Towards Ubiquitous Computing in Indonesia: Automated Bus System

Dewi Agushinta R.1, Astie Darmayantie2, Hauliza Rindhayanti2, Jessica Permatasari2, D. Suryadi H. S.1
1 Information System, 2 Informatics Department
Gunadarma University, Jl. Margonda Raya 100, Depok, Indonesia
Ruitai76@ovi.com

ABSTRACT

The traffic jam becomes the biggest problem in urban area especially in Jakarta as the capital city of Indonesia. This is due to inadequate facilities of public transportation so, people prefers to use the private vehicles. The government has given the solution to enhance that but it is still not effective and it made the situation of traffic jam became worst. This paper proposed the Automated Bus System (ABS) to improve the existing system and enhance the traffic jam problem. This bus system has the ability to ride on its own without relying on any human driver. It can recognize any obstacles and avoid any collision using stereo vision technology. RFID technology is used to improve the accuracy. Still, this whole system is monitored by human operators. If there is any failure beyond the ability of system, the human operators could recognize the problem.

Keywords: Automated bus system, HCI, smart system, stereo vision, ubiquitous computing

INTRODUCTION

In last few years, the traffic jam has become the major problem of Jakarta. It is like a cancer that undermines the body of Jakarta. This is because by the increasing number of vehicles which are not balanced by accretion road. The crucial factor causing that situation is the inadequate facilities of public transportation. People prefer to use private vehicles rather than public transportation. This can be proved that in 2010, Jakarta produces 240 units of cars and 890 units of new motorcycles everyday [1].

To overcome this traffic jam, Governor of Jakarta proposed a solution to solve this problem with Macro Transportation Pattern initiated, such as the Transjakarta. Transjakarta adopts the Bus Rapid Transit (BRT) system. BRT is a rapid transit mode that is flexible and has high performance with combining elements of physical, implementation, and systems into an integrated system that has a qualified image and unique identity.

After several years, the performance of Transjakarta has not fulfilled the people expectation. It is because the services and facilities of Transjakarta are not satisfying the commuters. From the survey of 3000 commuter done by the Yayasan Lembaga Konsumen Indonesia (YLKI)’s, it shows that more than 41% correspondents complained about the travel time of Transjakarta and the other complained about long time to wait at the bus stop, still often stuck in traffic, safety, and the lack of comfort [2]. This several problems might be solved by automating the existing system. The benefits are to save time, manpower and to improve the service quality.

This paper proposes preliminary system about ABS, that is the system of automated and integrated Transjakarta will be, but it just constraint in the performance system. How it works is discussed in detail on methodology section. The problem arises when the road of Transjakarta is unclear, it means that there are other vehicles use the bus way (the government provides the special way for Transjakarta and other vehicles can’t enter the way but, it is often violated).

RELATED WORKS

Many big cities face the same problems when it comes to the use of private vehicles. People tend to use private vehicles rather than public transportations. Problems include road congestion, energy expenditure, noise and pollution, all of which degrade the quality of urban life. Michel Parenta and Georges Gallais developing a project called CTS (Cybernetic Transporta...
Transportation System) [3]. It is a new option of Intelligence Transport Systems based on road vehicle with fully automated capabilities. This system implements the car-sharing concept which has been improved. The cyber cars vehicles are made to move by themselves in order to respond the demand of the commuter. Cyber cars move on a small track (approx. the size of 2 wheels).

There are many methods that can be used in ABS, a non-linear control law for an automobile to autonomously track trajectory for off-road driving proposed by Gabriel et al. [4]. This works treats automobile trajectory tracking in a new manner, by considering the orientation of the front wheels—not the vehicle’s body—with respect to the desired trajectory, enabling collocated control of the system. This system provided in real-time, on rapidly varying, off-road terrain. Global asymptotic stability was proven for the control law, using kinematics equations of motion.

Tullio et al. [5] proposed a case study in embedded system design: an Engine Control Unit (ECU) because it is important to address a number of relevant design problems and solve them to demonstrate the power of the new approaches, to validate the design methodology an industrial example in automotive electronic was chosen. This offered the advantages in terms of performance and design time. Moreover, a product should be flexible to adapt to changes during its lifetime, which is best obtained by using software, and must also meet tight timing constraints, which is most suitable for hardware components. An ABS needs to be equipped by various sensors to maintain the performance. Kai Goebel & Alice M. Agogino proposed a method for validation and fusion of redundant sensor information which coming from several sensors information (several sensors employing different physical principles) [6]. This method will help controlling an automated vehicle to validate each of sensors value.

Many papers proposed about the automated vehicles, which were implemented in the train and for automated transmission cars. In this paper, the system of automated is used for bus to improve the existing system. This paper proposes new methods, namely the use of the Electronic Control Units (ECU), Controller Area Network (CAN) used for communicating of ECU, image processing is needed for tracking bus way, and RFID for the problem of stop accuracy.

**METHODOLOGY**

To create the good performance of ABS, this paper concerns with 3 things, first is how the system of ABS can be implemented in Transjakarta, second is how the ABS can tracking the bus way, and the last is the detail performance of sensors. Each ABS is equipped with sensors to recognize the obstacle, the road map, and the condition when the bus stop in the shelter (station stop point to lower and carry commuter) and road back again.

**AUTO BUS SYSTEM.**

ABS as an automatic vehicle must concern with several things in performance such as safety, riding comfort, stop accuracy, on-time arrival, etc. To realize that the system operation must capable to similar with human operator, fuzzy control is use to handle these problems. Fuzzy control is used to realize a skilled human operator’s control by evaluating safety, riding comfort, traceability of target velocity, energy saving, running time, and the accuracy of a stop gap [7]. ABS electronic system will be embedded with ECU, typically the biggest processor is the Engine Control Module (ECM), and CAN. ECU is a generic term for any embedded system to controls one or more of the electrical system or subsystem in a motor cycle [8]. There are many types of ECU and in ABS some of the types will be used, such as ECM, Speed Control Unit (SCU), and Transmission Control Unit (TCU). The whole system must still be monitored by human beings as shown in figure 1.
SCU is a system that automatically controls the speed. In this case, fuzzy control system must evaluate the target velocity first, after that the SCU takes its speed signal from a rotating driveshift, speedometer cable, wheel speed sensor from the engine’s RPM or from internal speed pulses produced electronically by the vehicle. The vehicle will maintain the speed by pulling the throttle cable with a solenoid, a vacuum driven servo mechanism or by using the electronic systems built into the vehicle (fully electronic) if it uses a ‘drive-by-wire’ system. When the bus must face obstacles, the system must be capable to handle it. In such condition, the bus must stop at the shelter, prior to that, it must decrease the speed, that’s all will discuss later in the next subsection because it will depend on sensors to solve the obstacle problem.

ECM is a type of electronic control unit that determines the amount of fuel, ignition timing and other parameters an internal combustion engine needs to keep running. These systems use a microprocessor which can process the inputs from the engine sensors in real time. An electronic control unit contains the hardware and software (firmware). The hardware consists of electronic components on a printed circuit board (PCB). The main component on this circuit board is a microcontroller chip (CPU). The software is stored in the microcontroller or other chips on the PCB, typically in EPROMs or flash memory so the CPU can be re-programmed by uploading updated code or replacing chips. This is also referred to as an (electronic) Engine Management System (EMS).

TCU generally uses sensors from the vehicle as well as data provided by the ECM to calculate how and when to change gears in the vehicle for optimum performance, fuel economy and shift quality. Input parameters for TCU are current speed of the vehicle, wheel speed to determine whether the vehicle is going downhill or uphill and also adapt gear changes according to road speed, throttle position to determine the optimum time and characteristics for a gear change according to load on the engine, and inputs from other controllers. The output parameters are shift lock, output to ECM, outputs to other controllers.

To avoid any collision and obstacles, the stereo vision technology is used. This technology allows the bus to any of things impede the track. This paper will not discuss in detail the sensors using in TCU, just the sensors that used in SCU. For tracking road map will be discussed in detail in the next subsection.

CAN is a multi-master broadcast serial bus standard for connecting ECU. Each node is able to send and receive messages but not simultaneously. A message consists primarily of an id, which represents the priority of the message, and up to eight data bytes. It is transmitted serially onto the bus. The devices that are connected by a CAN network are typically sensors, actuators, and other control devices. These devices are not connected directly to the bus but through a host processor and a CAN controller. Each node requires:

- Host processor deciding what received messages mean and which message wants to transmit itself.
- CAN controller (hardware with a synchronous clock)
- Transceiver (possibly integrated into the CAN controller).

**ROAD MAPPING.**

Transjakarta has its own path track on public road, called busway. This path is separated from the main road. Other public transportation like private vehicle, public buses, “angkot”, etc. They have to use the main road and should not use the busway track. This will help the road mapping procedure.
The color line shows the corridor (the Transjakarta route) and the dots are the shelter. Each of Transjakarta Bus is assigned to serve different corridors. Each bus should stop at each shelter listed on the corridor route.

As shown in figure 2, there are 15 corridors on the existing system of Transjakarta but, for now, only 10 corridors operated. The government still builds five other corridors.

**INFRASTRUCTURE TECHNOLOGY.**

The traditional transportation system usually requires a massive infrastructure that cost lots of money. The infrastructure that ABS requires is already in place. The only thing that matters now is the technology. On the other hand, the driver role was replaced by the use of sensors and system communication as in discuss on the previous section. The consolidation of this 2 mechanism will overcome the ABS (Automated Bus System). The powerfulness of this new system is relying on these 3 tasks: management of the resources, remote control of the vehicle, and the communication of each sub-system.

There are 3 kinds of conditions when an ABS is operated: tracing the route, crossing traffic light, and approaching the shelter. Each of these stages depends on the sensor readings.

The ABS will be equipped by various sensors. These sensors will provide the information to keep the fleet on the track. By tracking the existing busway track, the automated bus will able to ‘know’ the routes. This paper proposed the use laser and color-recognition sensors for the track detection. The use of color-recognition sensor is to acknowledge the system when the bus is crossing the road (passing a traffic light). According to the busway path pattern, the color-recognition sensors will be placed on the bottom part of the bus. The use of DGPS might improve the effectiveness and the accuracy of this system but, the technology is still in research stage [3].

![Fig. 2 Transjakarta Map][9]

![Fig. 3 RFID Placement][10]
The smart-shelter is able to recognize whether there is a bus approaching or not. Once the shelter detected the bus, the shelter automatically sends interrupt to the Transjakarta fleet using RFID. The RFID will notify 3 different instructions to the bus. The first RFID will tell the bus that the shelter is approx. 5-10 meters away. The second RFID will tell that the bus is approaching the shelter area and need to lower the speed and hit the break. The last RFID tells the bus is already arrived at the shelter precisely (as shown on figure 3). To avoid miss-calculating, the shelter will be equipped by sensor in the front and the rear side. This sensor will synchronize values with the device implanted on the bus. This method will prevent the bus for stopping out of the shelter area.

Once the bus is approaching a shelter, the speed is automatically slow down. Depending on the way systems will be design, whether the speed rules are more or less complicated. On a simple system, these rules are set at the beginning (initialize) by former calculation and research. However, the system will be more complex when it faces the operational problems. The system should be able to recalculate the speed due to any unexpected condition such as the damage of the shelter devices or system failure. Once the bus is finished loading the commuters, the bus will automatically switch into dispatching mode and heading to the next destination shelter.

The management of resource plays very crucial role of this system. The management of resource has to know the real time availability and the states of each resource that the system has: vehicles, tracks, remain gas, and so on. The management of resources need to be prepared with various problems that might occur and capable to provide an effective solution in short period of time. To cope with the operational problems, the management of resource has to have plenty scenarios and its solutions. For example to prevent the bus from deviating, the management system use GPS technology to tracking each of operated buses.

**SUMMARY**

The beneficial of this Automated Bus System (ABS) is to increase the performance of Transjakarta system such as on-time arrival, safety, riding comfort, etc. The performance improvement of Transjakarta system is expected to change the use of private vehicles into the Transjakarta. So it will be reduced the traffic jam in Jakarta. For now in Indonesia, this system is still a concept. Once the government implements this concept, it will be shown which part of the system that needs to be improved.

**REFERENCES**

[1] Information on http://bataviase.co.id/node/310157