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Research Article

Response Surface Methodology in-Cooperating Embedded System for Bus's Route Optimization

[1]Muhammad Rauf, [1]Ahmed N. Abdalla, [1]Azhar Fakharuddin and [2]Elisha Tadiwa
[1]Faculty of Electrical and Electronics, University Malaysia Pahang, Pekan, Pahang, 26300,
[2]Computer Information System, University Technology Petronas, Tronoh, Perak, 31750, Malaysia

Abstract: The incessant increment of the population and lack of the reliable bus position notification system in big cities is causing the boost of the private owned cars, has reasoned traffic congestion problems. A reliable public transport notification system for passengers is able to resolve the issue stated above. First ever time, Response Surface Methodology (RSM) is adopted in this study to presents a new real time intelligent buses notification system using routes' coordinates optimization and wireless mesh network emerged in an embedded design. The von Mises and displacement equation is obtained through RSM and trained to the dedicated controller unit. A mature experimental setup is designed to analyze the equation validation. The result from statistical and experimental analysis using RSM implies that the target to optimize a single route coordinates into one digit representing bus stop number is achieved by ~98%. The outcomes of research as location data minimizing and transmission time reduction have a promised potential to a better and reliable public transport notification system using route's coordinates optimization.

Keywords: Embedded system, intelligent transportation system, optimization, radio transceivers

INTRODUCTION

The lack of fideism upon the public transport infrastructure led the travelers to shift to their own private car. The requirement of a reliable public transport monitoring structure is the outcome from the unnecessary congestions of traffic observed due to steep increment in personal vehicle. A large scale dedicated monitoring infrastructure with reliable displaying position for public transport can facilitate passengers to revolutionize the trend from own vehicle to public transport as well international image of a city (United States Government Accountability Office (GAO), 2009; GR Reporter, 2011).

Intelligent Transportation System (ITS) has witnessed tremendous growth over last few years. It is adopting implementation of newest technology, specifically a network of sensors, microchips, and communication devices that collect and disseminate information about the functioning of the transportation system (Ban *et al*., 2011; Ezell, 2010). In the past, the traffic monitoring infrastructure had mainly consisted of dedicated equipment, such as loop detectors, cameras, and radars. Later on Installation and maintenance expenses discouraged the deployment of these technologies for the entire transport network. Moreover, inductive loop detectors are prone to errors and malfunctioning (daily in California, 30% out of 25,000 detectors do not work properly according to the PeMS system) (Herrera *et al*., 2010).

Through the advent of GPS technology, conventional positioning methods have been replaced. As far as the vehicle fleet management and monitoring is concerned, one of the main applications of the GPS technology is the fleet monitoring in urban or suburban areas, from a central monitoring station (reference station) (Mintsis *et al*., 2004; Lee and Han, 2003). Moreover, the location data transmission link had also been the subject of keen interest for several researches. The numbers of studies are found using GPRS for the vehicle monitoring to an IP fix control center. In cooperating GPRS and other data transmission techniques like GSM, RFID and Bluetooth, the vast utilization of embedded system is observed as well for receiving, matching and transmitting location data (Bao *et al*., 2002; Niu *et al*., 2009; Qin *et al*., 2008; Lu *et al*., 2007; Soo *et al*., 2007; Bong *et al*., 2007). From the contrast of past tool for efficient communication, GSM based monitoring system seems to be the better research tool (Herrera *et al*., 2010; Soo *et al*., 2007). However, the cellular network based monitoring system for public transport may cause various drawbacks including unavailability of service, server down, no network coverage and cost consuming even after implementation. In a review paper by Xuesong *et al*. (2008), it is intend to evaluate the technical feasibility

Corresponding Author: Muhammad Rauf, Faculty of Electrical and Electronics, University Malaysia Pahang, Pekan, Pahang, 26300, Malaysia

of applying emerging wireless network technologies for resources tracking at building construction sites. Based on critical reviews of available localization methods and state-of-the-art wireless communication technologies, it is identified that the Zig-Bee-based wireless sensor network and the Received Signal Strength Indicator (RSSI) method are most promising for solving on-site resources tracking problems.

Numerous researches can be observed on the utilization of intelligence techniques to enhance the visibility and observability of GPS. The navigational errors reduction like multipath amplitude delay and phase relative to the direct path are well documented in Liu and Amin (2009). Another approach of neural network integration with the kalman filter based optimization techniques on the GPS design and its application for better utilization in the area of vehicular navigation was presented (Fan and Jiancheng, 2007). However, INS/GPS integration techniques using kalman filtiring, have some inadequacies related to the stochastic error models of inertial sensors, immunity to noise, and observability. In the perspective, Sharaf and Noureldin (2007) aimed to introduce multi sensor system integration approach for fusing data from INS and GPS for the navigation purpose, utilizing Artificial Neural Networks (ANN). A multi layer perceptron ANN has been recently suggested to fuse data from INS and Differential GPS (DGPS). Recently, methods based on Artificial Intelligence (AI) like Input-Delayed Neural Networks (IDNN) have been suggested for integrating the Global Positioning System (GPS) with the Inertial Navigation System (INS) (Noureldin *et al*., 2011).

Regarding other optimization techniques, Design of Experiments (DOE) had been a useful tool that used for exploring new processes, gaining increased knowledge of the exiting processes and optimizing these processes to achieving a better performance (Rowland and Antony, 2003). Dynamic and foremost important tool of Design of Experiment (DOE), wherein the relationship between responses of a process with its input decision variables is mapped to achieve the objective of maximization or minimization of the response properties (Raymond and Douglas, 2002).

The related art and literature evidently describes that in the vast domains of navigation system for transport, the crucial issues are the consistent monitoring system with reliable error compensation using maximum faultless techniques. In order to challenge past exertions, this study focus on developing a new intelligent multi ID buses monitoring system for passengers. For the purpose, first field experiment was conducted in the Kuala Lumpur city of Malaysia to record the static coordinates for bus stops of single route to create suitable input factors for RSM, the response methodology of DOE. Regarding technological approaches, the improved accuracy of GPS technology and long range Zigbee standards has seemingly become as the preferred choice of location detection and transmission method for ‘high-end’ system because of their compatibility with prevalent used embedded system design. Technically, the comprehensive proposed system comprises of two major modules; one is master module (the buses) while second one is named slave module (the bus stations). For the efficient location data forwarding, looping of the radio chips, impressed by the concept of wireless sensor networking is applied. This location data transmission is made for the best visualization result at each station node. PROTON+ IDE and DOE version 8 are chosen as software research tools. First time, in the

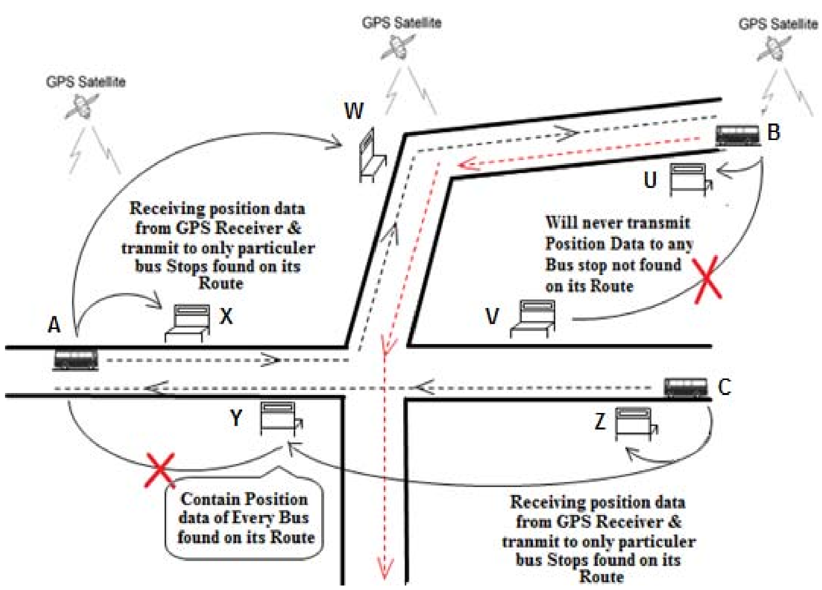

Fig. 1: Conceptual frame work of system

field of ITS, DOE is selected to utilized. Response Surface Method (RSM) is used to estimate the response at the optimal region. The estimated function is then used to optimize the responses. Similar to the factorial design, linear regression and ANOVA are the tools for data analysis in RSM. Hence Central Composite Design (CCD) approach from RSM was selected for the present study in order to shape out the response of the fixed coordinates into a single linear equation. Later on the equation is trained to the controller unit for efficient and improved communication link between vehicle and its related infrastructure.

CONCEPTUAL FRAMEWORK

Real-time traffic notification system for virtually every bus stop in the city has the ability to change the trend of a traveler from using their personal vehicle to the single public transport. During an informal survey to the roads of KL, many problems are commonly observed which must consider during framework designing. Like many time buses having same IDs draw closer together. Some time bus stops are found in front of each other across the road. The conceptual solution suggested for the difficulties found, are the scheming of our system using GPS based monitoring and their location transmission down to the specific bus stops only found on their routes, not even at the bus stop found across the road as exposed in Fig. 1. This specific location transmission is actually the function of specially configured transceivers and initially inputs by the drivers. The earlier version of this conceptual framework can be found at Rauf *et al*. (2010) and Abd Alla *et al*. (2011).

In order to elaborate the conceptual framework, an example is taken into account containing three buses with different routes named A, B and C and 6 bus stops with different route location named U, V, W, X, Y and Z as shown in Fig. 1. Bus ID "A" will pass through bus stop W and X. It can be observed from figure that bus stop X and Y are found in front each other and there is a sound possibility for Y to receive the signal from bus "A". This problem is figure out by giving dedicated PAN ID same as the bus ID. Let suppose, the bus A have its ID 'B103', then transceiver modules of bus "A" and its stops W and X are configured "0103" as PAN ID. Through this scheme, the bus is made responsible to communicate or to send its location information to its relevant bus stops, not even the one found in front or in range.

FRAMEWORK DESIGNING

Given the lack of an established body of research on the design of public transport network services and the small number of practitioners concerned in this field, a comprehensive approach seems to be required. For the purpose, initially some rules and regulations are described as the initial system assumptions. These assumptions are described to make the proposed frame work as resourceful as possible. Second is the hardware implementable design, the center of focus of this study, for the overall system to work. This phase contains best functional components selection according to the proposed design.

Assumptions: The frame work presented in the methodology below, is based on the following some assumptions must be imposed by the regulators:

- Each bus route is isolated entities, are assigned similar activities
- The inter-linked network of nodes represents the service along a bus route and hence the efficiency of the network is equivalent to that of the service provided along the route
- Buses of same IDs are sent by a proper interval of time. In case, any two or more buses of same IDs join each other due to any reason then 2nd one need to stop for the time until first one reach at the next bus stations

Table 1: Bus stops coordinate data (Bus-B103)

Name of bus stations (slave node)	Received coordinates						Trained coordinates				
	Longitude			Latitude			Longitude		Latitude		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.	Min.	Sec.	Min.	Sec.	Bus stop no.
Jalan Ipoh											
• Hospital Damai (Pi1)	101	41	42.44	03	10	12.36	41	42.4	10	12.3	1
• Stesen Monorel Chow Kit (Pi2)	101	41	55.51	03	10	03.11	41	55.5	10	03.1	2
Jalan Raja Muda Abd Aziz											
• Stadium Raja Muda (Pi3)	101	42	11.21	03	10	04.83	42	11.2	10	04.8	3
• Menara TH Selborn (Pi4)	101	42	43.02	03	10	04.71	42	43.0	10	04.7	4
Jalan Tun Razak											
• City Square (Pi5)	101	42	58.45	03	09	50.41	42	58.4	09	50.4	5
Jalan Ampang											
• Hotel Nikko (Pi6)	101	43	03.50	03	09	36.57	43	03.5	09	36.5	6
• KLCC (Pi7)	101	42	45.48	03	09	31.79	42	45.4	09	31.7	7
• Hotel Renaissance (Pi8)	101	42	19.08	03	09	23.84	42	19.0	09	23.8	8
Jalan Sultan Ismail											
• Hotel Concorde (Pi9)	101	42	20.94	03	09	18.55	42	20.9	09	18.5	9
Jalan P Ramlee											
• Menara KL(Pi10)	101	42	26.60	03	09	13.10	42	26.6	09	13.1	10
• Wisma Lim Foo Yong (Pi11)	101	42	30.21	03	09	01.93	42	30.2	09	01.9	11

- Buses' driver are strictly ensured not to change the predefined route. In case any emergency, they are restricted to inform to the monitoring room so that the monitoring plan could be change to facilitate the passengers

System description: The design assures the real time processing of data related to the position monitoring of bus and more towards its implementation through notification system for passengers. Complexity of overall system is ensured to reduce by dividing it into two basic parts; master part and slave part 1, 2 and so on, as described in the concept, depending on number of bus stations.

Master module:

Master module integration: Given the design needs and requirement for the problem, it is proposed to come up with the simplest and efficient design that would be able to forecast the real time localization down to the respective node. In order to construct an appropriate design of master module, several best functioning components are selected for lab and field test. In this section of methodology, there are three key modules used in master node: MCU: PIC16f877A, GPS module: Parallex RXM-SG GPS Module and the advance wireless: Xbee pro RF Modules (IEEE802.15.4). In the integrated system, RSM is adopted to minimize the location data for better, reliable data and time saving comparison and transmission. On the basis of prescribed dedicated equipment, standard prototype system architecture was build to present optimized experimental results. Two different experiments were conducted to exploit the modules. Firstly the equation obtained from RSM is validated using the master module. The efficient outcomes from the proposed heuristic will be shown in results section. Second is to analyze the one way communication for sending bus unique ID and one digit bus stop number from the master node to the nearest determined slave node and further more as looping. This determination is carried out by assigning a unique PAN ID (a number shared amongst each Xbee in a network) to the XBEEs of master and three slave module prototype (representing single route with its relevant bus). A single network may contain many more nodes since XBEEs on different networks do not communicate with each other. The configurations of the RF modules are carried out using X-CTU software. It allows setting all of the parameters using a Graphical User Interface.

Data collection for master module: Subsequent to the successful location data reception through GPS mount on master module, it is observed lack of exact data forwarding, missing or time delay using preliminary varying distance testing. It may play a considerable role against the resource full communication and real time implementation of the system. There are found many reasons beside like dense urban traffic, long buildings and atmospheric effect on data rate and reliability. Besides, there are also found some error possibilities of exact MM comparison, since the master node (bus) is observed, do not stop on the predefined slave node (bus stops). This lead the research to create idea of reduced amount of the location data to be compared and forward. To tackle this issue, this work is inspired by the fact that vehicles move along routes with a known map of coordinates.

In order to train the controller, a survey is carried out to observe and record the location data by using the acquisition utility of handheld GPS while driving the vehicle around the city of Kuala Lumpur, Malaysia. In all, approximately 40 min of driving, data were collected over 11 set of coordinates from bus stops of specific bus. The map and Table 1 shows the bus stops chosen to collect static position data. From the casual observation, it is found that during one full journey from first until last stop, there are few digits from the longitude and latitude are subject to be change while some remained unchanged. The Table 1 shows the actual static location address of bus stops. For an autonomous passive localization transmission loop, all together 05 significant digits from longitude and latitude will be decided to select as the input for the RSM. The apprehension behind this selection was the consistency of the degree digits throughout one full journey and last bit of second cast no any affect on representing the bus stop number. The coordinate’s data is collect from bus route B103.

Data pre-processing: Prior to use data from Table 1 for experimental testing, pre-processing was needed to generate data sets containing the necessary information to calculate the bus stop number. In light of the screening observation, it is selected to study the effects of the four significant factors, namely; longitude M, longitude S, latitude M and latitude S. Furthermore, parking violation on the pre identified bus stops to pick and drop passengers, have potential to produce unwanted outputs or malfunctioning for MM. The parking at bus stops is crucial part of the study for having proper MM and triggering of RF modules dedicated to bus stops in the loop. In order to avoid the error due to mismatching, each selected data set of coordinate are fragmented in to three more possibilities. The possibilities are recorded by observing the location coordinates just 15 meters before and after the exact bus stop. These possibilities are solely selected to utilize as input to get the response as predicted one digit bus stop number. The four variables, their levels and possibilities are listed in Table 2.

Table 2: Processed possibilities of coordinate data for RSM

	Received coordinates			
	Longitude		Latitude	
Case	Min.	Sec.	Min.	Sec.
$(P_{i\,1,1})$	41	42.2	10	12.4
$(P_{i\,1,2})$	41	42.4	10	12.3
$(P_{i\,1,3})$	41	42.5	10	12.2
$(P_{i\,2,1})$	41	55.2	10	03.4
$(P_{i\,2,2})$	41	55.5	10	03.1
$(P_{i\,2,3})$	41	55.7	10	03.0
$(P_{i\,3,1})$	42	11.0	10	04.9
$(P_{i\,3,2})$	42	11.2	10	04.8
$(P_{i\,3,3})$	42	11.5	10	04.8
$(P_{i\,4,1})$	42	42.6	10	04.7
$(P_{i\,4,2})$	42	43.0	10	04.7
$(P_{i\,4,3})$	42	43.3	10	04.7
$(P_{i\,5,1})$	42	58.2	09	50.7
$(P_{i\,5,2})$	42	58.4	09	50.4
$(P_{i\,5,3})$	42	58.7	09	50.1
$(P_{i\,6,1})$	43	03.3	09	36.8
$(P_{i\,6,2})$	43	03.5	09	36.5
$(P_{i\,6,3})$	43	03.8	09	36.3
$(P_{i\,7,1})$	42	45.1	09	31.5
$(P_{i\,7,2})$	42	45.4	09	31.7
$(P_{i\,7,3})$	42	45.8	09	31.9
$(P_{i\,8,1})$	42	18.6	09	24.1
$(P_{i\,8,2})$	42	19.0	09	23.8
$(P_{i\,8,3})$	42	19.2	09	23.5
$(P_{i\,9,1})$	42	20.6	09	18.9
$(P_{i\,9,2})$	42	20.9	09	18.5
$(P_{i\,9,3})$	42	21.1	09	18.3
$(P_{i10,1})$	42	26.3	09	12.8
$(P_{i10,2})$	42	26.6	09	13.1
$(P_{i10,3})$	42	26.8	09	13.5
$(P_{i\,11,1})$	42	30.0	09	02.3
$(P_{i\,11,2})$	42	30.2	09	01.9
$(P_{i\,11,3})$	42	30.7	09	01.6

$(P_{i\,l,\,m})$: P = Platform or bus station; i = Identical network ID for each bus route (PAN address); *l* = No. of bus stops (Slave modules); m = No. of possibilities of particular bus stoppage (master module)

Table 3: Configuring parameters for conducting loop test

For bus route B103	Xbee # 1	Xbee # 2	Xbee # 3
Baud rate	(3) 9600	(3) 9600	(3) 9600
Pan Id	0103	0103	0103
Atmy	10	11	12
Atdl	11	12	13

Surface response methodology: Considering RSM in the field of ITS for the first ever time, there are several steps needed to cogitate using the data from Table 2, to come up with required results. As mentioned earlier, the four (04) major factors named as longitudeM, LongitudeS, LatitudeM and LatitudeS are chosen in order to achieve their effects on the response as predefined output. The value range of the factor is determined by the range of coordinates from first bus stop until the 11th bus stop, selected as array. This design matrix CCD is selected to describe the experiment in terms of the actual values of factors and the test sequence of factor combinations. In this research, statistical method ANOVA is applied as the tools for data analysis. The clear objective for all the steps is to achieve a simplified mathematical response of the system. Recommendations and ANOVA are provided in results section.

Master module system flow: The GPS data acquisition utility was written in the PROTON IDE to interface the GPS receivers with the MCU as well as to compute the bus stop number for comparison. The GPS receivers output ASCII sentences every second using the NMEA 0183 serial communication standard. Subsequent to receive the position frame, MCU is programmed in such a way that only few significant digits (Table 2) will be allow for the map matching calculations to come up with the single digit bus stop number. The exact conditional approach is applied for comparison the bus stop number corresponds to its location address. On successful comparison, the real time response using equation will trigger the RF module. In short, all the processing tasks for master module can be generally distributed into three tasks, first is GPS location data reception, second is bus stop number computing using equation then third is transmitting the bus stop number to the first slave node.

Slave module: Subsequent to the successful reception of bus stop number to the respective node, special algorithms are designed to operate the number of slave modules corresponding to the number of bus stations. In order to develop a reliable communication link between master and its all respective slave module, it is decided to include looping concept of sensor nodes inspired by WSN. Each sensor node is also capable of receiving as well as transmitting the position output trigger data to the next node found on the same network only. The least number is slave nodes are kept equal to the maximum number of bus stops found on the way of particular bus ID. For testing and validation purpose, a set of three slave nodes are prepared to test the proper looping and distance between three nodes. The Table 3 shows the configuration parameters for efficient looping test between three slave node prototypes.

The PAN and Destination Addresses (DA) of the selected transceiver modules are configured by X-CTU software, so that a proficient looping of location until the last bus station could made possible The methodology used for selecting the destination and source is kept such a way that the destination address of first slave module is configured same as the source address of successive second salve module. The same destination and source address configuration technique is adopted between second and third. Successful testing of three modules showed the potential methodology application to any number of slave modules.

Initially while the bus (master module) is ready to move, it is programmed to configure as just transmitter first and the nearest bus station (slave module 1) will be configured as receiver first to send the bus unique ID. Subsequently, the master module will start receiving GPS signals for the bus location then after calculating

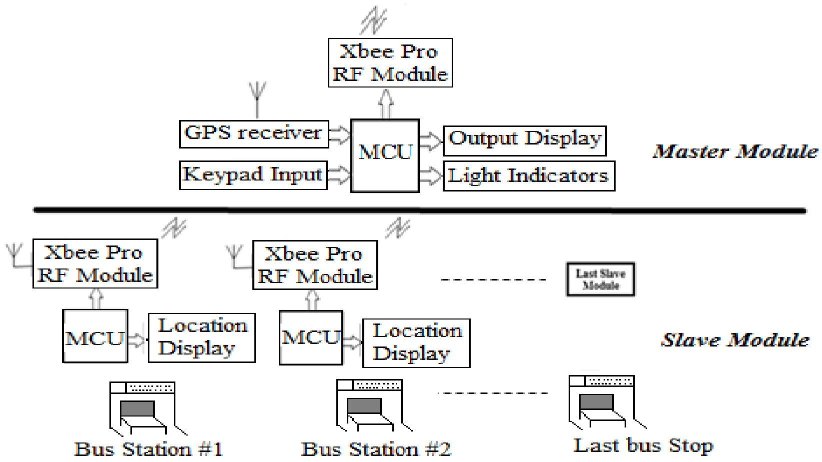

Fig. 2: Overall system integration

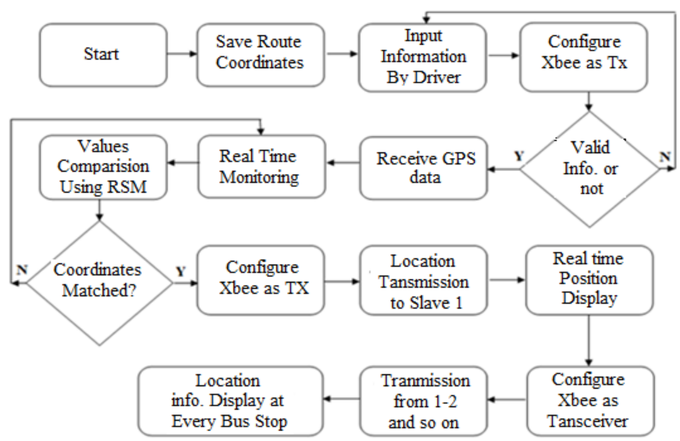

Fig. 3: Overall process flow

and matching, will literally start to transmit to the first nearest bus station. When the bus is on the move, the slave module 1 will be configured as transceiver and will send the one digit bus stop position to slave Module 2 (2nd next bus station) and up to so on. This chain for receiving, displaying and transmitting bus positioning information will be last till the final bus station for every bus found in the particular route. The same flow will be followed while the bus would pass through its relevant bus stops. For the prototype testing, light indicators (LEDs) are integrated to make sure of the prototype user friendly and implementable.

Overall system integration and flow: The methodology section above described the individual master and slave nodes integration, their proposed deployment architecture and functioning. Finally here is presenting the overall structural design and integration of proposed system. The block diagram described in Fig. 2 pictorially explains the real time hardware implementable form of the system.

The Fig. 3 describes the overall process flow of designed frame work. It focuses on the real time implementation to support our proposed buses notification system. It contains several intelligent decision support steps. The process flow starts by taking into consideration all the aspects from initial login system till the ending aim of user friendly display at all slave modules.

EXPERIMENTAL ANALYSIS

The major aim of the research is to optimize one single route's coordinates into its single digit representative through RSM. The techniques applied have a clear potential to provide a reliable public transport monitoring system by a reduced amount of data to compare for MM and obviously the time (data rate) saving. This paper also propose and identifies a unique design phase containing a system to mount GPS based embedded system with sophisticated RF transceiver on every bus and at the bus station. For the

Table 4: Analysis of variance

Source	SS	Mean Square	F-value	p-value Prob>F	
Model	246.98	24.70	906.18	< 0.0001	Significant
A-Longitude M	5.284E-003	5.284E-003	0.19	0.6647	
B-Longitude S	1.11	1.11	40.71	< 0.0001	
C-Latitude M	1.113E-005	1.113E-005	4.085E-004	0.9841	
D-Latitude S	4.146E-005	4.146E-005	1.521E-003	0.9693	
Residual	0.52	0.027	Residual		
Cor total	247.50				

purpose, mature prototypes are constructed presenting master and slave modules. This section analyzes and evaluates the main results obtained from prototype, which will prove the potential implementation of the proposed system. The evaluation is carried out by observing three aims:

- First is predicted output of the equation vs actual observation for bus stop number by RSM (ANOVA).
- Second is equation validation through MCU for accuracy measure.
- Third is the time reduction claim during MM for 1 digit output comparison vs casual necessary 17 digits for coordinates of particular location.

Analysis of Variance (ANOVA): The presented technique is aimed to develop the input-output relationships for prediction of bus stop ID. In order to arrive at the most influential variables and its effects a phase strategies were proposed. Response surface methodology (RSM) based on Central Composite Design (CCD) was utilized to develop a linear model for prediction as well as to estimate the transfer functions at the optimal region.

The Analysis of Variance (ANOVA) results are presented in Table 4. It can be seen that the model *F*-value of 906.18 implies the model is significant. There is only a 0.01% chance that a "Model *F*-Value" could occur. The reason behind this could be the irregular behavior of the coordinates as input. Values of probability less than 0.0500 indicates model terms will produce a minor difference among the trained and actual response.

Finally using the collected then pre processed data, a mathematical prediction model has been developed based on the most influencing factors and the validation simulation analysis proved its adequacy. The result aimed towards prediction of bus stop number and its effect on received coordinate's data. The von Mises and displacement equation representing the selected route's coordinates is expressed in Eq. (1).

$$P = 25.20266832 + 1.321582163*A + 0.02467396989*B - 7.753245435*C - 0.1525904315*D \quad (1)$$

Table 5: R^2 analysis

Parameter	Value
Std. Dev.	3.211308
Mean	6.000
R-Squared	0.980625
Adj R-Squared	0.977857
Pred R-Squared	0.97994

where,

P = Predicted bus stop number
A = Longitude Minutes
B = Longitute Second
C = Latitude Minute
D = Latitude Second

The Eq. (1) obtained gave a simple one digit representing particular bus stop number. The simplicity of the equation encouraged the researcher to use the RSM. This present form of the equation is uncomplicated to train the MCU using the parameters of data. The all four parameter are programmed in the MCU to receive as the long integer continuously. Instead of comparing digit by digit of all location coordinates digits, the above equation provides a single optimized value output representing whole location coordinates in order to trigger the RF modules for location transmission through looping of sensor network.

The R^2 analysis results are tabulated in Table 5. The "Pred *R*-Squared " 0.97994 is in reasonable agreement with the "Adj *R*-Squared " of 0.977857. In fact, when the value of correlation coefficient *R* is close to 1, it means the response correlation of actual received coordinates and predicted values are better. The average accuracy from the R^2 analysis is found out as 97.9%. The statistical analysis shows that, the developed mathematical model to predict the exact bus stop, based on central composite design is statistically adequate and can be used to trigger the slave module to start looping of transceiver for a single bus route.

Figure 4 shows the predicted versus actual plot how the model predicts over the range of data. The best fit line plot of the 33 points, Table 6 is found to be close to the ideal line (Y = X). The predicted responses show the good agreement with actual results. The scatter shows the bus stop number representing casual position data from longitude and latitude can be predicted very precisely through RSM.

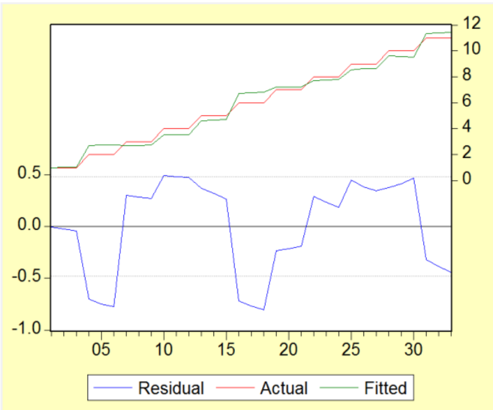

Fig. 4: Predicted versus actual plot

Table 6: Actual versus predicted (Fitted)

Observations	Actual	Fitted	Residual
1	1.00000	1.00420	-0.00420
2	1.00000	1.02440	-0.02440
3	1.00000	1.04212	-0.04212
4	2.00000	2.69828	-0.69828
5	2.00000	2.75146	-0.75146
6	2.00000	2.77165	-0.77165
7	3.00000	2.70039	0.29961
8	3.00000	2.72058	0.27942
9	3.00000	2.72798	0.27202
10	4.00000	3.51060	0.48940
11	4.00000	3.52047	0.47953
12	4.00000	3.52787	0.47213
13	5.00000	4.62960	0.37040
14	5.00000	4.68031	0.31969
15	5.00000	4.73349	0.26651
16	6.00000	6.71759	-0.71759
17	6.00000	6.76830	-0.76830
18	6.00000	6.80622	-0.80622
19	7.00000	7.23611	-0.23611
20	7.00000	7.21299	-0.21299
21	7.00000	7.19234	-0.19234
22	8.00000	7.71142	0.28858
23	8.00000	7.76706	0.23294
24	8.00000	7.81778	0.18222
25	9.00000	8.55423	0.44577
26	9.00000	8.62267	0.37733
27	9.00000	8.65813	0.34187
28	10.0000	9.62568	0.37432
29	10.0000	9.58730	0.41270
30	10.0000	9.53120	0.46880
31	11.0000	11.3192	-0.31917
32	11.0000	11.3851	-0.38514
33	11.0000	11.4433	-0.44326

Equation validation and field test: RSM results provided a good agreement between the received and trained coordinates in terms of single digit representing whole location data. The novel equation obtained, gave a simple functional dimension to train to the MCU. The subsequent step is to embed the equation into the MCU. In order to embed and validate the equation, MCU is programmed such that all the constants and variables of equation are taken as floating point. While the necessary location coordinates are received such that the selected digits from them can be utilized for the variables A, B, C and D mentioned in the Eq. (1).

For the testing and equation validation purpose, the master module prototype was brought to the exact route of KL corresponding to the collected coordinates for training (Table 1). The equation and modules gave well expected results in the form of one digit representing the exact bus stop number at each slave node destination. During master module testing, the equation is programmed in MCU to calculate the output up to only one (01) digit after decimal number for conditioning and comparison. Later on the five digits (05) after decimals are taken as to verify the accuracy of the system since the calculation comprise of floating point based mathematics. This selection is inspired by the same quantity of digits obtained by DOE using RSM (Table 6).

Accuracy measure: The evidence is collected by programming the MCU to obtain the results of equation calculation step by step on the serial communicator provided by PIC kit 2 and display at the LCD as well. The purpose is to reach at the accuracy for the equation validation. Although there is a very slight difference found in the digits, (the reason is floating point calculation capabilities by selected 8 bit MCU) however these distinctions did not cast any effect on calculating the one digit value representing the bus stop number. This neglect-able error factor is also avoided by the help of conditioning of the output of the equation. For example for bus stop “01”, the output of the equation by MCU “1.02” is conditioned to “1” The condition is applied by observing the maximum limit of the 1 digit after decimal. Therefore, it can be interpreted

Table 7: Comparison with accuracy measure for all 11 bus stops calculation results by RSM and MCU

Observations	Actual	Fitted (RSM)	Fitted (MCU)	Error (%)
1	1	1.0244	1.02439	9.76E-04
2	2	2.75146	2.75144	7.27E-04
3	3	2.72058	2.72058	0.00E+00
4	4	3.52047	3.52046	2.84E-04
5	5	4.68031	4.68031	0.00E+00
6	6	6.7683	6.76829	1.48E-04
7	7	7.21299	7.21298	1.39E-04
8	8	7.76706	7.76705	1.29E-04
9	9	8.62267	8.62266	1.16E-04
10	10	9.5873	9.58729	1.04E-04
11	11	11.3851	11.38513	-2.64E-04

that the accuracy measure check after testing the hardware for more than 8 digits based calculation have no error effect on overall functionality of the system. The Table 7 shows the overall calculation end results comparison through DOE and MCU for all 11 bus stops.

The Table 7 shows a comparative analysis of end bus stop results after all calculation for all 11 observations. The remarkable results can be seen above. In the worst condition, it is observed a deviation of 9.76E-04 by calculation for bus stop number 01. Therefore, the overall results from RSM as well as MCU implies that the goal to achieve the target of obtaining single digit bus stop number representative of 17 casual digits of location data was found to be capable efficient enough as compared to the RSM based simulation, since the required significant bits for conditioning is just one digit after decimal.

Data and time reduction claim: The successful data size reduction for efficient comparison, the outcomes of the research cast a considerable influence on limiting the time consumption as well for MM and transmission. This contribution is accomplished using one digit output by the novel route equation. The one digit will represent 17 digits necessary location data consist of longitude and latitude. Theoretically one digit replacing 17 digits position data must have a potential to reduce the data and time by 17 times. But practically it does not happen so. For the purpose being, several testing based experiments were conducted to evaluate the actual processing time taken by the modules. Master module is selected since it is the hub for all the operations done in overall system.

Figure 5 shows that the processing time for master module includes receiving, calculating and transmitting. The objective of this finding is to estimate the time at which PIC16F877A with 4MHz crystal performs certain calculations since the equation contains several floating point based calculations and to verify the overall time reduction claim. We managed to compute the processing time period during three steps through digital oscilloscope GDS 1062A along with its serial simulator to capture on laptop as well as PICkit2 logic analyzer tool (LA).

Initially it was checked either the system is free of error or not. For the purpose, a simple delay of 100ms and 50ms routine was made and verified through the oscilloscope and logic analyzer tool using the digital output and cursor feature respectively at the output pin of PIC using the blinking LED. The code displayed a square wave with the period cycle of 200ms with 100ms delay and 100ms with 50ms delay. It was observed no error in our procedure. Later on, actual master module processing tasks for time measurement was checked through the change of state by LED.

As mentioned earlier, the processing spectra contain three tasks that is receiving, computing and transmitting. The code was written to do all three tasks one by one in loop. Three LED are selected for each tasks. Before every task, the respective LED was made HIGH and, LOW after finishing particular task. Since

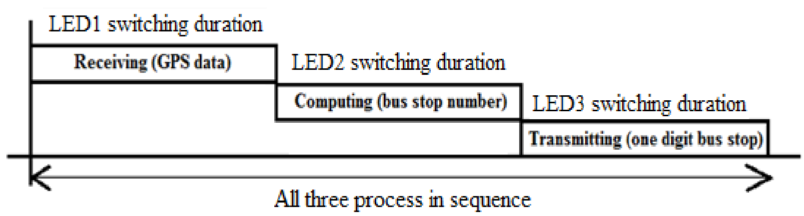

Fig. 5: Overall processing tasks in time sequence

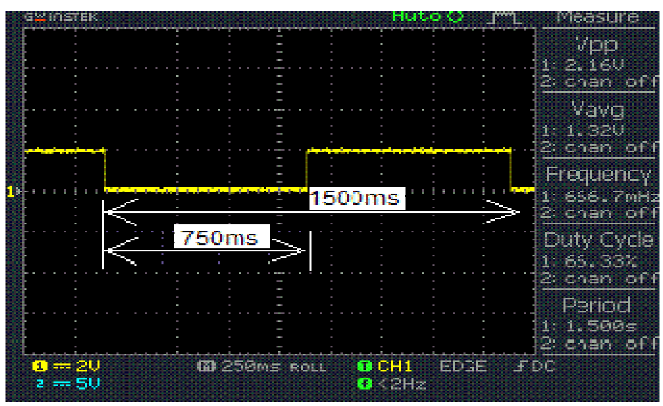

Fig. 6: Time taken by MCU to receive GPS selected data (Longitude, Latitude, valid and direction character) by oscilloscope

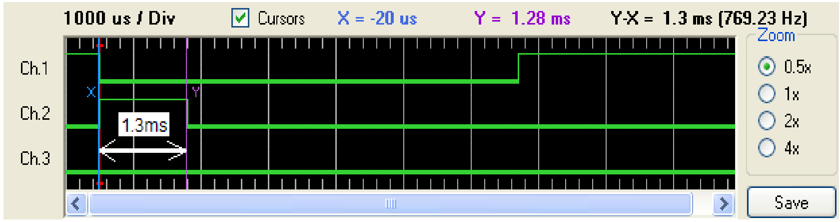

Fig. 7: Time taken by MCU for all floating point calculation using LA

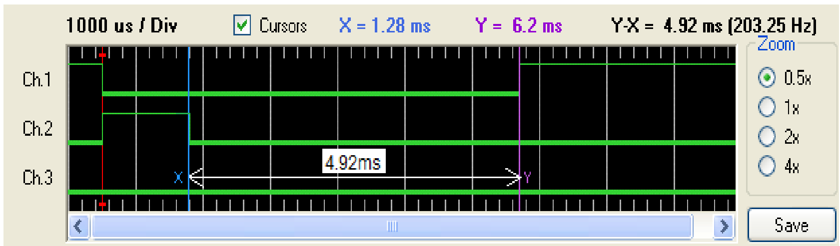

Fig. 8: Time taken by MCU for transmitting one digit

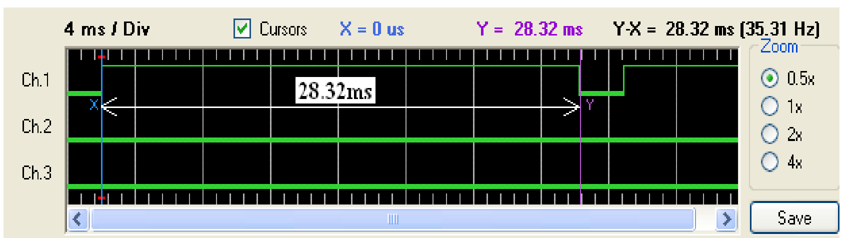

Fig. 9: Time taken by MCU for transmitting 17 necessary digits

the duration between them to toggle will help to estimate the actual time consumption. The output was observed at the oscilloscope as well as logic analyzer. For the first task, location data reception was found unable to measure accurately by LA. For the purpose, the oscilloscope was utilized.

The Fig. 6 shows the time consumption for receiving specific location data by MCU as master module. As mentioned above, in order to capture the duration, LED1 output is programmed to toggle after receiving GPS data, is captured at the channel 1 for both LA and oscilloscope. LA was found having insufficient range to compute the time taken by MCU. Furthermore, the same procedure was followed using oscilloscope as an individual step. Reception is initiated with a high pulse and ended by low one, but the total time period is taken for one complete cycle of period, which is found to be 1500ms as shown in the figure. These results are taken as average by capturing the reading after 5 run by the oscilloscope. It implies the average actual time taken by MCU to receive the selected GPS data took ~1500/2=~750ms.

Figure 7 shows the time consumption for the floating point based calculation inside master module. In order to capture the duration, an LED2 output is programmed to toggle after completion of all calculation until gives the one digit bus stop number, is captured at the channel 2 using LA. In the programming sequence, this task is kept right second after GPS reception. This can be evidence by the figure, that the X for calculation time starts right after GPS reception pulse fall down at channel 1. The duration is estimated about ~1.3ms.

Figure 8 shows the time consumption for transmitting one digit output from the calculation. The one digit output is the bus stop number sent serially to the prototype slave node. In order to capture the duration, an LED3 output is programmed to toggle after transmitting the digit representing minimum 17digits of location data, at channel 3 using LA. However as mentioned earlier, the selected LA was found incapable of capturing 3 channels at a time. This problem is resolved by the programming sequence. In the sequence, this task is kept right third after calculation complete (2^{nd} task). The time taken was easily captured from falling edge of 2^{nd} task until the rising edge of 1^{st} task, as evidence by the figure. The duration is estimated about ~4.92ms.

The Fig. 9 shows the time consumption for transmitting 17 necessary digits output prior to calculation. It was captured through LA separately in order to verify the claim of saving the time and data

Table 8: Processing time measurement summery

Operation	Captured estimated time
GPS Location reception	~750ms
All floating points calculations	1.3ms
One digit transmission	4.92ms
17 digits transmission	28.32ms

consumption. The figure clearly shows that the minimum time taken by 17 digits to transmit serially through the MCU is found to be 28.32ms. This time is about 6 times higher than the time taken by 1 digit. The Table 8 summarizes the overall time taken for the selected tasks.

The conclusion of the task is to verify time taken for transmitting/ receiving 17 digits vs. 1 digit. The time reduction is found as 5.75 time more than formal GPS data MM and transmitting. The table clearly shows the time reduction objective was achieved during transmitting the one digit bus stop number from master node and receiving, comparing and transmitting through each slave modules. The major portion of the time taken by overall operation was coordinates reception. Since this operation is not only the function of just 17 digits reception but also several other necessities such as waiting for valid variable “A” and distinction amongst the degree, minutes and seconds by waiting for their proper sign of “.” and “,” etc.

DISCUSSION ON OPERATIONAL EFFECTIVENESS

The overall performance and implementation for proposed study at individual bus companies is determined by its technical as well as organizational factors too. Technically the implementation of the provided solution in the field of the intelligent transportation system seems a huge task since it required a profound cooperation of the transport service provider and the urban management system. So during the prototype designing, there are several tribulations faced, one of them is the delay in receiving the position data by GPS and second one can be the node failure for the wireless sensor systems at Buses' station. Therefore, these conditions should be taken into account that the whole system can work properly, even if some of the nodes do not work temporarily. According to looping routing mechanism designed using RF modules, the basic idea ensuring the reliability of communication is: the unique ID of bus must transmit properly, the main path must be created first from the master module to the slave module one by one. By keeping above scenario, this research adopts an individual as well distributed looping algorithm. That is, the communication is utilized in the way to have a greater functioning capability in the network for the Intelligent Transportation System.

CONCLUSION

This study presents an approach that includes both the individual bus route optimization and the technological utilization to provide the public transport an implementable structure in the wider aspect. MM algorithm through RSM for better and reliable route’s coordinate optimization brought remarkable performance evaluation to be used as public transport notification system in terms of data and time reduction. In case decision support system, the generic needs of the user, such as updated information with reliability are well documented in the literature and are subsequently reinforced in this study up to more technological enhancement. The design of the framework impacts the fruitful investment in long term to the companies operating the services. The model presented, illustrates several key stages which have to be taken into account by the transport planner. Anyhow, successful designing, its optimization, designed results matching, equation validation and testing directs a clear potential to bring the system in the leading solutions to resolve the overall public transport monitoring system for passengers. After testing prototype and modifications in the documentation for about a year by taking extensive field test and surveys, the proposed framework tends to have potential for commanding public transit operations and lend a hand to change the trend of passengers to switch to use public transport instead of private own cars. And finally the reliable solution for the traffic congestion by providing facilitated bus stops to the travelers.

As far as the future works concern, our focus will be on designing of centrally monitoring server based system by which the positioning data base of all the tracked vehicles could be examined. This would be help full to realize the driver efficiency as well as the factors effecting on well-organized monitoring system. For the purpose being, the GSM technology will be suggested to utilize.

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