Design and Development of Spinning LED Message Display System

Liong Boon Yoong[1], Mohamad Fauzi Zakaria[1,*], Hairulazwan Hashim[2]

[1] Department of Mechatronics and Robotics Engineering
[2] Department of Electrical Technology
Faculty of Electrical and Electronic Engineering
Universiti Tun Hussein Onn Malaysia
86400 Parit Raja, Batu Pahat, Johor, MALAYSIA

Abstract: The popularity of Spinning Message System can be found in many existing projects which apply the creative concept of Persistence of Vision (POV) by using LEDs in the phenomenon of creating an after-image which is thought to persist for a period of time by humans' eyes. However, most of the existing projects share the similarity of displaying spinning LED message with fixed patterns. The objective of this paper is to design a spinning LED message system with adjustable displayed patterns in a more user-friendly way. The scope of this paper is to create a spinning LED message system which able to display patterns of totals 24x7 pixels of characters. The limitation of characters displayed includes the ASCII alphabets from 'A' to 'Z' and numbers from '0' to '9'. The proposed system is designed by interfacing the ASCII characters input by the user with the patterns stored inside the Microchip PIC18F4550 with desired timing delays of 0.76ms for every pixel. The results obtained are verified that the proposed spinning LED message system is capable to produce a desired POV patterns by the user.

Keywords: Persistent Of Vision (POV), Spinning LED Message, Microcontroller PIC18F4550

1. Introduction

Spinning LED message system is a system which capable to display LED message by applying the concept of POV on a row of LED. The afterimage phenomenon occurs as images which appear briefly and then are removed appear to persist for a short period of time. After that, a blurred illusion is formed that the image remains for a longer period. This is due to the characteristic of the human eye which does not allow it to perceive changes in motion at rate faster than approximately 15Hz [1]. The resolution of an image can be enhanced by higher frequency in displaying the image [2]. In [3] states that the minimum visibility for human to observe a rotating LED clearly is around 24 or 25 frames per seconds for countries using frequency of 50Hz. Besides, in [4] found that the better quality of visibility for human is more than 30 frames per seconds. The proposed system is a circuit controller board together with seven LEDs mounted on the blade of a 12" table fan. As the table fan rotates, the LEDs will switch on and off with desired timing delays for each pixel as controlled by a microcontroller on the circuit to display four alpha-numeric characters. The algorithm of the system is assisted by the estimation of combining the detection of changes in the motion pattern [5]. The features detected from the patterns of image are of various numbers and in a different order depending on the lighting condition changes. The features are then being mapped to a visual word analogous to the words in text documents [6].

Most of the existing projects capable to display limited patterns of text message while spinning. Furthermore, some commercialized spinning LED message systems have fixed alpha-numeric characters for the user to select using buttons. Users are unable to change and display the alpha-numeric characters out of the fixed and less choices set by the manufacturer. Besides, there are some weaknesses that can be seen from the existing projects. Some LED text message displayed while spinning will drift and move inconsistently during the process. Other than that, most of the spinning LED message system which spin using DC motors will face the problems of shorter duration of displaying LED message or the LED message is failed to be displayed properly and constantly as the battery which supply power to the DC motor runs out.

The objective of this proposed system is to design, develop and analyze a flexible and user-friendly spinning LED message. This project is primarily concerned with the ability of the system to display maximum four alpha-numeric characters such as 'UTHM' due to the constraints of the size displaying area.

2. Methodology

2.1 System Overview

Generally, the proposed system is designed to display spinning LED message which appears to be more attractive and better visibility. The theory by producing such prototype rely on the parameters of rotational speed, weight of the components on the rotational blade, and the delay timing set to display every pixels of the alpha-numeric characters. After building the relationship of all the parameters required, programming work relating all the parameters was done in MPLAB IDE software to design the system. The system was then being simulated using Proteus ISIS software to observe the waveform patterns. Next, the analysis on the system was done by using real time oscilloscope. Finally, the comparison between results obtained from theoretical parts, simulation part and real time testing part was done.

2.2 System Requirements

The system requirement is based on inputs and output of the system features. Fig. 1 shows the system features that are divided into two main categories, which are data collection unit and also the display function.

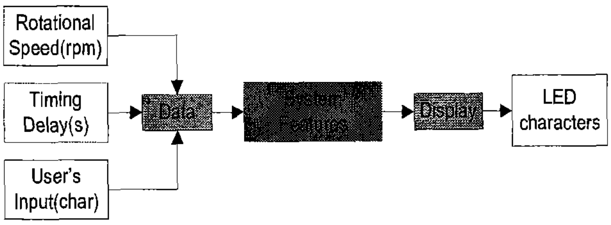


Fig. 1 System Features of proposed system

Basically, the data collection unit is the input unit for the system features which includes the data of rotational speed (rpm), timing delay data that should be inserted among the pixels, and also the user's input of alphanumeric characters. The output unit is the display function which displays the LED to form 5x7 pixels alphanumeric character.

The system is designed based on three considerations: persistent capability, update capability, and user friendly. The persistent capability means that the LED message displayed during spinning time need to be persist so that the message can be seen clearly. Next, update capability refers to the ability of the application software to be modified and updated easily without any further modification in the system software. Thus, user is able to update the message which is going to be displayed. Finally, user friendly feature is a necessary feature so that it is easier for the user to program the message.

2.3 System Architecture

The proposed system architecture is shown in Fig. 2. The proposed system is basically being divided into two units, which are AC unit and DC unit. It needs to collect data from AC hardware part to be interfaced with inputs and outputs hardware in DC unit. It requires one input hardware of speed button which will control the speed of another input hardware of AC fan motor. Next, data of speed of motor in rpm unit is interfaced with an input hardware of IR sensor and output hardware of a row of seven LEDs. All of this hardware is controlled by a microcontroller PIC18F4550.

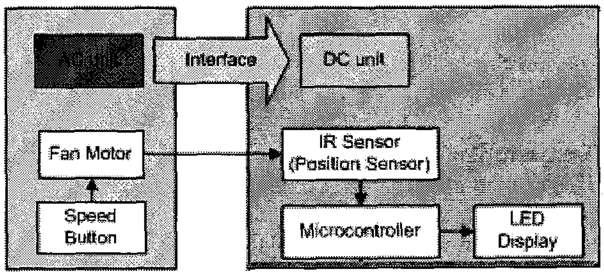


Fig. 2 System Architecture

2.4 Hardware Design

The proposed system which includes a table fan is sketched using AutoCAD software and is shown in Fig. 3. The table fan size is measured to be 230cm. The microcontroller board is be located at the centre of the rotor with one of its blade consists of seven LEDs which are used to display a message while spinning. Table 1 shows the hardware component being used in this proposed system.

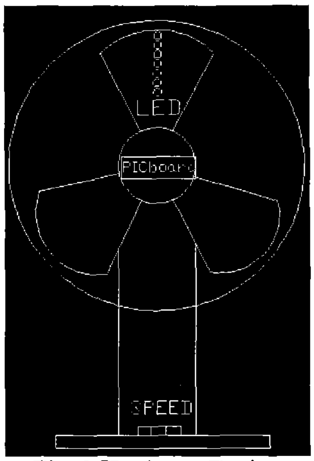


Fig. 3 Hardware Design

Table 1 Main Hardware Components

No.	Unit	Component
1	Microcontroller	PIC18F4550
2	Medium Range IR Sensor	IR01A
3	White LED	DS-LED-5SW
4	USB ICSP PIC Programmer	UIC00B (PICKit2)
5	AC motor of Table Fan	JZ-FM03

2.5 Software Design

There are few tools of software that have been used in this project. Software such as MPLAB IDE is used together with C18 compiler to compile and simulate the programming coding that is included inside this proposed system. Besides, Proteus ISIS software is used to simulate the system output by preparing schematic of proposed system which is similar to the real schematic that has been used. After that, the schematic of the circuit is printed into PCB form via Proteus. The software design was divided into three levels: low, middle and high level.

The low level software is a subroutine that interacts directly to the hardware as a driver. In this project, low level software includes the subroutine for switching on and off of the LED display. 36 alphanumerical characters are defined and being set with 5x7 pixels for each characters. Next, the seven LEDs are switched on and off accordingly in desired manners in every pixel as being defined as shown in Fig. 4.

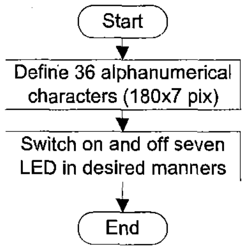


Fig. 4 Flow chart of low-level software

The medium-level software is a subroutine which combines the sensor output and also the timing delay for the LED to be switched on and off. Timing delay is set at the beginning. As the IR sensor input HIGH, it will keep detecting. As the IR sensor input LOW, it will output HIGH to the microcontroller. Then microcontroller will send signals to LED to be switched on and off accordingly in desired manners. Next, the lighting manner is supported by timing delay of 0.76ms for every 1x7 pixel as shown in Fig. 5.

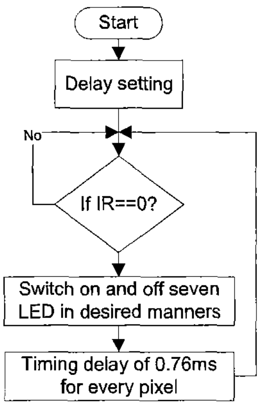


Fig. 5 Flow chart of medium-level software

The high level software combines all the subroutines by calling the function to display user inputs. The program will read the user input in looping for every 1x7 pixel. While the user input is read, it will be compared with the defined alphanumerical characters in the program. If the user input is same with the defined character and the condition of IR sensor is LOW, LED will be switched on and off accordingly in correct manners with suitable timing delay. The program will continue looping until all the user input has been read as shown in Fig. 6.

To achieve and satisfy with the requirement of the proposed system, several testing have been conducted. Firstly, the fan's AC motor speed was tested by using tachometer equipment and the data in rpm was recorded. Then, timing delay is calculated based on the speed provided by the motor. Before assembling on the prototype of the proposed system, the relationship between speed and timing delay were determined via Proteus's simulation to obtain the output waveform of the voltage output in time in oscilloscope. Lastly, the program was assembled into the prototype and it was tested to obtain the output waveform in real time oscilloscope.

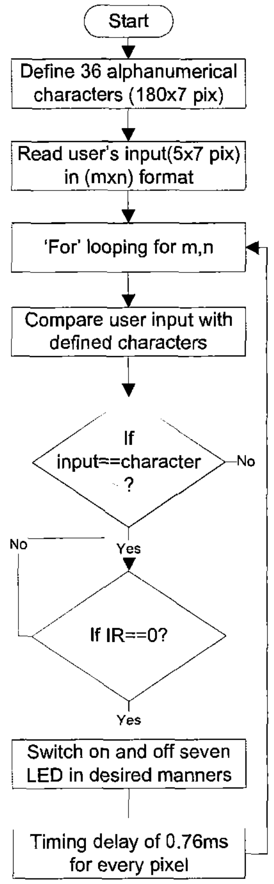


Fig. 6 Flow chart of high-level software

3. Results and Discussion

The interfacing test was done to verify the compatibility of the hardware components and the software are expressed in this topic.

3.1 Hardware Development

The hardware prototype board has been developed and printed into printed circuit board (PCB) format. It consists of a microcontroller, programmer port, voltage regulator, reset button, capacitors and resistors. The voltage source is a 9V battery or dc power adaptor which then being regulated down to 5V for powering controller board. The general image of the proposed system has been shown in Fig. 7 and the hardware description data has been shown in Table 2.

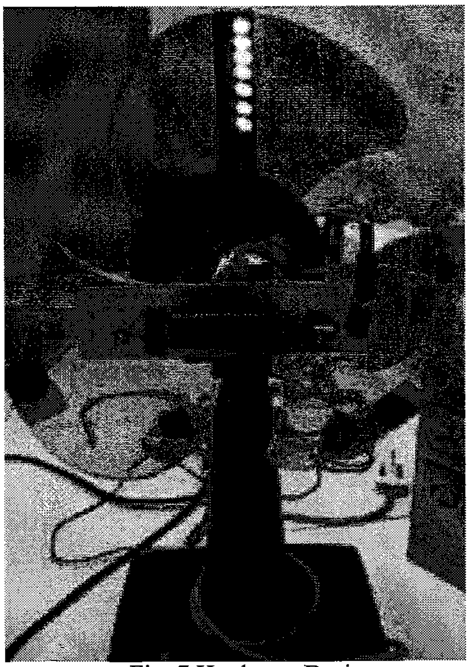


Fig. 7 Hardware Design

Table 2 Hardware descriptions

No	Hardware Feature	
1	Size	30cm
2	Weight	200g
3	Motor speed	1276rpm
4	Power consumed	38W
5	Voltage ratings	220-240V/50Hz

Before using the table fan AC motor as the hardware for this proposed system, few tests were conducted on 24V DC brushless Vexta motor and the 12V starter motor from Modenas brand. However, Vexta motor offers low speed at 300 rpm and Modenas starter motor consumed power very fast and lack of stability although high speed of rotation is provided. Table fan AC motor offers the most suitable speed and moderate consumption of power. Therefore, it has been chosen to be the main rotary hardware in this proposed system.

3.2 Software Development

Calculation of the timing delay is determined at the early stage. The calculation which relates the speed of rotation with the timing delay is obtained. Interfacing testing was conducted on both low-level software and medium-level software. The testing tools that have been used in this proposed system are Proteus simulation tool and also the oscilloscope. The theoretical calculation of timing delay, output waveform in Proteus simulation and real time hardware test of an alphanumerical character "U" are shown in Fig. 9.

It is observed that the timing delay in simulation for each pixel is 0.76ms with the sequence of LED being arranged on the hardware is the same as the simulation with the first LED on the very top of the waveform. From the waveform of real time hardware test, it is observed that the timing delay, Δt for the first frame of "U" is 0.76ms. Then, the data result from calculation part; simulation part; and real time testing part were compared. It is found that the result gained from every parts give the same value of timing delay for each frame, which is 0.76ms.

After getting the accurate result of readings for the proposed system, IR sensor is added into the system as position sensor. It is used to avoid the drifting of the message and fix the message starting at the same place. The sensing distance is adjusted manually. The image of the proposed system displaying LED message is shown in Fig. 8. Other alphanumerical characters were also tested during the project duration such as "2011".

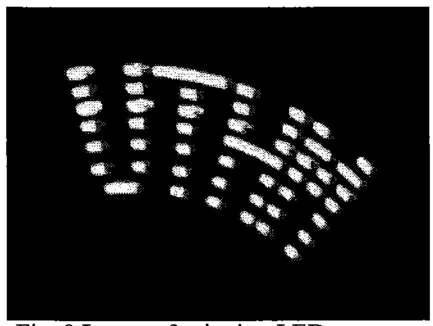


Fig. 8 Image of spinning LED message

4. Summary

The proposed system was successfully tested for verifying its interface functionality and the system testing that concerning on basic and application software. It was found that the timing delay for every frame was obtained to be 0.76ms for calculation part, simulation part, and real time testing part. The image of displaying "UTHM" in the result part proved that the proposed system can function accordingly. The character message was displayed successfully without drifting. Therefore, objective of this proposed system has been achieved and satisfied.

References

[1] Steve Liu ,Gabe Knezek, Brandon Gulrich, and Warren Linhan," Design and Implementation of a Real Time Spherical Persistence of Vision Display System,"Texas A&M University, Jan 1999.

[2] Hassan Demireli, and Gholamreza, "Image Resolution Enhancement By Using Discrete And Stationary Wavelet Decomposition," *Journal of IEEE Trans. Image Processing,* vol.1, pp.99, October 2010.

[3] M Armstrong, D Flynn, M Hammond, S Jolly, and R Salmon,"High Frame-Rate Television,".BBC Research White Paper WHP 169, September 2008.

[4] T. Morris, P. Blenkhorn, and Farhan Zaidi,"Blink Detection For Real-Time Eye Tracking," Department of Computation UMIST, Manchester, M601QD, UK, November 2001.

[5] Ying Weng, and Jianmin Jiang, "Fast Camera Motion Estimation in MPEG Compressed Domain," *Journal of IEEE Trans. Circuits Syst. Video Technol,* vol.1, pp.99, November 2009.

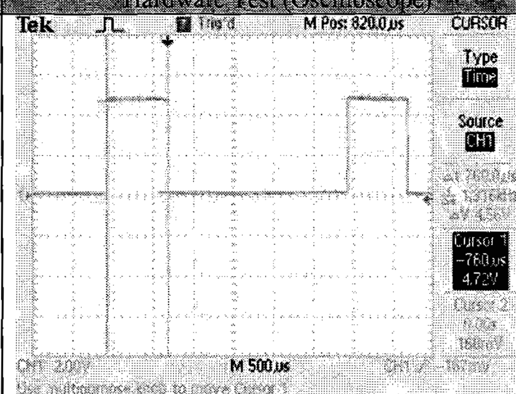
[6] Teng Li, Tao Mei, In-So Kweon, and Xian-Sheng Hua, "Contextual Bag-of-Words for Visual Categorization," *Journal of IEEE Trans. Circuits Syst. Video Technol,* vol. 21, no. 4, April 2011.

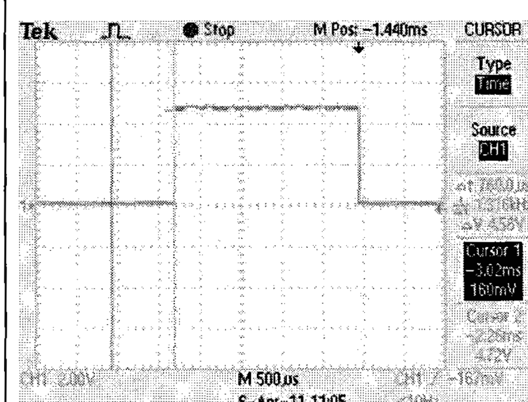
<table>
<tr><th>Calculation</th><th>Simulation (Proteus)</th><th>Hardware Test (Oscilloscope)</th></tr>
<tr>
<td>Speed of motor
= 1276rpm
$= \frac{1276rpm}{60s}$
= 21.27rps

Time required for 1 rotation(360°)
$= \frac{1}{21.27rps}$
= 0.047sec

Time required for 140° of vision
$= \frac{140}{360} \times 0.047sec$
= 0.01828sec

Total frame of time in 140° of vision will be 24 frames.

Timing delays in each frame
$= \frac{0.01828sec}{24\ frames}$
= 0.76ms</td>
<td>
Timing delay for each pixel is 0.76ms.</td>
<td>

Waveform for LED1,2,3,4,5,and 6


Waveform for LED 7

Δt for the first frame is 0.76ms.</td>
</tr>
</table>

Fig. 9 Output Waveform of Character 'U'