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Automatic Gas Control System In The Motorcycle Braking Process With The Concept Of Non-Uniform Slowing Down Motion

Anang Suryana
Electrical Engineering
Nusa Putra University
Sukabumi, Indonesia
anang.suryana@nusaputra.ac.id

Ilman Himawan Kusumah
Electrical Engineering
Nusa Putra University
Sukabumi, Indonesia
Ilman.himawan@nusaputra.ac.id

Aryo De Wibowo Muhammad Sidik
Electrical Engineering
Nusa Putra University
Sukabumi, Indonesia
aryo.dewibowo@nusaputra.ac.id

Edwinanto
Electrical Engineering
Nusa Putra University
Sukabumi, Indonesia
edwinanto@nusaputra.ac.id

Marina Artiyasa
Electrical Engineering
Nusa Putra University
Sukabumi, Indonesia
marina@nusaputra.ac.id

Anggy Pradiftha Junfithrana
Electrical Engineering
Nusa Putra University
Sukabumi, Indonesia
anggy.pradiftha@nusaputra.ac.id

Yufriana Imamulhak
Electrical Engineering
Nusa Putra University
Sukabumi, Indonesia
yufriana.imamulhak@nusaputra.ac.id

Yudha Putra
Electrical Engineering
Nusa Putra University
Sukabumi, Indonesia
yudha.putra@nusaputra.ac.id

***Abstract*—When motorcyclists have an accident, they are at high risk of suffering severe or fatal injuries. The difficulty experienced by motorcyclists and considered one of the most complicated to do in an emergency is braking because motorcycle accidents are often caused by loss of control or stability when braking as evasive action. In the braking process, a motorcycle must pay attention to distance and speed so that the deceleration during braking is by the kinematic concept to avoid the shock force during braking, in this study uses research and development methods in making automatic braking systems on motorbikes. The actuator system controls the brake pedal, and the gas pedal uses a stepper motor. The two stepper motors will move automatically if the motorbike detects an object in front of it at less than 4 meters. The angle of the stepper motor that drives the brake lever is in a span between 0 degrees to 30 degrees, while the tip of motion of the stepper motor that moves the gas pedal is in a span of 0 degrees to 70 degrees. The angle movement of the stepper motor is influenced by the distance detected by the HC-SR04 type proximity sensor and the motorbike speed detected by the KY-003 type speed sensor, which works by utilizing the hall effect principle. The results of the tests that have been carried out show that the automatic braking system created can work well with an indicator that there is no shock force during the automatic braking process.**

***Keywords*—kinematics, automatic braking, actuators, sensors**

I. Introduction

When in an accident, motorcycle riders will be at high risk of suffering severe or fatal injuries [1,2,3]. The development and implementation of motorcycle safety systems lag far behind passenger cars because motorcycle riders are involved in more accidents per kilometer driven than passenger car drivers [4]. The difficulty experienced by motorcycle riders and is considered one of the most complicated to do in an emergency is braking because motorcycle accidents are often caused by loss of control or stability when braking as an evasive action [5].

Louw et al. (2017) have conducted a study using a driving simulator that involved 75 drivers exposed to various screen manipulations that varied the amount of visual information available from the road environment and automation status, with the results obtained in the form of an analysis of time, type, and response rate. Driver collision avoidance, as well as investigating how this is affected by the criticality of the ongoing situation. the conclusion obtained from the results of the study states that the design of the braking system should focus on achieving kinematically early avoidance initiation, rather than a short takeover time [6].

Anang and Familiana, In 2019, made a brake control system to automatically focus on the brake pedal by using the concept of straight motion kinematics change regularly to avoid sudden braking caused by too short a distance and driving speed that is too high [7].

Sitthiracha et al. l (2020) have researched rear-end collisions caused by motorcyclists due to too short a distance. His research proposes a model based on the piecewise linear braking profile of a motorbike and a kinematic equation to calculate the stopping distance in the worst-case scenario[8].

These three studies show that the braking process on a motorcycle must pay attention to distance and speed so that the slowdown during braking is to the kinematics concept [6,7,8]. Kinematics is the study of the motion of an object system without directly considering the force or potential field that affects movement [9]. The kinematic analysis of activity involves measuring position, velocity, and acceleration [10]. Acceleration increases speed, whereas deceleration is a decrease in gait [11]. The slowdown occurs when braking the motorcycle. The braking system on a bike serves to slow down the rate of the motorcycle [12]. The deceleration will continue to work on the vehicle's braking system until it reaches a stopping distance. The stopping distance is the distance a vehicle travels between sensing danger and stopping the car [13, 14]. The slowdown in straight motion kinematics changes regularly occurs with constant acceleration so that to get the length of braking time from a certain speed to the final velocity, which is zero, it can be formulated as follows:

$$t = (u - v)/2x \qquad (1)$$

From the above formulation, t is the time of motion, u is the particle's initial velocity, v is the final velocity of the particle, and x is the distance traveled [15]. In this study, a braking system that works automatically using the kinematics concept of straight motion changes regularly involves controls on the brake pedal and gas handle.

II. Research And Method

In general, this research is a research that aims to produce a product, namely an automatic braking system on motorbikes in hardware and software using the concept of linear motion kinematics with regular changes. So that the method used is research and development or known as R&D (Research & Development). Meanwhile, researchers used a prototype model in the development process of this automatic braking system. The prototype model is a process method for making a system that is structured and has several stages that must be passed in its manufacture, but if the final stage states that the system that has been created is not perfect or still has deficiencies, the system will be re-evaluated and will go through the process early. The prototyping approach is an iterative process that involves a close working relationship between the designer and the user. The methods in the prototyping model consist of three stages: gathering information needs, designing and manufacturing, and evaluating and testing the prototype [16].

In figure 1, the first stage is collecting information on material requirements, namely by identifying and knowing the characteristics of a motorcycle braking, so that from the two processes, it is understood the material conditions for the braking system consisting of a stepper motor as an actuator that functions as a mechanic on the brake pedal and gas pedal Then the need for a sensor composed of an ultrasonic sensor type hc-sr04 as a proximity sensor and a hall effect sensor type KY-003 as a speed sensor, and an ATmega2650 microcontroller as a data processor and actuator performance controller.

The second stage, namely the design and manufacture of an automatic braking system on a motorcycle, consists of making a mathematical system model that refers to the kinematic principle of straight motion changing regularly, then proceeding to manufacture mechanical systems and electronic systems.

Finally, the evaluation and testing of the performance of the automatic braking system for motorbikes consist of laboratory tests to evaluate each design made. If not successful, it will return to the mathematical formulation stage. On the other hand, if the laboratory test is successful, it will be followed by installing an automatic braking system on the motorbike, and field tests are carried out for the reliability of the design made. If mechanical reliability still encounters problems, the process will repeat itself in automated manufacturing, but the prototype manufacturing process is successful if there are no obstacles.

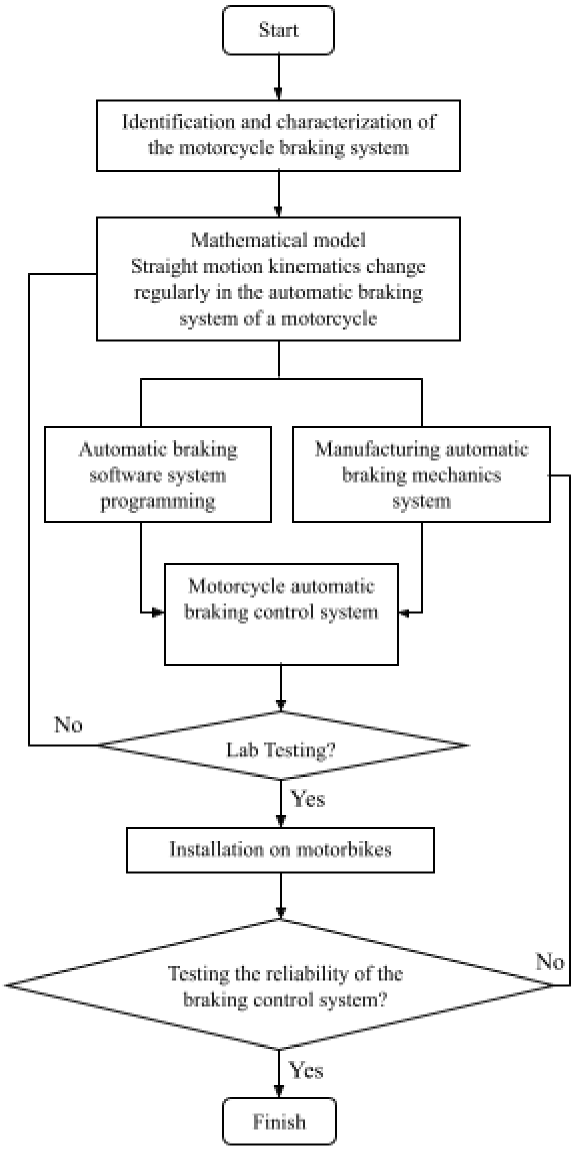

Figure 1. Chart of the prototyping method

III. Results and Discussion

A. Braking identification and characterization

This automatic motorcycle braking system requires an actuator system for the brake pedal and gas pedal that can work automatically. For the braking system to follow the kinematics concept of straight motion changing slowed regularly, two measurement variables are needed, namely distance and velocity. To measure the distance between the position of the motorbike to the final part or stopping position, a distance measuring instrument called a distance sensor is needed. The proximity sensor used is an ultrasonic sensor type HC-SR04, as in figure 2 below.

Figure 2. Ultrasonic Sensor HC-SR04

The HC-SR04 sensor is a sensor that can read the distance of an object [16]. The working principle of the HC-SR04 sensor is based on sound wave reflection. The HC-SR04 hardware consists of an ultrasonic transmitter and an ultrasonic receiver. The ultrasonic receiver can capture the reflected ultrasonic sound waves transmitted by the transmitter at 40 kHz. The distance value is obtained from half the travel time of the ultrasonic wave emission from the transmitter to the ultrasonic receiver [17]. Then to measure the speed of a motorcycle, a sensor is needed that can read the bike's speed. The sensor used is a hall effect sensor type KY-003, as shown in Figure 3.

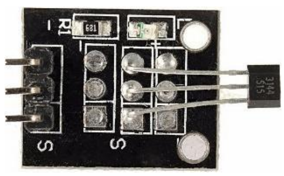

Figure 3. Hall Effect Sensor KY-003

The way the hall effect sensor works is to detect the effect of changing magnetic fields on moving charged particles so that the frequency value will be obtained so that this type of sensor can be used to measure the rotational speed [7]. The signal obtained from the proximity and speed sensors has been converted into an indication that the microcontroller can process. The microcontroller is a device that can process digital signals. With a digital scale, all-digital processing can be done on the sign, including displaying the LCD results and controlling the actuator [18, 19].

The microcontroller used is the ATmega2560 type as follows.

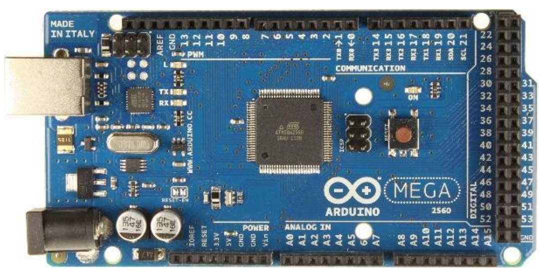

Figure 4. ATmega 2560 microcontroller

ATmega2560 in Figure 4, there are 54 I / O pins, 15 pins as PWM outputs, 16 hooks for analog input, and 4 UART. ATmega2560 uses 16 Mhz crystal. Use of an input voltage of 7-12 V DC.

Two stepper motors are used to drive the brake pedal and gas pedal.

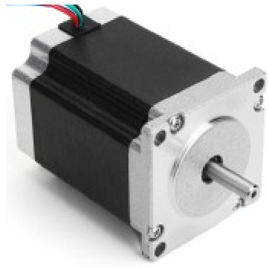

Figure 5. Stepper Motor Nema 23

The stepper motor used has a torque of 9.9 kg / f with a step of 1.8 degrees, meaning that it takes 200 steps to reach one full rotation. The stepper motor will move the brake lever by 17 steps to reach an angle of 300, and the stepper will carry the gas pedal as an actuator for 39 degrees to get 700 on the braking system automatically.

B. Manufacture of an automatic braking system

Making an automatic motorcycle braking system is divided into two phases, namely, making the hardware system and making the system software. The stage of making the hardware system is divided into two parts. The first part makes a mechanical system a driving force for the brake pedal and gas pedal. The second part is designing an electronic system that functions as an actuator for an automatic braking system. In the brake pedal mechanical system, the design in Figure 6.

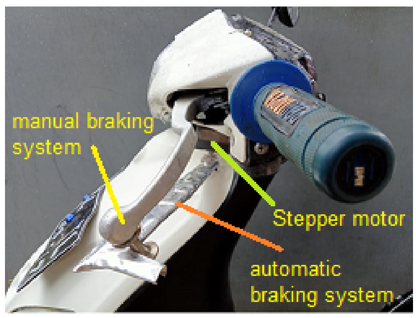

Figure 6. Automatic brake pedal mechanical system

In Figure 6, there are two braking system levers, namely the manual system braking lever and the automatic system braking lever, which is driven by a stepper motor. The rider can manually apply the braking system at any time. For the automated braking system, the stepper motor as an actuator will start moving the braking lever when the distance sensor detects an object in front of it at a distance of fewer than 4 meters, and the speed sensor detects a speed of at least 10 m / s. The rate of the stepper motor will follow the kinematics rules of slow motion of straight motion, which are influenced by distance and speed. So that in the open or no braking position, the brake pedal lever position is at an angle of 00, and maximum braking at an angle of 300 moves clockwise as much as 17 steps.

The mechanical system on the gas pedal is almost the same as the brake pedal works, which can work manually. It can also work automatically using an actuator, a stepper motor.

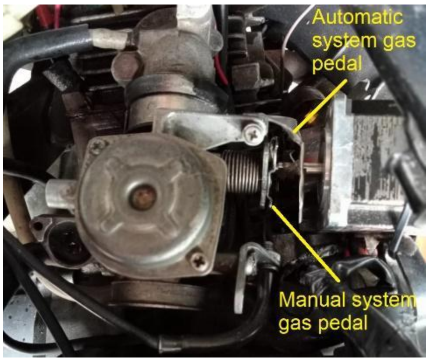

Figure 7. Gas pedal system

The gas pedal system in Figure 7 is a mechanical system that automatically moves the gas pedal using a stepper motor actuator. The way the actuator works on the gas pedal is when the standby or distance sensor detects a distance of more than 4 meters between the motorcycle and the object in front of it, the pedal controlled by the actuator will be in an open position at an angle of 00 or at the maximum available gas position so that the gas pedal at the same time it can work or can be manually controlled by a driver. However, if the distance sensor detects an object in front of the motorbike, the stepper motor will move by 700 CW clockwise or 39 steps to close the gas pedal.

Electronically, an automatic braking system can move the two actuators, namely the stepper motor on the brake pedal and the stepper motor on the gas pedal.

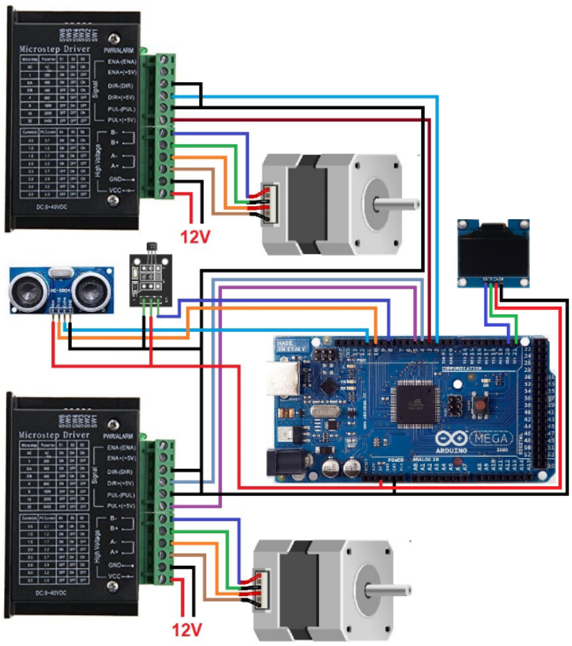

Figure 8. Electronic braking system

From Figure 8, the provision of power or electricity is divided into two parts, namely electricity on the sensor and OLED display taken from the microcontroller, and the electrical system in the TB6600 driver is taken from the motorcycle battery.

As for how automatic braking works electronically, as shown in Figure 8. Suppose the distance sensor detects the motorcycle's distance from the object in front of it is more than 4 meters, and the speed sensor detects a speed of less than ten m/s. In that case, the two actuators will be open or at an angle of 00. However, if the two sensors, namely the distance sensor, detect the distance between the object and the motorbike is less than 4 meters, and the speed sensor detects a speed of more than ten m/s, then the two actuators will move clockwise. As a result, the gas pedal actuator will rotate as far as 700 or as many as 39 steps, and the brake pedal actuator will rotate until the motorcycle stops, which is at a maximum angle as far as 300 or 1 step. The rotation speed of the actuator on the brake pedal follows the kinematics concept of slowed straight motion.

The implementation of the proximity sensor and speed sensor on the motorcycle body is as follows.

Figure 9. Installation of sensors on a motorcycle

In figure 9, the speed sensor works by reading the number of revolutions of a tiny magnet attached to the brake disc so that the angular speed value is obtained in rounds per minute (RPM). However, the RPM value must first be converted to the motorcycle angular speed value (ω) in rad/s in the following way:

$$\omega = RPM \times \left(\frac{2\pi}{60}\right) \qquad (2)$$

C. Testing and evaluation

At the stage of testing the accuracy of the automatic braking system, the first thing that will be obtained is the acceleration value of the motorcycle with the formulation:

$$a = \omega^2 \times r \qquad (3)$$

Where is the angular velocity value obtained by the KY-003 sensor from the rotation of the motorcycle front tire, and r is the radius of the motorcycle front tire?

To find the braking time until the stopping point (tv) using the equation $t_v = S / (v_t - v_o)$, where vt is the final speed is set with a value of 0, which is considered as the absolute speed at a stop, and o is obtained from the rate when the motorcycle is moving. Meanwhile, S is the distance of the bike to the object in front of it, which is determined to be less than 4 meters.

In this study, to find the rotation time of the stepper motor on the speed of the motorbike at a distance of 4 meters, the formulation must be found so that from the graph in Figure 10, the equation used as a function of braking time against the speed of the motorbike is obtained as follows:

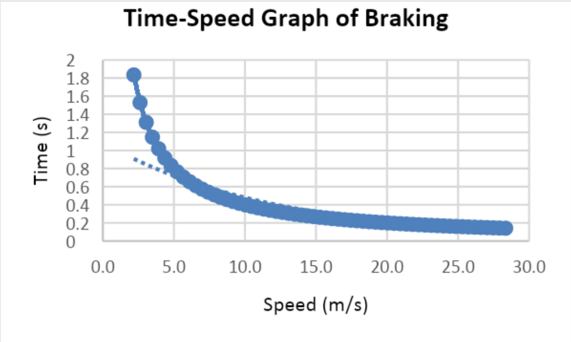

Figure 10. Graph of the difference between time and speed

Figure 10 is a graph of the time it takes to brake as far as 4 meters from the motorcycle's speed so that an equation is obtained to get the time interval for stopping the bike in units of seconds as Y and X variables are speed variables. This equation is used to determine the difference in the rotation time of the stepper motor.

Direct braking system testing is carried out at predetermined speeds, namely 30 km/hour, 40 km/hour, 50 km/hour, 60 km/hour, and 70 km/hour. Each test at a predetermined speed is taken 10 test data. The test results between the speed sensor and the stopping time of the motorcycle at a distance of fewer than 4 meters are obtained in the following table.

Table 1. Time data from each speed

No	t_{30}(s)	t_{40}(s)	t_{50}(s)	t_{60}(s)	t_{70}(s)
1	0.480	0.360	0.288	0.236	0.206
2	0.465	0.343	0.272	0.232	0.203
3	0.480	0.351	0.288	0.229	0.206
4	0.450	0.360	0.282	0.240	0.200
5	0.480	0.351	0.294	0.232	0.197
6	0.465	0.343	0.288	0.232	0.200
7	0.480	0.360	0.282	0.240	0.206
8	0.450	0.351	0.277	0.232	0.197
9	0.480	0.360	0.272	0.236	0.197
10	0.480	0.343	0.267	0.232	0.206
% error =	1.90	2.16	2.27	2.57	2.62

From table 1, it is obtained that the time in seconds for each predetermined speed is taken 10 data so that the percentage error of the measurement results is obtained. For example, at a rate of 30 km/hour, the time t30 is obtained with a percentage error of 1.90%, for a speed of 40 km/hour, at a time of t40 with a percentage error of 2.16%, for a rate of 50 km/hour, the time t50 is obtained with an error percentage of 2.27%, for a speed of 60 km/hour accepted time t60 with a percentage error of 2.574%, for a rate of 70 km/hour obtained time t70 with a percentage error of 2.62%.

The test results between the proximity sensor and the angular position of the stepper motor that moves the gas lever are as follows:

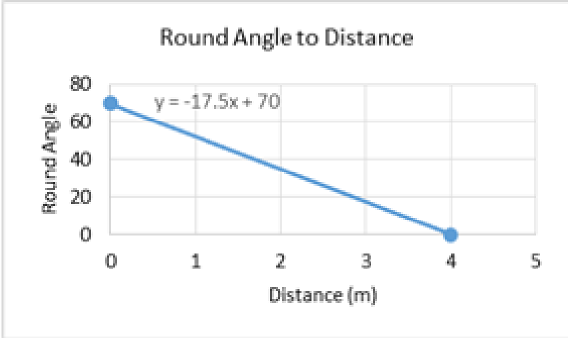

Figure 12. Graph of rotation angle against distance

From the graph in Figure 12, the equation data is obtained for the angular position of the stepper motor rotation that moves the gas lever to the distance read by the proximity sensor. However, to move the gas lever when the space has been detected is less than 4 meters, the stepper angle must reach 700 tips faster because the deceleration on the gas pedal does not have to be slow. Instead, it must close the gas more quickly not to increase the motorcycle's speed.

IV. Conclusion

The equation obtained from the results of this study can be concluded that the braking system can be automatically applied using the principles of the laws of physics, namely the concept of kinematics which is a sub-concept of mechanics using the idea of slowed down uniformly changing straight motion and slowing down the concept of uniform circular motion. When calibrating the angle of the stepper motor to the distance between the motorbike and the object in front of it, you can use a linear regression equation. The function of the stepper motor in this study is as an actuator that moves the brake pedal and gas pedal so that it can work automatically based on the variable speed and distance of the motor to the object in front of it, ranging from 0 cm to 400 cm. After testing the automatic braking system in this study, the automated braking system that has been made can work well with the achievement that there is no jerking force when braking and the motorcycle can stop appropriately before touching the object in front of it.

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