

Design Of Moving Simulator Fabrication For Disabled People

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ABSTRACT

Transportation has become an integral part of people day to day life. At certain times, in large countries like India, people are forced to travel a long distance from their workplace to their place of residence. People with upper limb amputation and hands have difficulties in traveling and cannot travel these long distances. They use devices such as wheelchairs, crutches, and artificial limbs for mobility. These, however, cannot be used for long-distance outdoor transportation. Therefore, this project aims to design and fabricate Foot operated system for armless people. The contents include a description of the design and selection process including all important information about the vehicle. Due to rapid industrialization and the development of the economy, the expectation of the customer and their ability and willingness to pay for the product has changed drastically.

Keywords: Foot controller steering, Handicapped, Steering system

INTRODUCTION

Nowadays transportation has become a great difficulty for an individual to reach their destination on time. Everyone has their vehicle and people with all body parts are fortunate. It is unfortunate for partially disabled people with hands. Disability is the repercussion of an impairment which can be mental, physical, emotional, vision, or sensory. Disabilities can occur in the upper extremities and lower extremities. These people become more dependants and lose their confidence. Due to this effect, they stand a great disadvantage in using the public as well as private transportation facilities. Foot Operated Steering vehicle was something new to come up with and we had the interest to make something innovative. The main objective of the project is to design a foot-operated system for handicapped people. To suit the requirements of disabled drivers with these special circumstances, this high-technology solution allows for

the vehicle to be steered using the left leg through a rotating footplate. There is no use of the arms in using primary driving controls. A national-level survey conducted in India by the Central Government of India once in ten years revealed that around 27 million people which are about 2.21% of the Indians are differently able. Among them, around 14.98 million were men while 11.84 million were women. Thus, the percentage of disabled people in rural areas was higher than those in urban areas. In general, one of the procedures for learning to drive is to obtain a driver's license, as it is stated in Constitution No.22. The year 2009 Article 77 Act 1 regarding the requirement for motorized vehicle drivers to own a driver's license [5]. One of the things that must be done to acquire a driver's license is to take a practical test. The point of a mandatory practical test is to gauge the candidate's abilities from practice. Commonly, driving practice is done directly on main roads. Needless to say, it holds risks for new drivers. A solution to reduce risk and evaluate the competence of novice drivers is to use a simulator. According to the World Health Organization (WHO), an estimated 1.25 million people passed away and 20 to 50 million people suffer minor injuries. The percentage of teenagers and adults aged from 15 to 44 years that lost their lives in road accidents has reached 59% [2]. Aside from that, based on accident statistics from KORLANTAS POLRI, 106,702 accidents took place in the year 2016 [3]. Out of several factors of traffic accidents, one of the causes is the drivers, in terms of knowledge and skill [4]. Hence, learning to drive is important, especially for beginner drivers. A simulator is a device for simulation, or a real physical object [6]. In this case, a driving simulator would provide actual learning mechanisms to learn to drive in a safe and controlled environment [7]. In driving simulators, the input components such as the steering wheel, acceleration, brakes, and gear shift become essential to control the car's movement in the visual software. Hence, in this paper, we made an input device that can provide inputs for software.

PID CONTROL

PID is an algorithm used for control systems. PID serves the

function to decide the precision (stability) of an instrumentation system with feedback characteristics on the system. PID is designed based on a basic system diagram block, as shown in Figure 1.

PID has an 'error' that represents the value difference between the set point (the system's target outcome) and the measured process variables. There are three main parameters in PID, which are proportional (P), integral (I), and derivative (D), where each parameter has its strong points and setbacks [9]. In their implementation, each of the main parameters can either work alone or perform in combination as needed to achieve a certain goal. But, when all the three main parameters of PID are combined, the downsides of each parameter can be diminished [10]. The block diagram illustrated in Figure 1 has a 'process', which is a system to be controlled.

ROTARY ENCODER

The rotary encoder is an electro-mechanic device that detects movement and positioning [11]. A rotary encoder consists of two main components: an encoder disk, round (thin plate), has a dark and light side, with holes through the plate used for angle measurement; the second component is an optocoupler as an optical sensor that produces serial pulses to be interpreted as movement, position, and direction. Thus, the angular position can be known when the rotary encoder is spun, where each rotation outputs digital binary information which will be transmitted to the microcontroller to be accumulated, producing the angular position of an object as output.

Figure 2 shows the structure of a rotary encoder, made up of an encoder disk and an optocoupler. The structure has the encoder disk attached to a shaft that rotates the encoder disk. The outer edges of the encoder disk's plate are placed in the optocoupler gap so that the holes on the encoder disk can allow the optocoupler to detect when it moves and then calculated to output an angular value. A part of the optocoupler is a component that serves as an illuminator and detector placed across from each other. The illumination would be done by an LED light by continuously directing light on the rotating encoder disk. When the light shines on the holes of the encoder disk, it will pass through into the detector. But if it shines the part of the encoder disk without holes, the light will not pass through into the detector. The detector itself has a phototransistor sensor that enables the detection of light. The phototransistor will accumulate the amount of light received from the LED that has passed through the encoder disk. Besides accumulating incoming light, it also determines the encoder disk's direction of rotation, giving information on whether the encoder disk is rotating clockwise or counter-clockwise [12].

Figure 3 shows the output signal produced by the rotary encoder. Inside the optocoupler, there are a phototransistor catching signals produced by the LED light that passed through the encoder disk. The output difference between channel A and channel B can be used to distinguish the direction of movement.

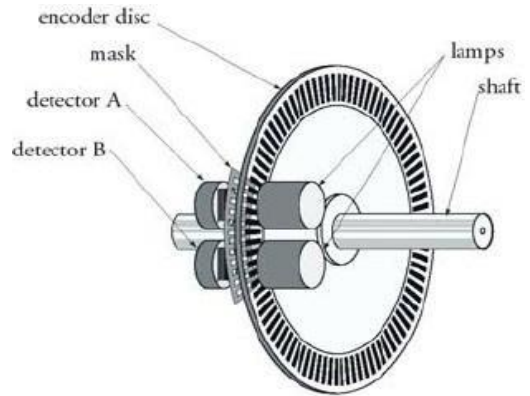


Figure 2: Structure of rotary encoder

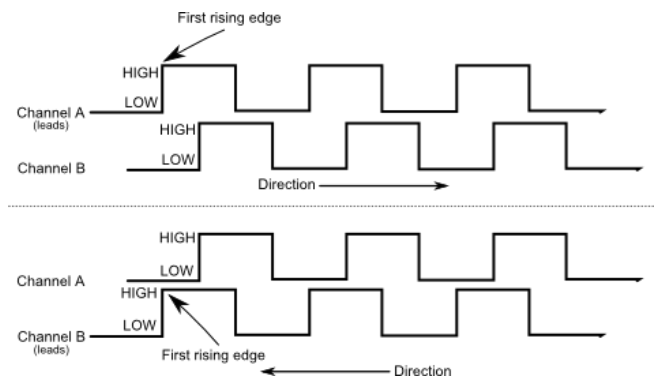


Figure 3: Rotary encoder output signal

BIDIRECTIONAL COMMUNICATION

Bidirectional communication allows systems to do two-way communication. To use bidirectional communication, a system must have the ability to send and receive data [14]. In this paper, every system can send and receive data.

Figure 4 shows the communication scheme between the systems in the simulator. It is seen that the systems in the simulator need effort to perform bidirectional communication, especially for the visual system. Aside from that, the important thing is the ability to send and receive data at the same time, because data transmission from one system to another system should be done in real-time. If the systems do not have bidirectional communication ability, the output system cannot give feedback or process results from the visual system.

In serial communication, there are two methods to send data, synchronous and asynchronous. One asynchronous method example is Universal Asynchronous Receiver Transmitter (UART). It is used as a delivery method from computer to peripheral or controller [15]. UART consists of three parts: transmitter, receiver, and baud rate. The transmitter is used to change the parallel data to serial before sending it. The receiver is used to receive data and convert it from serial data to parallel, so it can be used for the next process in the simulator. Meanwhile, the baud rate is used to control the signal delivery speed [16]. The receiver and transmitter use the same baud rate for communication. In this case, between the visual system and the control system, the baud rates should be synchronized. Generally, a baud rate of 9600 is used, but that does not close the possibilities of using other

baud rate values such as 115200 or 5200, corresponding to what the system needs. In this paper, we use Arduino as the controller and the standard baud rate of 9600 for Arduino controllers.

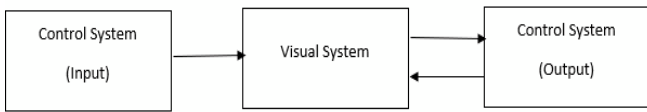


Figure 4: Communication scheme

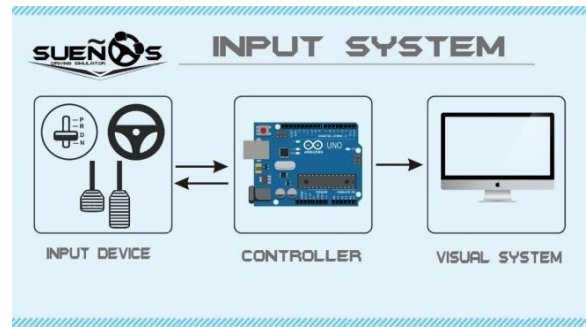


Figure 5: Driving simulator input system scheme

SYSTEM DESIGN

A. Input System

The research done puts more emphasis on the input system of the driving simulator. The input system has the role of providing input values for the system, causing a system response. The given input values will affect the visual system.

Figure 5 illustrates the driving simulator’s input system which comprises three specialized parts integrated. The input system works as follows: the input system controller made up of the steering wheel, acceleration pedal, brake pedal, and gear shift will produce a value to be taken in by the sensors. The sensors will be linked to a microcontroller that can read the sensor values. Then, the microcontroller is connected to the visual system, where every input value will affect the appearance of the visual system. The connection to the visual system implements serial communication which is bidirectional communication. It enables two-way communication between interconnected components.

B. System Data Processing

Figure 6 shows a data processing flowchart that takes place in the microcontroller. Initially, the microcontroller receives input data from three components: potentiometer, optocoupler, and limit switch. For input 1, i.e. potentiometer, the data passed onto the microcontroller will be run through PID calculations. While for input 2, i.e. the optocoupler, incoming data will be processed by the microcontroller. The data from input 1 that has gone through PID adjustments, results from input 2 that has been calculated for angle, and input 3 that are obtained from the limit switch values will be integrated into a variable to be sent to the initial process. Else, the data processing will stop.

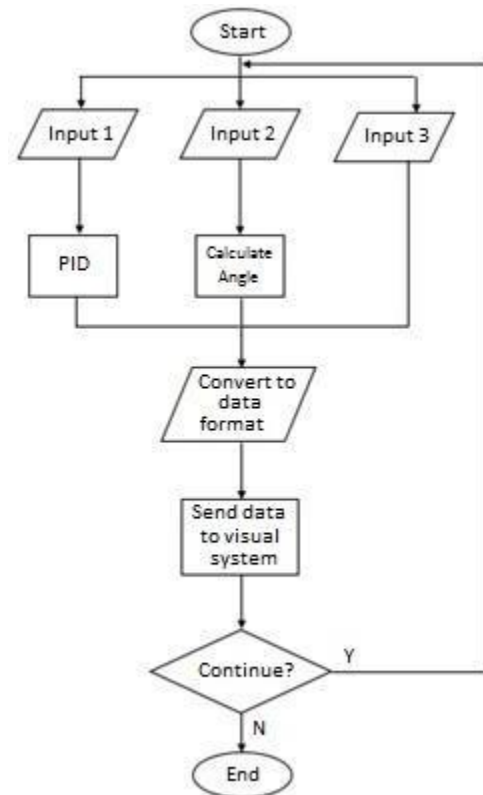


Figure 6: Data processing flowchart

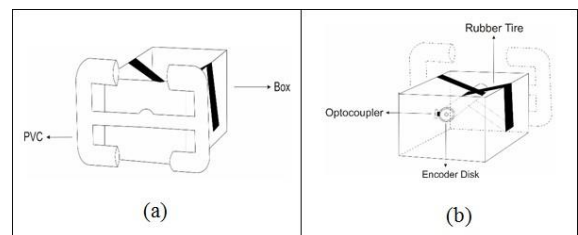


Figure 7: Steering wheel design

DEVICE MODEL DESIGN

A. Steering Wheel Design

The steering wheel design in this research requires the capability to determine the rotation angle when the steering wheel is turned right or left at certain degrees. The maximum angle of rotation used is 450°, and when the steering wheel is turned, it has to provide feedback returning to position 0° or approaching 0°.

Figure 7 is the design for the driving simulator steering wheel implemented in this research. Picture (a) is the steering wheel design seen from the front and picture (b) shows the steering wheel design from the back. In this research, we used a rotary encoder disk with a precision of 0.01 mm which is taken from a printer.

B. Acceleration and Brake Pedal Design

In this research, the design of the pedals produces an output in degree whenever the acceleration or brake pedals are stepped on. The maximum stepping angle in this research is set to 40° . When the pedals are not stepped on, a feedback response will goad the pedals to return to the initial position of 0° . The acceleration and brake pedals work similarly, the only difference is the effect of each pedal's output on the visual system.

Figure 8 illustrates the design of the pedals used in this research. Picture (a) is an unstepped pedal and picture (b) is a

stepped pedal.

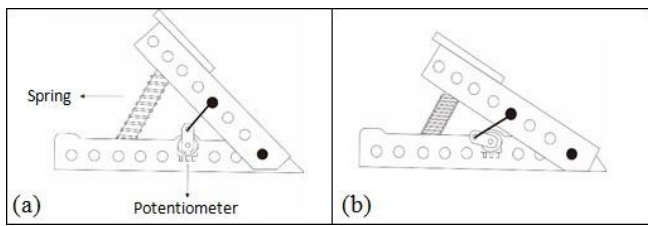


Figure 8: Acceleration and brake pedal design

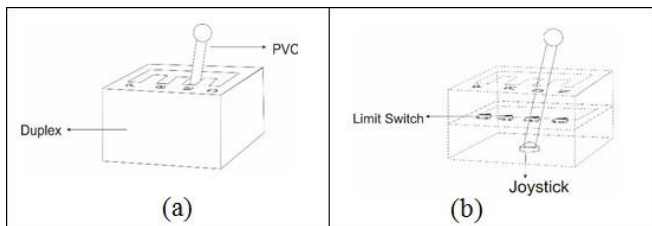


Figure 9: Gear shift design

C. Gear Shift Design

The gear shift design in this research is aimed to assign a mode to the visual system. There are four modes available for this driving simulator: N for neutral, D for the drive, R for reverse, and P for parking. When the gear shift is on a mode, it will inform the current mode to the visual system. Each mode is mutually exclusive, meaning only one mode can be active at the same time, thus to activate every mode has to be done in an alternating fashion.

Several components make up the gear shift as shown in Figure 9. Picture (a) is the outer part and picture (b) is the inner part. The inner frame of the gear shift uses a block-shaped duplex that has four holes attached with a limit switch to allow alternating each available mode.

DATA TRANSMISSION DESIGN

Data transmission designated for the visual system is performed by the microcontroller. The microcontroller will obtain results from the readings of the sensors used. After the microcontroller acquires data from the sensors, it will begin to sort the received data in a specific format. This is done to simplify data transmission to the visual system and gives high readability to the data from the input system to the visual system. The following is a pseudo-code for data transmission done by the input system.

```

SendData () {
    data = direct + wheel + acc + brake + gear;
    msg = char (data);
    Serial.print(msg);
}
    
```

into five parts: D, W, A, B, and M. Part D is a single character information used to pass information regarding the steering wheel's turning direction, where the steering wheel will output R for right and L for left.

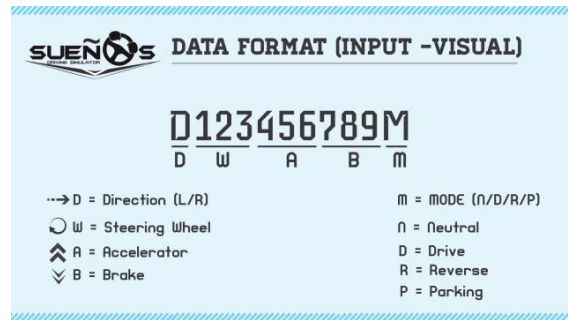


Figure 10: Transmission data format

Part W passes three characters of information used to represent the turning angle of the steering wheel. Part A contains information in a size of three characters, to show the angle of how far down the acceleration pedal is stepped. Part B, which also holds three characters of information, shows the angle of how far down the brake pedal is stepped, represented in a percentage value. Part M holds one character of information indicating the active mode on the gear shift: N for neutral, D for a drive, R for reverse, and P for parking.

TESTING AND RESULT

A. Steering Wheel Accuracy Test

The experiment is performed using three different set points and the results are shown in Table 1. It can be observed that the highest accuracy lies at the angle of 450°. Based on the tests performed, when the steering wheel is turned to 450° there will be high resistance to movements beyond 450°, due to the steering having a turning limit of 450° to both left and right directions. This limits the turning angle to no more than 450°.

In most of every test iteration, the error value is caused by rotations of the steering wheel beyond the normal limit of the target angle. Aside from that, this can also be affected by the turning of the steering wheel during different test iterations in determining a certain angle but is still within the preset limits.

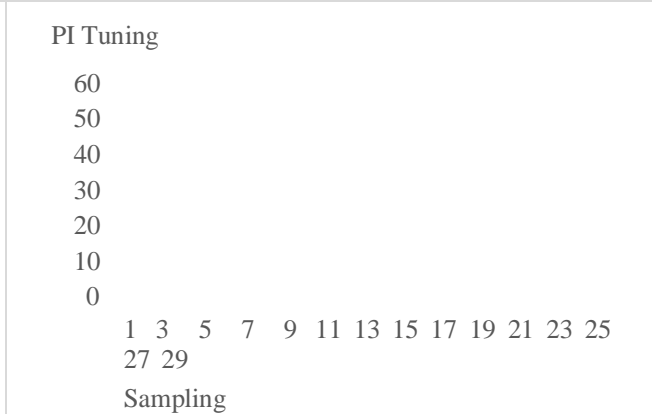
B. Acceleration and Brake Pedal Test

In this experiment, there will be showing PID tuning results that directly use the accelerator and brake pedals to determine the optimal parameter required in this research. Figure 11 shows the results of PID tuning using varying parameters. The best result is obtained when the system implements the PD parameters.

Figure 10 shows the data format used for data transmission in the driving simulator sent from the input system to the visual system. There are eleven characters used in the format, split

Table 1. Steering wheel mean data accuracy

Angle	Angle to Right		Angle to Left	
	Error	Accuracy	Error	Accuracy
45°	0,49°	99,73%	0,44°	99,75%
225°	0,48°	99,73%	0,57°	99,69%
450°	0,44°	99,76%	0,35°	99,81%



time (t_r) of 0.25 seconds, then time to reach the peak (t_p) requires 0.5 seconds whilst producing a maximum overshoot (M_p) of 24.36%. The system also has a settling time (t_s) of 1.7 seconds, which means it will reach a stable condition in around 1.7 seconds.

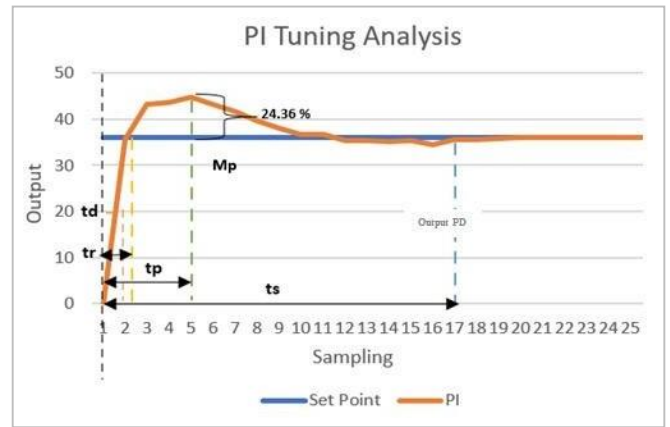


Figure 12: PI tuning analysis

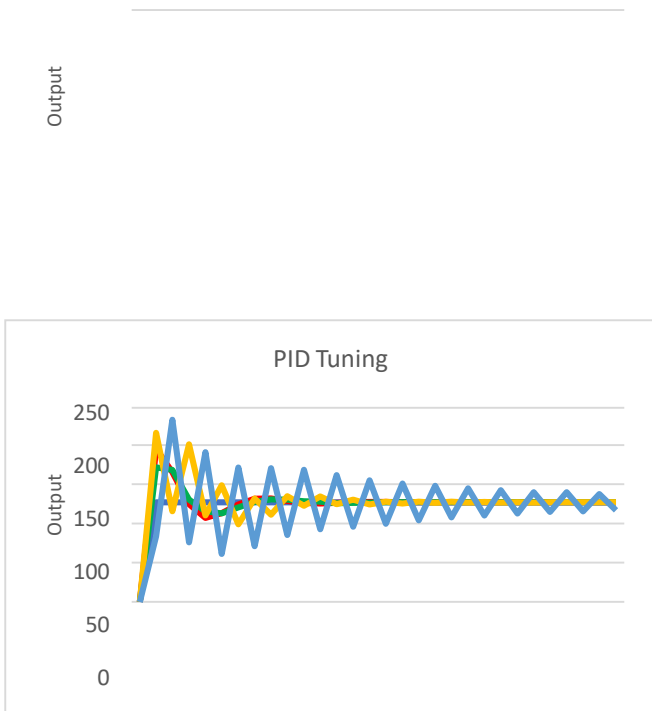


Figure 11: PID tuning results

Figure 12 shows the analysis result of the output from the system implementing PI parameters. In this research, the use of PI parameters is suitable if implemented in the system for the accelerator and brake pedals. According to the analysis, the response output from the system using PI parameters is quick, stable, and bearing small error values. This can be captured by the stability parameter analysis from Figure 13, where the system has a time delay (t_d) of 0.2 seconds, a rise

Table 2. Input system to visual system data transmission

Data sent from Input System	Data received by Visual System	Result
R000001001D	R000001001D	Match
R000003000D	R000003000D	Match
R000002001D	R000002001D	Match
R005099001P	R005099001P	Match
R005100002P	R005100002P	Match
L028039001R	L028039001R	Match
R035036000R	R035036000R	Match
R035036000R	R035036000R	Match
R001079001N	R001079001N	Match
R001073002N	R001073002N	Match

A. Data Communication Test

The experiment results are shown in Table 2, providing details of the data sent by the input system and the data received by the visual system. The experiment's yield is that the sent and received data matches for all ten iterations. Thus, it is concluded that the data transmission from the input system to the visual system is successful.

CONCLUSION

The control system is successfully implemented as an embedded system within the input system using the Proportional- Integral (PI) parameter of constants $P = 0.5$ and $I = 0.2$, which is applied in the accelerator pedal and brake pedal, yielding a system with a stable output for use in

acceleration or deceleration in time around ± 1.7 seconds. Besides, the use of an encoder with a precision of 0.01 mm in angle calculation proved excellent for steering, as shown by the test results with accuracy ranging from 99.69% to 99.81%. At last, UART data transmission between the input and visual systems has been successfully implemented with a bidirectional data transmission rate of 1560 bits/s in a baud rate of 9600, using char data type, and satisfying data transmission success standards.

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