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Research paper

Travel data collection using a smart phone for the estimation of multimodal travel times of intra-city public transportation

Kanala Teja Vinay Kumar Reddy[1], Surya Prakash Challagulla[2]

Abstract: All the available modes of travel and their respective travel parameters must be known to the commuters before their trip. Otherwise they may either spend more money or more time for the trip. In addition to this, recent pandemic, rapidly spreading novel corona virus is demanding a smart solution for contactless commuting. This paper suggests a practical solution to make both the above possible and it emphasizes the applicability of two developed android applications, one for travel data collection and another to predict travel time for a multimodal trip within the study area. If the whole trip is by a single mode, the user can get the corresponding travel time estimate from "Google maps". But, if the trip is by multiple modes, it is not possible to get the total travel time estimate for the whole trip at a time from "Google maps". A separate travel mode for "auto" is unavailable in "Google maps" alongside drive, two-wheeler, train or bus and walk alternatives. It is also observed that the travel time estimate of "Google maps" for the city buses is inaccurate. Hence, the two modes (Buses and Autos) were chosen for the study. Unless and until the travel times and stopping times of the two modes are known, it is not possible to predict their trip times. Hence, the mobility analysis was performed for the two modes in the study area to find their respective average travel rate at peak hours, across 15 corridors and the results were presented.

Keywords: commuters, multimodal travel time, public transport, stopping time, travel rate, travel time

[1]PhD Scholar, Dept. of Civil Engineering, K. L. University, Vijayawada-522502, AP, India, e-mail: tejavinaykumarreddy@gmail.com, ORCID: 0000-0003-1312-8452
[2]PhD Scholar, Dept. of Civil Engineering, K. L. University, Vijayawada-522502, AP, India, e-mail: chsuryaprakash@kluniversity.in, ORCID: 0000-0003-0125-1488

1. Introduction

Transportation is necessary in almost every human's life but it is also clear that there are important inefficiencies and uncertainties related to transportation [1]. Those inefficiencies and uncertainties impact the mode choice behavior of the commuters that cause increase in the trip cost, enormous travel time delay, huge waste of fuel which ultimately lead to high pollution and degradation of quality of life. The commuters must know all the available modes of transport and their respective travel parameters such as trip time, cost, occupancy, frequency etc before their trip. Otherwise they may either spend more money or more time for the trip. In addition to this, recent pandemic, rapidly spreading novel corona virus posing a serious challenge to the transportation planners across the world and is demanding a smart solution for contactless commuting. Hence, before the trip itself, the commuter must know the occupancy of the vehicle besides its corresponding trip time and trip cost. In response to the above, transportation management has been attracting immediate research efforts and actions that prevent overcrowding in public transportation services, by "Information and Communication Technologies (ICT)". Previously, efforts were done to motivate people to use public transportation due to which, the vehicular volume on roads can be reduced. But, in most of the metropolitan cities and especially in the study area (Hyderabad, India), the local city buses are often being overcrowded especially during peak hours and the passengers are being travelled by standing over footboards. As many of the passengers are not even getting the space to stand and travel, they are simply shifting to expensive mode choices such as taxi or cab services etc.

If a commuter wants to travel from one place to another, the mode choice depends on various factors such as fare, time, comfort etc. The commuter may not always choose the same or single mode of transport for all the trips. If the trip distance is less, usually a single mode of transport is preferred. But, for long distances, the commuters travel by different modes one after the other due to non-availability of a single mode of transport for the whole distance, expensive fares, non-frequency etc. Moreover, travelling by a single mode of transport for the whole trip may be sometimes expensive such as travelling by cab. If the commuters are in a hurry to reach their destinations irrespective of the fare, they can take a cab but if they are not in a hurry, they can use public transportation facilities such as city bus, metro rail, local train and auto etc. But all those public transportation modes travel through the major trunk roads in the city and hence the commuters cannot reach their destinations by them. They have to either walk for a distance or catch an auto to reach their destinations from the public transport stations. Moreover, commuters sometimes may not prefer the modes of public transportation. Not just because they have to travel by different modes of transport but predominantly due to the unreliable timings and unwanted delay caused by the stopping of the vehicles (City buses, autos etc) at their stops and time wasted in waiting for catching another vehicle such as an auto to reach their destinations. With the idea to include various modes of public transportation in every medium to long trip, in order to cut down the travel cost besides promoting multi modality by making accurate travel time estimates available to the commuters, a need for developing a mobile application is identified. Multimodal traffic and traveler information systems have a positive influence on commuter's behavior and mode choice [7]. Hence, the goal of this study is to portray accurate multimodal travel time estimates of public transportation modes at the study area to promote multimodality. Unless and until the travel times and stopping times of public transport modes are known, it is not possible to predict their trip times. Hence, the mobility analysis was performed for the two modes of public transportation (city buses and autos) in the study area. The organization of the paper is as follows. Section 2 gives a brief overview of the study area. Collection of travel data using a developed android application at the study area has been discussed in Section 3. Section 4 presents the results of statistical mobility analysis to find average travel rate through the selected corridors and average travel time between the stops. Section 5 explains about the developed android application for this research work to display its results followed by conclusion.

2. Study area

Hyderabad is a rapidly growing Indian megacity[8]. It is a metropolitan city in India with a population of about 6.5 million [2]. Currently, it is estimated that the city population is above 10 millions [3]. The most widely used mode of public transportation in Hyderabad is ‘City Buses’. Approximately 35 percent of all trips in the greater metropolitan region of Hyderabad are made using the city bus service and 0.2 million passengers travel everyday by metro rail and that accounts to only 2%. The city bus service, operated by the ‘Telangana State Road Transport Corporation (TSRTC)’, provides about 44,000 trips every day for approximately 3 million commuters [4]. Inspite of this, no actions were taken in terms of traffic management, dedicated lanes, and better upkeep/ maintenance of vehicles resulting in that common man who can afford even slightly is shifting from buses to self owned vehicles. It may be two-wheelers or four wheelers or even bicycles because of which, the number of vehicles on the roads are increasing ultimately which is leading to further lowering of speed, congestion, increase in pollution level etc [5]. As the traffic congestion on roads gets worst, it leads to high rate of road accidents [9]. It is found that most public transport agencies in India, do a poor job of making even a basic route information available to public. TSRTC has also stopped publishing the route time table for buses in 2009 [4]. The main problem here is that, if the arrival or departure time of one bus is disturbed, it will be continued and further it will be cumulative in nature. As that happens at the morning peak time hours itself, there is no guarantee about the arrival, departure and travel times of any bus as those depends on various factors.

3. Data collection

Hyderabad city occupies 650 square kilometers (250 sq mi), along the banks of the Musi River [6]. The city Hyderabad Master Plan 2031 for Hyderabad Metropolitan Region covers an area of around 5965 Sq.Kms. The HMDA master plan 2031 of Hyderabad has proposed a radial-concentric structure of development with new urban nodes and urban centers in all directions to promote balanced development in the Hyderabad Metropolitan Region with a Peri Urban Zone all along the urban area, hierarchy of circulation network to cater to the present and future travel needs of population and activities. It will be a herculean task to do the study for the entire city. Hence, initially the unpublished bus routes information has been obtained from TSRTC. According to it, there are 1005 different buses are there, making 44000 trips each day. Out of them, 15 buses were chosen and their respective routes are the corridors, which pass through different major areas and covers 30% of the extent of the city but however, the routes may intersect for a distance. Along all these routes, Autos travel within their respective travel limits. In order to carry out the research, the traffic data such as travel time from one stop to another and stopping time at each stop must be found. Usually, licensed plate method, video graphic methods, GPS Tracking etc are the methods used for these studies. But, here in this study, as the number of stops are more (out of the 15 corridors, 10 were the minimum number of bus-stops in a corridor and the maximum is 87 bus-stops) and further, the travel times and stopping times are to be measured at each segment. One way to do this is, by attaching GPS devices to the vehicles. As the number of vehicles are more, it will be expensive to fix GPS devices to all of them. Hence, we developed an android application which after installing in a smart phone, a series of start and stop times at all the stops can be recorded manually, besides it automatically measures and records the distance between the stops using smart phone GPS only. For this, the user has to travel by the vehicle with a smart phone with the developed application installed in it. This is a new method further, most economical way as it neither needs laborious work nor expensive devices. In each corridor, the travel time and stopping time data of the two selected modes (City Bus and Auto) has been collected for one week duration, during only working days at peak hours i.e., from Monday to Saturday from 8 A.M to 10 A.M and from 4 P.M to 6 P.M. The 6-Day average data has been utilized for the analysis. The name of the developed application is 'VTWOD (Vehicle Travel time, Waiting time and Occupancy Data logger)'. Language used for the app, in the back end is JAVA and for front end is XML. GPS is used for noting the location. The system time is recorded while saving the location. The minimum support API level is 17. No external libraries were used for this application. Hence, it is simple but very useful for those who are working on travel time, delay and vehicle occupancy studies. If the vehicle occupancy increases, less vehicles needed and road will be less congested [10]. Hence, provision is made to collect vehicle occupancy data also. In the UI of the application, there are three buttons: Start, Stop and Finish as shown in Fig. 3. Before every click on the Start and Stop buttons, the user has to enter the Bus-stop or Auto-stop name, Occupancy of the vehicle in which the user is travelling and any other data (if required). Once the destination reached, the user has to click on finish button so that the points of time at which the user clicked on the buttons, the distance between the points for every set of Start & Stop buttons and the Stop name or Vehicle Occupancy etc will be displayed in the form of a table. Fig. 1 shows the application icon and the functional block diagram of the application has been shown in Fig. 2.

Fig. 1. 'VTWOD' Android Application Icon

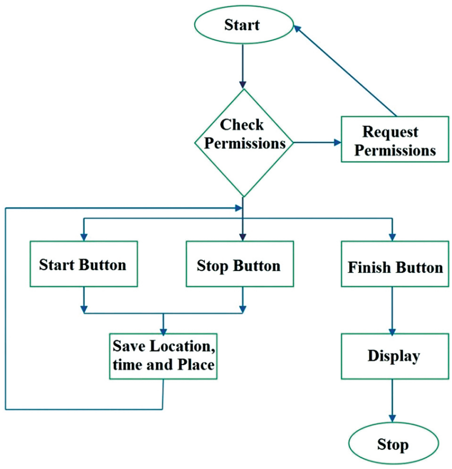

Fig. 2. Functional Block Diagram of ‘VTWOD’ Application

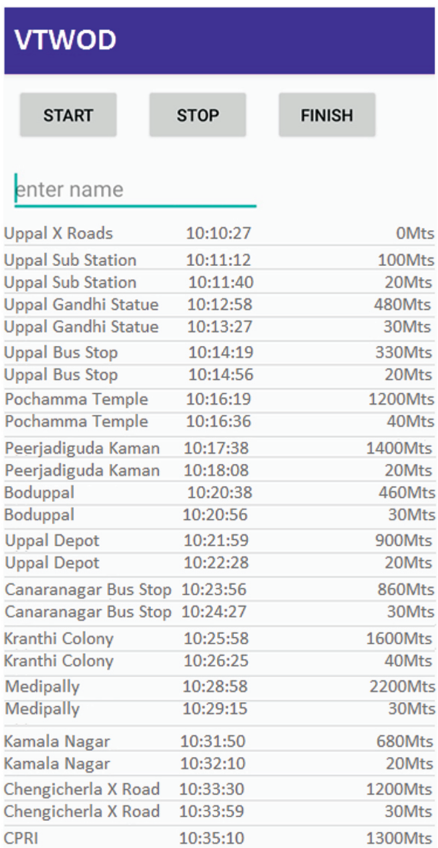

Fig. 3. User Interface of ‘VTWOD’ Application

4. Data analysis and results

The developed android application "VTWOD", gives the points of time at which the vehicle started or stopped. With this data, the travel time between two consecutive stations and the stopping time of the vehicle while on-board and off-board of the passengers as well as at the traffic signals were calculated. Also the cumulative travel time and stopping time were calculated for each route, for both the modes of transport at morning and evening peak hours. These calculations were done for the 6-day data obtained from 15 corridors chosen and the 6-day average has been calculated to ultimately find the average travel rate in minutes per kilometer at each corridor. Table 1 represents the details of the corridors chosen.

Table 1. Details of the selected corridors

S. No	Bus number/Route number	Distance (km)	Number of stops
1	1	9.5	20
2	2U	15.8	29
3	3	20.4	42
4	5M	12.5	19
5	6C	20.2	32
6	10	9.8	26
7	280	23.2	33
8	8C	19.3	34
9	113K/L	31.8	72
10	118	8.1	10
11	158/277D	36.6	68
12	158/299	28.3	61
13	277	33.5	42
14	225L/299	50.4	87
15	219/229	40.5	64

Some portion of the corridors intersect with one another but however once after the collection of 6-day data for all the routes is done, for the repeated portion of the routes, average of obtained travel times and stopping times were taken for the analysis. The Average travel rate has been calculated at each corridor for both the peak hours i.e., morning and evening for the two modes of transport. The obtained average travel rates and average travel times of city buses and autos are expressed in the Table 2 and Table 3 respectively.

Fig. 4 and Fig. 5 corresponds to the Average travel rate and Average travel time of city buses respectively and similarly, Fig. 6 and Fig. 7 are of autos. If the distance to be traveled is more, the corresponding travel time will also be more. Hence, the total distance traveled and the average travel time are directly related. The same can be seen in Fig. 5 and Fig. 7.

Table 2. 6-Day Average travel rate and travel time for city buses during

For City Buses						
S. No	Route no.	Total distance [km]	Average travel rate [minutes/km]		Average travel time [minutes]	
			Morning peak hours	Evening peak hours	Morning peak hours	Evening peak hours
1	1	9.5	6.23	5.49	59.17	52.16
2	2U	15.8	4.44	4.24	70.17	67.00
3	3	20.4	4.67	4.77	95.33	97.33
4	5M	12.5	4.25	4.52	53.16	56.50
5	6C	20.2	3.57	3.94	72.17	79.50
6	10	9.8	6.43	5.26	63.00	51.50
7	280	23.2	3.70	3.00	85.83	69.67
8	8C	19.3	4.27	3.46	82.33	66.83
9	113KL	31.8	4.76	4.80	151.50	152.66
10	118	8.1	3.50	3.33	28.33	27.00
11	158.277D	36.6	4.34	4.16	158.67	152.33
12	158.299	28.3	4.33	3.57	122.50	101.00
13	277	33.5	3.13	3.07	104.83	102.83
14	225L.299	50.4	3.38	3.39	170.17	171.00
15	219.229	40.5	3.49	3.27	141.33	132.51

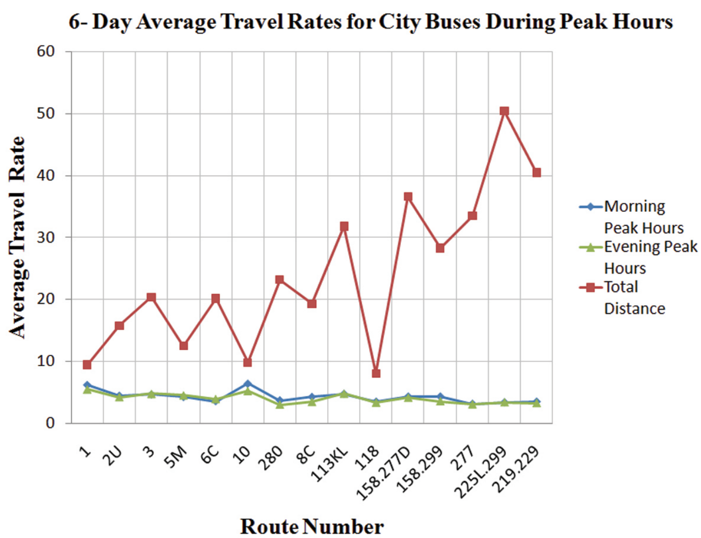

Fig. 4. Graph showing 6-Day Average travel rates for city buses during peak hours

Table 3. 6-Day Average travel rate and travel time for autos during peak hours

For Autos						
S. No	Route no.	Total distance [km]	Average travel rate [minutes/km]		Average travel time [minutes]	
			Morning peak hours	Evening peak hours	Morning peak hours	Evening peak hours
1	1	9.5	6.03	5.61	57.29	53.30
2	2U	15.8	4.28	4.04	67.62	63.83
3	3	20.4	4.51	4.59	92.00	93.64
4	5M	12.5	4.02	4.49	50.25	56.13
5	6C	20.2	3.39	3.83	68.48	77.37
6	10	9.8	6.18	5.04	60.56	49.39
7	280	23.2	3.54	2.87	82.13	66.58
8	8C	19.3	4.07	3.35	78.55	64.66
9	113KL	31.8	4.49	4.55	142.78	144.69
10	118	8.1	3.46	3.24	28.03	26.24
11	158.277D	36.6	4.08	3.95	149.33	144.57
12	158.3	28.3	4.16	3.44	117.73	97.35
13	277	33.5	2.95	2.93	98.83	98.16
14	225L.299	50.4	3.15	3.20	158.76	161.28
15	219.23	40.5	3.30	3.11	133.65	125.96

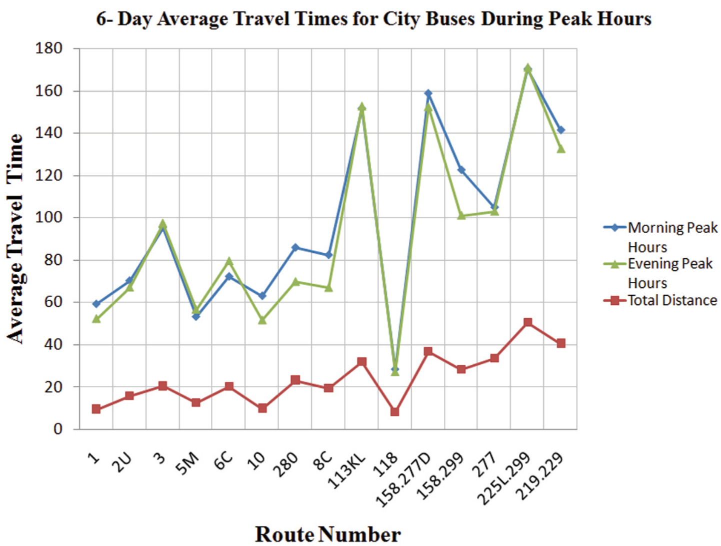

Fig. 5. Graph showing 6-Day Average travel times for city buses during peak hours

But the travel rate is not related to the travel distance, it depends on various factors related to pavement, traffic, weather etc. Hence, from Fig. 4 and Fig. 6, it can be clearly seen that the average travel rate and the total travel distance are not related. Also, It can be observed that Fig. 4–6 and Fig. 5–7 are similar, in spite of small variations in the magnitudes of

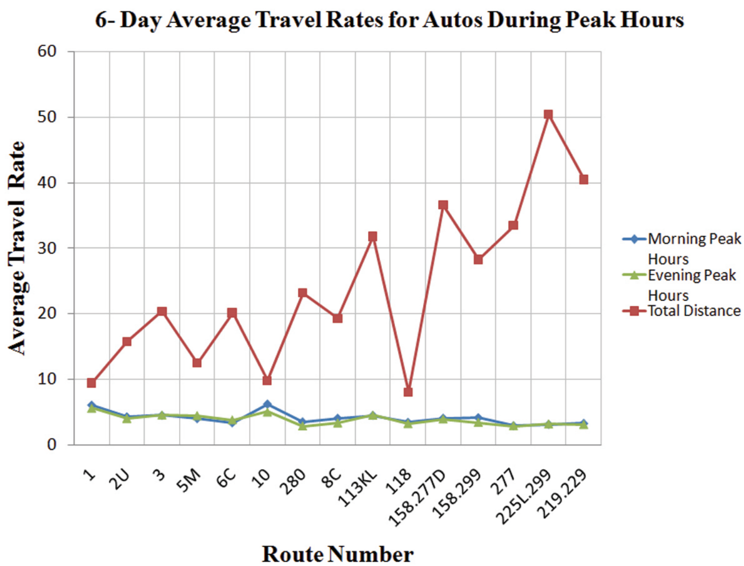

Fig. 6. View of the concrete slurry wall with supports and some construction elements that may obstruct surveying

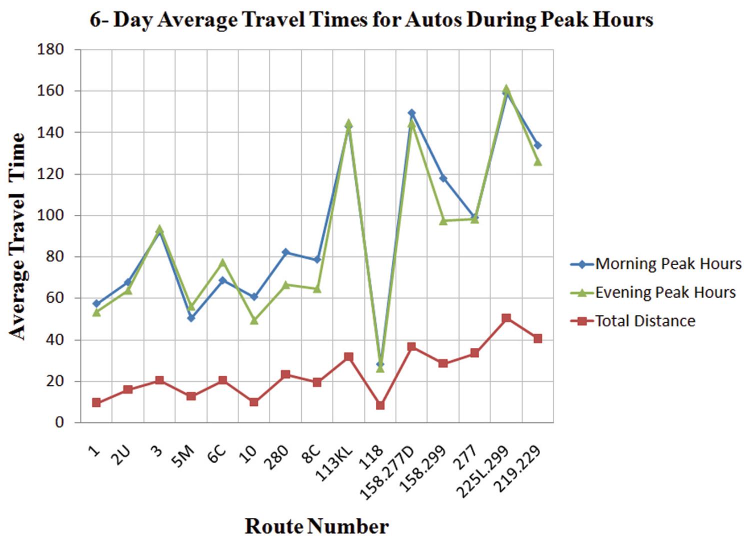

Fig. 7. Graph showing 6-Day Average travel times for autos during peak hours

travel rates and travel times of city buses and autos. Although there is a much difference in the size of both the vehicles, surprisingly no much difference is observed in terms of travel rate and travel time.

5. Android application developed (MMTTC)

An android application named ‘MMTTC (Multimodal travel time calculator)’ was developed to calculate and display the travel time between any two points within the study area using the obtained average travel rates from mobility analysis. The developed application can be directly used to find the best time to start a trip from one place to another within the city (Hyderabad) by the two modes of interest or it can be added as an extra feature for existing ridesharing and cab service applications for giving more flexible and economical options for the commuters. As the goal of this study is to promote multimodality, the developed application assists to make it happen. To make the prediction more dynamic and accurate, real-time data should be collected. Once if it is done, whenever an user wants to travel from one place to another within the city, he just has to enter the number of passengers, start point, end point and the start time at the origin. The application gives a number of combinations of travel modes besides their respective times of travel from the start point till their destination. So that the users have a bunch of options to choose the best one for them. Language used for the developed application ‘MMTTC (Multimodal travel time calculator)’ in the back end is JAVA and for front end is XML. GPS is used for noting the location. The system time is recorded while saving the location. The functional block diagram of the application is in the Fig. 8 and the step by step usage of the application has been shown in Fig. 9.

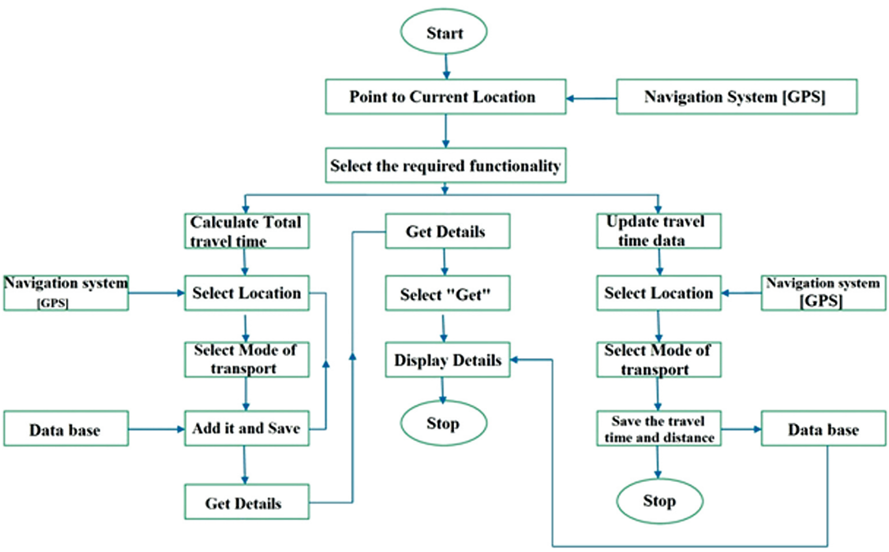

Fig. 8. Functional Block diagram of ‘MMTTC’ Application

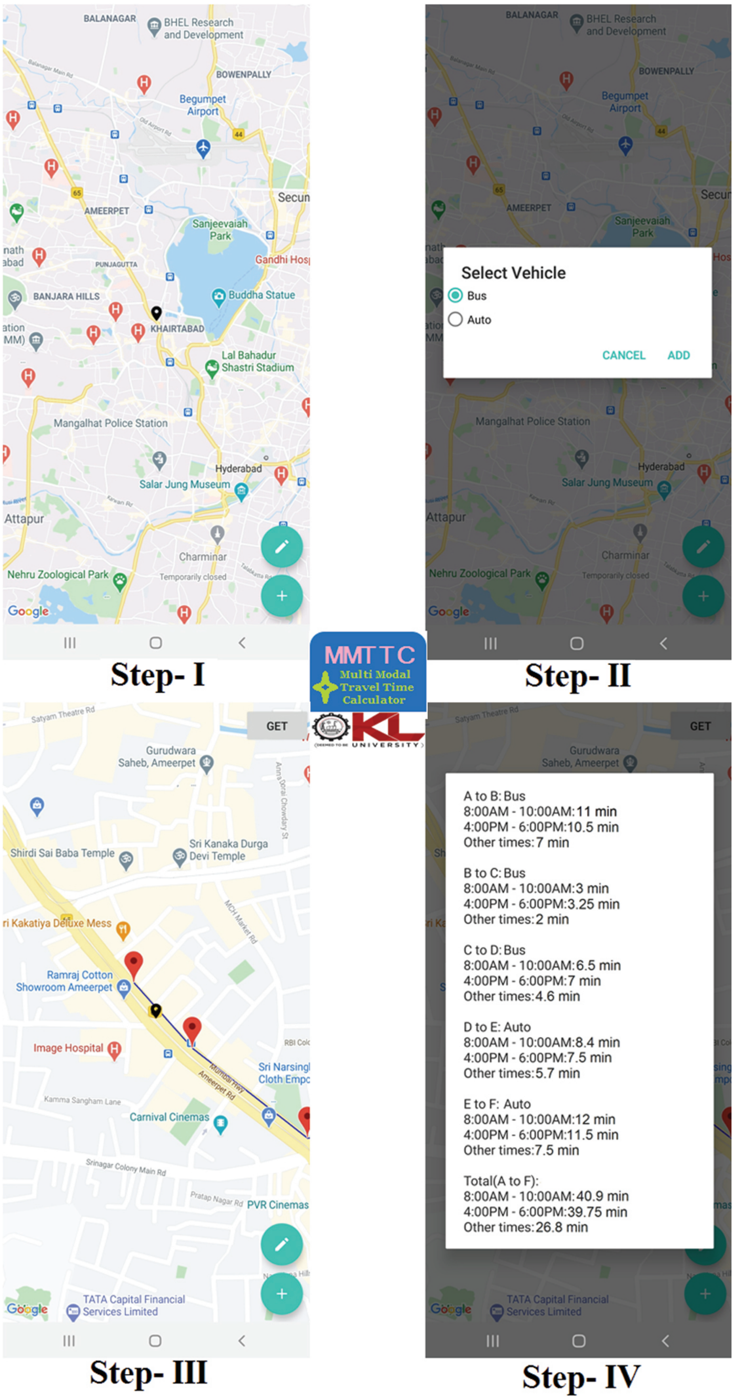

Fig. 9. ‘MMTTC’ Android Application: Step by step process to use

6. Conclusions

- Usually "Google maps" application gives travel time and distance between any two points in a city for any specific mode of transport except few. It calculates the travel time, based on the real-time data received by smart phones. The travel time data given by "Google maps" application may be accurate for personal vehicles such as two-wheelers and cars but for public transportation such as buses and autos etc, it is observed that the travel time data is being displayed inaccurately as when tested, it is showing same travel time at different times of the day.
- "Google maps" may not consider the stopping time of the public transport vehicles at each stop. Hence, this study is to measure the travel time and also the stopping time at stops, for two modes of public transportation during peak hours across 15 major corridors in the city Hyderabad, India.
- For this study, two android applications were developed, one for the data collection and another to calculate and display Multimodal travel time. The two applications can be downloaded from the link: https://www.techlectures.in/p/applications.html.
- When compared with the vehicular size, the buses are huge and hence it is assumed that they may have more travel rate (Minutes/km) than the autos but in reality, the difference is very less. The possible reason for this is that the buses have higher travel time and lesser stopping time at each stop but for autos, it is quite opposite i.e., less travel time but more stopping time. This is because, the auto drivers collect the fare from the passengers at their respective stops which in turn increases the stopping time at each stop.
- The android application "Multimodal travel time calculator" was developed to give the multi modal travel time for the trips in the selected corridors. If either start point or stop point or both are not in the range of our study area, the application considers the default travel rate that is "2 minutes/km" for calculating the travel time between those two points.
- Integration of different modes of transport especially the modes of public transport in the ridesharing and cab service applications for accomplishing integrated multi modal trips is really an acceptable and economical initiative that on one hand reduces the number of personal vehicles, their usage, reducing overall vehicular emissions and on the other hand it cut downs the travel expense of commuters making their trips economical.

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