Investigation on Haptic sensor – Actuation system in a joystick

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Abstract---A Joystick is an input device that can be used in a variety of applications, starting from gaming to vehicle operation. The joystick sends out electric current or voltage signal depending on the position of the plastic stick. The signal generated by the joystick actuates a system based on its intensity. However, usually, the feedback on the operation of the system will not be sent back to the joystick. Hence, the operator misses the haptic component of the system and is likely to lead to asynchrony in the operation of the system. In this study, a system will be developed to create synchronous operation between the vehicle navigation systems and the vehicle operator. The joystick will be used to maneuver a car effortlessly, however with virtual operating environment.

Keywords: Haptic Feedback, Joystick, Servo Motor

I. INTRODUCTION

The sensing of physical information from environment by humans is a complex procedure. When manipulating some object with arms the reaction forces, temperature, pressure and many other factors are to be considered. The study related to sense of touch and the feedback can be classified under the branch haptics. In this study, a system will be developed to create synchronous operation between the vehicle navigation systems and the vehicle operator. The operator should get a feedback if he deviates from normal running of the vehicle.

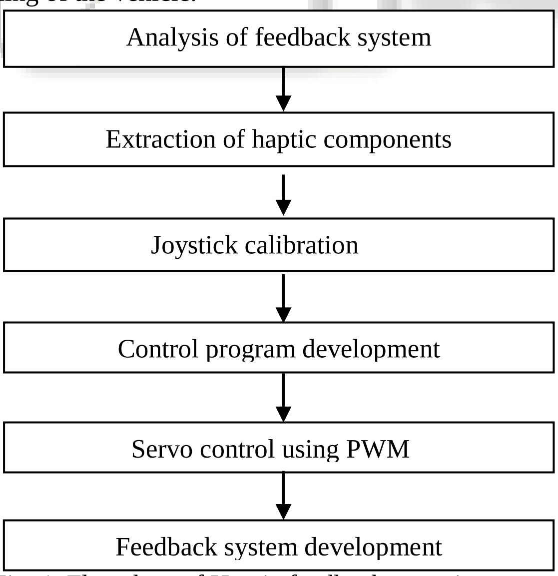

Fig. 1: Flowchart of Haptic feedback actuation system

In the past studies about haptic feedback systems and the actuation mechanism Benjamin Osafo-Yeboah *et-al*[1] studied the force feedback range values that can deliver best operator performance using haptic controlled excavator interface. The result of this study showed force feedback significantly affects the operator performance. Douglas P. Haanpaa *et-al*[2] investigated how haptic feedback interaction is made possible through both hardware and software interface. The study also dealt with different motor controllers and communication software needed for host system and feedback device. Ozgur Baser *et-al*[3] studied torque feedback system which is based on feedback from the motor. A closed loop algorithm for impedance control was made to improve the feedback performance. W.H. Li *et-al* [4] presented the design and development of a magneto rheological (MR) fluid-based haptic system and studies its applications in virtual reality. The set up consisting of MR joystick, controllers and display devices. The actuators are designed in such a way that the operator feels the resistance in his hands.

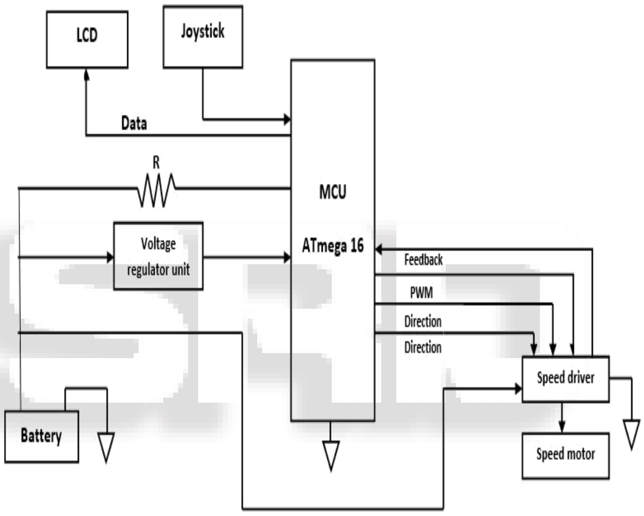

Fig. 2: Schematic diagram

II. EXPERIMENTAL WORK

The circuit diagram and design are discussed below

A. Circuit diagram

The circuit consist of microcontroller unit, voltage regulator unit, servomotor, LCD display and battery. The main part of the circuit is the microcontroller unit. The microcontroller used here is Atmega 16. It uses AVR architecture and it delivers high performance at low power ranges. Atmega 16 is 40 pin IC with 8-channel, 10-bit ADC and four PWM channels. This will operate at 2.7V - 5.5V. Servo motor used is having a torque of 2 kg.cm. A 12 v battery is used, voltage required for the microcontroller is in the range 2.7 - 5 v this is provided by using the voltage regulator circuit. This circuit will maintain a constant 5v supply.

Wheel speed sensor, also known as "ABS sensor" is part of this system. It is placed on the tires near to the brake rotors. The wheel speed sensor is to constantly monitor and report the rotational speed of each tire. By monitoring the output of this sensors speed calculations can be made. The joystick is used to translate the movement of the plastic stick into an electronic information that a system or computer can process. When the system identifies charge on a particular wire, it computes the joystick is in the correct position to complete the circuit. Pushing the joystick forward closes the "forward switch," pushing the stick to the left closes the "left switch," and so on. The computer can recognize the diagonal position of the stick when two switches are closed.

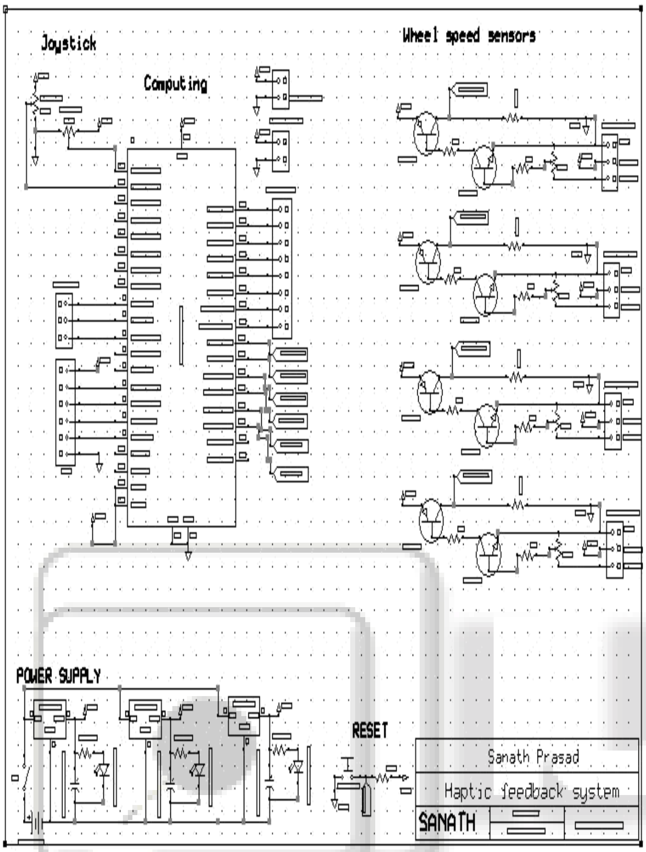

Fig. 3: Circuit Diagram

B. Servo control using PWM

Servo motors have been around for a long time and are used in many applications. They are small size but will have good torque due to the potentiometer dc motor setup inside the servo. The force feedback required for the experiment is provided by the servo motor. Controlling the servo motor using PWM is the key part here. Electrical pulse of variable width are used to control servo motor. These pulses are called PWM and are send through control wires. There will be a minimum and maximum pulse repetition rate. Servo motor turns only 90 degrees in one direction resulting in a total of 180 degrees in either direction. PWM which is transmitted to the motor determines the shaft position and based on the duration of the pulses.

Rather than continuously varying analog signal PWM uses successive pulses as input to the servo .The controller regulates the energy flow to the motor shaft by increasing or decreasing the pulse width. The inductance of the motor acts like a filter, storing energy during the 'ON' cycle while releasing it at a rate corresponding to the input reference signal

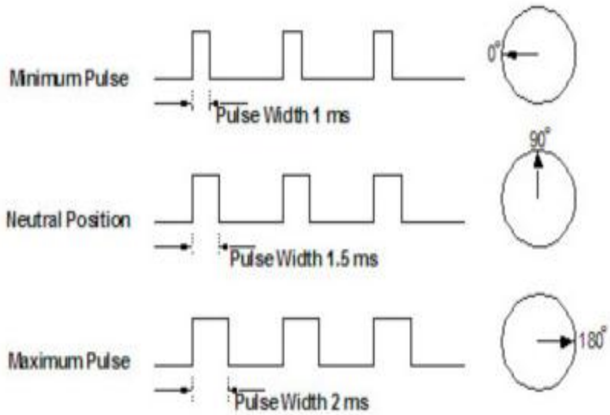

Fig. 4: Variable Pulse width control servo position

When servo motor is programed to move if there is any variations in the PWM they will hold at that position the servo will resist any external forces acting against it. The maximum amount of force that servo can exert is called torque rating.

III. DESIGN

Proposed designs of the mechanical feedback structures is shown below Figure 4 shows the rack and pinion feedback setup. The whole system consist of servo motor, even stepper motor can be used. The system consist of rack and pinion attached to a motor. The rack is attached to a spring which is then mounted on joystick axis at the bottom.

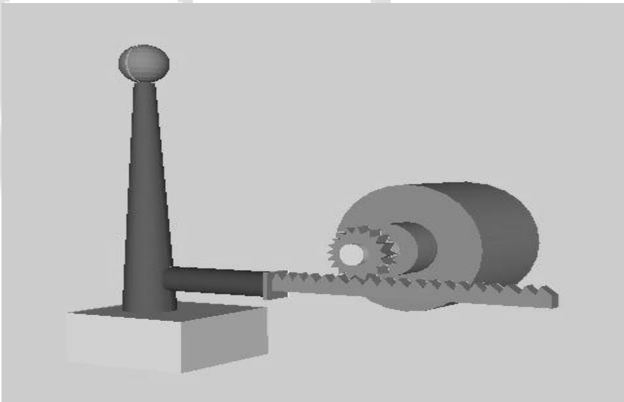

Fig. 4: Rack and pinion feedback setup

When the operator goes above the required speed the microcontroller sends signals to the servo or stepper motor and the motor moves to the required angle. When the motor moves the rack is been pushed and the pinion connected to it compresses the spring attached to it and hence due to this tension operator feels a force feedback.

Figure 5 shows a spring and ring set up. It consist of two rings and in between the ring springs are attached. The springs are aligned in the direction of motion of the joystick that is in the four directions that the joystick moves the springs are attached. The spring will act as the mechanical component which exerts an opposing force when the shape is changed from the existing state. This resisting force can be calculated using Hooke's law. $F=kx$ where k is the spring constant, x is the displacement, F is the resisting force. By using this law spring can be selected according to the requirements.

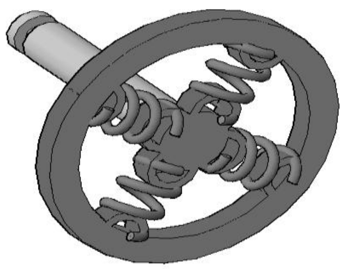

Fig. 5: Spring and ring setup

IV. RESULTS AND DISCUSSIONS

The joystick positions are monitored in order to find the voltage levels at each points. When the joystick is moved backward or forward the resistance changes, at the middle point there will be some resistance so as at the end and the initial position. These resistance are converted to voltage levels and feed to microcontroller. These values are monitored using ADC which is an inbuilt property of atmega 16. Figure 6 and 7 depicts different voltage level at different angles in the joystick used.

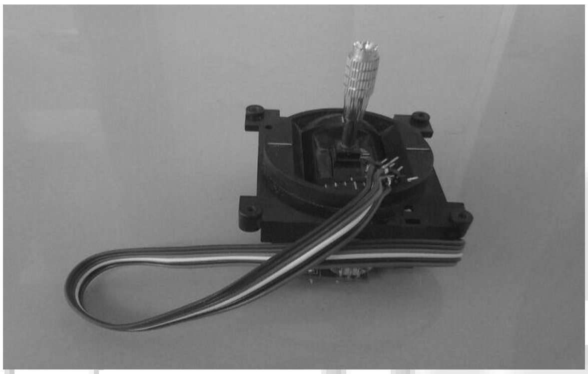

Fig. 6: Joystick used for the work

The microcontroller monitors speed from the speed sensors located in the wheels at different positions of the joystick .An offset is set in the program written to microcontroller .If the joystick is moved above that offset the servo connected to the mechanical feedback system holds its position. When the operator pushes the joystick above that value the servo holds and the spring connected elongates and a tension is created .due to the resisting force of the spring the operator feels the haptic sense in his hands.

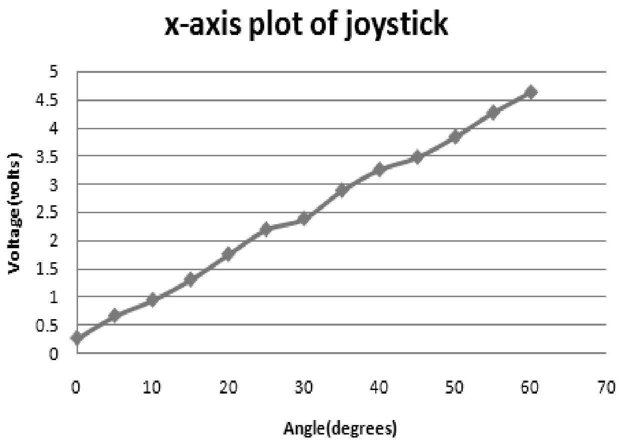

Fig. 7(a): Voltage Vs Angle plot of joystick x-axis

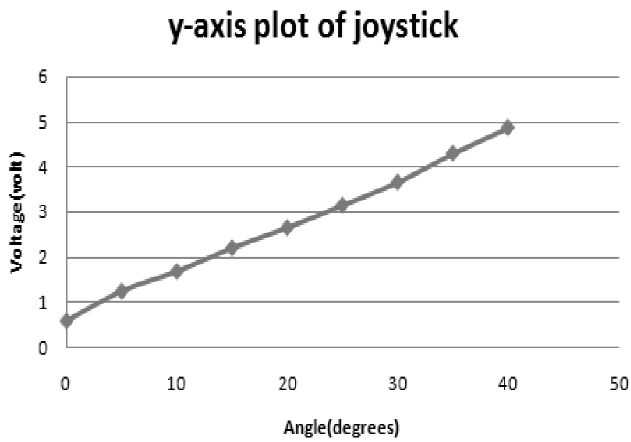

Fig. 7(b): Voltage vs Angle plot of joystick y-axis

V. CONCLUSION

Haptic sensors are application based and the force feedback required is nonlinear. Servo motor based feedback system is enough for giving haptic feedbacks in small joysticks. The programing part done in Atmel studio sinks well with the system. For accurate holding torque much more sensitive joystick is needed.

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