Motor Vehicle Condition Monitoring and Recording System Using Arduino Mega

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Motor Vehicle Condition Monitoring and Recording System Using Arduino Mega

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Abstract – *Transportation is needed to overcome the gap in distance and communication between the place of origin and the one of destination. For this reason, transportation and communication systems have been developed in the form of facilities (vehicles) and infrastructures (roads). Safety and security in driving are important in every country in the world, especially in Indonesia. Over the past five years, traffic accidents in Indonesia have claimed nearly eight hundred thousand lives. About 17 percent of the accident rate has resulted in many deaths. Most motor vehicle accidents occur because of drivers and motor vehicle conditions. Therefore, a monitoring system for both the condition of the driver and the condition of the vehicle, especially on four-wheeled vehicles, is needed. This study is focused on monitoring and recording the condition of motorized vehicles. If a malfunction of the motor vehicle's vital functions occurs, this system will provide an early warning. Then the recording function is carried out as a preventive measure for periodic motor vehicle condition analysis so that prevention efforts can be made. The parameters to be monitored and recorded are the orientation of motion, speed, and position of the motorized vehicle. Then the vehicle recording data can be monitored in real-time and can be downloaded wirelessly. Based on the results of testing the system, both monitoring and recording have obtained an accuracy for Rolls of 99.50%, Pitches of 99.21%, and Yaw of 99.5%. As for the position with GPS, the accuracy results are very good at 99.99%.*

Keywords*: Motion Orientation, Position, Monitoring, Recording*

I. Introduction

In 2009, there were 62,960 cases of an accident with 19,979 fatalities. In 2010, there were 66,488 accident cases with 19,873 fatalities, and then in 2011, there were 108,696 cases with 31,195 fatalities. Whereas in 2012, the number of accidents was 117,949 in 29,544 fatalities, and in 2013 the number of accidents was 100,106 with 26,416 fatalities. Furthermore, in 2014 there were 95,906 accidents with 28,297 fatalities. In 2015, there were 98,970 accidents, with 26,495 fatalities. In 2016, there were 106,129 accidents with 26,185 fatalities. This figure is classified as high and even the highest in ASEAN [1].

These problems can be reduced by providing alternative solutions, including by making monitoring tools and recording the condition of motor vehicles, especially public transport in real-time [2]. Monitoring and recording efforts are made so that the condition of the vehicle is monitored when on the road and in the event of an accident [3], [4]. The position of the vehicle, the orientation of the vehicle's motion, the speed, the acceleration, the pressure on the brakes, and the condition of the vehicle's environment can be monitored and recorded for periodic maintenance purposes and data analysis in the event of an accident [5], [6]. The position of the vehicle's coordinates can be monitored if an accident can be identified so that it can be handled immediately. The system integration process uses a computer with a small size, namely Raspberry Pi [7], [8].

Then, the data can be stored and downloaded for purposes of analysis and regular maintenance [9]-[13].

The motivation of this research is based on the majority of motor vehicle accidents occurring due to driver factors and the condition of motor vehicles.

Therefore, a monitoring system for both the condition of the driver and the condition of the vehicle, especially on four or more wheeled vehicles, is needed. The purpose of this research is to design a monitoring system and record the condition of four or more wheeled vehicles in order to prevent accidents. This study has focused on monitoring and recording the condition of motor vehicles, especially four or more wheeled vehicles.

If a malfunction of the motor vehicle's vital functions occurs, this system will provide an early warning. Then the recording function is carried out as a preventive effort to analyze the condition of motor vehicles periodically so that prevention efforts can be made. The parameters to be monitored or recorded are motion orientation, speed, acceleration, brake pressure conditions, environmental conditions with the camera, and motor vehicle position.

Then the vehicle recording data can be monitored in real-time and can be downloaded wirelessly. This paper will discuss only on the condition of vehicles, which include orientation and position parameters of four or

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more wheeled motorized vehicles.

This paper is organized as follows. Section II describes the research review from several researches that support this research on vehicle monitoring systems.

Section III describes the materials and the methods for designing a vehicle monitoring system. Section IV describes the results, the analysis, and the testing of the vehicle monitoring system. Section V presents the conclusions and future work.

II. Research Review

Deaths caused by traffic accidents around the world are already at an alarming rate. Deaths and injuries due to road traffic accidents are one of the parameters to see the level of road safety crisis, so that it will cause emergency services to family members not being provided on time.

This will result in delayed emergency services and in death or serious injury. The aim of this research is to reduce emergency response time in certain situations such as traffic accidents, fire, theft, and medical emergencies. Therefore, it takes a system to detect traffic accidents and report it to the nearest emergency service, then provide tracking of the location of the victim. This system will increase the chances of life for victims and will help to save emergency services time and resources [14]. The growth of cities around the world will result in increased population mobility and an increase in the number of vehicles on the road. Therefore, it becomes a bigger challenge for the authorities for road traffic management. The consequences of an increase in the number of vehicles are traffic jams, more accidents, and air pollution. Currently, traffic accidents are still the main cause of death, although traffic management systems and vehicle-related technology have been developed. Therefore, it is necessary to develop a traffic management system on the highway; for example, traffic congestion in most urban areas can be reduced by planning routes and time. However, designing methods for efficient and globally optimal route planning is a challenge that needs to be solved by taking into account the unique preferences of the drivers. Therefore, the purpose of this study is to build an accident management system by utilizing an ad hoc vehicle network using cellular technology on public transportation. This system will carry out real-time communication between vehicles, ambulances, hospitals, roadside units and a central server. In addition, the accident management system can reduce the time it takes to call an ambulance at the accident site by using the optimal multi-loop forward algorithm. In addition, an Optimal Route Planning Algorithm (ORPA) is proposed in this system in order to increase the aggregate spatial use of the road network and reduce travel costs for operating vehicles. Therefore, the developed system can reduce vehicles stuck in traffic jams. Then a simulation is performed in order to evaluate the ORPA and the results are compared with other algorithms. The results of the evaluation provide evidence that ORPA outperforms other algorithms, namely: average ambulance speed and travel time. The system developed makes it easier for ambulances to get through traffic jams, so that the chances of saving lives can be increased [15].

Monitoring and recording of motor vehicle parameters when running is mostly done lately, like the monitoring system that can detect the position of the car when running in real-time from each vehicle [2]. Monitoring efforts are made to control the condition of the vehicle when on the road, and an accident occurs [3], [4]. A system to monitor speed, acceleration, and distance digitally can be used by an accelerometer [5], [6]. It is a sensor that can measure acceleration, detect and measure vibrations (vibrations), and measure the acceleration due to gravity. Based on the measured acceleration, the distance and the direction can be measured when the movement is made. With technological advances and rapid overpopulation, people are constantly trying to make their daily lives easier by adapting to newer technologies. Transportation is one of the daily facilities to rely on, but it is not sufficient for population growth.

This is one of the common problems that people try to solve with vehicle purchases. The increasing number of vehicles makes management mismanagement in traffic, leading to accidents. Although accidents occur due to various factors besides traffic management, such as unstable weather, reckless driving, damaged vehicles or possibly road conditions. However, the most important part after an accident is to detect it and take action immediately after detection. So far, the fact that direct assistance to the accident site can reduce this amount has been ignored. People experience trauma, disability, or lose their valuable lives due to lack of emergency facilities. In addition, delayed action can cause the criminal activity of the accident perpetrator because the person has enough time to escape from the scene. This system has been built in order to solve this problem by detecting and confirming accidents using the MPU6050 module, and notifying the appropriate authority by sending the location of the incident using the SIM808 module [16]. The coordinate position measurement system for the integration of multi-source information from a moving subway based on the IMU inertia navigation system is proposed that underground sensor network (WSN) underground location technology is difficult to set anchor nodes and with a lack of high costs and low location accuracy in a complex mine environment coal. This system uses an ARM processing chip, combined with an NAV2 inertia navigation unit and PNP photoelectric speed sensing, using wireless networks to achieve real-time interactions with the top monitor, in order to eliminate the cumulative error of the effect of the positioning of the IMU in the mine with the beacon location calibration method. The experimental results show that the average position accuracy of this system is 0.25 m and the position accuracy is 98.6%, which can meet the requirements of high-precision sub-meter navigation and unmanned vehicle positioning at the mine [17]. Some researchers have applied the Internet of Things (IoT) in order to monitor the condition of motorized vehicles. The use of IoT for intelligent sensor systems in motor vehicles had an extraordinary impact [9]. IoT has also been applied to support smart cities, smart transportation, and motor vehicle monitoring in real-time [10]-[12]. The process of data collection and analysis can be simplified by applying technology, such as the Internet of Things (IoT) [26]-[30], which has been developed to monitor, track the location and measure vehicle parameters for further analysis. The system uses a GPS / GSM / GPRS module, which is used for data transfer [13]. The use of IoT can be helpful to monitor motorized vehicles in real-time [18]. The problem that arises at the stage of developing an unmanned car on the road is monitoring the condition of the vehicle due to different weather and environmental impacts. Weather and environmental conditions are very difficult to predict with a real-time and an accurate system. The development in this research includes several important parts, namely hardware development, digital communication modules, web servers, data analysis, and mobile application development. The vehicle condition monitoring system is equipped with an onboard diagnostic module that sends data to the server in real-time. The system has been successfully designed and developed using the ELM327, ESP32, and SIM808 for the communication module. This study supports the development of an unmanned car that requires real-time data input between the vehicle and the server [19]. The development of a vehicle monitoring and tracking system uses the Blynk platform, which functions as a medium for data transfer and visualization. This system has been developed to monitor driver parameters such as eye blinking, alcohol consumption, and vehicle parameters such as engine temperature, distance between vehicles, and direct vehicle location. The ultrasonic sensor is placed on the front of the vehicle, if two vehicles are close together, a warning message is sent to email via the Blynk application. Then the temperature sensor is placed on the engine. When the engine temperature increases, the system will give an email alert. In addition, the blinking sensor and the alcohol sensor are used to monitor the driver's condition, and if the driver is not normal, a notification will be sent to an email. The purpose of developing this system is to improve the safety of vehicles and drivers [20]. In the automotive industry, predictive maintenance is very important. It has been developed in order to anticipate the difficulties of failure diagnosis that have occurred previously in the automotive industry due to the limited availability of sensors. However, with the very rapid development of technology in the automotive field, it is possible to analyze sensor data on engines and study failure predictions. In this study, the development of a system for predicting faults in the four main subsystems of a vehicle is carried out, namely: the fuel system, the ignition system, the exhaust system and the cooling system. The system will collect data from the sensors while the vehicle is running, such as in a damaged condition (when a certain system failure occurs) and under normal conditions. Then the data is sent to the server, which will analyze the data. Data analysis has been performed by studying an interesting pattern using four classifiers of Decision Tree, Support Vector Machines, K-Nearest Neighbor, and Random Forest.

Therefore, the results of the pattern analysis are used to detect future failures in vehicles [21]. In addition, several studies to monitor vehicle conditions using Fuzzy have obtained very promising results [22]. Another research has developed a track condition monitoring system using an onboard sensing device used to monitor the condition of regional railways in Japan, which is of benefit to regional railway operators. Track fault classification has been developed to detect track faults automatically. Then the simulation uses SIMPACK to detect and isolate track disturbances from the vibration of the car body. The results have showed that the track error feature can be extracted from the vibration of the car body and it can be classified from several features [23].

The development of Intelligent Transportation Systems (ITS) is a solution to improve traffic safety in smart cities. An increase in the number of vehicles will lead to a significant increase in the number of road accidents. Vehicles that are equipped with a large number of sensors make it possible to monitor the vehicle situation and facilitate accident detection. Research on the use of Information and Communication Technology (ICT), which is utilized for efficient and fast accident rescue operations with reduced response time has been done. However, this system has not been available in all the types of vehicles, so an Internet-based accident detection and reporting system has been developed. This study aims to take advantage of the advanced specifications of smartphones in order to design and develop low-cost solutions to transportation systems that can be used in older vehicles. Android application is developed to collect information about speed, gravity, pressure, sound, and location. Speed is the main factor used to assist accident identification. The difference in environmental conditions (eg, noise, deceleration rate) occurs in a low-speed collision (it would be different compared to a high-speed collision). Then the information obtained is processed to detect road accidents. The development of a navigation system is used to report the incident to the nearest hospital. The proposed system is validated through simulations and a series of real road accident data. The results of this study show promising accuracy results [24], [25]. Based on some of these research developments, this research includes the development of hardware and software that support monitoring the condition of motor vehicles, especially for public transportation. Besides the speed and acceleration, the orientation of the movement of motor vehicles needs to be monitored and recorded, especially four or more wheels namely tilt up and down if the vehicle is climbing or decreasing, left and right oblique movements (sloping), as well as left and right turn movements (turning). Sensors capable of monitoring these parameters can be used (gyroscope) [7], [8]. The L3G4200D gyroscope sensor module can be used to measure three x, y, and z axes. The x-axis faces the gyroscope forward, the y-axis faces upward in the opposite direction of the direction of gravity of the earth, and the z-axis is perpendicular to the x-axis and faces left. This sensor module can work up to an acceleration of 10000 times the acceleration of Earth's gravity and can measure angular acceleration in three full-scale options, namely 250 DPS, 500 DPS, 2000 DPS.

III. Material and Methods

The design of a monitoring system and recording the condition of a motorized vehicle is shown in Figure 1.

The block diagram of the monitoring and recording system consists of a signal processor with Arduino Mega, Accelerometer and Gyroscope Sensor (GY-801), GSM Module (SIM800L), SD Card Module, LCD 128×64, Battery and Raspberry Pi to display the results. The GSM module will be used as a data sender for online monitoring and recording systems. Arduino is an inexpensive and easy-to-use hardware and software-based open-source platform designed to develop interactive sensor applications. Several Arduino developments boards are now available with various features. The main differences between them are the processor type, the number of inputs and outputs, and the form factors. Arduino DUE is characterized by using a 32-bit ARM processor, which is far more powerful than traditional Arduino, besides having more memory for programs and data. Arduino Uno R3 is a microcontroller development board based on the ATmega328P chip. Arduino Uno has 14 digital input / output pins (or I / O, where 14 of them can be used as PWM outputs including pins 0 to 13), 6 analog input pins, using a 16 MHz crystal such as A0 to A5 pins, connections USB, power jack, ICSP header and reset button. That is all that is needed to support a microcontroller circuit. The Arduino Uno R3 specifications are as follows:

- Microcontroller: ATmega328;
- Operating Voltage: 5 V;
- Input Voltage (recommended): 7-12 V;
- Input Voltage (limits): 6-20 V;
- Digital I / O Pins: 14 (of which 6 provide PWM output);
- Analog Input Pins: 6;
- DC Current per I / O Pin: 40 mA;
- DC Current for 3.3V Pin: 50 mA;
- Flash Memory: 32 KB (ATmega328) of which 0.5 KB is used by the bootloader;
- SRAM: 2 KB (ATmega328);
- EEPROM: 1 KB (ATmega328);
- Clock Speed: 16 MHz.

Gyroscope is a sensor to detect the rotation of the device based on changes in movement. This tool is commonly used to determine the tilt and the movement of mobile devices or mobile phones.

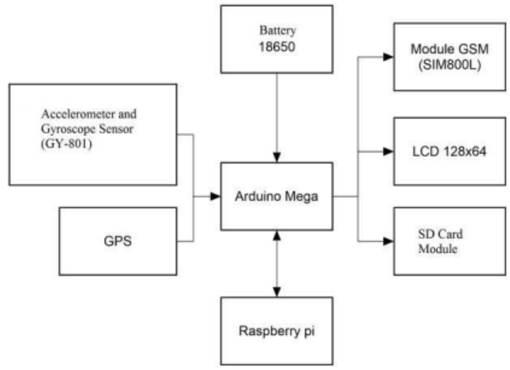


Fig. 1. Block diagram of a motor vehicle condition monitoring and recording system

The gyro sensor moves or changes from the initial value will issue a value that is then used as a reference of the slope of the object used. The x, y, and z axes are the calculated angles of the Gyroscope. Phi is the value of the x-axis used to determine right and left, theta is the value of the y-axis to determine top and bottom, and Psi is the value of the axis to determine front and back. The GY-521 MPU-6050 Module is an MPU-6050 core module which is a 6 axis Motion Processing Unit with the addition of a voltage regulator and several other complementary components that make this module ready for use with a supply voltage of 3-5VDC. This module has an I2C interface that can be connected directly to an MCU that has I2C facilities. The MPU-6050 sensor contains a MEMS Accelerometer and an integrated Gyro MEMS. This sensor is very accurate with 16-bit ADC internal hardware facilities for each channel. This sensor will capture the value of the X, Y and Z axis channels together at one time. The specifications of this module are as follows:

- Chip-based MPU-6050;
- Supply voltage is around 3-5 V;
- Gyroscope range + 250 500 1000 2000 °/s
- Acceleration range: ± 2 ± 4 ± 8 ± 16 g;
- I2C communication standard;
- Built-in 16-bit AD converter chip, 16 bits data output;
- The distance between the header pins is 2.54 mm;
- Module dimensions are 20.3 mm × 15.6 mm.

SIM800 GSM module is a device used to replace the mobile function for data communication between cellular network systems. SIM800 GSM is used as a cellular telephone call media. The communication protocol used is standard modem communication, namely AT Command. It is a collection of commands combined with other characters after the character "AT", which is usually used in serial communication. In this research, AT command is used to manage or give GSM/CDMA module commands. The AT Command starts with the "AT" or "at" character and ends with the code (0×0d).

GSM GPRS module supports quad-band frequency (850/900/1800/1900 MHz). This module can be used to send and receive SMS from one microcontroller to another. The specifications of the GSM / GPRS module are as follows:

- Network: Quad-band 850/900/1800/1900 MHz;
- GPRS class: class 12;
- Data speed: 85.6 kbps;
- Interface: Serial;
- Working voltage: 3.4 ~ 4.3V.

Serial communication is a method of sending data where data is sent one at a time so that it only requires a little cabling and has a far enough data transmission range. There are two types of serial communication, synchronous and asynchronous. Synchronous serial communication requires clock synchronization so that data transmission or reception can run. Whereas, asynchronous serial communication uses start bits and stops bits to synchronize data. SD Card Module is a module to access micro SD for reading and writing data using the SPI (Serial Parallel Interface) interface system.

The specifications of the SD Card module are as follows:

- Supports reading of normal SD Card (<= 2G) and SDHC card (high-speed card) (<= 32G);
- Operating voltage can use 5 V or 3.3 V;
- The operational current used is 80 mA (0.2 ~ 200 mA);
- Using the SPI interface;
- There are already 4 bolt holes in this module for installation in other circuits;
- Module size is 42 × 24 × 12 mm.

The UBLOX NEO6MV2 (Global Positioning System) GPS Module is useful for providing map location coordinate data from GPS satellites to a microcontroller or Raspberry Pi.

Usage is quite easy using UART / TTL communication with MCU with specification below:

- Receiver type: 50 channels, GPS L1 Freq, C / A code
- SBAS: WAAS, EGNOS, MSAS;
- First Fix time: 27 s (cold / warm start), 1s (hot start), <3s (aided start);
- Sensitivity: -161 dBm (Tracking and navigation), -160 dBm (Reacquisition), -147 dBm (Cold start), -156 dBm (Hot start);
- Max update rate: 1 Hz;
- Time pulse frequency range: 0.25 - 1 Hz;
- Horizontal accuracy: 2.5 m (GPS), 2.0 m (SBAS);
- Time pulse signal accuracy: 30 ns (RMS), <60 ns (99%), 21 ns (Granularity), 15 ns (Compensated);
- Velocity accuracy: 0.1 m/s;
- Heading accuracy: 0.5 degree;
- Operational limits: 4g (dynamics), 50,000 m (altitude), 500 m/s (velocity);
- Input voltage: 3.3 V - 5 V;
- Logic level: 3.6 V.

Figure 2 is the layout of the monitoring system and recording the condition of motor vehicles. It illustrates the connection of several components and pins on the Arduino Mega microcontroller.

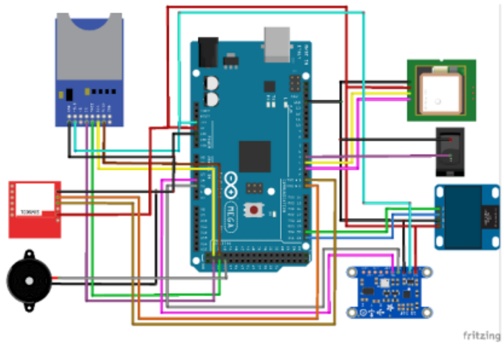


Fig. 2. The layout of a motor vehicle condition monitoring and recording system

The monitoring and recording system for vehicles condition has three main parts namely sensors, signal processing and display or storage. The data obtained from the gyroscope and the GPS sensors will be processed by an Arduino microcontroller. Then the data will be saved, transmitted, and displayed via the LCD.

The data transmitted will be sent to the data center in real-time via the GSM module. Then in the data center the data analysis process will be carried out to determine the condition of the vehicle. In addition to the data transmitted online, the data is then stored in the data logger using the SD Card module. Data stored on the SD Card will be read specifically with certain software in order to carry out the data analysis process. In addition to these modules, Raspberry Pi and touchscreen are also used to display data and settings on the monitoring and storage system of vehicle conditions. The test is carried out on several important components, namely testing the sensor, storage module, and LCD. Then the measurement results are compared with standard equipment to be able to find out the accuracy of the monitoring system and the condition of the motorized vehicle storage. If the results of the test have not obtained data that has high accuracy, then the system is set up.

IV. Result and Discussion

The results of the design of a monitoring system and recording the condition of motor vehicles are shown in Figure 3. It shows the realization of a motor vehicle condition monitoring and recording system. Then the system is tested and compared with standard equipment. In Figure 3, the system consists of an Arduino Mega microcontroller as a signal processor obtained from the sensor. Then the Accelerometer and Gyroscope Sensor (GY-801) are used to obtain velocity data and motion orientation. Global Positioning System UBLOX NEO6MV2 is used to get the position of the motorized vehicle to be monitored. Then the position data is displayed and sent to the server using the GMS module.

The SIM800L GSM module is used to transmit sensor data to the server.

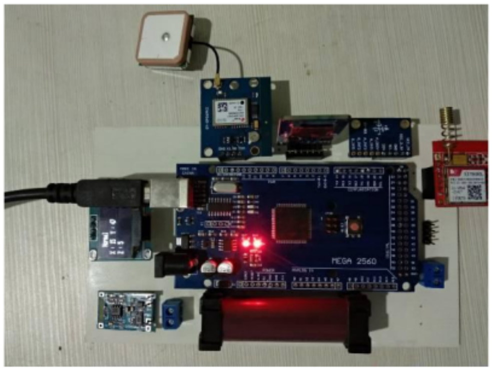


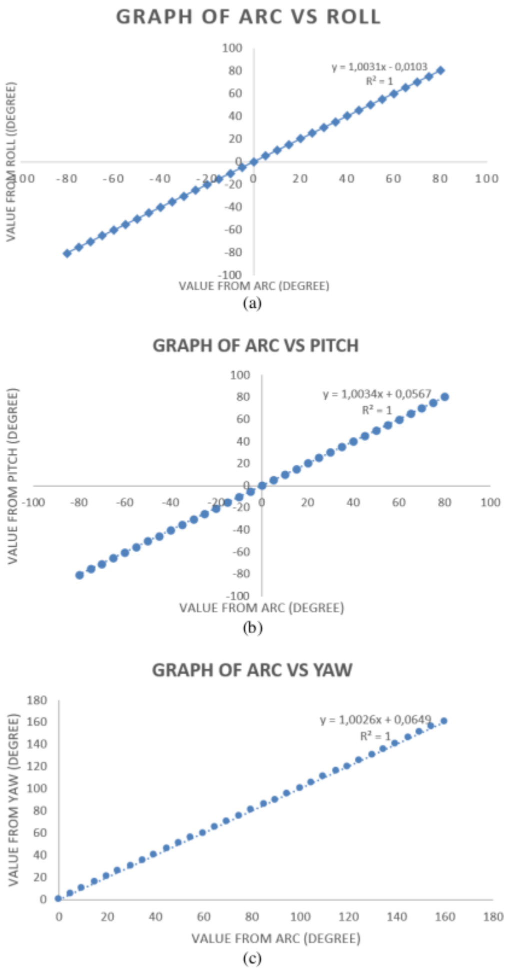
Fig. 3. Realization of the motor vehicle condition monitoring and recording system

Sensor measurement data is also stored on the SD Card Module and displayed on a 128 x 64 LCD. Overall, this system can work properly, and it can be used to monitor the condition of four-wheeled vehicles or more.

The results of the system testing measure the orientation of motion, namely on Roll (x-Sensor), Pitch (y-Sensor), and Yaw (z-Sensor) as in Table I. Based on the results of testing the motion orientation sensor device with standard equipment, namely arc, the accuracy of the Roll results is 99.5%, the Pitch is 99.21%, and the Yaw is 99.5%. This result is in line with the graphical analysis as in Figures 4. It can be seen in the figure that on each graph Roll, Pitch and Yaw give the value of R = 1. This means that with a value of R = 1 the measurement results of the system developed with standard equipment have given excellent results. These results are influenced by several factors, including the selection of components and the calibration in the signal processor. Accelerometer and Gyroscope Sensor (GY-801) consists of two sensors, namely three Axis of Accelerometer (ax, ay, az) and three Axis of Gyroscope (gx, gy, gz). This sensor functions to monitor the angle of a motorized vehicle with four or more wheels. The transmission of sensor data that has been processed by the Arduino Mega microcontroller uses a 57600 baud rate. In this test, the Gyroscope test is carried out on the x-axis, y-axis and z-axis. The test results for the tilt sensor using the 3 Axis accelerometer where the results of the measurement of the slope at the angle of the roll are obtained when the condition of a motorized vehicle that is four or more tilted to the left is obtained with positive tilt angle data with a value of 0-180 degrees. Meanwhile, when the payload is tilted to the right, negative data is obtained with a value of 0 - (- 180) degrees. Based on these data, it can be seen that when the condition of a motorized vehicle with four or more wheels is normal, the roll angle is 0 degrees.

TABLE I
TEST RESULTS FOR MOTION ORIENTATION SENSORS

Measurement (Degree) with standard (Arc)							
Arc	Roll (x sensor)	Pitch (y sensor)	Error of Roll	Error of Pitch	Arc	Yaw (z/ Compass)	Error of Yaw
-80	-80.54	-80.52	0.54	0.52	0	0	0
-75	-75.27	-75.06	0.27	0.06	5	5.05	0.05
-70	-70.26	-70.34	0.26	0.34	10	10.09	0.09
-65	-65.05	-65.03	0.05	0.03	15	15.25	0.25
-60	-60.17	-60.08	0.17	0.08	20	20.33	0.33
-55	-55.09	-55.19	0.09	0.19	25	25.33	0.33
-50	-50.26	-50	0.26	0	30	30.05	0.05
-45	-45.15	-45.36	0.15	0.36	35	35.09	0.09
-40	-40.12	-40.01	0.12	0.01	40	40.01	0.01
-35	-35.04	-35.11	0.04	0.11	45	45.1	0.1
-30	-30.16	-30.15	0.16	0.15	50	50.11	0.11
-25	-25.13	-25.05	0.13	0.05	55	55.2	0.2
-20	-20	-20.16	0	0.16	60	60.24	0.24
-15	-15.08	-15.01	0.08	0.01	65	65.09	0.09
-10	-10.14	-10.06	0.14	0.06	70	70.05	0.05
-5	-5.09	-5.02	0.09	0.02	75	75.13	0.13
0	0.03	0.18	0.03	0.18	80	80.77	0.77
5	5.11	5.31	0.11	0.31	85	85.15	0.15
10	10.05	10.48	0.05	0.48	90	90.16	0.16
15	15.06	15.1	0.06	0.1	95	95.27	0.27
20	20.42	20.84	0.42	0.84	100	100.55	0.55
25	25.05	25.24	0.05	0.24	105	105.24	0.24
30	30.33	30.36	0.33	0.36	110	110.5	0.5
35	35.07	35.15	0.07	0.15	115	115.67	0.67
40	40.17	40.03	0.17	0.03	120	120.1	0.1
45	45.05	45.3	0.05	0.3	125	125.36	0.36
50	50.14	49.99	0.14	0.01	130	130.4	0.4
55	55.04	55.03	0.04	0.03	135	135.45	0.45
60	60.06	60.06	0.06	0.06	140	140.71	0.71
65	65.01	65.03	0.01	0.03	145	145.31	0.31
70	70.12	70.34	0.12	0.34	150	150.22	0.22
75	75.08	75.06	0.08	0.06	155	155.7	0.7
80	80.42	80.52	0.42	0.52	160	160.35	0.35
	Average		0.14	0.19			0.28



Figs. 4. Graph of Testing (a) Arc vs. Roll, (b) Arc vs. Pitch, and (c) Arc vs. Yaw

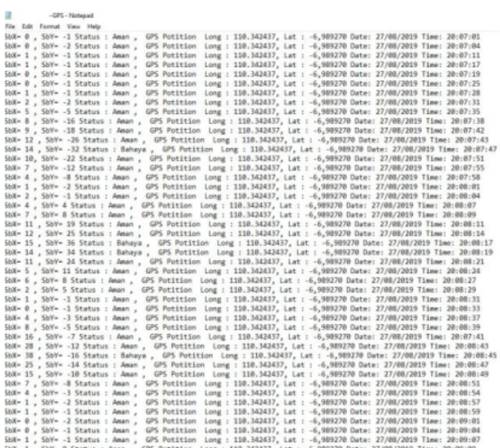
Meanwhile, when the condition of the motorized wheel of four or more is reversed, an angle of ± 180 degrees is obtained. In testing the measurement of the slope value, sometimes the motorized condition of the four or more wheels is at rest, the data of the pitch and roll tilt changes. However, when the motorized condition is four or more tilted, the measured angle corresponds to the tilt angle. Based on the test results, it can be concluded that the sensor can function as a measure of the slope of an object and still has noise when the object is at rest. Furthermore, GPS testing as a position sensor is carried out in various places with different coordinates and compared with standard GPS equipment that already exists as in Table II. It can be seen from the results of the test that the results with high accuracy values are respectively for longitude and latitude of 99.99%. This system uses a number of satellites that are in earth orbit, which transmits the signal to the earth and which is captured by a signal receiver. Apart from satellites, two other systems are interconnected, so that there are three important parts in the GPS system. The three parts consist of GPS Control Segment (Control Section), GPS Space Segment (space section), and GPS User Segment (user section). Since GPS works by relying on satellites, it is recommended to use it in an open place. Using it indoors, or in a place that blocks the direction of the satellite (in the sky), the GPS will work neither optimally nor accurately. Every area above the earth's surface is at least covered by 3-4 satellites. Every new GPS can receive up to 12 satellite channels at once. If the sky is clear and free from obstructions, the satellite can be easily received by GPS, so the accuracy given will also be higher. Signals are transmitted from satellites to GPS devices (pure portable or smartphones that already have GPS). GPS will require transmissions from three satellites to get two-dimensional information (latitude and longitude), and four satellites for three dimensions (latitude, longitude and altitude). Figure 5 is the source code for data storage on the SD Card. The data stored on the SD Card is motion orientation data and position data generated by GPS. Then, Figure 6 shows the data stored on the SD Card. Looking at Figure 5 and Figure 6, the data stored on the SD Card is as desired. The data is taken from motion orientation sensor data and GPS. Data stored at any time can be opened for analysis of events such as those provided by sensors. Based on the test results, as long as the data is not deleted, then the storage will always add the latest data until the storage media is full.

TABLE II
GPS TEST RESULTS COMPARED TO STANDARD EQUIPMENT

No.	Loc	Standard GPS (Garmin)		GPS Prototype		Error	
		Long	Lat	Long	Lat	Long	Lat
1	A	110.34252	-6.98914	110.342453	-6.989220	6.7×10^{-5}	8.0×10^{-5}
2	B	110.44221	-7.04904	110.442199	-7.048874	1.1×10^{-5}	1.7×10^{-4}
3	C	110.43137	-6.97855	110.431419	-6.978551	4.9×10^{-5}	1.0×10^{-6}
4	D	110.46060	-7.05758	110.460563	-7.057622	3.7×10^{-5}	4.2×10^{-5}
5	E	110.46305	-7.02263	110.463104	-7.022613	5.4×10^{-5}	1.7×10^{-5}
6	F	110.46745	-7.00982	110.467483	-7.009887	3.3×10^{-5}	6.7×10^{-5}
7	G	110.42716	-7.00023	110.427131	-7.000284	2.9×10^{-5}	5.4×10^{-5}
8	H	110.39842	-6.99453	110.398422	-6.994544	2.0×10^{-6}	1.4×10^{-5}
9	I	110.34820	-6.99671	110.348144	-6.996697	5.6×10^{-5}	1.3×10^{-5}
10	J	110.41171	-7.06962	110.411720	-7.069604	1.0×10^{-5}	1.6×10^{-5}
			Average			3.2×10^{-5}	6.7×10^{-4}

```
    if (gps.time.centisecond() < 10) Serial.print(F("0"));
    Serial.print(gps.time.centisecond());
  }
  else
  {
    Serial.print(F("INVALID"));
  }

  Serial.println();
}

void SDCardTulis(){
  if (!SD.begin(chipSelect)) {
  Serial.println("Card failed, or not present");

  }
 else
 {
  Serial.println("card initialized.");
 }
////////////////////// Tulis Data //////////////////////
  {
    dataString += "SbX= ";
    dataString += String(GyroX);
    dataString += " , ";
    dataString += "SbY= ";
    dataString += String(GyroY);
    dataString += "Status : ";
    if (batas_status<30)
    {
    dataString += "Aman ,";
    }
    else
    {
    dataString += "Bahaya ,";
    }

    dataString += " GPS Potition ";
    if (gps.location.isValid())
    {
    dataString += " Long : ";
    dataString += String(gps.location.lat(), 6);
    dataString += ",";
    dataString += " Lat : ";
    dataString += String(gps.location.lng(), 6);
    dataString += " Date: ";
    dataString += String(gps.date.month());
    dataString += "/";
    dataString += String(gps.date.day());
    dataString += "/";
    dataString += String(gps.date.year());
    dataString += " Time: ";
    dataString += String(gps.time.hour());
    dataString += ":";
    dataString += String(gps.time.minute());
    dataString += ":";
    dataString += String(gps.time.second());
    }
    else
    {
    dataString += "DEVICE INVALID";
    }
   }
```

Fig. 5. Source code for storing data into SD Card



```
-GPS - Notepad
File  Edit  Format  View  Help
SbX= 0 , SbY= -1 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:01
SbX= 0 , SbY= -2 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:04
SbX= 1 , SbY= -1 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:11
SbX= 1 , SbY= -1 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:17
SbX= 0 , SbY= -1 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:19
SbX= 0 , SbY= -1 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:25
SbX= 1 , SbY= -1 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:28
SbX= 2 , SbY= -2 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:31
SbX= 5 , SbY= -5 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:35
SbX= 8 , SbY= -16 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:38
SbX= 9 , SbY= -18 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:42
SbX= 12 , SbY= -26 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:43
SbX= 14 , SbY= -32 Status : Bahaya ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:47
SbX= 10, SbY= -22 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:51
SbX= 7 , SbY= -12 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:55
SbX= 4 , SbY= -8 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:58
SbX= 1 , SbY= -2 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:01
SbX= 2 , SbY= -1 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:04
SbX= 4 , SbY= 4 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:07
SbX= 7 , SbY= 8 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:09
SbX= 11 , SbY= 19 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:11
SbX= 12 , SbY= 25 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:14
SbX= 15 , SbY= 36 Status : Bahaya ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:17
SbX= 14 , SbY= 34 Status : Bahaya ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:19
SbX= 11 , SbY= 24 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:21
SbX= 5 , SbY= 11 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:24
SbX= 6 , SbY= 8 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:27
SbX= 2 , SbY= 5 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:29
SbX= 1 , SbY= -1 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:31
SbX= 0 , SbY= -1 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:33
SbX= 4 , SbY= -3 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:37
SbX= 8 , SbY= -5 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:39
SbX= 16 , SbY= -7 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:07:41
SbX= 28 , SbY= -12 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:43
SbX= 38 , SbY= -16 Status : Bahaya ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:45
SbX= 25 , SbY= -14 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:47
SbX= 15 , SbY= -10 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:49
SbX= 7 , SbY= -8 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:51
SbX= 4 , SbY= -3 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:54
SbX= 1 , SbY= -2 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:57
SbX= 1 , SbY= -1 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:08:59
SbX= 0 , SbY= -2 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:09:01
SbX= 0 , SbY= -1 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:09:04
SbX= 1 , SbY= -1 Status : Aman ,  GPS Potition  Long : 110.342437, Lat : -6,989270 Date: 27/08/2019 Time: 20:09:07
SbX= 1 . SbY= 0 Status : Aman .  GPS Potition  Long : 110.342437. Lat : -6.989270 Date: 27/08/2019 Time: 20:09:09
```

Fig. 6. Example of data stored on SD Card

V. Conclusion

This research has been developed with the aim of designing and implementing a system capable of monitoring and recording vehicle conditions in real time. Recorded data can be stored on an SD Card or on a server via an internet connection for the analysis by the authorities. This research is very important to do considering the incidence of traffic accidents contributes to high data of population deaths in the world. This research has successfully developed a system of monitoring and recording of vehicle condition. Based on the results of testing the motion orientation sensor device with standard equipment, namely arc, the accuracy of the Roll results is 99.5%, the Pitch is 99.21%, and the Yaw is 99.5%. The results of GPS testing are respectively for longitude and latitude of 99.99%. The future development of this system can be developed like a black box on an airplane, but this system has the advantage of being able to store it in cloud computing. Therefore, data access is easier by the authorities without having to get a black box first. The next development is in this system besides monitoring and recording the condition of the motorized vehicle; it will also record the condition of the driver. This system will be better if applied to public transportation, so that it will provide convenience in monitoring and maintenance. This system will facilitate the investigation process in case of an accident, because all data is recorded in cloud computing.

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