PERSISTENT VISION DISPLAY

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ABSTRACT

A spinning display is a device that creates a stable image which is constructed by a stick turning around its center which is filled with LEDs. Using this method and a limited number of LEDs, it is possible construct an image in the form of normal displays, than the other conventional LED displays. With the support of a motor which provides the rotational motion for the single array of LEDs, the display has its ability to provide an image including 9 different color combinations. The conventional spinning displays focus more on obtaining the image, but our key aim is displaying a much clearer image compared to the others. In addition to that, this persistent vision display is a horizontal display unlike the other displays which are vertical. Two displays are made as the solution: a black and white display (resolution: 40x40) and a color display (resolution: 32x32).

Key words**:** Persistent, LED, Display

1. INTRODUCTION

"Spinning Display" is a general name for the type of displays which create images using one or small number of columns of LEDs placed on a plate. The plate is attached to a motor which will cause its turn around a circular orbit. By this way, the LEDs turning around this orbit will create an image for human eye, using the fact that the human eye is not able to clearly distinguish movements beyond a particular frequency [5][6].

There are some examples of these type of displays created by both hobbyists and commercial companies [1], but our solution has a more complete and different approach in mind. First of all, most of these examples have no LED intensity controls or sophisticated color creation. In fact, this makes them incomparable to our solution, which has both intensity controls for each led and 24-bit color creation. In some sophisticated commercial products, we see sharp LED positioning controls and very good color schemes, but actually they have plates turning around the orbit which is perpendicular to itself. By this approach, they create a 360 degree view in contrast to our display which has a flat view and different sized pixels.

As far as the conventional LED displays are concerned, the revolutionary approach pursued by this type of display can be noticed remarkably. This mentioned approach may be described as following; in conventional displays, even in LCD's, each pixel is defined as a hardware pixel. If you want to design a 1024*768 display, you have to use 1024*768 LEDs. However, in our display approach we have 2 coordinate axes: one of them is r; which is implemented physically and the second one is theta which is implemented virtually. In our display, the resolution principle is totally different, but for comparison, a total number of 24*pi*16 virtual pixels can be created by only using 16 pixels^2.

2. METHODOLOGY

2.1 Persistence of Vision concept

When you look through a narrow slit, you can see only a thin strip of the environment around you. But if you move the slit around rapidly, your eye and brain combine these thin strips to make a single complete picture. [2]

Persistence of vision is the theory where an afterimage is thought to persist for approximately one sixteenth of a second on the retina. The discovery of persistence of vision is attributed to the Roman poet Lucretius, although he only mentions it in connection with images seen in a dream. In the modern era, some stroboscopic experiments performed by Peter Mark Roger in 1824 were also cited as the basis for the theory

A visual form of memory known as iconic memory has been described as the cause of this phenomenon. Although psychologists and physiologists have rejected the relevance of this theory to film viewership, film academics and theorists generally have not.

The motion picture, the scanning of an image for television, and the sequential reproduction of the flickering visual images they produce, work in part, because of an optical phenomena called the persistence of vision and its psychological partner, the phi phenomenon—the mental bridge that the mind forms to conceptually complete the gaps between the frames or pictures. Persistence of vision also plays a role in keeping the world from going pitch black every time we blink our eyes.

Whenever light strikes the retina, the brain retains the impression of that light for about a tenth of a second—depending on the brightness of the image—after the source of that light is removed from the eye. This is due to a prolonged chemical reaction. As a result, the eye cannot clearly distinguish fast changes in light that occur faster than this retention period. The changes either go unnoticed or they appear to be one continuous picture to the human observer. This fundamental fact of the way we see has been used to our advantage. A class of display device described as "POV" is one that composes an image by displaying one spatial portion at a time in rapid succession [3][4] for example, one column of pixels every few milliseconds. A two-dimensional POV display is often accomplished by means of rapidly moving a single row of LEDs along a linear or circular path. The effect is that the image is perceived as a whole by the viewer as long as the entire path is completed during the visual persistence time of the human eye. A further effect is often to give the illusion of the image floating in mid-air. A three-dimensional POV display is often constructed using a 2D grid of LEDs which is swept or rotated through a volume. POV display devices can be used in combination with long camera exposures to produce light writing.

2.2 Image Processing

The images should be converted from rectangular to polar coordinates in order to overcome the overlapping of pixels when choosing the values for the LED array. For an example, if the images remained in the form of

Cartesian, and as the array takes a circular rotation in order to form the image, it would encounter the following problem as illustrated in figure 1.

The LED's in the array requires a fixed value to give a final clear image. However the rectangular image would have combinations of different values and would not provide a specific value so that the display would be clear enough. Thus, the images are transformed to polar coordinates as illustrated in figure 2, (r and theta) thus the array can be assigned by r values in correspondence with the theta value at a certain time.

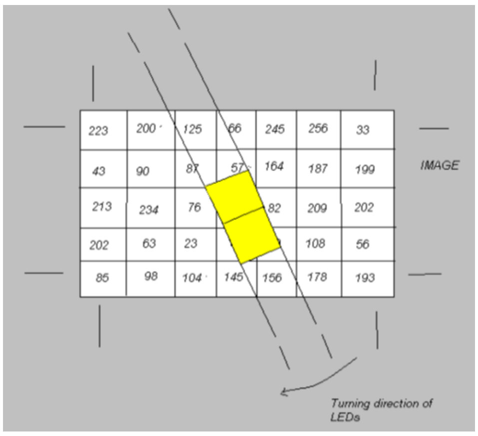

Figure 1 – Overlapping of polar and cartesian plots

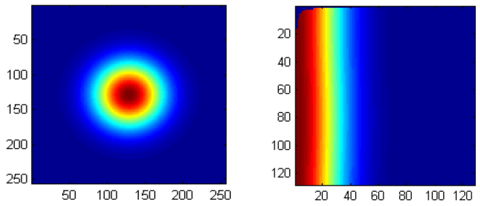

Figure 2 – Conversion from Cartesian to polar

2.3 Design and Implementation

In this project two main displays are to be developed, one black and white display (which displays only 2 colors) and one color display (which can display 9 colors including black and white). For the first display sets of white LEDs were used for the black and white display where as for the color display, RGB LEDS were used.

The main display consists of two parts:

1. LED array which gives different patterns for the display
2. Motor drive which rotates the LED display

For each part mentioned above, a 12V battery is used as the power source and a microcontroller is used to control the operation. The main block diagram of the design of the whole device is shown below.

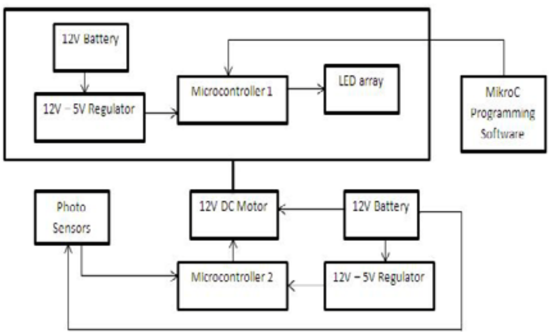

Figure 3 – Block Diagram

This product mainly operates with 2 microcontrollers (2 - PIC16F877A) [7] functioning separately. One microcontroller is used for the lighting of the LEDs, where direct output ports are used to send the particular signals for the LEDs in the array to perform showing the image. The other microcontroller is used to maintain the speed at a constant level. The mechanism that this process is executed is explained under Rotational Kinematic Equations section.

2.4 Mechanical Setup

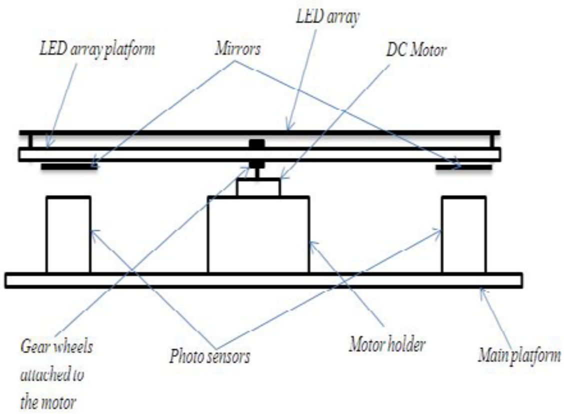

Figure 4 – Mechanical Setup

For the best display:

- Motor should rotate at a constant speed without any vibrations
- Frame rate of the display should be greater than the minimum flicker fusion threshold, i.e. 60Hz and should span the whole display.
- Motor speed and the frame rate should be equal to each other.

2.5 Rotational Kinematic Equations

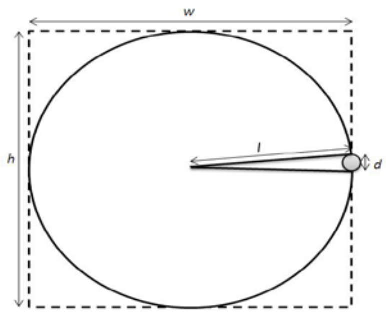

Figure 5 – Spanning of the display by 1 LED

As illustrated in figure 5:

h = height of the display = 125mm

w = width of the display = 125mm

d = diameter of a LED = 6mm

l = radius of the array = 125mm

Angle covered by a single LED line = $\theta = (d \times 180) / (l \times \pi)$

Arrays per frame = $a_f = 360 / \theta$

The above equation gives the approximated number of arrays per frame as **120**.

Frame rate = $f_s = 60Hz$

Speed of the meter in revolutions per minute = $\omega = 60 \times fs$

Delay time for the array to change = $(\delta t) = 1 / (a_f \times f_s)$

The above equations give the speed of the motor to be run at as 3600 rpm and the delay for an array to change as 5/36 milliseconds.

In order to equalize the motor speed to the speed of the rotation, motor is controlled with a PID control. Three photo sensors are used to take readings each time the array passes the certain 3 points on the ground per one revolution, thus the time for 1/3 revolution is measured, hence the angular velocity is calculated. Subsequently it is adjusted in accordance with the rate of frame change to equalize each other. Below pseudo code summarizes the task carried out by the microcontroller.

```
START
SET Time = 0
For 90 cycles
        Switch on timer
        Check for photo sensors
        SET Time = Time + timer value
Frame rate = 1 / Time
Compare Frame rate against 60
If Frame rate is high, decrease motor speed
If Frame rate is low, increase motor speed
REPEAT
```

Figure 6 – Pseudo code

The pre-calculated minimum values for the frame rate and the arrays per frame gives a fractional value for the time between two arrays which makes the microcontroller difficult to make a particular constant delay. Therefore the frame rate had to be increased to 80Hz and arrays per frame to 125, which results in a delay time of 100microseconds.

3. CONCLUSION

Two displays were designed in this project, one black and white and the other a color display. This type of display has its own advantages when compared with other LED displays, it uses less number of light sources. However this product has its own limitations the color display is limited only to display 9 colors (i.e. without changing the intensity of the LEDs used). In addition to that, the power required to drive the motor with coloring the LEDs may be greater than the power required by a normal display.

For further improvement of the display, as mentioned in limitations above, the number of colors that can be obtained with the use of LEDs can be increased. I.e. up to 256 and almost then almost the full color range. In addition to that, this display runs only at a constant speed driven by the motor, but future works can be implemented in order to run it at any speed.

4. REFERENCES

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