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Open-Data and Data Acquisition for Smart Cities and Urban Mobility Studies: Potential Approaches and Current Challenges

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Abstract

The experience of urban users is shaped by cities—by their shapes, components, and how they function. An immense quantity of data is included in the process of how the city functions, how it affects its inhabitants, and how its residents view its components. Researchers need an extensive number of datasets on land use (type & quantification) and geometric dimensions of the built environment (3D, form, & pattern) to fully grasp this relationship. In addition to the need to collect data about users' experience via using web-based/location-based surveys. The acquisition, exploration, and analysis of these datasets contributes to enabling a better understanding, operation, and monitoring of the city's systems. Thus, facilitating the design, implementation, and operation of functional, efficient, and reliable smart cities. This paper focuses on transportation and mobility, and how can open-data sources be utilized for data acquisition for urban mobility studies. This highlights possible, simple, and accessible open-data acquisition tools for urban planners. It further outlines the limitations and challenges for data acquisition related to the global south context.

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The main aim is to explore the potential of integrating different open-data sources, web-based tools, and data analytics in defining travel time map and accessibility with respect to modality of mobility. It examines the accessibility, availability, and obtainability of data from these open-data sources (i.e., OpenStreetMap, Uber Movement, Jupyter Notebook) to be further used in urban studies, specifically in the context of the selected case study area. An exploratory approach is adopted to perform an analysis between the built environment and travel time during mobility, using Isochrone map acquired from open-data sources. The aim is to delineate an approach that could be adopted by urban planners who are not well acquainted with open-data sources, python scripts and codes. This approach could be utilized, modified, and replicated in further urban studies related to other regional contexts similar to the Egyptian context.

Keywords: Isochrone Maps; Open-Data; Open-data Source; Smart Cities; Travel Time; Urban Mobility.

1. Introduction

Population growth is inevitable for a great number of cities. According to the World Bank, around 55% of the world population lives in urban settlements. This percentage is expected to proliferate to more than 65% of the population expected in 2050 [1]. Accordingly, cities are expanding out and up as result of this rapid urbanization and proliferating number of populations. While cities expand out horizontally, commuting population encounters more pressure during mobility and transportation to access different services and activities [2, 3]. Consequently, this impacts accessibility to services, quality of living and live ability of cities. Moreover, this process of rapid urbanization, population growth, and urban sprawl resembles a significant amount of data influx that needs to be observed, analyzed, and evaluated [4]. To gather and acquire this amount of data, modern technology of Information and communication technology (ICT) could be deployed to acquire, analyze and evaluate it. This would pave the road towards better decision making for urban planners and governments [5].

Several scholars tackled this point via using some web-based tools that provide satellite imageries, remote sensing imageries in case study analysis in different countries [6]. Some web-based tools and websites provide access to data related to different cities, specifically European cities [5]. However, few to little studies were conducted on the Egyptian context. This is due to the lack of data availability. This paper has investigated on the potential applications, web-based tools, and websites to access data related to Egyptian context. Web based tools can be divided into two main groups: mapping-based websites; and python-based mapping websites [7]. Some of these were: OpenStreetMap's; Geofabric (provides shapefile files to process on GIS); and Urban Movement. On the other hand, access to satellite images differs from one country to another. Multiple websites offer various satellite images for different countries. While access to satellite and remote sensing imageries can take place through space agencies in the Egyptian context [8]. Thus, availability of satellite images is limited, especially for researchers who are not affiliated with specific entities that have access to remote sensing imagery.

Free and Open sources data providers, however, are present and provide useful opportunities for transportation, accessibility, and mobility data [7, 9]. This in order will open the door for extensive, solid, and concrete studies that will help urban planners, city principals, decision makers to direct city's plans towards more sustainable, accessible, safe transport and mobility plans. One of these data sources is the Uber Movement: "provides data and tools for cities to more deeply understand and address urban transportation challenges”. “Uber movements aids urban planners to: identify and measure congestion in their jurisdictions; Calibrate and validate travel demand models; Measure the efficacy of policies and infrastructure investments; Build a ‘transportation scorecard' for a city or across a region.”. Uber movement also provides the following datasets: travel times, speed, new mobility heat maps. This paper focuses on the travel time data set provided by Uber movement.

1.1. Traditional Cities Vis-à-vis Smart Cities

Traditional cities are built around the traditional model of centralized government and hierarchical social order. The traditional city model was designed to facilitate the flow of goods and people between various parts of the city. Traditional city planning, based on classic urbanism, emphasizes the building of functional, walkable, and aesthetically beautiful urban areas. It emphasizes human-scale design, mixed-use land development, and the integration of natural and constructed features [10]. To establish a feeling of place and foster social interaction, traditional city design frequently contains characteristics such as well-defined streets, livable public squares, and consistent building types “Ibid.”. This method attempts to create a harmonious interaction between the built environment and its residents' needs and goals. However, traditional cities are currently challenged by the proliferating number of populations, increasing transport and mobility demands, and growing need for better services [11]. Additionally, when traditional cities were being established, they did not take into consideration the facilitation of the flow of data or information between various parts of the city. While recently, new urban challenges and demand for current urban planning methods have evolved, which makes it an imperative to design cities that can accommodate data-driven technologies [12]: to create efficient, safe and livable cities. Thus, understanding traditional city planning can provide useful insights and lessons that can educate current urban design practices, and positively influence to the establishment of more livable and resilient cities [10]. This is supported by the Sustainable Development Goals (SDG’s) proposed by the United Nations towards cities which are “sustainable, energy efficient, inclusive, and resilient” [13]. On the hand Smart cities initiative is a global movement to develop sustainable, resilient, and inclusive cities [11]. The main objective of the smart cities’ initiative is to make urban areas more efficient by integrating data from various sources such as sensors, mobile phones, web-based services, and other sources [6, 14]. This data can be deployed in decision-making processes that help improve urban planning and management [15]. Smart city projects have been implemented in many countries across the world with different objectives but all of them share one thing: they use open data for their development. The term “Open data” refers to any kind of information available on the internet that can be freely accessed by anyone without restrictions or control.

A smart city is a planned community that uses information and communication technologies (ICT) to improve urban management [16]. Smart cities are important because they offer opportunities for more efficient use of resources and improved quality of life [17]. They also have the potential to reduce pollution levels, save money on infrastructure costs, promote economic development in underdeveloped areas, improve public safety by enhancing response times to emergencies, and reducing crime rates overall [11, 17, 18]. In conclusion, the traditional model of city management is unable to keep up with the challenges of the modern world. For example, the traditional model is unable to address the challenges of increased traffic, environmental concerns, and the demand for more efficient and sustainable public transportation. As a result, smart cities are a necessary solution to these challenges. A smart city is a city that is able to collect and use data from a variety of sources (i.e., weather, traffic, public transportation), to improve the city's overall management and operations. Using this data, smart cities can make better decisions about how to allocate resources and manage infrastructure.

Table 1: Smart city indicators and their corresponding open-data sources. Sources: amended and collected from: Kumar, A. and colleagues (2020): Kaluarachchi, Y (2022); Gillis, D and colleagues (2015); Tafidis, P and colleagues (2017); Urban Mobility Indicators (2019).

Key Driver	**Dimension**	**Indicator**	**Data Source (OS: Open Source)**
Smart Living	Comfort & Safety	Overall Experience	
		Safety	government portals
		Security	Surveillance camera, Crime Statistics
		Walking Infrastructure	OpenStreetMap (OS)
		Public Transport Infrastructure	Public Transport Agencies
		Operational Performance	Transit Agency Data
		Vehicle Quality	Environmental Agency
		Impact of Motorised Traffic on Walkability (Traffic Flow)	Uber Movement (OS)
	Perception of Built environment and urban space	Perception of the urban space	Social Media Sentiment Analysis
		Perception of the Experience in the Urban Space	Surveys, Social Media Sentiment Analysis
Smart Mobility	Availability of ICT Infrastructure	Service Demand	Vehicle Sharing usage data.
		Daily Trips	GPS data from shared mobility services (OS) Surveys conducted by transportation authorities
	Accessibility	Access to Public Transport Stops	GIS
		Connecting Destinations/ Connectivity	Transportation Agency
		Access to Jobs and Services	Census data
	Sustainable, innovative, and safe transport system	Availability of Walking Amenities	OpenStreetMap (OS)
Smart Environment	Built Environment and its effects	Urban space characteristics	GIS Data OpenStreetMap (OS)
		Urban Landscape	
		Heat Island	Satellite Images Uber movement (OS)
	Appeal of Urban Environment (Built environment and Landscape)		Surveys, Social Media Sentiment Analysis

1.2. Open data, big data, and internet of things (IoT): technology that facilitates data acquisition for Urban datasets

Urban studies are a rapidly growing field that explores the relationships between people and their environment in cities. Open data sources are essential for urban studies because they make it possible to collect large sets of data through public means, which can be used to study different aspects of city life [16]. In recent years, several open data projects launched with the goal of making government information more accessible and usable by citizens, researchers, journalists, and developers “Ibid.”.

Urban big data sources are categorized into five main types as follows: Sensor systems, user-generated content, administrative data, private sector transaction data, and data from collections of arts and humanities [4, 19]. This paper focuses on the user-generated content as the primary source of urban data sets. Since Data is a core component of Urban Studies, it is vital that researchers have access to as much data as possible to conduct their research effectively. When administrative data is concerned, governments need to take significant steps in facilitating data acquisition, by providing open-data access, specifically for urban studies. This is especially true for data that relates to public policy and planning, as it allows for a more holistic understanding of the urban environment.

1.3. Data Acquisition from open-data sources: urban space, urban mobility, and travel time

Urban spaces are constantly changing, as a result of human activity, and this has profound consequences in shaping the understanding of how people live in cities. New research techniques allowed collection of data on city dynamics that were once unobtainable or difficult to measure [20]. By understanding how people move around, decision makers can better manage resources, plan transportation systems, and make informed decisions about where settlements should be situated [21, 23].

There are various potential sources to collect data about urban space and mobility. For instance, Physical observation is conducted to collect data about the layout and design of urban spaces. Other data sources include surveys, measurements, and GPS tracking [16, 24]. Other sources of data collection include social media and open-source data platforms [7, 25]. This data can be used to generate maps and visualizations of the spatial layout of urban spaces. Additionally, surveys can be used to collect data about the activities that occur in urban spaces. This data can be used to generate insights about the use of urban spaces. Web-based platforms can be used to collect data about the transportation patterns of urban residents [9, 25]. This data can be used to generate insights about the use of urban spaces and the transportation patterns of urban residents.

On the other hand, open-source data can be used to collect data about the transportation patterns of urban residents [7]. This data can be used to generate insights about the use of urban spaces, trends of mobility and transit, and transformations in the urban form. Open-source data can be classified into various categories. This paper will classify open data sources according to the simplicity of the process of acquiring the data: open-data sources with easy web page interface such as OpenStreetMap and Uber Movement. While on the other side of the Simple-Sophisticated continuum of open-source data acquisition tools lies a more sophisticated open-data source which requires understanding in a programming language (e.g., Python) [26]. To list one of those sophisticated open-source data is “Jupyter Notebook” which can be combined with OpenStreetMap to acquire urban datasets [25].

OpenStreetMap OpenStreetMap (OSM) is a crowd-sourced based world map where users can digitize, edit, and update maps of their cities, settlements and neighborhoods in real time [25]. Currently, local governments in the Global North supports “Open Data” platforms. However, there is still an inequality in the scale, quality, and availability of worldwide mapping data, especially data in the Global South. OSM acts as a platform for people to contribute with their individual or community efforts to facilitate the availability of data in any city. It has an essential role in filling in the gap in data availability with an efficient, accessible, and simple method. This method facilitates data acquisition more than governments or non-profit organizations can. This is demonstrated by OSM’s “mapathons” which are held after natural catastrophes. In which individuals from different universities, non-profit organizations, and firms collaborate in updating road, building, and other essential infrastructure data. This is achieved by using updated satellite images, so emergency workers can utilize the up-to-date data in their response efforts [27].

“Uber Movement” Uber movement is a tool developed by Uber. It provides datasets that could be utilized in various urban studies. These datasets are travel time, speed, and new mobility heatmap. This tool was developed to support in addressing transportation challenges. It is an open-data source that provides data for different cities. The tool provides access to a vast collection of datasets [28]. These datasets can be utilized to contribute to better decision-making in transportation planning and policymaking. Uber Movement is designed to integrate seamlessly with other analytical toolsets, providing an added analytical advantage to urban planners. The datasets provided by the Uber Movement Tool offer information that can help urban planners optimize their decision-making processes and identify potential areas for improvement in transit systems. The tool has the potential to provide transportation experts with a comprehensive understanding of traffic patterns and help them make informed decisions “Ibid.”.

The Uber Movement tool has revolutionized the way of analyzing travel times and speeds [28, 29]. This tool has the potential to transform the approaches adopted to tackle urban transportation planning. The Uber Movement “Speed” datasets target pedestrian and bicycle vulnerability when they interact with vehicles and trucks. It accomplishes this by providing local governments with a useful metric for measuring traffic safety [30]. While the new mobility heat map functionality, Uber Movement can provide transport planners with valuable insights into the current movement patterns of a city and identify areas where congestion is causing significant delays [31]. By working closely with urban planners and transportation authorities, Uber Movement has the potential to make a significant positive impact on the lives of people.

An attempt was made in this study to acquire data from uber movement travel time datasets for the selected case study of this manuscript. However, this attempt was not successfully conducted due to the limitation of the data available for the city of Cairo, Egypt. Since the data available on uber movement (i.e., Travel Time datasets) was not up to date. The most recent available data was in 2019. This imposed a limitation on this exploratory study, which lead to excluding uber movement as an open-source tool in this exploratory study.

Jupyter Notebook Jupyter is an open-source project that enables data analysts to create and run code [9, 25]. It is a notebook system that runs on Linux, macOS and Windows. The name Jupyter comes from a combination of the words Julia and Python. The name Julia came from the creator of Jupyter, Julia Computing Lab at MIT [32]. Many computer science courses use Jupyter to teach programming languages. Essentially, Jupyter has many uses for programmers and data scientists. Jupyter is an open-source platform for data science, developed by the Jupyter Foundation. Jupyter enables the creation of notebooks that contain maps, images, equations, rich text, and more.

As Jupyter notebooks have extensible potentials which allows data scientists to manage projects that deals with big data and data analytics. Some common uses of Jupyter include: data mining, programming languages, scientific research, and scientific computation among others [32]. There is no limit on what can be accomplished with Jupyter since it is built in a manner that allows users to extend Python with custom code module “Ibid.”. Accordingly, Jupyter has many advantages over traditional methods when pursuing data science projects. Using notebooks makes it easy to promptly develop new tools for analyzing data- which makes them ideal for conference presentations or document creation purposes.

Table 3: A List of open-data sources for urban analytics.

Tool	Data Provided
Uber movement	Travel time averages, Speed, New Urban Mobility Heat Maps
Open street maps	Shapefile (Buildings, Streets…etc)
Jupyter notebook (Python-based mapping website)	Network density, Isochrone Map…etc

2. Methodology

The methodology followed in this exploratory manuscript adopts the hybrid method of Osmnx & Jupyter Notebook. The Osmnx is an environment that could be loaded to Jupyter notebook. Which allows mapping data using Jupyter notebooks. Since Open Street Map is an open platform for mapping data. This allows for the creation, editing and sharing of cartographic data. Government agencies, companies, and individuals can utilize this to find, map, and analyze streets and roads around the world.

The development of Osmnx and Jupyter Notebook has become a promising approach in the field of transportation studies. With the availability of geospatial data, travel time maps have become a useful tool for transportation planners and researchers. In this selected case study, the methodology demonstrated for generating isochrones can be further replicated, modified, and adopted to inform transportation planning decisions. In this exploratory manuscript, the analysis of the selected case study is carried out using Travel Time Maps or Isochrones, which is created using the Osmnx library in Jupyter Notebook. This manuscript’s methodology involves obtaining data from OpenStreetMap and using a Python script to create isochrones based on travel time, rather than distance. This method allows for a more realistic representation of travel patterns and can be applied to a variety of research areas, such as transportation planning and urban development. The script used in this study was adopted and amended from a study which was previously carried out by [25].

Isochrone maps, urban planning, and transportation, are spatial representations that indicate areas reachable from a certain point within a specific time interval [33]. They are useful for analyzing city accessibility and travel patterns [34]. This method facilitates for planners the visualization of how far individuals can travel within a certain time limit by mapping isochrones, taking into account various forms of transportation and the existing transportation network [35]. Isochrones aid in the identification of locations with varied levels of accessibility and can help guide decisions about the placement of amenities, services, and transportation infrastructure [35]. They allow planners to evaluate the spatial equity of access to vital facilities and aid in the design of efficient transport systems.

```
Iscorone_New_cairo_walk_90 ×   isoscrone_New_cairo_drive_9 ×   +
Code                                                Python 3 (ipykernel)

[68]: import geopandas as gpd
      import matplotlib.pyplot as plt
      import networkx as nx
      import osmnx as ox
      from shapely.geometry import LineString
      from shapely.geometry import Point
      from shapely.geometry import Polygon

      %matplotlib inline
      ox.__version__

[68]: '1.2.2'

[69]: # configure the place, network type, trip times, and travel speed
      region = {"city":"New Cairo",'country':'Egypt'}
      network_type = "walk"
      trip_times = [5, 10, 15, 20, 25]  # in minutes
      travel_speed = 4.5  # walking speed in km/hour

[70]: # download the street network
      G = ox.graph_from_place(region, network_type=network_type)

[71]: # find the centermost node and then project the graph to UTM
      gdf_nodes = ox.graph_to_gdfs(G, edges=False)
      x = 31.456269
      y = 30.024775
      center_node = ox.distance.nearest_nodes(G, x, y)
      G = ox.project_graph(G)
```

Figure 1: Adopted Python Script. Amended script from [25].

The case study that has been chosen for this research is New Cairo, a growing city located in the eastern part of Cairo, Egypt. This relatively new urban development has been gaining importance in recent years due to its strategic location and rapidly growing population. In fact, the latest statistics show that the population of New Cairo has been on a steady increase since its establishment, making it one of the cities with proliferating number of populations. One of the key features of New Cairo is its street network. In order to accommodate the growing population, the city's infrastructure has been designed to serve the needs of both pedestrians and motorists alike. This has resulted in a well-planned network of roads and highways that not only connects various parts of the city but also aids in the efficient movement of traffic. In conclusion, the location, population, and street network of New Cairo make it a suitable case study for urban planners, policymakers, and researchers alike.

3. Case Study: Exploratory Application of Osmnx & Jupyter Notebook using Isochrone Map on Selected Study Area

The process of generating an isochrone map for a case study involves the use of a Python script. Firstly, the location of interest must be defined within the script using the appropriate geospatial coordinates. Next, the mode of transport must be specified. In this case, the selected mode is walking and driving. Moreover, defining the travel time intervals is crucial for accurately depicting the isochrone map, as the intervals determine the shape and extent of the resulting map. Once the script is run, it will produce a detailed isochrone map that visualizes the area within the specified travel time intervals.

The trip time duration was fixed for both modes. Since this is an exploratory study, using fixed travel time (in minutes) provides a better opportunity for validating the results. The travel speed for each mode is set based on the standard speeds: driving speed limitations imposed by the city and walking speed standards. Also, for ease of application, the geospatial coordinates are set through identifying the location as “New Cairo” in the python script. The center point for the isochrone map is an approximate midpoint along Southern 90 street with coordinates (31.456269,30.024775). The coordinates were extracted from bboxfinder (i.e., an online website). The center point from which the isochrones are calculated is illustrated in the figure below (Figure 2).

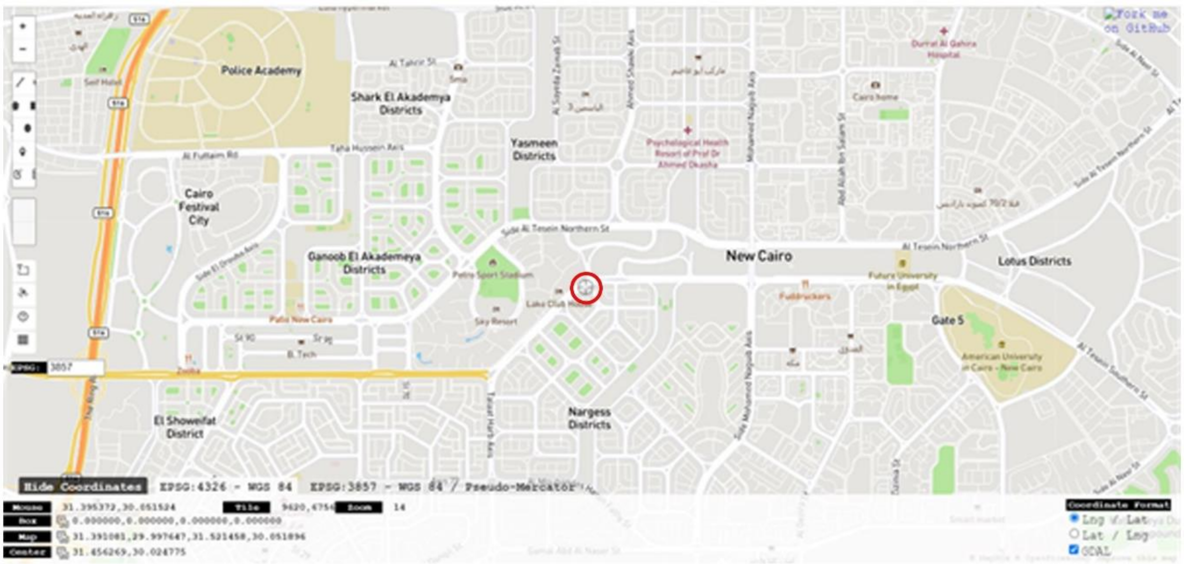

Figure 2: Centre point coordinates as origin for the isochrone analysis. Extracted from bboxfinder.com and illustrated in red circle.

In this case study, an analysis is carried out for the trip characteristics of the population's mobility means, specifically walking, using isochrones (See Table 4). The isochrone analysis was conducted using Python and its library, matplotlib, osmnx, and NetworkX. This exploratory study takes into consideration two main trip characteristics. First, an analysis is conducted on driving as network type. The travel speed set for driving was 60km/hour. Then another analysis is processed using “walking” as a network type, to isolate walking routes. Trip times ranging from 5 to 25 minutes in this study were analyzed for both network types (i.e., Driving and Walking).

Table 4: Driving vs. Walking Trip Characteristics.

Mobility Means	Trip Characteristics

Walking	network_type = "walk"
	trip_times = [5, 10, 15, 20, 25] # in minutes
	travel_speed = 4.5 # walking speed in km/hour

Driving Travel Time	network_type = "drive"
	trip_times = [5, 10, 15, 20, 25] # in minutes
	travel_speed = 60 # walking speed in km/hour

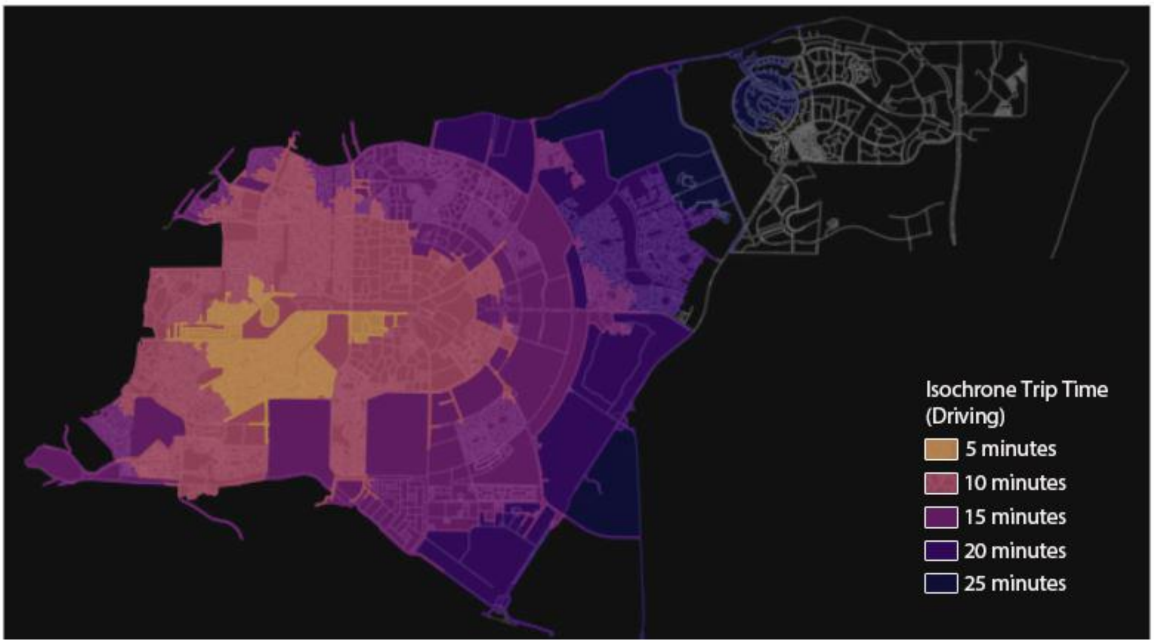

Figure 3: Driving isochrone Map (Source : Generated from Jupyter Notebook using Osmnx by Author).

The isochrone map (Figure 3) illustrates that most of the neighbourhoods to the southern 90 street is accessible within 5 minutes of driving from the origin point, on an average speed 60 km/hr. This entails the need to access those neighbourhoods (5-minute-driving-zone) for services or activities. It also implies that the street network is more connected than the other zones (i.e., 10; 15; 20; and 25 minutes zones). While the walking isochrone map (Figure 4) illustrates that the northern part of the southern 90 street is accessible by walking within the travel time intervals (5; 10; and 15 minutes) from the origin point. This denotes that the street network in these zones is more pedestrian friendly than the southern part of the 90 street. While it is essential to highlight that the zone outlined in red is not accessible, since it is a gated community, in which accessibility to it is exclusive for its residents.

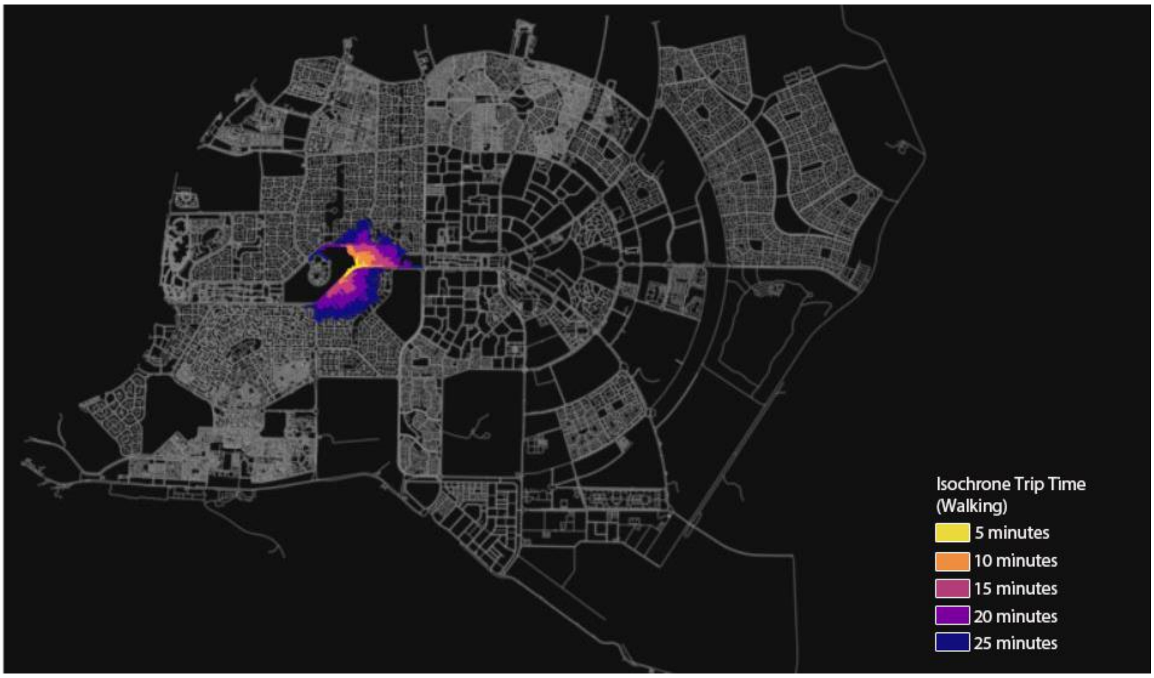

Figure 4: Walking Isochrone Map (Source : Generated from Jupyter Notebook using Osmnx by Author).

4. Discussion

The exploratory application of using Osmnx with Jupyter Notebook was carried out on the selected case study successfully. Unlike, using Uber movement which imposed limitation on retrieving data for the case study. The limitations associated with using Uber for transportation and mobility highlight the difficulties in retrieving the necessary data for the case study. As discussed earlier, an attempt was carried out to retrieve a travel time map from uber movement. However, this attempt was not successful in terms of retrieving up-to-date data. The only travel time data available on uber movement for the selected case study is out of date (i.e., 2019). This implies that relying solely on data from Uber movements could not give a thorough insight of the status quo of transportation and mobility dynamics in the research area. However, the integration of Osmnx with Jupyter Notebook offered a potentially better method for gathering comprehensive and accurate data for urban transportation studies. Using Jupyter Notebook and Osmnx environment and python script, it was made possible to generate two isochrone maps for the selected case study: Driving Isochrone Map, and Walking Isochrone Map. As illustrated in Figure 1 and Figure 2, the catchment area of the driving travel time covers a larger area than the walking travel time. As earlier mentioned, this is an exploratory study for testing the availability, easiness, and usage of open data sources along with using python code for urban planners.

The driving behavior of individuals can be analyzed by studying the time it takes for them to reach certain destinations. By using isochrones, creation of maps that represent the travel time from a single origin to multiple destinations became achievable. Thus, providing more potential to analyze the mobility means of the individuals in the study area. The analysis shows that the trip characteristics of the study area were heavily influenced by the driving behavior of the individuals. The isochrones revealed that the majority of the individuals preferred to drive to their destinations, even for short distances. This indicates a strong preference for personal vehicles over other modes of transportation, such as public transit or active transportation. The results of the analysis revealed several interesting insights. Firstly, most of the walking trips fell within the 5 to 10-minute range, indicating that most of the population preferred to walk short distances. Secondly, the isochrones revealed that the walking routes were highly concentrated in certain areas, highlighting the importance of infrastructure development in these areas. Furthermore, the utilization of isochrones allows the exploration, identification and analysis of areas that have low levels of walkability. This information could be used to improve the pedestrian infrastructure in these areas and make them more accessible to the population. Overall, the use of isochrones in this case study provided valuable insights into the trip characteristics of the population's mobility means. The analysis showed that walking was the preferred mode of transportation for short distances and highlighted the need for infrastructure development in certain areas to improve accessibility. Additionally, walkable zones (See Figure 4) are mainly concentrated in the northern part of the origin point. This implies that the southern part to the point of origin requires more infrastructural improvements to support walkability. The approach of this study aligns with prior studies that used isochrones to analyze transportation accessibility and spatial connectivity. Wang and colleagues[35], for example, used a similar methodology to study the effect of transport infrastructure on commute times in urban areas. Their findings support the use of isochrones in analyzing the spatial distribution of journey times and identifying regions that may have accessibility issues. In a related investigation, Forsch and colleagues [33] utilized isochrones to analyze the accessible zones from user's specific location in a specific amount of time. Their study demonstrated that isochrone maps have the potential to provide valuable insights, for instance, to fares of different zones of metro maps through creating schematic travel time maps. This supports our findings, as we similarly used isochrones to assess travel time to reachable regions, which can contribute to urban planning and resource allocation efforts. Overall, the successful utilization of isochrones in our study resonates with the findings of previous research and reinforces the importance of this method for understanding travel time dynamics and accessibility in various domains. These collective studies highlight the significance of isochrone mapping as a valuable tool for policymakers, urban planners, and transportation analysts to make informed decisions and address accessibility challenges in a wide range of contexts.

5. Conclusion

Urban planners have been using a range of tools and techniques to analyze spatial data for a long time. However, there are limitations in the processing of spatial data when it comes to travel time data and analysis. Jupyter Notebook with Osmnx presents a unique opportunity to tackle these limitations and extract insights from urban data. Despite its potential, the use of Jupyter Notebook with Osmnx requires a degree of technical expertise, which can be a significant barrier to entry. Additionally, there is a learning curve associated with using Python and its associated libraries that may present difficulty for some urban planners. However, there are available repositories of python scripts that is open for public use. This acts as an opportunity for urban planners to easily access and acquire data for further studies and analysis. The access to urban data is an essential part of smart cities. Overall, the use of isochrones to analyze the trip characteristics of the case study proved to be an effective tool in studying the mobility means and driving behavior of individuals in the study area. This information can be used to inform transportation planning and policy decisions aimed at promoting sustainable and efficient transportation options.

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