ROTATION INDEPENDENT 3D DISPLAY

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ABSTRACT

Nowadays, large flat screen advertisement can be seen everywhere, in terms of public information display and business advertising, playing a crucial role of disseminating messages. However, ordinary LED flat screen has limitation on dealing with 3D images due to the planar structure. With the development of technology, people can expect an application of displaying 3D image so advertising companies can bring about more creative ad design. To such demand, the LED cube can easily meet the criteria of a 3D display. The LED cube which we have made has a lower resolution, but its true 3D image creation ability is not something a normal LED flat screen can achieve. In this project we add the concept of accelerometer which makes it rotation independent. This project is the extension of IEEE project of LED 3D display. However, this paper will focus on providing a proof of concept for the True 3D image technology. Other than the LED Cube the Accelerometer and ATmega16 are two of the other major components in this project. The Accelerometer is responsible for detecting rotation and the ATmega16 is responsible for transmitting the control signals to the LED cube. Overall, this report will explain each part of the project, including project research, implementation plan, project milestones, alternatives and detail project design.

As the technology for 3D displays improve a new window of opportunity for 3D manipulation is also emerging in the market. It is our hope that we can create a cheap and effective way of initial prototyping that does not require the user to spend lots of money on a solid prototype. Our solution to this problem is to create a 3D display that will present the model and allows the user to interact with it using simple rotations.

This paper also focuses on various decoding techniques which we have used to control large number of components from minimum possible input ports. The whole project (including programming) is completed successfully in our B.tech final year curriculum project.

Keyword: Led Cube, Accelerometer, Atmega16, Decoding Techniques, 3d Images.

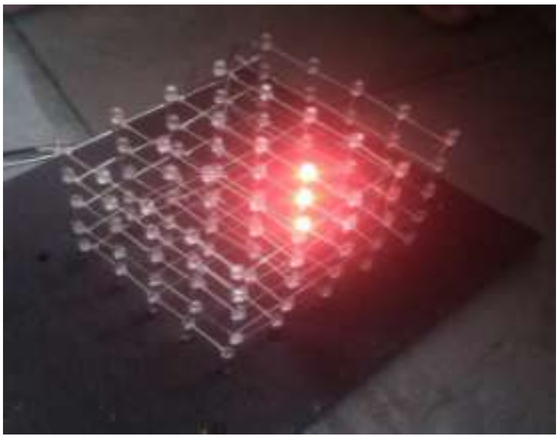
I. INTRODUCTION

True 3D effect has always been the ultimate goal of display technology. With the growing popularity of pseudo-3D screens that can be found in movie theatres, TV's, and mobile devices there is growing pressure to make displays that are truly 3 dimensional. It is necessary to point out that there are still some significant problems with this pseudo-3D technology. For example, when the angle is changed between a person's eyes and the pseudo-3D screen the three dimensional image will disappear. A truly 3D image will not be constrained by the same issues.

In this project we have constructed LED cube by using 125 LED's that are positioned in a 5x5x5 grid. This LED cube then communicates to a computer that is programmed with a 3D image. By using the Accelerometer, which is able to detect motion in its spatial grid, we will be able to manipulate the 3D image which is orientation independent.

For driving LED CUBE to work for 3D display we need a driver circuit so we used microcontrollers, transistors and accelerometer to accomplish this task. The microcontroller can be used to translate commands from the computer's USB port to commands for the cube. Controlling 125 LEDs we need 250 connections so devised to connect LEDs in such a way so that the connections reduced to 30 only. And we further reduced them by using DECODERs to the I/O expansion of the microcontroller ports. To generate pattern and images we have to on-off LED. To accomplish this task we have used BJT switching properties and use of decoders which we have learnt in our curriculum [].

The 3D LED cube creates images by flashing the appropriate LEDs fast enough to appear as constantly on. The microcontroller controls which LED is lit through GPIO pins. The outputs are determined by software functions, which control which LEDs are turned on for the sequence. Timer interrupts are initialized and enabled inside the functions to determine when the LEDs are turned on.




II. PROJECT RESEARCH

2.1 Led Cube Research

There are many LEDs are available in the market, for better vision results bright LED must be used. After a lot of research we found that COM-00528 red led seems good for our project because of its high performance, stability and low current requirements.

After LED selection, soldering them is major task as proper arrangements helps in decoding and I/O expansion. In LED cube for controlling each LED individually, it seems to generate pattern at least 1 wire to each and every LED. But using digital devices like decoders, not gate, microcontroller etc. this task is easily accomplished. Taking example of 5*5*5 (which we have done in our project) in which we could address LEDs one at a time without having to run a ton of wires by connecting all of the up and down columns of LED's to the same positive terminal (25 columns total, with 5 LED's each) and then connect all of the horizontal levels to the same 'ground' (5 levels with 25 LED's each).

2.2 Led Driving Circuit

In addition to building the LED cube itself we also had to design and build our own custom LED driver circuit. The microcontroller can be used to translate commands from the computer's USB port to commands for the cube. However, not all types of micro-controller are able to satisfy the LED cube. There are three major considerations when choosing a proper microcontroller: compatibility with the LED cube, an open-source development platform, and expansibility. We found that ATmega16 proves to be good for this project.

This driving circuit also includes 3x8 Decoder (4) -74F138PC with NOT gate (CMOS) - HEF4069UBP. We have chosen CMOS not gate because CMOS ICs have low power dissipation and high fan out [] so that we supply more current to LED to lit brighter. The microcontroller's GPIO pin outputs are connected to 3-to-8 decoders (74F138PC). The 3-to-8 decoder outputs are connected to NOT ICs (HEF4069UBP). When a 3-to-8 decoder output is asserted low then NOT IC changes to 1 high, the BJT (2N2222A) allows current to flow across its collector to emitter, which then flows to a LED.

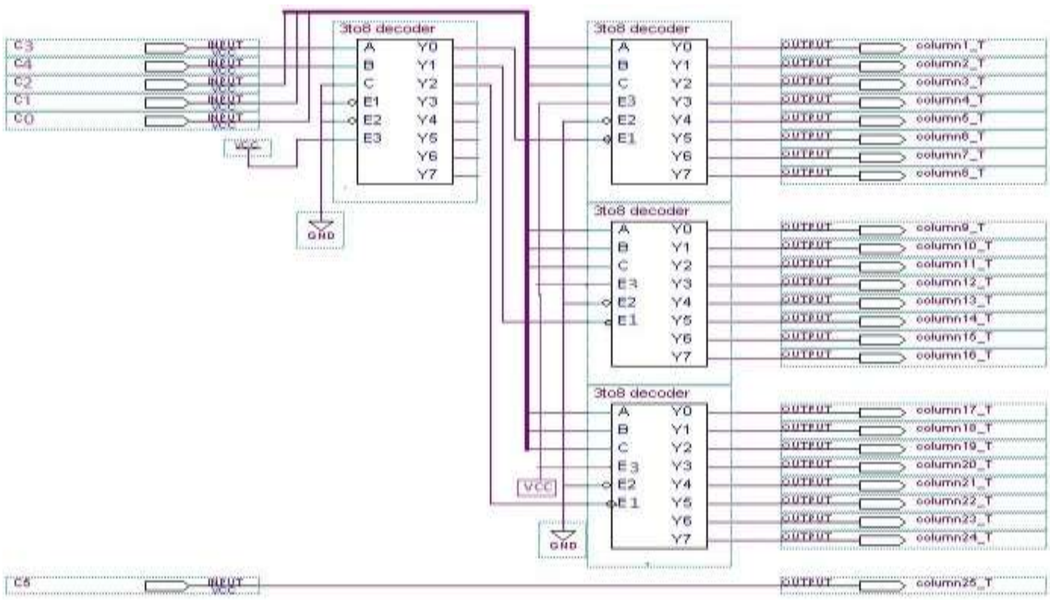
III. HARDWARE DESCRIPTION AND WORKING

First of all we need to construct the cube. We built each horizontal 5x5 plane individually by laying the LED's flat on top of wooden jig and soldering all the negative terminals of the LED's onto the wire and leaving the positive terminal hanging. This essentially connected all the negative terminals of the LED's in the same level to the same ground plane. We then carefully soldered the 5 horizontal planes together by first mounting them on one layer using thermocol and taping them into place in a upright position and then soldering 1 wire to connect all the LED's in a vertical column together for each of the 25 columns.

In this cube the lightening of LEDs is controlled by the microcontroller Atmega16 but the number of port of microcontroller are not sufficient to drive LEDs so we did I/O expansion (by which we needed only 11 pins of microcontroller in all) using decoders as well as the microcontroller cannot provide enough current to make the LED cube to lit properly so we use amplification property of BJT, same BJT can be used for switching of LEDs by controlling the base of BJT.

3.1 Led Cathode Driving

We used six pins of Port C of the microcontroller i.e. C_0-C_5, out of which C_5 is directly connected to 25[th] column and C_0-C_4 are used for the port expansion that is done through 4-Decoders which is shown in the figure (1). First the pin C_4 and C_3 are connected to the inputs of the first decoder, whose outputs Y_0, Y1 and Y_2 are connected to the active low enable of the decoders of second stage, according to which these decoders get enabled one at a time and the pin C_0, C1 and C_2 are connected to the input pins of all the three decoders of the second stage according to which a particular output of the decoder gets enabled.



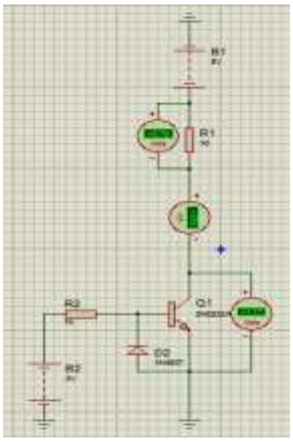
Now we have to lit led's by connecting the outputs of decoder to the cathodes of the led's i.e. the columns of the cube but the outputs are active low so we used an inverter to convert the active low to high output which is now connected to the columns of the cube via minimum possible resistance so we used 10Ω. Now since only one column can be high at a time so to make more than one led to get enlighten we use the concept of persistence of vision so that we can make any pattern to be viewed on the cube. Basically using this decoding scheme we can select any of the first 24 columns simply by sending the binary number of the column to the port of microcontroller (the top two bits being a control for the master decoder and the bottom three being the input to the selected decoder).

3.2 Led Anode Driving

The pin C_6, C_7, B_0, B_1 and B_2 are used for driving the anodes of the led's i.e. the layers of the cube but the current needed to drive the led's is not sufficiently provided by the microcontroller and the decoder since each decoder output had to drive 5 leds in parallel so we used BJT 2N2222 for increasing the current up to 500mA(maximum current) which is sufficient for driving one layer of led's. Since each led require 25mA current and in our cube to make patterns to be displayed we have to do very fast switching which need a lot of current and for need is successfully fulfilled by this bjt which works as an amplifier using an external power and ground. The base of the bjt is connected to the microcontroller port pins and the collector is connected to the layers of the cube and emitter is grounded.

The power now comes directly from a 5V regulator that is rated to supply at least an amp of current, which was more than enough, but the BJT transistors that we used are only rated to supply 160 mA of continuous current. This meant that we would still have trouble driving all 5 of the LED's at the same time since each of the 5 LED's would try to draw 40 mA of current for a total of 200 mA. In order to get around this we employed a trick in the software that, instead of turning on all 5 LED's at the same time, would turn on the bottom 3 LED's first and then turn on the top 2 LED's.

The circuit is shown below



The diode here is used so as to prevent the bjt from reverse saturation current so that when the output of the microcontroller is low the bjt is not harmed due to reverse bias of base-emitter junction.

3.3 Accelerometer Circuit

The accelerometer is a device used for detecting the rotation of the display. We used ADXL335 which is a 3-axis analog accelerometer which can detect the motion in all the three axes but in our project we used only one axis rotation i.e. x axis. Accelerometer has 5 pins one V_{cc}, one ground and rest three as outputs corresponding to the rotation in three axes. Since microcontroller works on digital logic, we need digital output from accelerometer, for converting the analog output into digital we used dual opamp ics (LM358). For each axis we needed two opamps to detect rotation in both the directions i.e. positive and negative axis.

Opamp is used as a comparator which compares the output from the accelerometer with a threshold which is set using a variac (potentiometer) by varying whose resistance desired voltage can be achieved. The output of the comparator is then connected to the port A of the microcontroller according to which the rotation in a particular direction can be detected. One more alternative is there i.e. we can use the analog to digital conversion property of the port A of the microcontroller this will eliminate the need of opamps but as the same time we have to use LCD to know the threshold values of the accelerometer.

IV. SOFTWARE DESCRIPTION

For proper display we wanted to cycle through all the LED's every 16 ms giving us approximately a 62.5 Hz refresh rate and eliminating any visible flicker. This meant that in 16 ms we would need to cycle through all 25 of our columns and for each column, hold the bottom three LED's that are currently lit on for a time, turn them off, and then hold the top two. We found that we could hold each of the 50 sets of LED's (top and bottom of each of the 25 columns) on for 180 μS and still meet our refresh rate requirements; each "frame" would take 9 ms to render leaving us with 7 ms of grace time to perform any necessary calculations for the next frame.

The algorithm used to display patterns on cube includes initialization of 2 arrays one containing the details of which column to select (the last 6 bits tells the value of C_0-C_5) and other contains the information about how many of the five layers in a particular are going to be lit for a particular pattern. Looping is done in which the 2 arrays are scanned in such a way that first we retrieve the information of the last three layers from 2nd array and store it into a variable then display them using information from first array then a delay of 180µs is provided then the information about upper two layers are retrieved and stored in the variable and then these two are displayed in the similar way as above and then again a delay of 180µs after that the loop goes on and the same process is repeated for another column. In this way all the columns are scanned in (25*2*180=9ms) 9ms and any pattern can be displayed.

Now before starting this algorithm we have to detect the rotation mode of the cube, which is accomplished by reading the port A (input port) whose last two bits decide the rotation mode, if A_0=1 and A_1=0 then the cube is not rotated, if A_0=0 and A_1=0 then positive x axis rotation and if A_0=1 and A_1=1 then negative x axis rotation. According to these values we give the commands for frame rotation and one important consideration is that if the rotation is in positive direction we need to rotate the frame in negative direction for correct display.

V. RESULT

The cube was able to display messages and images with no apparent flicker or delay due to proper setting of delay which takes advantage of persistence of vision of our eyes. Despite lighting a maximum of 3 LED's at a time we were still able to produce images requiring more than 3 LED's to be lit by strobing through multiple LED's at a high rate. The structure was also surprisingly rigid and could withstand mild shaking and turning. This was originally a concern since the entire cube is held together by solder, copper wires, and foam board.

Our final product was both usable and safe. The cube can be battery powered also and all the necessary components are contained within the base so the device is both portable and safe.

The display is rotating around the four faces of cube thus message can be seen from all four sides of cube. Also the X, Y, Z directions shown in cube which gives a perfect 3D experience to learn the concepts of EMFT. Accelerometer makes the cube rotation independent means if cube is rotated in any axis (eg. +x to -x) the image reoriented to display proper image in rotated direction, this features of our research makes the cube attractive to use and proves to be revolutionary in display technology.

VI. CONCLUSION

Our cube performed reasonably well; we were able to display a message on the cube that was readable if the room was relatively dark. Our light cube show also worked as expected and both the message and the light show adjusted themselves when you turned to cube sideways. If we were to redo our project we would have designed a slightly different LED driver circuit that would be able to supply enough current to power all 5 LED's at once and also make each LED brighter. We might also consider making some sort of plexiglass case to make the structure stronger and more visually pleasing. Additionally we would look into displaying some other interesting pattern or images on our cube.

The most substantial result of this documentation was the learning experience of the individual group members. This project helps us to practically understand the concept of Digital, Analog, Embedded C and other curriculum concepts of electrical, electronics and computer science. Also the skill development was broad-based, including time management, team building, communication, and technical writing; the primary growth came from achieving the goal of this project: establishing a functional 3D LED cube prototype design. This success accompanied the new skills and knowledge obtained such as embedded processor development, discrete component integration, printed circuit board construction, communication protocols, embedded software development, and software design.

VII. FUTURE WORKS

Wherever 2D display is used if replace them by 3D display then there will be a revolution in display technology. For example:

- In railway station one 3D display can replace 4 2D ones.
- In Education sector various difficult subjects like Wave theory, Geometry, Physics etc. can be taught effectively and efficiently using 3D display.
- 3D cubes can be proved to be milestone in video gaming.

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