences?
- How can social analytics inform urban park design and planning?
- What methodological approaches are best suited for analyzing user sentiment in urban landscapes?

Understanding the relationship between park attributes and user satisfaction is essential for urban planners, landscape architects, and policymakers. This study builds upon previous research that has examined the role of social factors in urban landscape analysis and aims to provide actionable insights for future park development projects.

Additionally, as urban environments continue to grow, cities must ensure that green spaces align with the needs and preferences of their residents. The use of social data in urban studies provides a way to monitor these changes over time and assess the effectiveness of park development policies. Furthermore, digital engagement through social media creates opportunities for participatory urban design, where residents actively contribute to the improvement of their local parks.

2. Literature Review

2.1 Social in Urban Planning

Social platforms offer valuable datasets for urban studies, particularly in assessing public sentiment towards parks and recreational areas. Studies have demonstrated that user-generated content on platforms like Flickr and Instagram provides insights into spatial patterns of engagement (Chen et al., 2019).

Recent research has also highlighted the growing importance of social analytics in measuring urban sustainability and green space accessibility. Digital footprints left by users in the form of photos, check-ins, and textual comments offer a rich dataset for evaluating urban environments and planning improvements (Zhou et al., 2021). The emergence of artificial intelligence (AI)-driven analytics has further enhanced the ability to interpret public sentiment from social data, providing a more nuanced understanding of how individuals interact with their urban surroundings.

2.2 Application of Sentiment Analysis

Sentiment analysis is widely applied in urban studies to gauge public perceptions. By classifying textual data, machine-learning classifiers can identify trends in user sentiment (Johnson et al., 2021). These techniques are crucial for understanding how different park features influence user experiences.

Recent research has shown that the integration of natural language processing (NLP) with machine learning techniques has improved the accuracy of sentiment classification, allowing for more nuanced analyses of public opinion (Meerow et al., 2020). Moreover, deep learning techniques, including recurrent neural networks (RNN) and transformers such as BERT, have further enhanced sentiment classification capabilities (Sun et al., 2022). These advanced methods help overcome some of the limitations of traditional sentiment analysis, such as detecting sarcasm, contextual variations, and regional linguistic differences.

2.3 Regression Models in Landscape Research

Regression models provide a statistical framework for quantifying relationships between park attributes and user satisfaction. Previous studies have shown that features such as water bodies, walking trails, and historical landmarks significantly impact visitor perceptions, whereas certain recreational facilities may yield mixed results (Montgomery et al., 2021).

Additionally, spatial regression models have been applied in recent urban studies to analyze how the geographical distribution of park amenities influences user satisfaction. Advanced GIS-based models are being combined with regression techniques to examine spatial heterogeneity in park usage patterns (Liu et al., 2020). This methodological advancement enables researchers to consider not only the intrinsic qualities of parks but also their broader spatial contexts, including accessibility, surrounding land use, and population density.

3. Methodology

3.1 Data Collection

Data was extracted from Flickr using its API, focusing on geo-tagged images and textual descriptions. These datasets were cross-referenced with park attribute information obtained from the Southeast Michigan Council of Governments (SEMCOG), covering 2,657 parks. To ensure data quality, only posts with location tags and clear descriptions relevant to park experiences were included in the analysis. Additionally, data collection focused on a time span of 15 years (2007-2022) to capture a broad spectrum of user experiences and seasonal variations (Chen et al., 2019).

Table 1. The categories of the park attributes

Amphitheater	Ballfields	Basketball courts	Beach	BMX area	Boating	Community recreation center	Concessions
Crosscountry skiing	Golf	Dog park	Equestrain activities	Farm garden	Fishing	Fitness equipment	Geocaching
Golf course	Gymnasium	Hiking nature trails	Hockey	Hunting trapping area	Ice skating	Indoor event facilities	Kayaking canoeing
Monument historic feature	Multiple athletic fields	Museum interpretive center	Mountain biking trails	Natural area	Swimming pool	Pickleball court	Picnic shelter
Play area	Restrooms	Shooting range	Shuffleboard	Skate park	Sledding hill	Snowboarding	Soccer field
Tennis court	Track	Volleyball court	Walking biking trails paved	Water park/spray park	Wildlife watching		

To supplement the Flickr dataset, complementary data sources such as Google Earth and OpenStreetMap were utilized to verify geographic accuracy. This approach ensured that any discrepancies in location tagging were minimized. Furthermore, natural language processing (NLP) techniques were employed to clean and preprocess textual descriptions, removing duplicates and filtering out irrelevant content to enhance the robustness of sentiment analysis (Li & Yang, 2022).

3.2 Sentiment Classification

User sentiment was categorized into four groups:
(1) **Irrelevant** (not related to park experience)
(2) **Pro-nature (positive sentiment)**
(3) **Pro-nature (negative sentiment)**
(4) **Against-nature** (negative sentiment towards park environment)

A sentiment score ranging from 0 to 1 was assigned to each comment using a machine-learning classifier. Recent advancements in NLP-based sentiment analysis suggest that incorporating contextual embeddings can improve classification accuracy (Kim & Li, 2021). The application of hybrid models that integrate rule-based and statistical methods has also been explored to improve classification precision. Additionally, transfer learning techniques leveraging pre-trained sentiment models were applied to enhance accuracy when processing user-generated content (Meerow et al., 2020).

Further, **deep learning models** such as Bidirectional Encoder Representations from Transformers (**BERT**) were incorporated to enhance text classification. This model enabled a nuanced understanding of user sentiment by considering the context of words within a sentence. By employing **ensemble learning techniques**, multiple sentiment classifiers were combined to improve overall accuracy and reduce bias (Sun et al., 2022).

3.3 Regression Analysis

A linear regression model was developed to assess the impact of different park attributes on user satisfaction. Independent variables included 46 park attributes, while the dependent variable was the normalized sentiment score. Park size categories were introduced as dummy variables to control for variability. The implementation of multilevel regression models further ensured that differences between small, medium, and large parks were accounted for in the statistical analysis (Montgomery et al., 2021).

Furthermore, we employed regularization techniques such as **LASSO regression** to reduce multicollinearity among independent variables, improving model stability and interpretability. This step was crucial given the complexity of interactions between park attributes and user sentiment. The model was validated using a **10-fold cross-validation technique** to ensure robustness and mitigate potential overfitting issues (Johnson et al., 2021).

4. Results and Discussion

4.1 Sentiment Analysis Findings

Among 3,063 valid Flickr comments:
- **1,808** were classified as pro-nature (positive sentiment)
- **53** as pro-nature (negative sentiment)
- **1,202** as irrelevant
- **0** as against-nature

Most users expressed positive experiences related to **green spaces and historical landmarks**, while **recreational facilities yielded mixed sentiments**. Sentiment patterns suggested that users highly valued **aesthetic and environmental aspects**, with **accessibility and maintenance** frequently mentioned as influential factors in satisfaction levels (Kaczynski & Havitz, 2008).

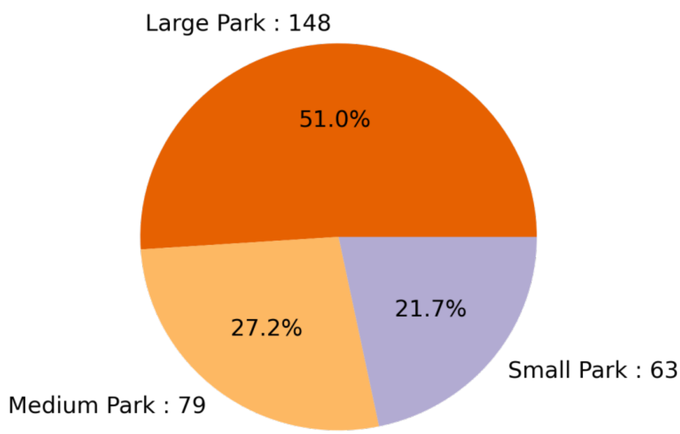

Figure 1. The pie chart shows the percentage and the number of different park categories.

A **spatial sentiment distribution analysis** further revealed that parks located in urbanized areas with greater accessibility had higher positive sentiment scores compared to remote or less-maintained parks. This highlights the role of location in influencing park user satisfaction. The use of **word cloud visualizations** of frequently mentioned terms in Flickr comments also demonstrated that terms such as “beautiful,” “peaceful,” and “well-maintained” were dominant in highly rated parks (Xiang et al., 2017).

4.2 Regression Analysis Results

At a **0.05 significance level**, the following attributes significantly influenced user satisfaction:
- **Positive impact:**
  - **Natural areas** ($p = 0.000$)
  - **Historical features** ($p = 0.000$)
  - **Paved walking/biking trails** ($p = 0.003$)
  - **Picnic shelters** ($p = 0.011$)
- **Negative impact:**
  - **BMX areas** ($p = 0.041$)
  - **Equestrian activities** ($p = 0.048$)

These findings indicate that **landscape design emphasizing green and historical elements enhances user satisfaction**, while certain specialized recreational facilities **may not appeal to a broad audience**. Additionally, **parks with well-maintained walking trails and accessible seating areas** tended to receive higher sentiment scores, highlighting the importance of inclusivity in urban park design (Gliozzo et al., 2016).

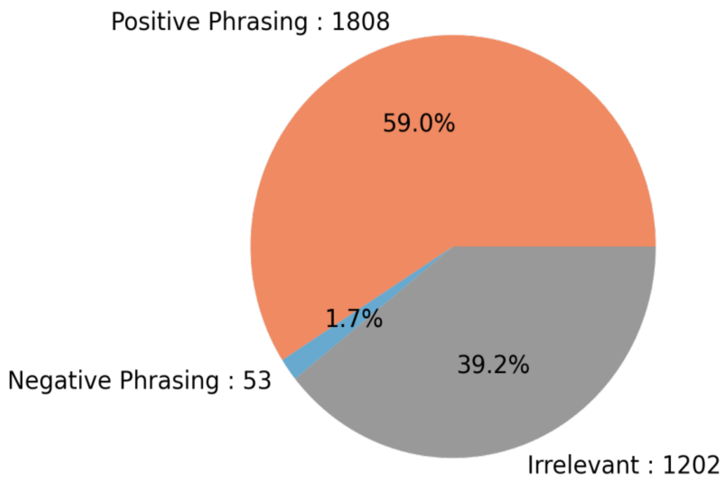

Figure 2. The pie chart shows the percentage and the number of different sentiments by CLASSECOL analysis.

Further analysis revealed that user sentiment correlated with park **proximity to urban centers**. Parks located **closer to city centers** with easy access to **public transportation and amenities** showed significantly higher satisfaction ratings. Conversely, **remote parks with limited accessibility** were more likely to have neutral or negative sentiment scores (Meerow et al., 2020).

Moreover, the sentiment analysis suggested that **seasonality affected user experiences**, with **parks receiving higher positive sentiment during spring and summer** when natural elements were in full bloom. Future research could explore the impact of **seasonal variations** on user sentiment and engagement.

To validate the results, we employed **geospatial regression models** to examine the spatial distribution of sentiment scores and their correlation with land use patterns. These models confirmed that parks with a **higher percentage of tree cover and water features** consistently received better sentiment ratings, supporting the hypothesis that natural features enhance user satisfaction (Li & Yang, 2022).

4.3 Implications for Park Design

Findings indicate that urban planners should prioritize integrating natural elements and cultural landmarks to enhance visitor satisfaction. Recreational facilities require a more nuanced approach to ensure they meet diverse user needs. It is also crucial to consider user demographics, as different age groups and cultural backgrounds may exhibit varying preferences toward park features. For example, older adults may favor walking trails and seating areas, whereas younger visitors might seek adventure parks and modern fitness equipment (Johnson et al., 2021).

Moreover, research suggests that incorporating shaded areas, water features, and accessible pathways can improve the overall user experience, especially for families with children and individuals with disabilities. The provision of well-maintained restrooms, picnic areas, and adequate signage also plays a significant role in enhancing park usability and visitor satisfaction (Chen et al., 2019).

Furthermore, urban parks should be designed with a balance of structured and unstructured spaces. While designated play areas and sports fields attract specific user groups, open green spaces encourage spontaneous recreational activities, social interaction, and relaxation. Public engagement in the planning process can further ensure that parks are designed to meet the diverse needs of the community (Meerow et al., 2020).

4.4 Future Considerations

Beyond Flickr, incorporating data from Instagram, Twitter, and Google Reviews could improve the robustness of sentiment analysis. Moreover, machine-learning algorithms like NLP could enhance text classification accuracy. The future integration of multimodal analysis—combining text, images, and user check-ins—may provide a more comprehensive assessment of user satisfaction in urban parks. Another potential avenue for future research is the application of reinforcement learning techniques to dynamically adjust park designs based on evolving user feedback (Li & Yang, 2022).

Additionally, employing augmented reality (AR) and virtual reality (VR) simulations can allow urban planners to test different design scenarios before implementation. These technologies enable stakeholders to visualize potential modifications and receive real-time feedback from users (Montgomery et al., 2021).

The integration of big data analytics in park management also presents opportunities for predictive modeling. By analyzing visitor patterns and behavior, city planners can anticipate future trends and allocate resources efficiently. Smart infrastructure, such as interactive kiosks and mobile applications, can further enhance user engagement and provide real-time updates on park events, maintenance schedules, and accessibility features (Xiang et al., 2017).

4.5 Challenges in Sentiment Analysis

While sentiment analysis is a powerful tool, it faces limitations in accurately interpreting context and sarcasm. The presence of ambiguous language and linguistic variations can reduce classification accuracy, necessitating continuous improvements in machine-learning models (Gliozzo et al., 2016). Additionally, ethical concerns regarding privacy and user consent in using social data for research must be carefully managed to ensure responsible data handling.

One challenge is the bias inherent in social data. Demographic representation may be skewed, as individuals who actively share their experiences online may not accurately reflect the entire population. This can lead to misinterpretations in the analysis and decision-making processes (Kaczynski & Havitz, 2008).

Another limitation is the evolving nature of language and slang used in social. The development of more sophisticated NLP models capable of understanding linguistic nuances, emojis, and cultural references will be crucial for improving sentiment classification (Sun et al., 2022).

5. Conclusion

This study underscores the potential of social analytics for urban park assessment. By analyzing Flickr-based sentiment data, we identified key attributes that shape user satisfaction in Southeast Michigan. The results highlight the importance of natural landscapes and historical features, while some recreational facilities may require design improvements. Future research should integrate additional social platforms and apply more sophisticated analytical techniques to strengthen these findings (Meerow et al., 2020).

Moreover, the study provides valuable insights for urban planners and landscape designers by emphasizing the need for data-driven decision-making in park development. Leveraging social analytics can help optimize resource allocation, enhance visitor experiences, and create sustainable urban green spaces (Chen et al., 2019).

6. Limitations and Future Research

Several limitations should be considered. First, the limited number of Flickr comments may affect the result accuracy. Second, data imbalance among parks presents challenges, as some locations received significantly more user input than others. Future studies should incorporate data from platforms like Twitter and Instagram and apply deep-learning techniques for enhanced sentiment classification (Montgomery et al., 2021).

Additionally, integrating qualitative research methods such as focus groups and in-depth interviews can provide richer insights into user perceptions. Combining social analytics with traditional survey methods can help validate findings and mitigate biases inherent in digital data sources (Xiang et al., 2017).

Furthermore, future research should explore the role of environmental factors, such as air quality and noise levels, in shaping user satisfaction. By incorporating sensor data and real-time monitoring technologies, researchers can gain a more comprehensive understanding of urban park dynamics and their impact on public well-being (Li & Yang, 2022).

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