Microcontroller based Hospital bed control

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Abstract. One of the causes of paralyses is stroke that occurs because of brain blood vessel disorder. Because of it, the patients suffered from stroke must lay most of their time on a bed. Laying too long can pressure a specific area in contact with the surface of the bed leading to decubitus. To prevent this, the nurse changes the patient's sleep position periodically. Most hospital beds have been designed to adjust the position of the patients. However, changing the bed position manually needs extra energy. The study aims to design a tool for hospital bed control using a DC motor controlled by a microcontroller. Nurses, patients and families of the patients can change the position of the bed by using a button connected to the microcontroller. The bed controller circuit uses the button to control the bed position using a dc motor. By using this device, the patients, nurses or caregivers and the patients' family can simply press the button to control the bed position according to the comfort of the patient's sleeping position so as to minimize the occurrence of decubitus

Keywords: decubitus; DC Motor; Microcontroller; Button; Bed Position.

1. Introduction

Stroke is a clinical syndrome due to brain vessel disorders. Stroke is a neurologic deficit arising from cerebral vascular disease. Stroke makes the patients lay down on the bed in a considerable time. The impact of it is decubitus, a disease caused by a pressure on the area in contact with the surface of the bed. Decubitus wounds are the effects of prolonged pressure on the prominent surface area of the bone and result in reduced blood circulation in the stressed area and over time the local tissue experiences ischemia, hypoxia, and develops into necrosis. Some studies on nursing interventions to prevent decubitus injury consist of lying position regulation which can reduce tissue pressure and can be an effective action to prevent decubitus injury. Changing the position can be done periodically every hour, starting at 08.00-10.00 (Western Indonesian time) the patient is tilted to the right, at 10.00-12.00 the patient is stretched, at 12.00-14.00 the patient is tilted to the left.

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Based on the problem, this paper presents an innovation to change the position of the patient's tilt angle on hospital bed by adding a DC motor. The motor is used to change the position of the patient's tilt angle driven by using the microcontroller. Microcontrollers have been used by previous researchers to control dc motors. Research on microcontrollers to control dc motor speed for wheeled robots was investigated by Ages (Abad et al. 2018). Microcontroller was investigated by Croock to control dc motor speed to drive a wheelchair (Croock, Al-Qaraawi, and Ali 2018). Microcontrollers were examined by Ages to control the position of the robotic arm to sort based on Fuzzy Logic-Controlled Feedback (Aliff et al. 2019). The angle position controller with a dc motor controlled by a microcontroller was examined by Hamid (Hamid et al. 2018). DC motor has been used to control the position of the angle with the control of the microcontroller.

The motorbike has been researched by researchers before, such as the study of permanent magnet DC motors studied by Wu for movement control and attitude adjustment for climbing robots on flexible surfaces. The sliding mode control (SMC) control algorithm is used to control the angle position of the dc motor (X. Wu et al. 2018). Position control was examined by Xuan Ba to control the angular position of a BLDC type DC motor with the Gain-Adaptive Robust Backstepping Position Control control algorithm (Xuan Ba et al. 2018). Control of angular position was examined by Shi for the control of mouse robots modified to study mouse movements. The dc motor is controlled by using an STM type microcontroller (Shi et al. 2018). Research on the angular control of electromagnetic fluid actuators for robotics rehabilitation was investigated by Davidson. DC motors are controlled using impedance control used for stroke rehabilitation robots (Davidson and Krebs 2018).

The control of the dual-axis tracking system using a DC motor was examined by Belkasmi. To drive a DC motor, a PIC type 18F4550 microcontroller was needed. An LDR sensor was needed to detect the position of the sun. Fuzzy logic controller algorithm was needed to drive the angular position of the DC motor (Belkasmi et al. 2015). A Low level control embedded in a DC motor to move robot's feet was examined by Bonci. The system used a Renesas type microcontroller with 32-bit processor YRDKRX63N board. This microcontroller controlled the angular position of the DC motor using PID control (Bonci et al. 2015). Wheelchair control for handicapped people was studied by Kim. The wheelchair was designed to be driven by a dc brushless. To be stable, the wheelchair required a controller consisting of a microprocessor (MPU), an accelerometer sensor, and a DC brushless motor driver (Kim et al. 2015).

A design and development of a continuous intelligent passive movement device for knee rehabilitation was examined by Umchid. The system consisted of ARM9 microcontroller, LCD touch screen, Arduino nano, current sensor, rotary encoder, limit switch, and DC motor. The DC motor was controlled by Arduino nano whose angular position was set by using an LCD touch screens connected to ARM9 (Umchid and Taraphongphan 2016). A design and development of Solar Tracking system using Single Axis and Azimuth-Altitude Dual Axis was investigated by Ray. The system consisted of light sensors using LDR sensor, microcontrollers, dc motor drivers and dc motors. An Atmega8 microcontroller was used to control the direction of solar panel position using a DC motor (Ray and Tripathi 2016). A design and construction of an automatic test bench for MCB testing was examined by Wickramarachchi. The system consisted of dc gear motors, a DC servo driver, microcontrollers, a halleffect current sensor, and an MCD. An Arduino type microcontroller was used to run dc motors and measure the current generated from the MCB (Wickramarachchi et al. 2016).

A Single Track Autonomous vehicle was investigated by Alshahadat. This vehicle system consisted of a gyroscope sensor, microcontroller, and bluetooth. A DC motor was connected to a microcontroller using a driver interface. (Alshahadat et al. 2018). A flexible platform with a wireless interface for remote control of a DC motor was examined by Litta. The system consisted of a microcontroller, Bluetooth, rotor position sensor, and dc motor. A 32-bit ARM cortex-M3 type controller was used to control DC motors (Litta et al. 2018). The 2DOF control system with a single chip computer was examined by Sladka. The system consisted of a single chip microcontroller, industrial personal computer, and dc motor. The dc motor was controlled by a PID control algorithm programmed on an industrial personal computer. The data were then transmitted to the microcontroller using serial communication (Sladka, Czebe, and Wagnerova 2018).

A four quadrant DC motor with regenerative braking was examined by Kumar. This system consisted of a microcontroller, high voltage insulation, four quadrant chopper, a DC motor, load, and Tacho-generator. An Arduino Mega2560 type microcontroller was used to control PWM on the four quadrant chopper to regulate the speed of high voltage DC motor (Kumar, Saraf, and Kumar 2018).The design of a two-way DC-DC converter based on a single chip microcomputer was investigated by Wu. The system consisted of a microcontroller, LCD, half-bridge rectifier circuit, and a series of DC-DC converter circuit. An STC12C5A60S2 microcontroller was used to control dc motors (Y. Wu, Wang, and Ning 2018). A machine for helping the elderly up and down lavatory were examined by Jangwanitlert. This system consisted of a microcontroller, dc motor, and a H-bridge circuit. There were two DC motors used in this system. An Arduino Uno microcontroller was used in this system to provide inputs in the form of PWM pulses to the H-bridge circuit (Jangwanitlert, Meesrisuk, and Sanajit 2018).

A DC motor angle control using a microcontroller has been investigated by many previous researchers such as researches on tracking dual-axis solar panels, robot legs, disaster rescue robots, insect robots, traction therapy, and knee rehabilitation. The DC motors used were BLDC motors, servo motors, and stepper motors. The PIC controller of PIC 18F4550, DSPIC30F4011, ATMEGA 2560, STC12C5A60S2, ARM cortex-M3, LPC1549, and PIC16F887 types were used by previous researchers to control DC motors. The purpose of this paper is to design the position control of hospital bed using a microcontroller. The DC motor was controlled using a microcontroller. The microcontroller was used to control the angle of the bed by using a DC motor mounted in the patient's bed. The control position of the angle was connected to the microcontroller to control the angular position. By using this device, the patient or nurse can simply press the button to control the position of the bed according to the patient's comfort.

2. Research Method

A control system for hospital bed with microcontrollers (Wijaya, Oktavihandani, et al. 2020; Megantoro et al. 2020; Tarigan, Sinurat, and Sinambela 2015; Ruifeng, Zhe, and Liying 2015; Kuantama, Setyawan, and Darma 2012) designed using block diagrams and flowcharts is presented in this paper. The design of the block diagram of the bed control system is shown in Figure 1. The figure shows that the there are three systems namely input system, control system and output system.

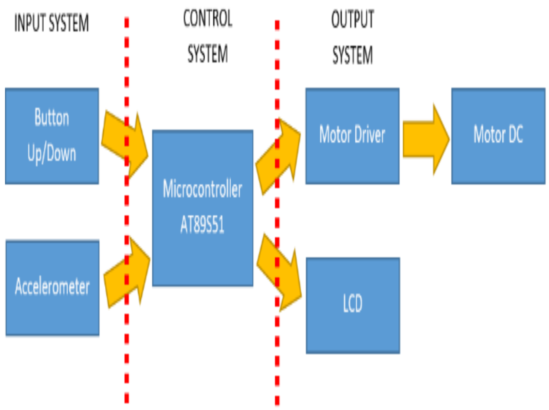

Figure 1: Block diagram of hospital bed position control.

Input system

Figure 2 shows an input system for the bed control in the hospital. This system consists of two input sensors that function to control the bed namely the button sensor (Dzulfikri et al. 2020) and accelerometer sensor. The up/down button sensor is used to control the position of the bed. The sensor button is connected to the digital port of the microcontroller (Tunggal et al. 2020; Latif et al. 2020; Yudi Limpraptono, Putri Ratna, and Sudibyo 2012; Limpraptono et al. 2011; Fanbiao et al. 2015) named port 2. The accelerometer sensor is used to detect the tilt angle of the controlled bed. This sensor is connected to the digital generator with i2c communication.

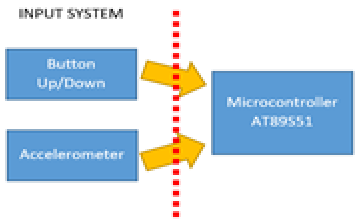

Figure 2: Block diagram of the bed control input system.

Control system

Figure 3 shows the process of input system from sensor data which is then released to the output system to control the DC motor. This system uses ATMEL AT89S51 type microcontroller which has low power input and low price. This microcontroller is used to control the DC motor using the inputs from the button up/down sensor.

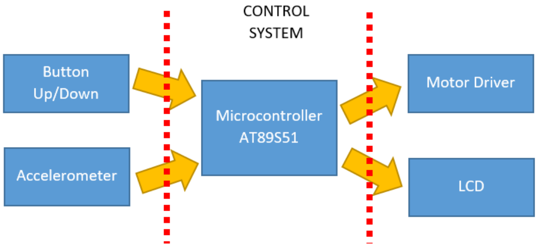

Figure 3: Block diagram of the bed control output system.

Output system

The output system for hospital bed control using a DC motor is shown in Figure 4. The figure shows that the DC motor is connected to the motor driver interface so that it can be controlled by the microcontroller. The microcontroller emits the PWM on the digital port of the microcontroller to control the motor (Kunal et al. 2020; Wijaya, Alvian, et al. 2020; Han 2015; Sharma and Sonwane 2017; Bais et al. 2016).

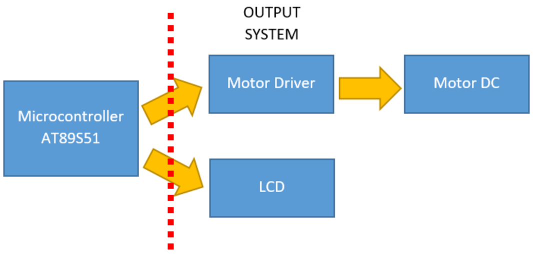

Figure 4: Block diagram of the bed control output system.

Figure 5 shows the flowchart of the hospital bed control algorithm. It can be seen in the figure that when the program run, the up/down button provides the data derived from the microcontroller delivered to the motor driver. When the bed is moved by the DC motor, the angular position is read by the angle sensor and then displayed on the display viewer.

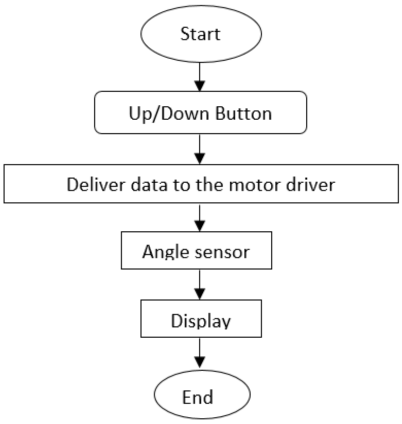

Figure 5: Flow chart of hospital bed position.

3. Copyright Form

The hospital control system test was performed in stages from the subsystem test to the entire system test as shown in Figure 6. The figure shows that there are three subsystems tested namely the input subsystem, control subsystem and output subsystem.

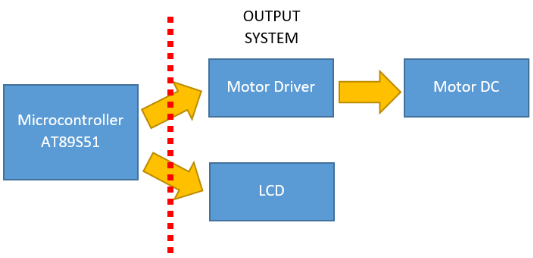

Figure 6: Bed control circuit

Input subsystem test

There are two testing methods for input subsystem as shown in table 1. The table shows that there are up and down buttons test and accelerometer sensor test. When the button is pressed, the LCD displays 'pressed button' and when the button is not pressed the LCD displays the 'not pressed' button. In the accelerometer test, when the accelerometer is rotated right to the direction of the x axis, the LCD displays 90 degrees and when it is rotated left in the direction of the x axis, the LCD displays -90 degrees

Table 1: Input subsystem test.

No	Test	LCD dsiplay	Remark
1	Button up	Pressed button	Pressed
2	Button up	Not pressed button	Not pressed
3	Button down	Pressed button	Pressed
4	Botton down	Not pressed button	Not pressed
5	Accelorometer rotates to x-axis	90 degrees	Rotated right to x-axis
6	Accelorometer rotates to x-axis	- 90 degrees	Rotated left to x-axis
7	Accelorometer rotates to y-axis	90 degrees	Rotated right to y-axis
8	Accelorometer rotates to y-axis	- 90 degrees	Rotated left to y-axis
9	Accelorometer rotates to z-axis	90 degrees	Rotated right to z-axis
10	Accelorometer rotates to z-axis	- 90 degrees	Rotated left to z-axis

Please note that the word "Table" is spelled out.

Subsystem Control test

When the Up/Down button is pressed, the microcontroller will direct the motor driver to move the motor and adjust the angle of the patient bed. The bed movement stops every time it reaches 10 degree and is set for maximum 60 degree. The change of the angles is received by the sensor and then displayed on the LCD.

Output subsystem test

The motor drive circuit shown in figure 7 actively moves the motor when the Up/Down button is pressed. It can be seen in the figure that when P1.0 logic is 0 and P1.1 logic is 1, the NPN1 and NPN2 transistors form the darlington transistor configuration and activate relay 1. Because the coil of relay 1 gets +12 voltage and 0 voltage (ground), the contact on relay 1 is connected to NO which gets 30V while the contact on relay 2 is connected to NC that gets 0 voltage (ground) so that the motor rotates clockwise and stops when the bed reaches 10 degree. When P1.0 logic is 1 and P1 .1 logic is 0, the NPN3 and NPN4 transistors form the darlington transistor configuration and activate relay 2. Because the coil of relay 2 gets +12 voltage and 0 voltage (ground), the contact on relay 2 is connected to NO which gets 30V while the contact on relay 1 is connected to NC that gets 0 voltage (ground) so that the motor rotates counterclockwise and stops the bed reaches 10 degree.

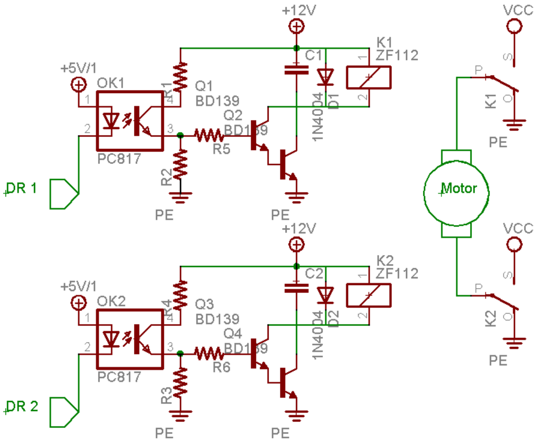

Figure 7: Motor drives circuit..

4. Conclusions

The hospital bed system proposed in this paper equipped with features that adjust the tilt position by simply pressing a button placed near the patient so that the patient can easily reach it. The bed is moved by using a DC motor controlled by a microcontroller. Every time the up/down button is pressed, the microcontroller directs the DC motor to move the bed to reach 10 degree and is set for maximum 60 degree. This system consists input system, control system and output system. The input system contains button sensor and accelerometer sensor. The button up/down sensor is used to control the position of the bed and the accelerometer sensor is used to detect the tilt angle of the controlled bed. The control system is used to control the DC motor using the inputs from the button up/down sensor. The output system emits the PWM on the digital port of the microcontroller to control the motor. By simply pressing the button, nurses, patients and families of the patients can change the position of the bed according to the comfort of the patient's sleeping position so as to minimize the disease caused by long staying on the same position such as decubitus.

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