ETA INVESTIGATIONS ON SUT SMART TRANSIT IN RED ROUTE USING ITS AND ARTIFICIAL INTELLIGENT TECHNOLOGY

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Abstract

Large urban community requires convenient public transportation system. In-coming of Intelligent Transportation System (ITS) and newest communication technology produce a fast development of conventional transportation system. Focus on mass transportation system, vehicle equips with commuication devices and GPS modules which transmit latitute, longtitute, ground speed to network or cloud. Estimated Time of Arrival (ETA) were computed by received data on cloud. As result, ETA show to passensgers via mobile application or LCD TV in bus stops. This work presents investigation of ETA error using V2N/ ITS technology. Moreover, AI technology was selected to vehicle classification in red route internal bus service period. Finally, ETA error of service period indicates 5-10 Minutes due to traffic especially rush hour in the red routes.

Keywords: ITS, Smart Mobility, ETA, RMSE

Introduction

Smart public transportation takes passengers from one place to another place with comfortable vehicles type. Intelligent Transportation System (ITS) bring conventional transportation system smart with telecommunication technology. Moreover, bus stop is another issues which attractive to passenger. Communication modules via cellular network are choosen. Focus on mass trasportation system, (Elkosantini and Darmoul, 2013; Sumalee and Ho, 2018) present location of bus stop and typical service bus scheduling time table are significant issues. Moreover, service routes depends on passengers needs is significant. This work focus on bus transporation system. Public transportation mode of Suranaree University of Technology (SUT) selected diesel bus due to small hill between student dormitory and study buliding zone. Noor *et al.* (2020) presents the prediction of bus arrival time using ML algorithm. Noor *et al.* (2020) introduces realtime delay and traffic model. Estimated Time of Arrival (ETA) is the main parameters for passengers who waiting on bus stop. Moreover, passengers wating bus on bus stop needs for available seats and ETA data. Passengers control scheduling life when ETA is appeared. The development of smart bus requires for more supporting system. Focus on ETA estimation, (Ding and Qing-An Zeng, 2009; Anokye *et al.*, 2013; Zaghal *et al.*; 2017; Billones *et al.*, 2018; Noor *et al.*, 2020) introduce delay due to traffic, average delay per person are the main causes of ETA error. This work presents an investigation of ETA error using AI and ITS technology. Results show that ETA error around 5 minute are explained.

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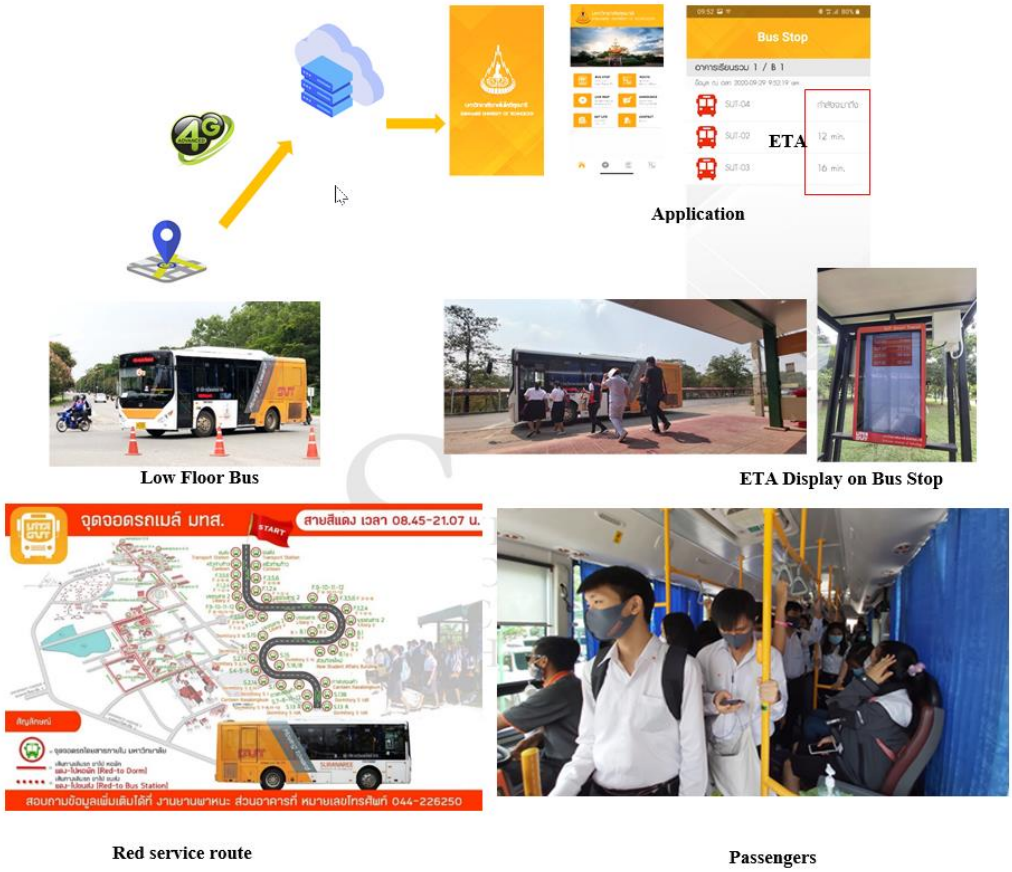

Figure 1. System Infrastructure

Materials and Methods

$$ETA = D_C + D_T + D_N + D_Q \quad (1)$$

$$ETA = \frac{D}{\overline{V}} + n\left(\frac{1}{\mu - \lambda}\right) + \left[N \times d\right] + D_Q \quad (2)$$

$$ETA_{Total} = \sum_{i=1}^{N} ETA_i \quad (3)$$

Application of ETA presenting on passenger smartphone and Bus stop LCD are explained in this section. According to Figure 1 and Figure 2, materials and methods describe as follow;

Vehicle types: Low Floor bus type was voted by SUT students. GPS module installed on bus for real time positon data disemmination.

Bus routes and Bus Stop signs: Six routes are created and revised accoriding to SUT master plan. This work focus on Red route according to Figure 3.

Bus scheduling time table: Bus scheduling time table separated in rush hour, normal hour, extra in evening. Delay due to traffic makes ETA error and bus delay when approching to bus stop or bus station.

Communication devices: 4G-LTE module is selected for data transmission.

SUT Smart Transit Application: Application for viewing the arrival time of buses. The server will take the information of the bus and the stop sign to calculate the ETA. After that, the application will show the data as shown in Figure 1.

Applying AI in public mass transportation system: YOLO was selected for categorizing vehicles types in each service periods. Figure 4 presents the result of vehicle types classification.

Figure 2. GPS and Communication modules

Figure 3. An example of ETA testing on the Red Service Route

Figure 4. Vehicles classification using AI

Using AI technology. Video of traffic volume was recorded by camera locating in the left lane.

Rush hour services period was collected and classification via YOLO. Vehicle types separated in three domain personal vehicles, motorcycles and Bus&Trucks. Recording video classified number of vehicle types passing investigation location according to service period. Classification results show in Table 2 and Table 3. Then, average service rate of the road and average arrival rate of the road replaced in (2) for increasing ETA estimation accuracy. ETA computed via (1), (2) and (3). Commuted time represents as (D_C). Distance between bus stops is calculated by real time GPS position from GPS modules according to Apisak, (2015). Real time speed of bus represents in (V). (D_T) is delay due to traffic. n represents number of inter-sections on service routes. μ represents average service rate of service road. λ is average arrival rate of service road.Our method refer to Office of Transport and Traffic Policy and Planning guideline (2016).

This work presents the comparsion of measurement versus ETA model in red route. Red routes was selected due to main service route. ETA measurement methodology followed Office of Transportation and Traffic Policy and Planning Ministry of Transport. Focus on Figure 5, three measurement persons located inside the bus. First person counted passenger taking into the bus, second person counted passenger taking off the bus. The last person measured ETA via application on passenger smartphone. ETA model with tuning parameter using AI and ITS technology was determined by (2). Comparison between measurement result and ETA model was investigated. RMSE was selected for the determination of ETA error according to (4).

Table 1. Parameters

Parameters	Mean	Value
N	Number of passengers	40 person
d	Average delay per person	2.7 Second
$\bar{V}$	Average speed of bus	40 Km/hr
D	Distance between bus stop	Real-time (GPS)
n	Number of intersections	Depend on service route
μ	Average service rate of the road	47 Vehicles/Minute
λ	Average arrival rate of the road	34 Vehicles/Minute
D_Q	Delays in retrieving data from server	10 ms

Table 2. Vehicle classification (Rush Hour)

Service Period		Vehicle Types			Total
Period	No.	Car	Motor	Bus&Truck	
7.45-8.15 a.m.	1	30	250	17	297
	2	48	197	14	259
	3	24	82	10	116
	4	30	60	10	100
8.45-9.15 a.m.	1	38	377	5	420
	2	49	241	4	294
	3	52	138	2	192
	4	35	94	8	137

Table 3. Vehicle classification (Normal Hour)

Service Period		Vehicle Types			Total
Period	No.	Car	Motor	Bus&Truck	
12.45-1.05 p.m.	1	47	245	4	296
	2	41	263	6	310
	3	53	215	3	271
	4	33	123	4	160
9.45-10.15 a.m.	1	52	263	1	316
	2	60	386	3	449
	3	44	218	2	264
	4	23	106	3	132
12.45-1.15 p.m.	1	63	386	7	456
	2	68	319	2	389
	3	98	190	3	291
	4	38	83	3	124

Figure 5. Experimental Setup

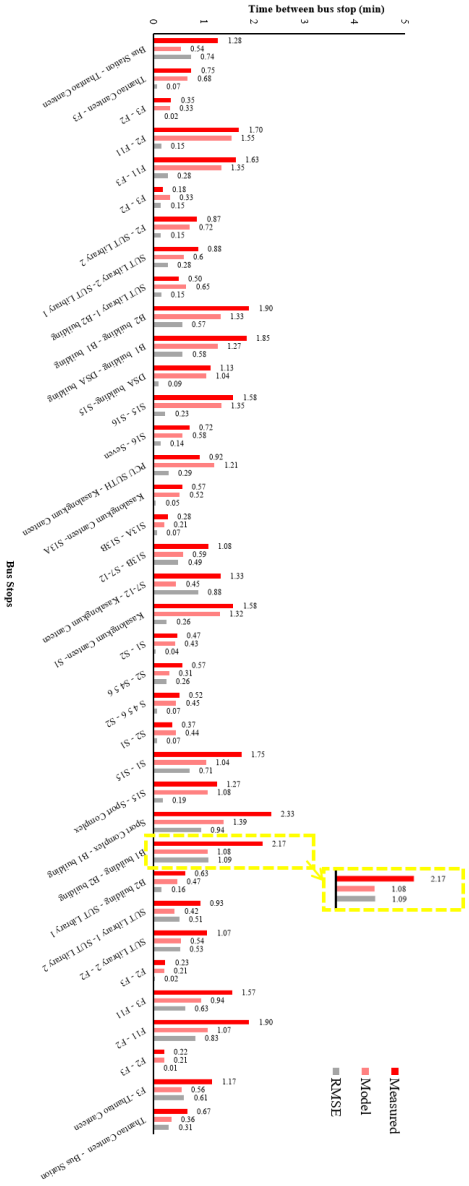

Figure 6. Comparison of experimental result and ETA model

$$RMSE = \sqrt{\frac{\sum_{i}^{n}\left(T_{A,i} - T_{P,i}\right)^{2}}{n}} \quad (4)$$

Where n is the number of events.

$T_{A.i}$ is the actual measurement time.

$T_{P.i}$ is time from model.

Results and Discussion

Experimental results present the comparison of ETA model versus experimental in Red route. Vehicle types classification using AI technology notifies average service rate of the road and average arrival rate of the road. Focus on normal service hour, average service rate of the road is 47 veh/min. Average arrival rate of the road is 34 veh/min. Then, parameters in table 1 fed into (2). ETA model according to (2) were computed. Also, total ETA in red service route were calculated using (3). Measurement results was collected by three measurement person. Morever, RMSE according to (4) are calculated. Measurement of ETA in real-time situation depend on traffic on the service route and service period. This work recored traffic video in rush hour and normal hour. Then, related parameters fed in (2) for ETA estimation. Comparison of ETA model and real time situation measurement presents in Figure 6. Focus on B1-Building bus stop according to yellow box, measurement of ETA is 2.17 minute. ETA model with adjust parameters using AI and ITS indicated 1.08 minute. Different of ETA model and measurement result related to driver behivior, traffic scenarios, passengers behavior affect to ETA. RMSE presents in 1.09 minute. Focus on real scenario, red service route is the major route. Bus driver took 45 minute from first bus stop to final bus stop. The red line has n 71 junctions. Bus driver follows bus scheduling time table which are installed at the bus stop and appearing in mobile application. Bus scheduling time table was established with Bus driver survey, student needs, service road infrastructures and obstructions along the road. Bus scheduling time table is a communication tool between passenger and bus driver. Bus driver drived on time to the bus stop. Then, on time Bus service increase passengers satisfaction. Moreover, more passengers took in the bus at student dormitory. As result, average delay per person increase. Average delay per person related to ETA. ETA error is occured due to average delay per person, traffic density. Also, results indicate average ETA error around 5 minutes.

Conclusions

This work presents application of ITS and AI technology for ETA error investigation. YOLO was selected for vehicle types classification which affect to ETA error. RMSE presents the diffence between ETA model and measurement values along the service route. Measurement results and ETA model results indicate delay due traffic, average delay per person and road infrastructures caues ETA error. RMSE indicates 5-10 minute of ETA error. Thus, ETA is the key attractiveness parameters for passengers of mass transportation system. On time service and low ETA error of mass transportation service introduce the successful of mass transportation development. Also, accident statistic decreases when using public transportation system. ETA error reduction method will determine in the future work.

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