Intelligent Transportation Cyber Physical system toward Comfort and Safety perspective using Fuzzy Logic

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Abstract — Intelligent transportation cyber physical system (ITCPS) is used to enhance the safety and performance of the road transportation of a country. A crucial element that affects road safety is passengers comfort factor since a large crowd always invites accidents. An Intelligent Transportation Cyber Physical System is proposed using fuzzy logic for automatic crowd monitoring in buses. Subsentential research has been undertaken in ITCPS to manage traffic, safety, and security among which safety measures in the public transportation system is crucial. The main focuses of this paper are on passengers comfort factor and safety. The proposed framework gathers a large set of input parameters using an onboard sensor. Fuzzy logic is applied to identify whether the passenger bus is crossing the safety limit, the data are stored in cloud storage. The Intelligent Transportation Cyber Physical System then monitors the crowded area and allocates another bus by providing proper intimation to the users, the process avoids bus bunching. The test bed is created to simulate the Intelligent Transportation Cyber Physical System framework, with the different scenario the performance is measured.

Keywords — Intelligent transportation system, passengers comfort factor, IR Sensor, Fuzzy Logic, Embedded system.

1. INTRODUCTION

ITCPS enrich the execution of the networks by handling real-time monitoring and also the management that includes the traffic light sequence is dynamic, the system that are controlled online, managing the demands, and promising off-peak travel. In Intelligent Transportation System, by using the law enforcement and security, the vehicle that are not following the traffic rules are been identified. This can be done by monitoring and recording vehicles movements of the roads through cameras. The environment is now more vulnerable to air and noise pollution [1]. Common causes of bus accidents are overcrowded in buses, driver distraction or negligence, vehicle handling problems, and equipment defects, weight distribution problems in the vehicle affects stability and lack of passenger protection. By comparing all these problems, the major issue is overcrowding in buses, which leads to loss of precious life. The noise pollution and the air pollution are monitored frequently by automated detector and the flows of traffics are managed timely.

The ongoing transportation avails the information technology to improve the performance of the system and making them more intelligent [1]. Air, rail, and water are said to be Intelligent Transportation System. Intelligent Transportation System contributes distinct services that are described to different modes of transportation, management of traffic, the users to be informed finer, integrate, security and for wise use of transportation networks. The ways of transportation network is more reliable and are more efficient because of a rapid growth of vehicle and the population from small cities to large cities and also in rural areas especially in the Asian countries. As of today most of the families have a vehicle to go anywhere and everyone using their own personal vehicle. The current transportation can be upgraded by using information technology and making the transportation more intelligent. The system of intelligent transportation can be executed to enhance adaptability,
security and for exploration aspect of transportation network by applying diverse types of technologies.

Each year many people got injure and die due to accidents on highways [2]. In a bid to enlarge their benefit, bus conductors and drivers pursue to disrupt traffic laws by putting lives of hundreds of passengers at risk every day. They pack their buses beyond the capacity, but authorities who are concerned are not taking any action. The private buses can take in only 44 to 46 passengers but it carries 65 to 70 passengers at a time. It is the common cause for overcrowding. Because of this, the passengers dangle on the doors of the buses. Incase if buses run out of seating space, passengers will travel on the roofs of buses, thus putting their lives in danger. It was unsafe to travel in overcrowded buses and passengers must act responsibly while boarding overcrowded buses.

The comfort factors mainly focus to avoid bus bunching that occurs due to excess of the crowd in public transport and information about the location of a vehicle are informed to the user about the arrival and departure times of buses. The advent time of a bus can be predicted by the velocity and the location of the vehicle [1]. The automated parking payment function in the parking lot does not require the exact location of the vehicle. The important component in the embedded system is sensors. A sensor is used to detect from physical environment and responds to the input. The input for the sensor can be stress, hot weather, act, humidity and so on. The output from the sensor is a signal that can be changed into human-readable pattern. The transmission can be done through Zigbee, Bluetooth, Wi-Fi, and GSM.

IR sensor counts the passengers by detecting motion and heat of an object and is fixed in entry and exit of the bus. The input from the sensor is transferred to the microcontroller[2] Fuzzy logic is used in the microcontroller to give an accurate result that performs setting the threshold limit which is based on the IF-ELSE statement. If the detected value is beyond the threshold limit then the specified routes are stored in cloud storage via WI-FI as a communication protocol. The authorized person will monitor the crowded area and allocate another bus for improving their business and to avoid bus bunching. The organization of this paper is as follows: In the second section, related work of this paper is been discussed. The hardware layer, software layer, and its working are discussed in the third section. A test bed of ITCPS framework and its result are discussed in the next two sections. Conclusion and future work are given in the final section.

2. RELATED WORK

A smart algorithm and an unified structure were advanced for localizing vehicle in intelligent transportation system discussed by Arghavan Amini [1]. The author uses information technology for the present transportation systems achievements and makes them intelligent. Intelligent Transportation System can be implemented in areas such as railways, water, and air. The Intelligent Transportation Systems are implemented to improve safety, security, traffic management, and efficiency in road transport. These systems are used for monitoring, maintaining, and forces different functionalities in the highways. To distribute the appropriate localization at the recommended latency, smart localization technique depends on the various applications and is used here. If a vehicle has five V2V and three V2I connections, it is not necessary to use RFID or GPS connections as the vehicle can localize itself using connections with sufficient accuracy and thereby the integrated positioning improves the performance of the localization in most conditions.

Abhinav S. V and Krishna Anand S [2] use a fuzzy expert system to maintain the vehicle transportation completely. The main focus of this model is to provide a threshold limit, in order to reduce the number of accidents and the expenditure. A bus transportation used a fuzzy expert system in which a large variety of inputs are been considered. The data includes hitting the break, traffic, fast, highway quality, bus capacity, usage of tire and kilometer per liter. These parameters are used for analyzing the factors like congestion in the bus. By considering the above input factors there are hundred and fourteen fuzzy rules have been framed. According to predefined rules, the defuzzification is been done to get the final outcome.
IoT based passenger monitoring system was developed by Andri Yoga Nur Pratama, et al. [3] in which the author explained the model for school shuttle system uses the vehicle for the students to go home from school. Bluetooth Low Energy technology is used for identifying the identity card of students. A localization sensor is to determine the position of the vehicle. Parents can access the passenger’s list and location information in real-time mobile applications. The vehicle, also equipped with Global Positioning System mounted on Raspberry as the gateway position to send GPS data to the server. In this system, a rule-based expert algorithm is used to select beacons based on limitation areas. By knowing the value of RSSI that is outside the vehicle, which is the limit for Reader to select Beacon. The goal of this system is to provide monitoring on the school shuttle process based on the algorithm and test results.

A system was developed by Jianghui Yan, et al. [4] for smart cities based on self-established system that depicts the approximate data analyses of smart city establishment. It is used to identify the robust condition. Also, it uses the self-established the concept to an overall framework for smart cities. The developmental mechanisms, Information and Communication Technology (ICT) offer professional support and the simple actions of smart cities. Three dimensions are connected into a appropriated and extensible smart city assessment system.

Swacheta Dutta, et.al [19], used Fuzzy Logic for Controlling the accidents. In this work the author worked on different algorithms such as shear-force algorithm for avoiding the accidents during the time of emergency. The fuzzy controller algorithm can be used to reduce the system error to zero. By doing this the model of the system can be identified by the driver. The driver wants to provide the actuators operation and to define the enrollment part. The restraint behavior is reduced. They maintain robustness to the control system and grant the monetary application through the user interface. This method gives zero overshoot with improving the transient return and this method is calculated largely. Control optimization algorithm provides better resolution and faster response to the system. The control development algorithm is applied for the boost of vehicle accident. The fuzzy control system controls the sample area in examining the nearby-field microscope. The fuzzy design controller includes one input signal that are determined as several of a scribe signal and the sampling signal. A few steps are been taken to pursue, for getting close to the sample shallow. It protects the tip from alternate collision that causes from outside communication, oscillation, where by using the micrometers; it separates the tip and the surface. These model improves the speed and reduces the time that is been set prior for the system. In the scanning method, it takes place the effectiveness to oscillate comparably by shear forces communication. The survey in accident control has the capability to vibrate proportionally by shear force and it also controls the distance.

Rajib Bag, et al. [5] adapt RR algorithm and VANET to map a smart transportation system. The architecture of Vehicular Ad-hoc Network is used for real-time traffic information transferred using the vehicle, the signal is been exchanged from one traffic to another traffic. Based on Round Robin (RR), Time Slices are assigned to each process in a circular manner and distributed in equal portions, which can handle all processes without any priority. It is easy to implement and more efficient. It is employed by network schedulers. Here time slices are been assigned to each process without any priority. It handles the process in circular order based on time slice. It is free from starvation. In this model Green color is used to express the neighboring traffic of red color. The yellow color is used for eventful traffic computation of count of the vehicle. A vehicle from Yellow to green is anticipated for Red color traffic panel. Red color traffic is our designed traffic signal. All traffic information will come to this panel; round robin will be tested here.

Susel Fernandez and Takayuki Ito [6] use Fuzzy Logic for Intelligent Transportation Systems to analyze the drivers according to their behavior based on different profiles. Fuzzy logic has been implemented to provide intelligence to the system. For real-time process, it is linked to the controller in which it generates a unique output for each input pattern. Inference engine consists of fuzzification and defuzzification interfaces. Fuzzification is the process of converting real-time data into a fuzzy value and defuzzification in used to deduce the data and produce new data. The system is unified with intelligent transportation, which can be used to improve the routing management and also it anticipates and to avoids the accidents which causes due to traffic. It consists of a
Knowledgebase and an inference engine. The inference engine is answerable for drawing the outcome from the significant data, using the laws guiding the fuzzy system. Inference engine contains fuzzification/defuzzification interfaces, and an inference system. Using the laws, the inference engine is capable of drawing the outcome from the significant data that have appear as input. For the defuzzification interface, FATI modes are used for driver classification.

### TABLE I: COMPARISON OF TRANSPORTATION ALGORITHMS

| S. No | Algorithm/Framework | Comfort Factor | Safety | Traffic | Security | Environmental Monitoring |
|-------|---------------------|----------------|--------|---------|----------|---------------------------|
| 1     | Fuzzy expert system[2] | X | X | X | X | X |
| 2     | Rule-based expert system[3] | X | X | X | X | X |
| 3     | Round Robin(RR)[5] | X | X | X | X | X |
| 4     | Support vector machines (SVM)[9] | X | X | X | X | X |
| 5     | Bayesian networks[9] | X | X | X | X | X |
| 6     | Fuzzy rule-based systems[6] | X | X | X | X | X |
| 7     | Artificial neural networks (ANN)[9] | X | X | X | X | X |
| 8     | Decision support system[14] | X | X | X | X | X |
| 9     | Fuzzy rule inference[13][3] | X | X | X | X | X |
| 10    | Fuzzy logic controller[13] | X | X | X | X | X |
By comparing all the framework mentioned in Table I, the solution for comfort factor and the safety is not been considered much, by using fuzzy logic, the problem for comfort factors such as passengers information, road, and weather information and the safety measures such as speed adaption, collision warning can be solved efficiently and accurately. On implementing the system using the fuzzy logic we can get an efficient.

3. ITCPS FRAMEWORK

A. Hardware layer

Hardware layer is the bottom layer which handles all hardware components and its working. It mainly senses information from sensors and identifies a location. The components used for sensing and the process carried out in a controller are been discussed below.

1) Sensing

Sensing is the process of detecting physical presence. The sensed is analog in nature. The sensed analog data is converted into a signal that can be read by an instrument or an observer. IR Sensor and GPS plays a major role in sensing, that collects the data in real time.

a) IR Sensor

IR Sensor is fixed in entry and exit of the bus door. If the passengers enter, it detects the number of passengers and gives the detected data to the controller. In the same way, if the passenger exits, the data is been sensed and sent to the controller. The distance range of the sensor is 2 to 10cm. The data sensed by the sensor is analog in nature.

b) GPS

Global Positioning System is used for tracking the location of the bus and sends the detected location to the controller. The location accuracy of GPS is from 10 to 100 meters. The data collected is analog in nature. The Global Positioning system is altogether a practical universe exploration Satellite System. GPS is been used globally for the reason of shipping. It is also a useful tool for making the map, surveying the land, scientific use and for commerce. GPS provides some time reference that is been used in different applications namely synchronizations networks and scientific study of earthquakes.

2) Controller

Controller act as an interpreter, the controller used in this framework is the PIC microcontroller 16f877a. The work of controller is to get sensed data from the sensors and convert the analog signal into digital. PIC16f877a contains 40 pins. It contains ports from A to E, in which 33 pins are input and output. The PIC microcontroller PIC16f877a is one the most eminent microcontroller in the industry. The PIC16f877a controller is more convenient to use, the coding and the programming in this controller is been done in a more efficient and easier manner. The advantage of using this controller is that the controllers use flash memory so, the user can write erases the data as many times they need.

a) GPS Location Identifier

GPS location identifier is used to get location information from the Global Positioning System and send it to analog to digital converter. Every GPS satellite broadcasts a navigation message continuously at 50 bit/s that gives the time of a day, the satellite health information and the GPS week number. These navigation messages are been sent in a frame, in which each message frame takes 30 seconds to transmit 1500 bits. Initially in the first 6 seconds of every message frame that contains data by describing the relationship to the GPS system time and the satellite clock time. The next 12 seconds depicts the ephemeris data, by giving the satellites own orbit.
b) Analog to Digital conversion
It gets the sensing information from the sensors and the location information from the GPS and converts that analog information into digital. The digital information is then sent to the sensor and GPS data.

c) Wi-Fi
Wi-Fi acts as an interface between the PIC microcontroller and the cloud storage. The collected data is processed in the middleware layer and the result is stored in the cloud using a Wi-Fi which is a wireless communication technology. Wi-Fi is a common approach for associating the computers to wireless networks. The computers and alternative components can be communicated by using a wireless signal. When a computer or a device authorizes a Wi-Fi relation with the router, it must be attached to the internet for giving the internet access to the connected devices.

B. Software Layer
Software layer is the top layer in the architecture that uses an algorithm called fuzzy logic for processing the data and cloud is used for storing the processed data.

1) Fuzzy logic
Fuzzy logic control has been carried out to bring intelligence to the system. For real-time, the process is further linked to the controller which generates a unique output for each input pattern. Inference engine consists of fuzzification and defuzzification interfaces. Fuzzification is the process of converting the data from sensor and data from the GPS into a fuzzy value. It is the process of allowing the continuous values of a variable to be transformed into a linguistic variable and an assignment of the input variable to the fuzzy set. Fuzzification is the action, that converts the definition to fuzzy terms based upon some fuzzy enrollment operation. The enrollment operation is used to make a degree for each term. In fuzzification, the input from the sensor is converted into short input or a fuzzy value. Inference engine applies certain logical rules based on the rule base to deduce new information.

Defuzzification is the process of producing the result in a consolidated logic with respect to the fuzzy set. This process is used for mapping a fuzzy set into a crisp set that is needed in the fuzzy control systems. The defuzzification is required to convert the desired data from the inference engine to some specific value. The system collects data from IR sensor for fuzzification after which the fuzzified values are passed to an inference engine for interpretation using rule-based inference engine and then the outcome is passed to defuzzifier to produce output and finally it is been sent to cloud storage. Inference engine applies certain logical rules based on the rule base to deduce new information. Here, IF-THEN operation is used, since it is possibility of a crowd in the bus (i.e.) if the counted value is more than the threshold value then buzzer will start ringing. The information from the defuzzifier is been sent to the decision maker and been updated in the cloud storage.

2) Cloud Storage
The Cloud storage is a way of storing data online and it is mainly based on virtualized infrastructure. The data from the updater is been stored in local storage and later it is stored in the server database, which is global storage. It keeps the data available, accessible, and the physical environment protected and running. Where the data can be reserved, handled, preserved, and are made feasible to the users over the network. It contains public cloud and private cloud. Users pay for the data that are desired for storing in the cloud storage on a per-utilization routine standard.
3) User Interface

User interface is an output layer where the data from the cloud are displayed on the website. The information such as route, number of passengers, vacancy in the bus, and the bus number. This information’s can be viewed by the user. If a user needs some information about the bus, then that user can ask query in the website and according to that query, the information is retrieved from the cloud and been displayed to the user.

4. WORKING

An Intelligent transportation cyber physical system is a two-layered system namely hardware layer and software layer as discussed in Fig. 1. The IR sensor in the hardware layer is used for counting the number of passengers who are getting in and off the bus. The global positioning system is used for tracking the location of the bus. The collected data from the sensors are sent to the PIC microcontroller (PIC16f877a). The microcontroller contains GPS location where it collects the data from the GPS sensor. The data from the IR sensor and the data from GPS location are sent to an analog to digital converter. The work of analog to digital converter is to covert the analog data from the sensor to the digital and sent to sensor and GPS data. The data from it is been sent to local template converter via local display driver. Then the data from local template converter is displayed in the local display where it contains the number passengers in the bus, number of vacancies, total capacity and the route of the bus where the bus is been traversing. The software layer in this system is used for processing the collected data from the hardware layer. The interpreter gets the data from the IR sensor and its work is conversion. That is the data from the IR sensor is analog data, it convert the analog data into digital and sent to fuzzification, where it converts the data from the sensor into a fuzzy value. The fuzzy value is sent to the inference engine. Inference engine applies certain logical rules based on the rule base to deduce new information. Here, IF-THEN operation is used, since it is a component of a knowledge base. Defuzzifier gets the processed data from the inference engine. Defuzzification is the process of producing the result in a consolidated logic with respect to the fuzzy set. If the counted value is more than the threshold value then the buzzer will start ringing and the information is sent to the cloud storage via Wi-Fi device.
Fig.1: Architecture for proposed model

Then through the website, the user and the person who is responsible for that transportation can view the details like, in which route the bus has been overcrowded, with the bus number, vacancies in a bus and the number of passengers traversing. And if a user needs information, they can ask their query in website according to that query, the information is retrieved from the cloud and been displayed to the user.
Based on the information given, the authorized person can allocate another bus for the route which has been overcrowded and the public user can be updated with the crowd in the bus. By implementing this method the user can improve their business and can avoid the problem called bus bunching.

5. TEST BED OF ITCPS FRAMEWORK

IR sensor is fixed in entry and exit of the bus. It detects the number of passengers getting in and out. The number of passengers on the bus is calculated, this actual count is compared with a threshold value which is a static value. The fuzzy logic based algorithm is used for comparison that provides intelligence to the system. The process that is used in fuzzy logic to compare the safety limit follows fuzzification and defuzzification, based on some set of rules the output is been fetched. The hardware setup for ITCPS framework is shown in Figure 2.

![Fig.2: Hardware setup](image)

6. RESULT AND ANALYSIS

Scenario 1: In this scenario, the real-time data cannot be fetched for the algorithm to get processed. The virtual data are created using a random generation algorithm and the data are injected into the controller at its input port. The injected data are IR sensor data and global positioning data. Once the data are populated the performance of the proposed system is validated as follows, the passenger data are counted and displayed in local transportation display and the cumulative data are transferred to the cloud storage and the passenger boarding and alighting at different stops are monitored and populated to the cloud storage. Figure 3,4,5 represents the graphical representation for date versus Crowd and the location.
Fig. 3: Date versus Crowd

Fig. 4: Date versus Latitude

Fig. 5: Date versus Longitude
Scenario 2: In this scenario, before populating the data to a cloud, the data are analyzed using fuzzy logic. If the counted data is greater than the threshold value, the intimation is given and necessary steps are been undertaken. (i.e.) if the counted value is above the threshold value the data are stored in the cloud else the data will only be displayed in local transportation display. As a result, the information in the cloud can be viewed by the authorized persons through a website and based on the count they can allocate another bus for the crowded route to improve their business and to avoid bus bunching.

7. CONCLUSION & FUTUREWORK
A crowd of travelers in the public transports has become fractious. Most of the accidents occur due to excess of a crowd in a bus. To maintain and control the crowd in a bus, a system is proposed. Here the crowd in the vehicle is monitored and if the number of passengers exceeds the safety limit, the information is sent to the cloud storage via a Wi-Fi device. Then the user can view the details about the route, bus number and the number of people traversing in the bus. Based on the information given the user can improve the business and can avoid the problem called bus bunching. This part will certainly avoid highway accidents and its ratio will get decreased in an adequate manner. An accident-free nation can be developed by implementing this technique. Although the designed system is more powerful, the system can be enhanced again by tracking the day to day development in transport sector. Some factors can be taken into consideration such as the frequency of bus, stops involving a relatively high degree of passenger movement and availability of buses at the location. These could help the incoming buses to modify the parameters like the vehicle speed and the travel direction.

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