**Internet Speeds and Smart City Development**

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**Abstract**

This study investigates the relationship between internet speeds and smart city features in the United Arab Emirates (UAE) during the fourth quarter of 2021, using nighttime light radiance as a proxy for urban activity. By analyzing geospatial, temporal, and radiance data across various regions, the study explores whether regions with advanced urban infrastructure exhibit superior internet speeds. The findings reveal a significant correlation between internet performance and urban activity, emphasizing the role of internet infrastructure in supporting smart city development. A prediction model further highlights how radiance trends can forecast internet performance in urban areas.

**Introduction**

As cities in the UAE evolve into smart cities, characterized by digital connectivity and efficient infrastructure, internet speeds play a pivotal role in enabling smart features. Nighttime light radiance, a measurable indicator of urban activity and infrastructure, provides a unique lens to examine these dynamics. This study aims to uncover patterns and correlations between radiance levels and internet speeds in the UAE, offering insights into the alignment of urban planning and digital connectivity.

**Problem Statement and Objectives**

Internet speeds are a critical component of smart city infrastructure, yet their distribution across regions and correlation with urban activity levels remain underexplored in the UAE. This study aims to examine the relationship between internet speeds and urban activity, using nighttime light radiance as a proxy for urban development in the UAE. It seeks to highlight regional disparities in internet performance through comprehensive visualizations such as heatmaps, scatter plots, and geospatial overlays. The study also tests the statistical significance of the relationship between radiance intensity and internet speeds to validate the underlying hypothesis. Furthermore, it develops a predictive model leveraging radiance data and urban activity trends to forecast internet performance in UAE cities, providing actionable insights for future infrastructure planning.

**Methods**

**Data Sources**

* **Nighttime Light Radiance**: Satellite-based radiance data to measure urban activity in the UAE.
* **Internet Speed Data**: Regional internet performance metrics for Q4 2021.

Our dataset preprocessing

A screenshot of a computer

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To make sure the dataset includes only necessary characteristics for analysis, redundant columns were first eliminated during the preparing phase. Because it did not provide useful information for the study, a column referring to certain time periods that are not covered on our analysis were removed. The average internet speeds, which combined network performance information from the several time windows, were also represented by a new column. The data were grouped into intervals (high, medium, and low) according to numerical ranges rather than using raw speed measurements. With this change, the general differences in internet speed across various regions were more clearly and accurately represented, making it easier to understand how they relate to measures for smart city development. The dataset was simplified by these preprocessing processes, which improved its ability to be used for analyzing the relationship between internet speeds and smart city infrastructure development.

**Results and Discussion**

**Exploratory Data Analysis (EDA)**:

**1.Heatmap**: Display regions in the UAE with high radiance and corresponding internet speed, it revealed that regions with high radiance levels, such as Dubai and Abu Dhabi, also exhibit superior internet speeds, highlighting the strong correlation between urban activity and internet performance. These areas, being centers of economic and technological development, show advanced infrastructure that supports high-speed internet connectivity

A screenshot of a computer screen

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**2.Scatter Plot:** Correlation analysis between radiance intensity and internet speeds, it displayed a clear positive correlation (ρ = 0.68) between radiance intensity and internet speeds. This result supports the hypothesis that areas with more intense urban activity, as measured by nighttime radiance, tend to have better internet infrastructure.

A graph of a blue and green line

Description automatically generated with medium confidence

**3.Bar Chart**: Comparison of internet speeds, there is a noticeable disparity emerged in the comparison of internet speeds across cities. Cities categorized as "high radiance" had internet speeds approximately 1.5 times faster than those in "low radiance" regions, suggesting that the level of urban activity is directly related to the quality of internet infrastructure.

A graph of a graph showing a number of internet speeds

Description automatically generated with medium confidence

**4.Geospatial Overlay:** Mapping smart city regions with internet performance metrics, it confirmed that smart city regions with robust infrastructure, like Dubai Silicon Oasis and Masdar City, displayed significant overlaps with areas of high internet performance, reinforcing the idea that smart city development drives improved internet connectivity.

A map of different colored dots

Description automatically generated

**5.Time-Series Plot**: Trends in internet speeds and radiance over time for selected UAE cities, it indicated a consistent upward trend in both radiance and internet speeds for cities like Dubai and Sharjah. These trends suggest that as urban development progresses, there is a direct impact on the quality of internet connectivity, supporting the idea that urban growth is essential for enhancing digital services.

A graph showing a green and blue line

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**1.Hypothesis Testing**:

The p-value obtained from hypothesis testing was 0.002, which is significantly lower than the threshold (α = 0.05). This result led to the rejection of the null hypothesis, affirming a significant relationship between internet speeds and urban activity levels in the UAE.

* + **Null Hypothesis**: No significant correlation exists between internet speeds and urban activity in the UAE.

A group of blue dots

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**2.Alternative Hypothesis**: Internet speeds are significantly correlated with urban activity in the UAE.

A graph of a graph of light and light energy

Description automatically generated with medium confidence

**.Prediction Model**:

The Random Forest regression model achieved a high R² value of 0.85, signifying excellent predictive accuracy in estimating internet speeds based on radiance levels and urban activity data. This indicates that nighttime light radiance is a strong predictor of internet performance across the UAE and the key features identified by the model, such as radiance intensity and temporal trends, further demonstrate the importance of urban activity and infrastructure in shaping internet connectivity in the region. The model's effectiveness suggests its potential for forecasting internet speeds in both existing and emerging smart city areas.

A close-up of a graph

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* + Objective: Predict internet performance using radiance levels and urban activity trends in the UAE.
  + Tools: Machine learning regression models (e.g., Linear Regression, Random Forest).

**Conclusion**

This analysis highlights how important internet infrastructure is to the development of smart cities in the United Arab Emirates. The results demonstrate a direct correlation between internet performance and urban activity, as demonstrated by nighttime radiance. Higher internet speeds are consistently seen in areas with advanced infrastructure, as shown by higher radiance levels. Additionally, the prediction model shows how radiance data may be utilized for predicting internet performance , As the UAE continues to advance its smart city plans, integrating digital connectivity with urban planning will be essential to promote sustainable growth and improve quality of life for residents. , the analysis suggests Prioritize investments in emerging urban areas to support the rapid development of smart city initiatives across the UAE, Utilizing nighttime radiance data as a tool for planning and resource allocation to ensure efficient infrastructure development and equitable internet access across regions, Using predictive models to identify regions requiring urgent upgrades in internet infrastructure, ensuring that emerging urban areas can keep pace with the growth of smart city technologies.