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Constructing Route Choice Mobile Application Using the Real-Time Traffic Information

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ABSTRACT

Traffic congestion is a major issue in Egyptian cities. It's a multifaceted problem with many challenges, making it difficult to solve in the short term because it requires predictable route choice behavior and decisions. Real-time traffic data may help passengers avoid congestion and save time and cost. Mobile route-choice applications are required to facilitate travelers' route choice decisions. Port-Said's location on Suez Canal makes transit to/from Port-Fouad important. This paper presents a route choice mobile application for people traveling from Port-Said to Port-Fouad. It depends on predicting the real travel time between the two cities with addition to queuing time. Intelligent traffic system techniques and the Google Application Programming Interface (API) maps have been used to collect travel data. The application travel time estimations have been corroborated using actual values. The results show that the model is performing well and give an acceptable prediction of the average percentage error around 7% which is lower than the average percentage error of Google Maps travel time estimates by about 23%. This indicates the recommended effective outcome of the introduced mobile application in addition to facilitate the provision of route data for the traveler at any time.

Keywords: Route Choice, Real-Time Traffic, Google Maps API, ITS, Suez Canal.

1 INTROUDUCTION

In congested networks, route choice is one of the important and basic concerns in the transportation and traffic field. The route choice dynamics is often influenced by real-time traffic information [1]. As traffic information is becoming global, navigation systems are used to notify travelers with route capacities to avoid traffic congestion. Route guidance systems compare many different routes and provide the traveler with options to select from a list of best route recommendations. Route choice decisions are normally based on the route with less travel time [1-4]. Nowadays, there is a big need for such systems to keep pace with the development of road networks and the continuous increase in car ownership.

As more vehicles have increased into urban regions, traffic congestion has become a serious issue in various cities, which poses many negative effects causing air pollution, commuter stress, and vast economic loss [5,6]. One of the significant solutions to decrease such undesirable effects is to develop Intelligent Traffic Systems (ITS) providing accurate real-time traveling information [7]. In Egypt, one of the important cities with multiple freight and travel activities is Port-Said city due to the presence of the entrance of the Suez Canal and East of Port Said Port [8]. Its importance and location, as a case study area, are illustrated in the following paragraph.

1.1 Case Study Area

This paper concentrates on studying the route choice behavior between the Port-Said and Port-Fouad as case study areas due to the importance of crossing between the two areas for many activities including (work, trade, business, entertainment, transportation, etc.) [9]. In addition to cutting Suez Canal which causes many challenges in determining the precise transit time for each transit method (e.g., ferries or floating bridge). Port Said gets its importance as it is an Egyptian city and has an important port. It`s located at the entrance to the Suez Canal overlooking the Mediterranean Sea. According to the Suez Canal Authority's annual statistics for the year 2021, 18,880 ships pass through the Suez Canal [10]. The total land area is estimated to be 1351 km². The total population is about 890,000 and the total number of trips is 114590 trips/day [11]. It consists of two towns (Port Said and Port Fouad) separated by Suez Canal and seven districts [12] as shown in Figure (1).

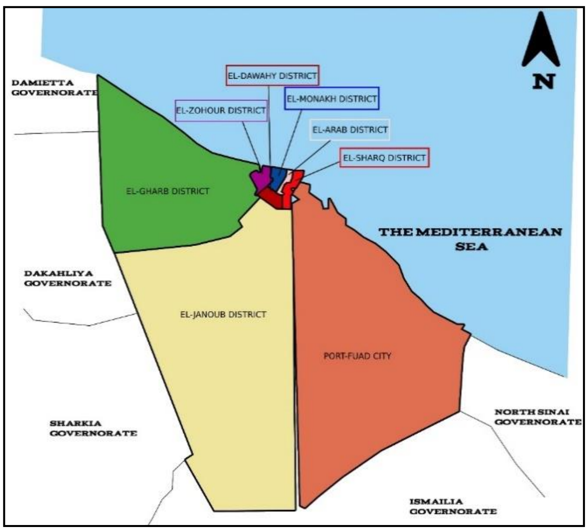
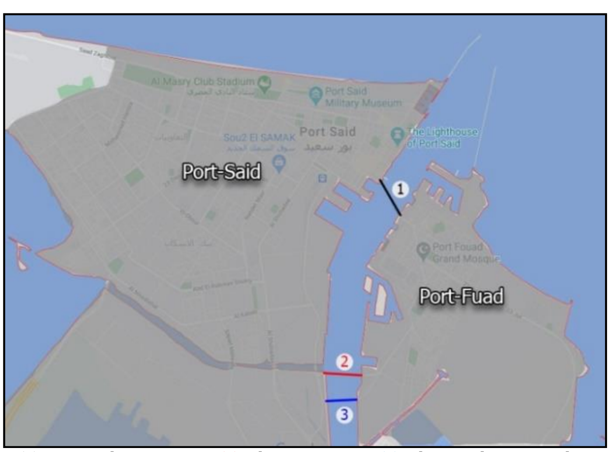


Figure 1: Administrative divisions of Port Said Governorate

Port-Fouad is a part of Port Said city that is located in the continent of Asia to transport a huge quantity of freights and people. The two cities are connected with three links or travel options; Port-Said Main Ferry, Al-Raswa Ferry, and Al-Nasr Floating Bridge as shown in Figure (2).



(1) Port-Said Main Ferry (2) Al-Raswa Ferry (3) Al-Nasr Floating Bridge

Figure 2: The main links/passageways between Port-Said and Port-Fouad towns

1.2 Problem Statement

Most people choose their routes to cross between Port-Said and Port-Fouad either according to their daily experience or habit. For example, a traveler who lives near the main ferry of Port-Said mostly chooses the ferry but suffer from delays. In real such delays causes from many factors such as large number of vehicles, bridge statute, and arrival rates with a large queue line which is not determined in the presence mobile application such as Google map. For instance, the delay reached about 30 minutes in summer and 20 minutes in winter for vehicles waiting for a ferry to cross the canal between Port-Said and Port-Fouad [9]. Whereas the route to Al-Nasr Floating bridge may have more time-saving, travelers go towards choosing the bridge route but he may find out that it is closed due to navigation circumstances. Sometimes, the closing time may reach one hour which is a crisis for people; especially in studying and working trips. So, a route choice system needs to be developed to estimate the shortest route taking into consideration the queuing time and the bridge statute. Route choice modeling is the way to solve this problem. The literature on route choice modeling will be illustrated below.

1.3 Literature Review

Route choice problem refers to the decision-making of route/path use between origins (O) and destinations (D) in transportation networks [13]. The various approaches of route choice can be classified into three main classifications: static traffic assignment, dynamic traffic assignment, and new techniques (online maps) of traffic assignment. This categorization reflects three common approaches to comprehending travelers' route-choice behavior [14]. The following literature concludes the results of previous works.

The prevalent traditional traffic assignment mechanism is an All-Or-Nothing (AON) assignment, which allocates all trips to the shortest route [15]. This method ignores the fact that travel time is a function of link traffic volume. It also doesn't consider congestion effects and thus tends to overload some links and under-load others [16]. Irwin et al. employed capacity restraint assignment by improving AON assignment taking link capacity into account. The capacity restraint technique understands that as the network's traffic flow goes beyond a certain point, traffic speed declines [17]. Wardrop defined a state resulting from many individuals' route choices, known as user equilibrium (UE), by assuming all road users behave entirely rationally and aim to minimize their disutility, but no user can improve his or her utility by changing routes unilaterally [18]. R. et al. proposed the solution of the UE assignment assumptions by an equivalent-nonlinear-mathematical-optimization program [19]. Daganzo & Sheffi proposed a stochastic user equilibrium (SUE) model that considers the passengers' imperfect estimates of trip time [20].

As static approaches have many limitations because the network is not detailed modeled, the assumption of perfect information about costs in all parts of networks is essentially unrealistic and can’t deal with the variations in demand from day to day. So, dynamic traffic assignment faces these limitations. One of the early attempts in modeling the user equilibrium dynamic traffic assignment problem is a mathematical program. The features of this technique are not well established enough and might lead to unrealistic traffic behavior. Also, it relies on traffic modeling static link functions [21,22].

Mahmassani et al.introduced a simulation-based DAT model called DYNASMART which is an acronym for Dynamic Network Assignment-Simulation Model for Advanced Road Telematics [23]. The model described the individual vehicle movement by employing a macroscopic speed-density relationship. Abdelghany & Mahmassani expanded the traffic simulator's capabilities by adding the ability to simulate movements of transit [24]. Some other models such as DYNAMIT that was proposed by M. Ben-Akiva et al. [25,26]. It is a simulation-based dynamic traffic assignment model that predicts and estimates present and future traffic circumstances in real-time. Also, VISTA stands for Visual Interactive System for Transportation Algorithms was created by A. K. Ziliaskopoulos & Waller [27]. The VISTA simulator RouteSim is a mesoscopic simulator based on an adaptation of the Daganzo [28] cell transmission model, which is based on the hydrodynamic traffic flow model, for propagating traffic.

All the previously studies discussed models assume that travelers make rational decisions to maximize predicted utility but a few behavioral scientists dispute the assumption of strict rationality in individual decision-making [14]. Moraes Ramos et al. study has shown that possessing trip information especially travel time improves travel comfort, as evidenced by interviews with participants [29]. Real-time information technology can provide network users with actual travel time and all conditions of the traffic network as pre-trip or in-route information, by a wide range of media [14,30]. But these technologies need to develop the network's infrastructure, which requires a lot of money and time. Therefore, the use of online traffic maps is an alternative solution in the short term.

Wang. & Xu. developed a desktop tool for estimating (O-D) travel time matrix by calling Google Maps (API) and compared the findings to those produced by the ArcGIS Network Analyst module to overcome the limitations of static and dynamic methods [31]. Jeff Ban. Hao. & Sun. estimated real-time queue lengths at signalized intersections in Albany, NY. QRNATs relate to non-smooth queuing delay patterns and queue length changes. The authors believe their method can be used to model mobile traffic[32]. Nanthawichit. Nakatsuji. & Suzuki. proposed a method for estimating traffic states in Tokyo, Japan using a probe-vehicle and conventional detector data. The method was tested under several traffic conditions using hypothetical data, giving much better estimation results than without probe data in a similar situation with no traffic detector[33]. García-Albertos et al. used the Google Maps API to determine (O-D) travel time matrices using mobile phone records. The findings indicate that these new geo-located data sources have a high potential for application in time-sensitive accessibility studies since they provide more precise and realistic information than static or partially dynamic analyses [34].

In this study, Google maps API had been used to estimate the travel time with supporting real-time technologies in critical locations that gives travel times without queing and bridge statue delays. The model of a real time is estimated to improve the estimated time within Google maps and introduces a mobile application with an easier technique to use it. Decision makers especially with the incremental growth of population and freight activities capacity give big attention to their route choice. As route choice is an important process to choose the suitable route depending on the behavior and habit of the traveler and affects the traffic congestion and travel delays in the urban transportation process, this study aims at developing a route choice model based on real-time traffic information that is constantly supplied using intelligent traffic systems technologies. The methodology of work will arrange as follows:

- Collecting data to identify the characteristics of traffic across Suez Canal between Port-Said and Port-Fouad in addition to the three-traveling links (travel options).
- Modeling the real time with the proposed queueing time and bridge statue delays.
- Constructing a mobile application depending on the estimated (O-D) real travel time matrix between the two cities.
- Estimating the percentage errors in the estimated travel time from the presented mobile application and Google maps results for all studied trips.
- Comparing between results from the proposed application and available Google map application.

2 THE ESTIMATED REAL-TRAVEL TIME FORMULAS FOR TRAVELING LINKS BETWEEN PORT-SAID AND PORT-FOUAD

In this study, Google Maps API is used to estimate the (O-D) travel time matrix between Port-Said and Port-Fouad cities. The main problem when using Google API maps is the lack of real-time information about the queue and systems of the cross the Suez Canal. Therefore, it is important to calculate the actual time of crossing the Suez Canal better than Google maps. The proposed model of travel time between the two cities is divided into three main parts as shown in Figure (3) which is calculated by the following equation:

$$T = t_{OI} + t_{IE} + t_{ED} \quad (1)$$

Where:

- $\boldsymbol{T}$ is the travel time between the origin point (O) and the destination point (D) (min.)
- $\boldsymbol{t_{OI}}$ is the travel time between the origin point (O) and the queue inlet (system inlet) point (I) (min.)
- $\boldsymbol{t_{IE}}$ is the total delay time in the system between the inlet point (I) and exit point (E) of the system (min.)
- $\boldsymbol{t_{ED}}$ is the travel time between the system exit point (E) to the destination point (D) (min.)

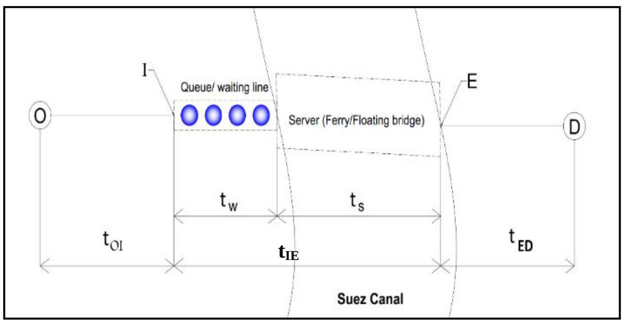


Figure 3: Travel time components

The travel time between the origin and system inlet points (t_{OI}), and between the system exit and destination points (t_{ED}) can be calculated by the google maps API. While the total delay time in the system of crossing the Suez Canal (t_{IE}) which Google API maps has a problem of the lack of real-time information to calculate it.

2.1 The Estimated Real-Time For Port-Said Main Ferry And Al-Raswa Ferry Trips

The total delay time of crossing the Suez Canal (t_{IE}) by the two ferries links is calculated by the following equation:

$$t_{IE} = t_w + t_s \quad (2)$$

Where:

- $\boldsymbol{t_{IE}}$ is the total delay time in the system between the inlet point (I) and exit point (E) of the system (min.)
- $\boldsymbol{t_w}$ is the waiting time of the vehicle in the queue (min.)
- $\boldsymbol{t_s}$ is the service time (min.)

The service time (t_s) and the waiting time in the queue (t_w) for Port-Said main ferry and Al-Raswa ferry can be calculated by the following equations (3) and (4) respectively:

$$t_s = t_L + t_c + t_u \quad (3)$$

Where:

- $\boldsymbol{t_s}$ is the service time (min.)
- $\boldsymbol{t_L}$ is the average time to load a ferry with vehicles (min.)
- $\boldsymbol{t_C}$ is the average crossing-time of the ferry through the Suez Canal (min.)
- $\boldsymbol{t_u}$ is the average time to unload the vehicles from the ferry (min.)

$$t_w = l_{q_{0,I}} / \mu \quad (4)$$

Where:

- $\boldsymbol{t_w}$ is the waiting time of the vehicle in the queue (min.)
- $\boldsymbol{l_{q_{0,I}}}$ is the estimated number of vehicles in the queue when arriving at inlet point (I) when t= t_{OI} (Veh.)
- $\boldsymbol{\mu}$ is the service rate of the system (Veh. /min.)

The estimated number of vehicles in the queue when arriving at inlet point (I) is calculated based on the queuing equations with the following equation:

$$l_{q_{0,I}} = l_{q_0} + \sum \mathrm{A(t)} - \sum D(t) \quad (5)$$

Where:

- $\boldsymbol{l_{q_{0,I}}}$ is the estimated number of vehicles in the queue when arriving at inlet point (I) when t= t_{OI} (Veh.)
- $\boldsymbol{l_{q_0}}$ is the number of vehicles in the queue at the start of traveling at the origin point (O) when t=0 (Veh.)
- $\boldsymbol{\sum A(t)}$ is the cumulative number of arrivals vehicles during $\boldsymbol{t_{OI}}$.
- $\boldsymbol{\sum D(t)}$ is the cumulative number of departures vehicles during $\boldsymbol{t_{OI}}$.

The cumulative number of arrivals vehicles A(t) and the cumulative number of departures vehicles D(t) during the time t_{iI} are respectively equal:

$$\mathrm{A(t)} = \int_0^{t_{OI}} \lambda(t)\, \mathrm{d}t \quad (6)$$

$$\mathrm{D(t)} = \int_0^{t_{OI}} \mu(t)\, \mathrm{d}t \quad (7)$$

Where:

- $\boldsymbol{\sum A(t)}$ is the cumulative number of arrivals vehicles during $\boldsymbol{t_{OI}}$(veh.)
- $\boldsymbol{\sum D(t)}$ is the cumulative number of departures vehicles during $\boldsymbol{t_{OI}}$ (veh.)
- $\boldsymbol{\lambda}$ is the arrival rate (Veh. /min.).
- $\boldsymbol{\mu}$ is the service rate of the system (Veh. /min.).

So, equation (5) can be written as the following formula:

$$l_{q_{0,I}} = l_{q_0} + \sum \int_0^{t_{OI}} \lambda(t)\, \mathrm{d}t - \sum \int_0^{t_{OI}} \mu(t)\, \mathrm{d}t$$
(8)

The service rate of all ferries is calculated by the following equation:

$$\mu = \frac{N \cdot C}{T_{round}} \quad (9)$$

Where:

- $\boldsymbol{\mu}$ is the service rate of the system (Veh. /min.).
- $\boldsymbol{N}$ is the working number of ferries (ferry)
- $\boldsymbol{C}$ is the average capacity of ferries (Veh.)
- $\boldsymbol{T_{round}}$ is the average required time for a single ferry to be ready to load from the same direction or circle time (min.)

$$T_{round} = t_L + 2(t_c + t_u) \quad (10)$$

Where:

- t_L is the average time to load a ferry with vehicles (min.).
- t_C is the average crossing-time of the ferry through the Suez Canal (min.).
- t_u is the average time to unload the vehicles from the ferry (min.).

2.2 The Estimated Real-Time For Al-Nasr Floating Bridge Trips

In the case of using the Al-Nasr floating bridge to cross between the two cities, the problem ,facing Google API maps, is the inability to know whether the bridge is on working or closing statue due to navigational conditions, whether for scheduled or emergency closing times. Travelers should be informed to takes precaution in choosing between routes. So, two conditions have been proposed:

- If the bridge is closing when ($t = t_{OI}$), drivers will be informed that the bridge is closed.
- If the bridge is working when ($t = t_{OI}$), the delay time of crossing the Suez Canal via the floating bridge link by the following equation:

$$t_{IE} = t_c \quad (11)$$

Where:

- t_{IE} is the total delay time in the system between the inlet point (I) and exit point (E) of the system (min.).
- t_C is the average crossing-time of a vehicle through the Suez Canal (min.).

All previous equations and steps are estimated to calculate the real-time for all traveling links. Data of variables is collected using manual and automatic methods which are illustrated in the following part.

3 DATA COLLECTION

Information data is collected to estimate a real-time travel time through the Suez Canal.

3.1 Travel Data of Ferries Systems

3.1.1 Queue Length (l_{q0}):

The queue length is the number of vehicles in the queue at the start of traveling (when t=0) from the origin point (O). Two detection methods can be used for counting as shown in Figure (4):

- Vehicle traffic counting cameras (CCTV Camera, IP Camera, etc..) .
- Automatic counters such as bending plates, pneumatic road tubes, piezoelectric sensors, inductive loops, etc. (at the inlet and the outlet of the queue) .The length of the queue represents the mathematical difference between the inlet counter and the outlet counter.

Figure 4: Example of the queue length detection methods; the right is the inductive loop and the left is CCTV Camera

Due to the difficulty of obtaining security approval for the installation of any of this equipment, it will be treated as input data to be entered manually.

3.1.2 Vehicle Demand

The number of vehicles arrive between the two towns is an important parameter to calculate the arrival rate (λ). It is collected by the above detection methods (Figure 4) which are used to calculate the queue length (using the cameras or using the queue inlet counter only) and saved as a historical data that is updated constantly. The application needs start-up historic vehicles arrival demand data that is collected through a direct manual site survey. The arrival number of vehicles is registered by one surveyor for each direction of movement with an interval time of half an hour. The survey has been carried out for one week, working and non-working days from 7.00 A.M. to 10:00 P.M. for both directions. Figure(5) illustrates the vehicle demand variation for the east bond at Port-Said main ferry.

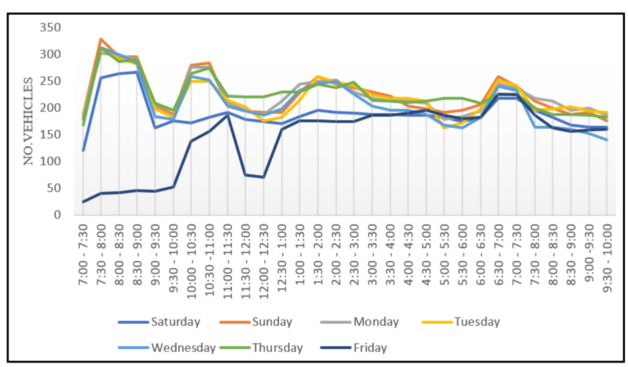


Figure 5: Vehicle demand during week hours for the east bond at Port-Said main ferry

3.1.3 Ferries' Characteristics

The working number of ferries is proposed to be an input data by the ferries control system that is replaced by the average working ferries number and capable to change anytime. Ferries' characteristics include loading time, capacity which is the number of vehicles carried by one ferry, crossing time, unloading time, and the number of working ferries. This data has been collected through a direct site survey manually using a form filled out by a person sitting on the ferry when crossing the canal. The data registers during the trip are the direction, capacity, the starting and ending times for ferry loading, crossing, and unloading times. The survey has been carried out for one week in working and non-working days from 7.00 A.M. to 10:00 P.M. for both directions.

3.2 Al-Nasr Floating Bridge Data

For the third possible links, the time data required to cross the bridge is collected manually by a person for one day. He fills out the form with the time of entry and exit of the vehicle and the regular closed time of the bridge due to the navigational conditions in the channel.

3.3 System Coordinates Data

The system coordinates are the coordinates of both the inlet and exit for the three links implying the starting point of the queue on either bank of the canal (I) and the exit point on the other bank (E) as shown in Figure (3). As a result, each direction has three inlet points and three exit points as shown in table (1). It is necessary to define and read by Google maps and determine the time required to travel.

Table 1. Inlet (I) and Exit (E) points of the three systems to cross the canal in each direction

If travel from Port-Said side to Port-Fouad side (East Bond)		
	I	E
Main Ferry	31.260117, 32.308510	31.254241, 32.314099
Al-Raswa Ferry	31.231983, 32.300205	31.231999, 32.307629
Al-Nasr Floating Bridge	31.228269, 32.301392	31.228595, 32.306674
If travel from Port-Fouad side to Port-Said side (West Bond)		
	I	E
Main Ferry	31.253578, 32.315259	31.259303, 32.310130
Al-Raswa Ferry	31.232396, 32.310169	31.232212, 32.301124
Al-Nasr Floating Bridge	31.228741, 32.307227	31.228422, 32.301338

4 MOBILE APP. PERFORMANCE

Due to the massive spread of smartphones with high technology capabilities and the emergence of many convenient applications, mobile application modeling had been introduced to offer real-time information for travelers to be easy for choosing a suitable route. *Kotlin* programming language was used to develop the application. It is a statically typed, general-purpose programming language with type inference [35]. It mainly targets the JVM but also compiles to JavaScript or native code. In 2017, Google announced Kotlin as an official language for android development [35,36]. The proposed basic application is divided into four main working steps; controlling systems, application server, database store, and mobile application as shown in Figure (6).

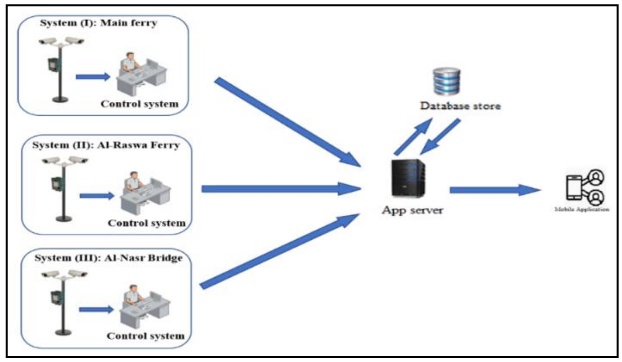


Figure 6: The proposed basic application working steps

The control system aims at collecting the required data in real-time by cameras or sensors at each of the three transit systems across the Suez Canal as shown in Figure (5). Then it transfers data to the control system for each one which analyzes the data and obtains the length of the waiting queue and the vehicles arrival rate at both ferry systems, the status of the bridge closed/open. The number of working ferries is a required data.

For the proposed basic mobile application, data is collected using the Internet interface as follows:

- Reading the required data from the database such as (the coordinates of the three systems, the vehicles arrival rate, the regular bridge closing times, ...).
- Storing the required data in the database as history data like (vehicles arrival rate to constantly update transport demand data).
- Performing calculations to know the routes and travel time for each route using real-time data and the required data from the database.
- Informing travelers by the results via mobile phones.

As a result of the presence of some security obstacles, there is no ability to establish the proposed system to predict travel time. The following modifications were made to develop the application:

- A screen was created in the application to manually input the queue length (l_{q0}) and the working ferries number (N) at the moment of travel starting from the origin point (O).

- The Regular closing times are used for the Al-Nasr Floating Bridge, and the emergency closing times were neglected.
- Manually collected vehicle arrival rate has been used on the two ferry systems with no possibility of updating it.

The final flow chart with these modifications is created to develop the application as shown in Figure (7).

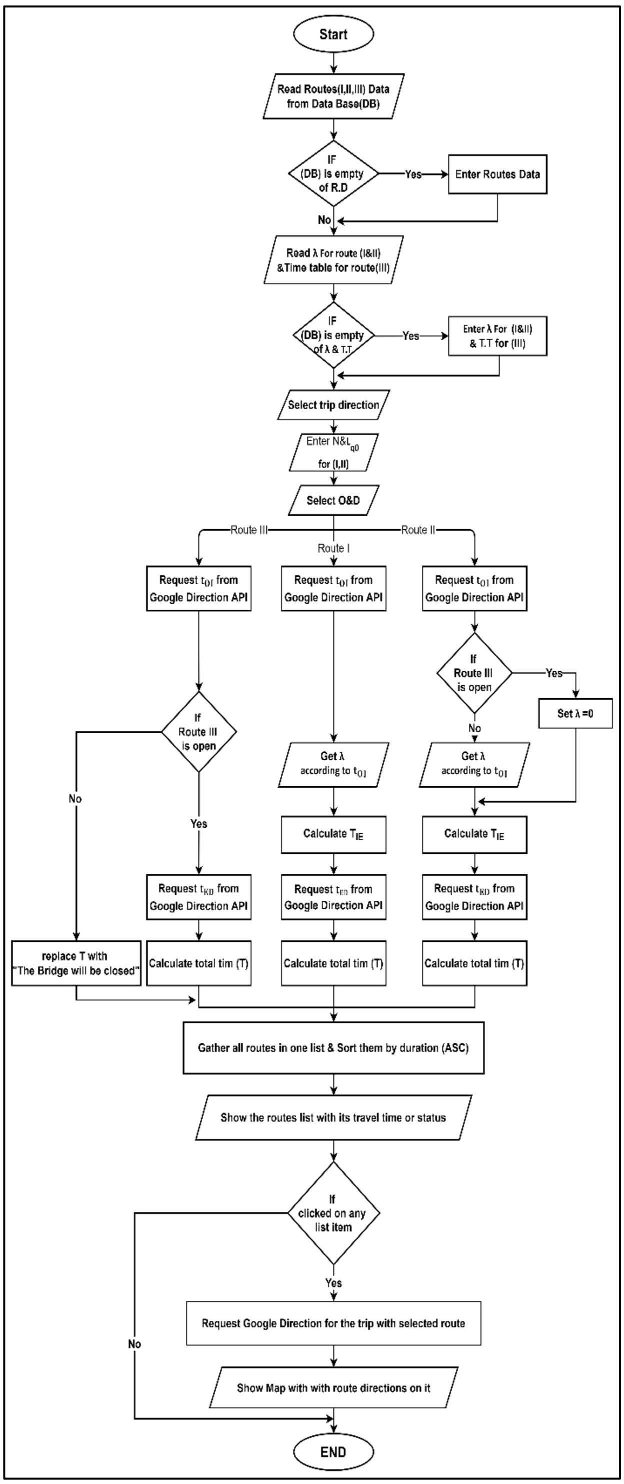


Figure 7: The performance flow chart for the proposed mobile application

5 RESULTS, ANALYSIS & DISCUSSION

The developed mobile application contains six screens as shown in Figure (8). The first screen allows choosing the direction of the trip (east bond or west bond). The second screen, through which the length of the queue is entered as input data at the moment of the start of the trip at both ferries systems, also allows the ability to change the number of working ferries at both systems. The third and fourth screens pick up both origin and destination points. While the fifth screen displays, a list of the three available routes sorted from the shortest to the longest one. Finally, the sixth screen appears after choosing one of the routes from the fifth screen to display a map of the desired route. Initially, the application presents the user with the expected time for each of the three routes to cross the Suez Canal. Secondly, it gives him the option of choosing amongst the three options. Thirdly, it displays the required path on a Google map.

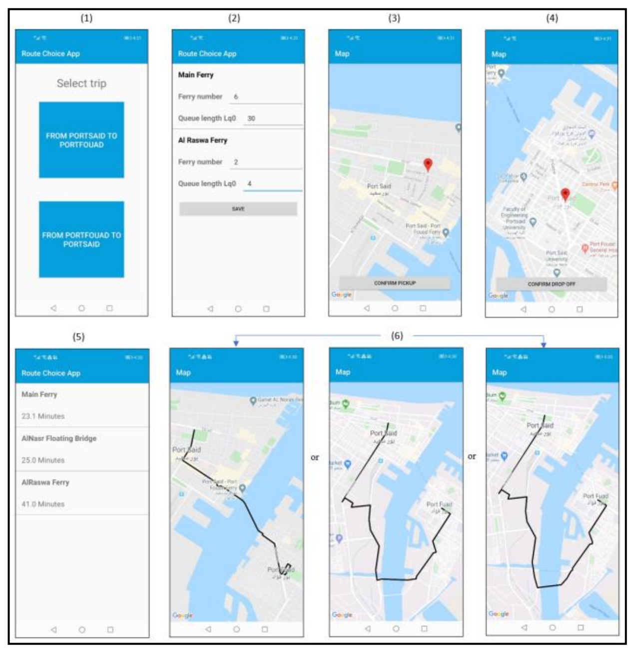


Figure 8: The developed mobile application screens

To check the results of the introduced mobile application, actual trips are made from different origins to different destinations in both directions. Trips take place in each direction during every hour of the application's working hours (From 7.00 A.M. to 10:00 P.M.) along weekdays.

The actual travel time and the estimated travel time by the application and also by Google Map are registered for Main Port-Said Ferry and Al-Nasr Floating Bridge routes. While the Al Raswa ferry route was neglected because it came as the worst choice continuously due to two reasons. The first reason is the proximity of the Al-Nasr Floating Bridge which certainly offers the possibility of the faster crossing of the canal with the absence of waiting queues. The second reason is that the Al-Raswa Ferry mainly serves commercial transport trucks. . As an example, as shown in Figure (9), the comparison of the three travel times during Sunday hours for the east bond at Port-Said main ferry with an error bar equivalent to 5 minutes. This confirms and demonstrates that the estimated travel time by the application presented in this study is superior to the estimated travel time by the Google Maps application between the two cities.

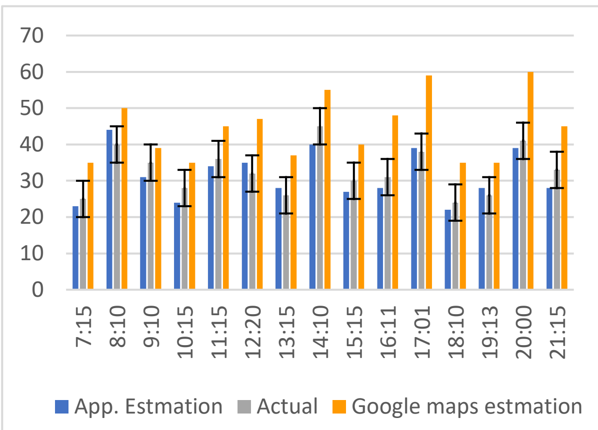


Figure 9: Travel times during Sunday hours for the east bond via Port-Said main Ferry route with an error bar of 5 minutes

The percentage error in travel time is calculated using each of the introduced mobile application and Google Maps for the main ferry route in the direction from Port-Said to Port-Fouad (East bond) as illustrated in Table (2).

Table 2. the percentage error in travel time via main Port-Said ferry during week hours (East direction)

	Sat.		Sun.		Mon		Tue		Wed		Thu		Fri	
7-8 AM	3.57	14.3	8	40	4.35	34.8	12	24	5	20	0	11.1	4	20
8-9 AM	7.41	14.8	10	25	6.38	8.51	2.7	2.7	3.33	16.7	6.45	0	4.17	29.2
9-10 AM	5.71	2.86	11.4	11.4	2.86	5.71	14	14	6.67	10	5.71	11.4	4.35	39.1
10-11 AM	2.78	36.1	14.3	25	0	22.2	6.67	15.6	3.45	27.6	0	45.7	6.06	39.4
11-12 AM	15.4	46.2	5.56	25	8.89	20	8.89	20	2.56	35.9	2.94	50	9.09	18.2
12-13 PM	7.69	50	9.38	46.9	5.41	37.8	11.5	30.8	0	54.5	10	70	9.38	18.8
13-14 PM	12	36	7.69	42.3	7.41	55.6	7.69	34.6	2.5	37.5	4.35	47.8	4.17	41.7
14-15 PM	8.89	26.7	11.1	22.2	6.98	34.9	3.57	28.6	11.4	14.3	4.17	45.8	9.09	27.3
15-16 PM	2.94	50	10	33.3	10.7	25	3.33	46.7	6.67	16.7	2.94	55.9	0	40
16-17 PM	4.35	52.2	9.68	54.8	6.9	51.7	12	40	8	40	3.85	34.6	17.9	32.1
17-18 PM	8.33	45.8	2.63	55.3	6.82	29.5	8.33	41.7	6.67	46.7	0	50	11.5	34.6
18-19 PM	5.41	37.8	8.33	45.8	21.4	25	12.5	25	2.94	52.9	4.76	66.7	14.6	19.5
19-20 PM	10.3	28.2	7.69	34.6	10.3	17.2	10	27.5	0	29.6	13.3	22.2	12.5	25
20-21 PM	2.94	52.9	4.88	46.3	8.89	42.2	6.67	56.7	10	85	7.69	42.3	0	42.3
21-22PM	12	40	15.2	36.4	20	31.4	7.69	42.3	13.6	72.7	12	56	7.69	42.3

• Application error %   • Google Maps error %

It can be noticed that the application has a percentage error in travel time less than the percentage error of Google Maps in almost most trips. The maximum percentage error during the week for the application is 21.4% while for Google Maps is 85%. Also, the average percentage error during the week is 7.4% and 34.4% for the application and Google Maps; respectively. The percentage error in travel time is calculated for the mobile application and Google Maps for the main ferry route in the direction from Port-Said to Port-Fouad (West bond) that illustrated in Table (3).

In Table (3), it can be noticed that the application has a percentage error less than the percentage error of Google Maps in almost most trips. The maximum percentage error during the week for the application is 18%, while for Google Maps is 57.1% whereas the average percentage error during the week is 7.2% and 26.6% for the application and Google Maps; respectively.

Table 3. the percentage error in travel time via main Port-Said ferry during week hours (West direction)

	Sat.		Sun.		Mon		Tue		Wed		Thu		Fri	
7-8 AM	16	24	12.1	18.2	3.57	17.9	12.1	3.03	6.25	0	7.69	0	4	20
8-9 AM	11.5	23.1	7.5	10	6.06	6.06	0	10	5.71	14.3	5	0	13.6	45.5
9-10 AM	8.57	8.57	5	7.5	5.56	5.56	6.67	13.3	3.13	25	12	32	11.4	25.7
10-11 AM	9.09	15.2	13	39.1	3.45	31	2.78	2.78	2.44	17.1	4.17	41.7	5	22.5
11-12 AM	18	4	8.93	19.6	2.22	13.3	0	5.56	10	8	2.22	11.1	17.9	42.9
12-13 PM	2.38	21.4	3.92	9.8	4.76	26.2	5.71	22.9	10.2	14.3	2.5	27.5	15.4	42.3
13-14 PM	3.23	35.5	2.38	26.2	6.67	22.2	11.1	22.2	6.67	30	7.14	25	8	48
14-15 PM	0	22.9	6.12	16.3	8	12	8.89	26.7	3.33	30	3.23	25.8	7.69	42.3
15-16 PM	4	52	8.89	20	10	23.3	13	32.6	3.85	46.2	10	43.3	10.5	15.8
16-17 PM	0	52	12.9	25.8	7.41	40.7	5.88	14.7	11.4	28.6	3.13	34.4	9.09	30.3
17-18 PM	7.5	37.5	3.45	48.3	3.7	37	4	36	0	40	5.71	51.4	2.5	32.5
18-19 PM	9.76	29.3	10.9	23.9	0	32.5	6.67	2.22	2.86	28.6	8.57	57.1	9.09	20.5
19-20 PM	12	56	2.38	33.3	6.67	22.2	4.76	19	12	4	6.67	30	11.8	14.7
20-21 PM	7.69	53.8	9.38	25	15.6	21.9	5.71	34.3	3.57	46.4	6.67	33.3	10.7	39.3
21-22PM	4	52	13.8	41.4	13.3	26.7	6.67	26.7	6.9	41.4	8.82	47.1	8	56

• Application error %   • Google Maps error %

For Al-Nasr Floating Bridge route, the estimated travel time from the application and Google Maps is almost equal and has the same percentage error if the bridge is open for vehicles. This is due to the ability of Google Maps to know the traffic situation with great accuracy just like any other road. On the other hand, when the bridge is closed for navigation, the feature of the application comes from the ability to inform the travelers that the bridge is closed. Unlike Google Maps that does not distinguish the closure case of the bridge. The performed application is predicted to represent a breakthrough in route choice modeling and it can be applied to transport freight in any of the queuing systems, anywhere in the world, with only minor modifications to the characteristics of each queue system. Also, it will be a solution of waiting times and congestion that will affect positively on the Egyptian economy.

6 CONCLUSION

Developing the infrastructure of the Egyptian transportation networks is a very vital mission. Also, establishing full intelligent transportation systems to solve the congestion problem requires a long-term plan. Due to the revolution of the Internet with the spread of smartphones, performing a mobile application is chosen to predict the real-travel time between the two towns; Port-Said and Port-Fouad to cross the Suez Canal as a study area. Google Maps Application Programming

Interface (API) is used to get the traffic information providing in real- travel time.

Intelligent transportation systems method is used in collecting data to improve the ability of the application which the Google Map system is having difficulty obtaining a sufficient amount of information. The queue delay time of waiting for ferries is illustrated. There were some limitations such as the inability to receive some security approvals to establish the ferry and bridge sites with the required systems for collecting data. The application's result is collected during a week of testing from 7 a.m. to 10 p.m. for 210 trips between the two towns for the three links; the main-ferry - Al Raswa Ferry - the floating bridge; demonstrated to achieve the satisfactory accuracy. The proposed application is able to reduce the average percentage error of the estimated trip time by Google Maps for the main ferry from 30% to 7% only. It can detect the statue of the floating bridge from operating or closing with high accuracy that Google Map is unable to find out at all. It is predicted to be a simple way to choose the appropriate route.

The proposed application provided a solution to the problem of queues, which can be developed for any system that contains waiting queues and delay times such as waiting for (ferries, port entry, collecting transit fees, signal intersections, etc.). Just studying the characteristics of the queues and a simple modification in the application data with these characteristics can provide the estimated travel time in any of the queuing systems and anywhere in the world.

The proposed application can be developed in the future by increasing the travel information provided to travelers such as distance or cost. It is also possible to study the impact of the application on the behavior of travelers between the two cities if the application can be implemented as an outcome of the promising results presented by this study. It is also possible to benefit from the data that the application can collect to improve the level of ferry service, as well as to rationalize its work at times that do not need to work at its full capacity. This paper is predicted to provide a solution to the route choice problems for networks having signalized intersections with queue length and traveling problems between any cities crossing by passageways because travelers choose the route with the smallest time.

Author Contributions

Each author is expected to have made considerable contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work; or have drafted the work or substantively revised it; AND has approved the submitted version (and subsequent versions edited by journal staff; AND agrees to be personally accountable for the author's contributions and for ensuring that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved.

REFERENCES

[1] D. Kwak, "Supporting route choice via real-time visual traffic information and counterfactual arrival times," *Rutgers Univ. Community Repos.*, 2017.

[2] N. Xia, L. Cheng, S. Chen, X. Y. Wei, W. W. Zong, and M. C. Li, "Accessibility based on Gravity-Radiation model and Google Maps API: A case study in Australia," *J. Transp. Geogr.*, vol. 72, no. September, pp. 178–190, 2018, doi: 10.1016/j.jtrangeo.2018.09.009.

[3] B. Dhivyabharathi, E. S. Hima, and L. Vanajakshi, "Stream travel time prediction using particle filtering approach," *Transp. Lett.*, vol. 10, no. 2, pp. 75–82, 2018, doi: 10.1080/19427867.2016.1192016.

[4] Z. Zhu, A. Mardan, S. Zhu, and H. Yang, "Capturing the interaction between travel time reliability and route choice behavior based on the generalized Bayesian traffic model," *Transp. Res. Part B Methodol.*, vol. 143, pp. 48–64, 2021, doi: 10.1016/j.trb.2020.11.005.

[5] K. Karuppanagounder, "Econommic Impact of Traffic Congestion- Estimatioon and Challenges," no. June 2018, pp. 1–19, 2018.

[6] S. R. Samal, P. Gireesh Kumar, J. Cyril Santhosh, and M. Santhakumar, "Analysis of Traffic Congestion Impacts of Urban Road Network under Indian Condition," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1006, no. 1, 2020, doi: 10.1088/1757-899X/1006/1/012002.

[7] J. Ma, J. Chan, G. Ristanoski, S. Rajasegarar, and C. Leckie, "Bus travel time prediction with real-time traffic information," *Transp. Res. Part C Emerg. Technol.*, vol. 105, no. June 2018, pp. 536–549, 2019, doi: 10.1016/j.trc.2019.06.008.

[8] M. El-Bany, M. Shahin, I. Hashim, and M. Serag, "Transport Accessibility: A Tool for Identification of Activity- Based Destination Choice Model for Port-Said City, Egypt," *Port-Said Eng. Res. J.*, vol. 18, no. 2, pp. 52–66, 2014, doi: 10.21608/pserj.2014.45291.

[9] H. M. Abdel-Latif and M. S. Serag, "Travel demand characteristics and transportation performance of ferries across the Suez Canal at Port-Said city," *Proceedings, Annu. Conf. - Can. Soc. Civ. Eng.*, vol. 4 B, no. June, pp. 67–76, 1998.

[10] "SCA-Navigation Statistics." https://www.suezcanal.gov.eg/English/Navigation/Pages/NavigationStatistics.aspx (accessed Jan. 01, 2022).

[11] marwa elbany, "Transportation Feasibility: Visions and Strategies of The Proposed Urban Transport Project in Port Said city," *Port-Said Eng. Res. J.*,

vol. 0, no. 0, pp. 0–0, 2021, doi: 10.21608/pserj.2021.57603.1087.
[12] "Port-Said districts map ." http://www.portsaid.gov.eg/mapsnew/a7ya2.aspx (accessed May 31, 2022).
[13] C. L. Zhao and H. J. Huang, "Experiment of boundedly rational route choice behavior and the model under satisficing rule," *Transp. Res. Part C Emerg. Technol.*, vol. 68, pp. 22–37, 2016, doi: 10.1016/j.trc.2016.03.006.
[14] Y. Liu, J. Bunker, and L. Ferreira, "Transit Users' Route-Choice Modelling in Transit Assignment: A Review," vol. 30, no. April 2013, pp. 37–41, 2010.
[15] D.-M. Chang, "A sensitivity analysis of traffic assignment," 1991.
[16] T. V. M. and K. V. K. Rao, "Introduction to Transportation Engineering," 2007, pp. 513–520.
[17] N. A. Irwin, N. Dodd, and G. H. Von Cube, "Capacity Restraint in Assignment Programs," *Highw. Res. Board Bull. 40th Annu. Meet. Highw. Res. Board*, no. 297, pp. 109–127, 1961.
[18] J. G. Wardrop, *Some theoretical aspects of road traffic research. Proc. Inst. Civil Eng. II 1, 325–362.* 1952.
[19] D. J. R., M. Beckman, C. B. McGuire, C. B. Winsten, and T. C. Koopmans, "Studies in the Economics of Transportation.," *or*, vol. 7, no. 4. p. 146, 1956, doi: 10.2307/3007560.
[20] C. F. Daganzo and Y. Sheffi, "On Stochastic Models of Traffic Assignment," *Transp. Sci.*, vol. 11, no. 3, pp. 253–274, 1977, doi: 10.1007/978-3-319-25861-4_25.
[21] B. N. Janson, "Dynamic traffic assignment for urban road networks," *Transp. Res. Part B*, vol. 25, no. 2–3, pp. 143–161, 1991, doi: 10.1016/0191-2615(91)90020-J.
[22] B. N. Janson, "Convergent Algorithm for Dynamic Traffic Assignment," *Transp. Res. Rec.*, vol. 1328, pp. 69–80, 1991.
[23] H. Mahmassani, S. Peeta, T.-Y. Hu, and A. Ziliaskopoulos, "DYNAMIC TRAFFIC ASSIGNMENT WITH MULTIPLE USER CLASSES FOR REAL-TIME ATIS/ATMS APPLICATIONS," 1993.
[24] K. F. Abdelghany and H. S. Mahmassani, "Dynamic trip assignment-simulation model for intermodal transportation networks," *Transp. Res. Rec.*, no. 1771, pp. 52–60, 2001, doi: 10.3141/1771-07.
[25] M. E. Ben-Akiva, H. N. Koutsopoulos, R. G. Mishalani, and Q. Yang, "Simulation laboratory for evaluating dynamic traffic management systems," *J. Transp. Eng.*, vol. 123, no. 4, pp. 283–289, 1997, doi: 10.1061/(ASCE)0733-947X(1997)123:4(283).
[26] M. Ben-Akiva, M. Bierlaire, J. Bottom, H. Koutsopoulos, and R. Mishalani, "Development of a Route Guidance Generation System for Real-Time Application," *IFAC Proc. Vol.*, vol. 30, no. 8, pp. 405–410, 1997, doi: 10.1016/s1474-6670(17)43857-2.
[27] A. K. Ziliaskopoulos and S. T. Waller, "An Internet-based geographic information system that integrates data, models and users for transportation applications," *Transp. Res. Part C Emerg. Technol.*, vol. 8, no. 1–6, pp. 427–444, 2000, doi: 10.1016/S0968-090X(00)00027-9.
[28] C. F. Daganzo, "The cell transmission model: A dynamic representation of highway traffic consistent with the hydrodynamic theory," *Transp. Res. Part B*, vol. 28, no. 4, pp. 269–287, 1994, doi: 10.1016/0191-2615(94)90002-7.
[29] G. de Moraes Ramos, T. Mai, W. Daamen, E. Frejinger, and S. P. Hoogendoorn, "Route choice behaviour and travel information in a congested network: Static and dynamic recursive models," *Transp. Res. Part C Emerg. Technol.*, vol. 114, no. June 2019, pp. 681–693, 2020, doi: 10.1016/j.trc.2020.02.014.
[30] J. Lopes, J. Bento, E. Huang, C. Antoniou, and M. Ben-Akiva, "Traffic and mobility data collection for real-time applications," *IEEE Conf. Intell. Transp. Syst. Proceedings, ITSC*, pp. 216–223, 2010, doi: 10.1109/ITSC.2010.5625282.
[31] F. Wang and Y. Xu, "Estimating O-D travel time matrix by Google Maps API: Implementation, advantages, and implications," *Ann. GIS*, vol. 17, no. 4, pp. 199–209, 2011, doi: 10.1080/19475683.2011.625977.
[32] X. Jeff Ban, P. Hao, and Z. Sun, "Real time queue length estimation for signalized intersections using travel times from mobile sensors," *Transp. Res. Part C Emerg. Technol.*, vol. 19, no. 6, pp. 1133–1156, 2011, doi: 10.1016/j.trc.2011.01.002.
[33] C. Nanthawichit, T. Nakatsuji, and H. Suzuki, "Application of Probe-Vehicle Data for Real-Time Traffic-State Estimation and Short-Term Travel-Time Prediction on a Freeway," *Transp. Res. Rec.*, no. 1855, pp. 49–59, 2003, doi: 10.3141/1855-06.
[34] P. García-Albertos, M. Picornell, M. H. Salas-Olmedo, and J. Gutiérrez, "Exploring the potential of mobile phone records and online route planners for dynamic accessibility analysis," *Transp. Res. Part A Policy Pract.*, vol. 125, no. February 2018, pp. 294–307, 2019, doi: 10.1016/j.tra.2018.02.008.
[35] JetBrains, "Kotlin Language Documentation," 2020.
[36] "Kotlin Tutorial." https://www.tutorialspoint.com/kotlin/index.htm (accessed Jan. 02, 2022).