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## Persistence of Vision Based Display

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**ABSTRACT:** This paper mainly emphasizes on the POV (Persistence Of Vision) technology. In current era in which energy is the main factor in designing all the applications, maximum and efficient use of the energy is very important. A POV display has many advantages over a traditional CRT, LCD or LED display, like power savings, less complexity, easy configuration, attractiveness etc. To overcome the drawback of old processor we have decided to implement the same display atop a new and advanced microprocessor, the Arduino duemilanove. This platform brings with it newer coding and a different understanding of peripherals. ARDUINO INTERFACE BOARDS provide us with a low-cost, easy-to use technology to create the project. We also aim to build the newer display to work with modern forms of interfaces. To accomplish this, we will be interfacing the display with an Android device. This project can be implemented with help of any Android Smartphone/tablet running Android 4.0+.

**KEYWORDS:** POV, Arduino, Android, ATmega 328, USB Interfacing, Piranha LED.

### I. INTRODUCTION

#### 1.1 Persistence of vision

Our eyes offer one of the five specialized means by which our mind is able to form a picture of the world. The eye is a remarkable instrument having certain characteristics to help us process the light we see in such a way that our mind can create meaning from it. Take the motion pictures, the scanning of an image in television, sequential reproduction of the flickering visual images they produce. These work because of an optical phenomenon known as POV (persistence of vision). In effect, POV plays a role in keeping the world from going pitch black every time we blink our eyes. Whenever the light strikes the retina the brain retains the impression of the light for about 10<sup>th</sup> to 15<sup>th</sup> of a second after the source of that light is removed (depends on the brightness). This is due to prolonged chemical reaction. As a result, the eye cannot clearly distinguish changes in light that occur faster than this retention period. The changes go unnoticed or they appear to be one continuous picture to the human observer. Persistence of vision is the theory where an afterimage is thought to persist for approximately one sixteenth of a second on the retina. The theory of persistence of vision is the belief that human perception of motion (brain centered) is the result of persistence of vision (eye centered). Persistence of vision refers to the phenomenon where the retina retains an image for a brief split-second after the image was actually seen, and lends itself to animation by fostering the illusion of motion when we view images in closely-timed sequence to one another. We don't notice the fractional skips between images because that persistence fills in the momentary gap to make the motion seem seamless.

A visual form of memory known as iconic memory has been described as the cause of this phenomenon. A critical part of understanding that emerges with these visual perception phenomena is that the eye is not a camera and does not see in frames per second. In other words vision is not as simple as light registering on a medium, since the brain has to make sense of the visual data the eye provides and construct a coherent picture of reality.

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 Roget in 1824 were also cited as the basis for the theory.

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## Film systems:

Persistence of vision is still the accepted term for this phenomenon in the realm of cinema history and theory. In the early days of film innovation, it was scientifically determined that a frame rate of less than 16 frames per second (frame/s) caused the mind to see flashing images. Audiences still interpret motion at rates as low as ten frames per second or slower (as in a flipbook), but the flicker caused by the shutter of a film projector is distracting below the 16-frame threshold.

## Computer monitors:

Aside from some configurations used until the early 1990s computer monitors do not use interlacing. They may sometimes be seen to flicker, often in a brightly lit room, and at close viewing distances. The greater flickering in close-up viewing is due to more of the screen being in the viewer's peripheral vision, which has more sensitivity to flickering. Generally, a refresh rate of 85 Hz or above (as found in most modern CRT monitors) is sufficient to minimize flicker in close viewing, and all recent computer monitors are capable of at least that rate.

## Cartoon animation:

In drawn animation, moving characters are often shot "on twos", that is to say, one drawing is shown for every two frames of film (which usually runs at 24 frames per second), meaning there are only 12 drawings per second. Even though the image update rate is low, the fluidity is satisfactory for most subjects. However, when a character is required to perform a quick movement, it is usually necessary to revert to animating "on ones", as "twos" are too slow to convey the motion adequately. A blend of the two techniques keeps the eye fooled without unnecessary production cost.

## Printed media:

Flipbooks use this principle. If the book is flipped at a fast enough speed, the illusion of smooth motion is created.

## Sparkler's trail effect:

The sparkler's trail effect occurs when one waves around a lit sparkler, creating a trail of light. Although it appears that this trail is created by the light left from the sparkler as it is waved through the air, there is, in fact, no light along this trail. The lighted trail is a creation of the mind, which retains a perception of the sparkler's light for a fraction of a second in sensory memory.

## Persistence of vision display:

A class of display device described as POV is the one that composes an image by displaying one spatial portion at a time in rapid succession (for example, one column of pixels every few milliseconds). A 2-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 of human eye. A further effect is often to give the illusion of the image floating in mid-air. A 3-dimensional POV display is often constructed using a 2-D 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.

## 1.2 Solar power

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic's (PV), or indirectly using concentrated solar power (CSP). Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic's convert light into electric current using the photovoltaic effect.

Photovoltaic's were initially, and still are, used to power small and medium-sized applications, from the calculator powered by a single solar cell to off-grid homes powered by a photovoltaic array. They are an important and relatively inexpensive source of electrical energy where grid power is inconvenient, unreasonably expensive to

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connect, or simply unavailable. However, as the cost of solar electricity is falling, solar power is also increasingly being used even in grid-connected situations as a way to feed low-carbon energy into the grid.

## Photovoltaic power systems:

The array of a photovoltaic power system, or PV system, produces direct current (DC) power which fluctuates with the sunlight's intensity. For practical use this usually requires conversion to certain desired voltages or alternating current (AC), through the use of inverters. Multiple solar cells are connected inside modules. Modules are wired together to form arrays, then tied to an inverter, which produces power at the desired voltage, and for AC, the desired frequency/phase.

Many residential PV systems are connected to the grid wherever available, especially in developed countries with large markets. In these grid-connected PV systems, use of energy storage is optional. In certain applications such as satellites, lighthouses, or in developing countries, batteries or additional power generators are often added as back-ups. Such stand-alone power systems permit operations at night and at other times of limited sunlight.

## Early days:

The early development of solar technologies starting in the 1860s was driven by an expectation that coal would soon become scarce. However, development of solar technologies stagnated in the early 20th century in the face of the increasing availability, economy, and utility of coal and petroleum. In 1974 it was estimated that only six private homes in all of North America were entirely heated or cooled by functional solar power systems. Between 1970 and 1983 installations of photovoltaic systems grew rapidly, but falling oil prices in the early 1980s moderated the growth of photovoltaic's from 1984 to 1996.

## Mid-1990s to early 2010s:

In the mid-1990s, development of both, residential and commercial rooftop solar as well as utility-scale photovoltaic power stations, began to accelerate again due to supply issues with oil and natural gas, global warming concerns, and the improving economic position of PV relative to other energy technologies.<sup>[24]</sup> In the early 2000s, the adoption of feed-in tariffs—a policy mechanism, that gives renewables priority on the grid and defines a fixed price for the generated electricity—lead to a high level of investment security and to a soaring number of PV deployment in Europe.

## Current status:

Worldwide growth of photovoltaic's has averaged 40% per year since 2000 and total installed capacity reached 139 GW at the end of 2013 with Germany having the most cumulative installations (35.7 GW) and Italy having the highest percentage of electricity generated by solar PV (7.0%). Photovoltaic systems use no fuel and modules typically last 25 to 40 years. The cost of installation is almost the only cost, as there is very little maintenance required. Installation cost is measured in \$/watt or €/watt of peak power. As of 2011, the cost per watt of PV has fallen well below that of nuclear power and is set to fall further.

Solar energy is not available at night, making energy storage an important issue in order to provide the continuous availability of energy. Both wind power and solar power are intermittent energy sources, meaning that all available output must be taken when it is available and either stored for when it can be used, or transported, over transmission lines, to where it can be used. Off-grid PV systems have traditionally used rechargeable batteries to store excess electricity. With grid-tied systems, excess electricity can be sent to the transmission grid. Most spacecraft operating in the inner solar system are usually solar powered and rely on the use of solar panels to derive electricity from sunlight. Space based solar power uses high efficient multi-junction photovoltaic cells.

## 1.3 Objective

The objective is to develop an LED display system which uses enormously lesser amount of LEDs and power consumption than the normal LED display and which is compact in nature using persistence of vision based technology.

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Our project focuses on meeting the tremendous growth of advertisement. Persistence of vision (POV) provides a unique technique to display our messages for advertising in an efficient way and proper utilization of provided space. It is much more attractive than LCD displays or dot matrix displays for displaying messages.

The objectives of this project are:

- To design a display system using LEDs which is rotated by a motor.
- To design a program using ARDUINO IDE.
- To display symbol using LEDs.
- To design an alternate solar power supply.
- To develop software that can generate LEDs display with accurate synchronization and timing.

The process of our project:

- The circuit is mounted on DC motor shaft.
- Design a circuitry to control the flashing of LEDs in a LED column.
- Program the circuit to flash in an appropriate pattern.
- Synchronize the flashing with the motion of the display.
- The power required for the circuit is generated using solar energy.

## II. LITERATURE REVIEW

This chapter is all about discussing the theory and concept from the past projects. The objective is to explain the perspective and method which has been used in the past projects and to observe how this project can be related with existing research and theory. This shows how the theory and concept have been implemented in order to solve project problem. The theory understanding is crucial as a guidance to start any project. The result of a project cannot be assessed if it's not compared to the theory.

This project is based on the microcontroller AT89C2051, which is a derivative of 8051 family, from Atmel Inc. This used an Interrupter module consisting of the IR interrupt sensor MOC7811, from Motorola Inc. This sensor was used because of its small size, precise interrupt sensing, and study casing. This module was interfaced with the microcontroller with two resistors and a general purpose transistor. MOC7811 is the sensing part of the interrupter module, while rest of the circuitry works as signal conditioning circuit. 3 wires emerged out from the module, respectively VCC, Signal and Ground. Output of the module is LOW, if interrupt occurs, otherwise it remains HIGH.

It consisted of IR LED and Photodiode mounted facing each other enclosed in plastic body. When light emitted by the IR LED is blocked because of some completely opaque object, logic level of the photo diode changed. This change in the logic level was sensed by the microcontroller or by discrete hardware. Interrupt module is used (Interrupt circuit), to introduce an interrupt after each revolution. In our project, the hardware is further simplified by removing the interrupt module and programmatically implementing it. Introducing interrupt module complicated the coding and the hardware part. It was not an effective way to generate the display as there would be an interrupt after displaying each column and this adds on to extra delay. In order to enhance the synchronization of the display we removed the interrupt module in our project.

The project referred in this paper used microcontroller AT89C2051, which had few drawbacks. We are using Arduino Atmega 328 due to its extended features and simple implementation. The Arduino hardware platform already has the power and reset circuitry setup as well as circuitry to program and communicate with the microcontroller over USB. In addition, the I/O pins of the microcontroller are typically already fed out to sockets/headers for easy access. On the software side, Arduino provides a number of libraries to make programming the microcontroller easier. It allows programming and serial communication over USB.

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The next paper that we referred was “Low Cost Propeller LED Display” by Manavi Sharma and Krishan Mohan<sup>2</sup> published at International Journal of Application or Innovation in Engineering & Management (IJAIEM)(Volume 4, Issue 2, February 2015)The project in this paper used a VCR motor in order to prevent noise. The circuit also consisted of a photo transistor to generate precise index pulse. In order to display the characters, the circuit had memory capacitor to keep the character displaying even when the power is not supplied to the circuit.

The memory capacitor is expensive plus, it bigger and heavy. To replace the memory capacitor, a small, cheap and light 3V lithium battery was used as a replacement. A voltage regulator also has to be used in order to allow rotation speed change without affecting the circuit and displayed images. This project is based on the PIC microcontroller. They are using 9v battery and a lower version of voltage regulator (LM117).The project referred in this paper used PIC microcontroller, which had few drawbacks. We are using Arduino ATmega 328 due to its extended features and simple implementation.The Arduino hardware platform already has the power and reset circuitry setup as well as circuitry to program and communicate with the microcontroller over USB. In addition, the I/O pins of the microcontroller are typically already fed out to sockets/headers for easy access. On the software side, Arduino provides a number of libraries to make programming the microcontroller easier. It allows programming and serial communication over USB.

In this project power is given to both dc motor and the microcontroller through two batteries separately. As the microcontroller is placed on the motor shaft if we use a separate battery for the controller then the load on the motor increases and hence the motor RPM decreases which is undesirable. In order to overcome this disadvantage we have designed the circuitry in such a way that the power for the microcontroller through the dc motor bushes.

Voltage regulator is a dc-dc converter and is used for synchronization of the dc motor speed and the LED display. In this project they have used a lower version of voltage regulator (LM117). In our project we are making use of LM317 it is a monolithic integrated circuit which is a positive adjustable voltage regulator designed to supply output current in excess of 1.5 amperes with output voltage adjustable over 1.2v-37v. It is a three terminal positive adjustable regulator and it has the following features: output is adjusted between 1.2v and 37v, internal thermal overhead protection, internal short circuit current limiting, thermal shut down and safe area compensation.

There were some POV projects that we referred consisted of oscillating shafts with LEDs mounted on the end of the shaft but the speed of the shaft was too low for POV display to work. Instead of shaft we are using DC motor as they are much cheaper and easily available compared to shafts.

After referring an ample number of papers regarding POV display we further wanted to improvise our project. Nowadays the main concern is the power consumption of the circuit, lower the power consumed more the demand. As solar energy is renewable and is available in abundance, taking this as an advantage we decided to design an alternate solar power supply for our project which is an alternative source for power supply.

### III. PROJECT DESCRIPTION AND DESIGN

In deciding on a project we looked for a challenge that would have a good mix of hardware and software problems. We ended up primarily concentrating on looking at unusual display technologies and decided that a persistence of vision (POV) display would be a good balance of hardware and software. A POV display is a display created by rotating an array of LEDs rapidly. Due to the fact that human eyes can only render about 10 images per second, the fast spinning LEDs seem like a solid display. While many POV projects have been designed before, they tend to be similar, in the sense that the LED's are mounted on to the plane of the circuit. This may cause limitations to the characters and figures which will be displayed flat in a disk manner.

Our original goal was to make a multi coloured LED display by using RGB (red-green-blue) LEDs. But the high cost of the RGB LEDs and the associated LED drivers prevented us from doing so. While we have made a monochrome (RED) display, our design makes it easy for the user to swap the LED array for a different one and put in suitable LED driver's .Thus, one can customize the display as per the need. A POV display exploits the ability of human eye by spinning 1-dimensional row of LEDs through 2-dimentional space at a high frequency such that 2-dimentional display

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is visible. In our case we create a cylindrical display by spinning a column of LEDs around the central motor shaft. The rotational speed of LEDs is fast enough such that the human eye perceives 2-dimensional image.

The overall design of our project is grouped into three categories: electrical design, mechanical design and software design.

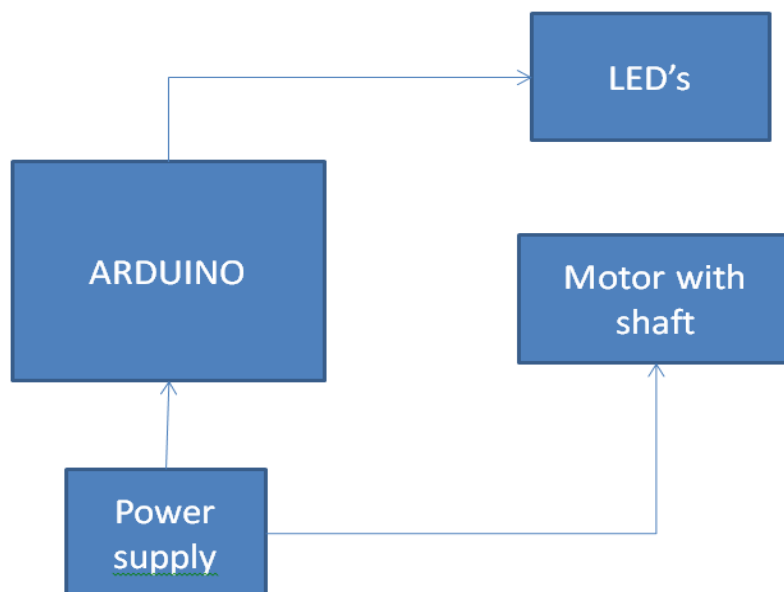
The logic behind this project is very straight forward. The nature of our design allows the software and hardware design to be independent of each other in terms of trade off. The more robust the hardware becomes (i.e. the tying down wires and securing boards), the safe the software becomes. The more robust the software (i.e. LED mapping), the more optimised and error free the project becomes.

The circuit of our project includes three parts:

1. Display part(base and the rotating part):
  - Arduino(ATMEGA 328) microcontroller
  - DC motor
  - LEDs
2. Solar supply:
  - Solar panel
  - Solar charger
  - Battery
3. Main supply:
  - Transformer
  - Rectifier
  - LM317
  - Hardware

## IV. BLOCK DIAGRAM

### 4.1 Display circuit-





4.2 Solar supply:



4.3 Main supply:



## V. IMPLEMENTATION RESULTS

We had many troubleshooting to implement throughout the project. Our first prototype was not capable of working due to many hardware issues. We were using a mantle in the following image: Afterwards, we decided to use a better mantle and have the lights rotate on a strip of plastic piece from a binder. However this led us to conclude that the plastic is not firm enough but reinforced it with a stronger piece of plastic. Our biggest troubleshooting issue we had was dealing with the spinning of the globe. The motor we used at first has enough speed but does not have enough torque to push the weight of the whole mantle in to the spinning motion.

### 5.1 Mechanical design:

Major mechanical challenge we faced was designing a robust rotating system capable of transmitting power to the display circuitry. The mechanical system also had to be sufficiently reliable to withstand multiple tests at a minimum rotation speed of 1200 rpm to achieve POV.

Our POV display use fixed speed motor. To create a platform to hold our LED array and circuit board, we clamped two flat Aluminium plate with semi-circular hole together around the shaft and held them tightly with screws and lock nuts. We used small L-shaped connectors from an erector set to both attach a circular plastic base to the sheet metal and mount LED array. The LED array consisted of 7 LED's through small drilled holes on the PCB strand.

### 5.2 Electrical Design:

The main challenge when designing the electrical system was to control 7 LED's, with Arduino ATmega328 for 2-dimensional display. To accomplish this, LED's are split into 5 columns of 7 LED's each which could be selectively turned on and off by synchronizing the flashing of LED's and rotation of the DC motor. The main component of electrical system was the timing system and LED control system for 7 LED's using Arduino.

### 5.3 Firmware Design:

In order to achieve POV, the rotating of LED's must be turned on and off at short controlled time intervals. We initially attempted to control the timing using interrupts, but determined that manual control of motor speed by adjusting input current was sufficient for the display and added more flexibility in creating the display. Another key challenge that we encountered when developing the firmware for our system was storage space in ATmega microcontroller.

In programming the microcontroller, we had to consider the synchronization for appropriate display. We had to consider the flashing of LED timing by increasing or decreasing the number of instruction cycles to introduce delay between switching of LED's. Moreover, adjusting rotational speed by controlling the power input to the motor in order to allow flexibility in display was also a challenging task.

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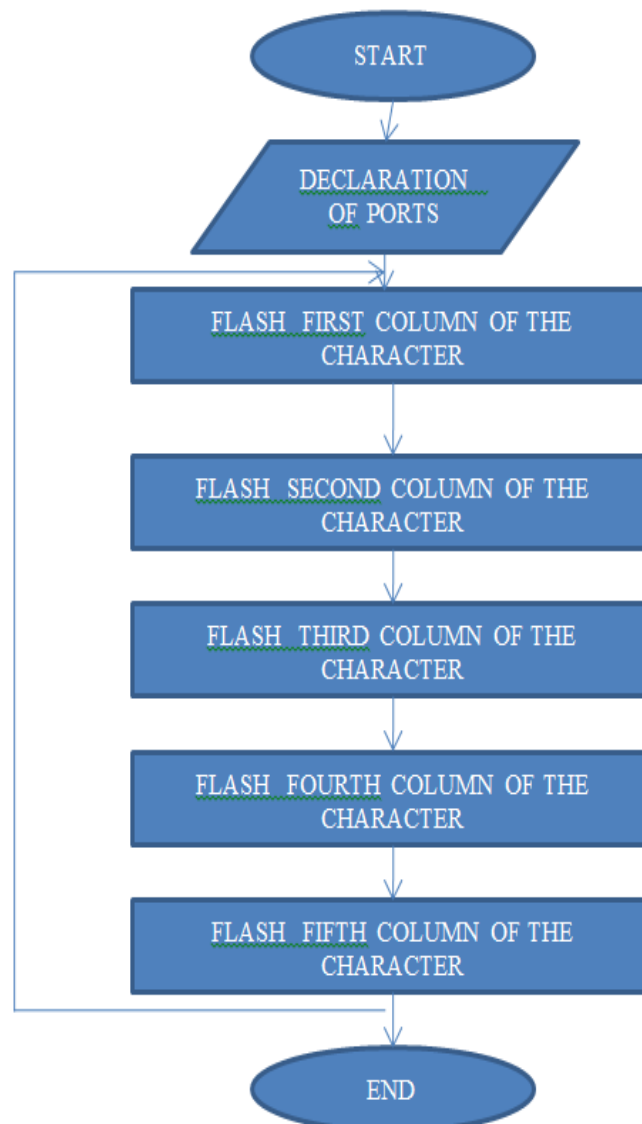
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## 5.4 Software design:

The final consideration of our project was user interactivity. While commercial POV display present a static image, our display was intended to be customized.

Another challenging aspect of the project was finalizing a mechanical system in time to test the functionality of our electrical and software systems. Since we were not mechanically inclined, this took a large amount of time for us and limited our ability to build in additional capabilities to the display.

## 5.5 Flowchart:





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## 5.6 Advantages

The more attractive the message will be, the more people will get influenced by it. The main motive of our project is to make the advertising media an effective one. Following are the areas in which POV plays a unique role:

1. Advertising
2. Education
3. Entertainment
4. Animation
5. Propeller Clock
6. Toys And Games
7. Malls
8. 3-D Display

## 5.7 Applications

Advertisement industries think that they can change the way of advertising their products through LED displays, both for indoor and outdoor use. LED displays with customized panel of any shape or size, which can work in day or night and even under heavy rains, integrated with world-class software, extra-energy-saving for 24/7 operations and specialized in weather-proof casing prove beneficial to advertisement industries. Hording displays which work on the basis of POV displays are large boards for displaying ads on the roadside, often on a temporary wooden fence or demolition site. They are similar to posters but on larger scale. As a form of outdoor advertising, hording display provides a very effecting way of reaching audiences quickly and is particularly effective at targeting local residents and niche markets with proven results.

1. POV display has a very active application in digital electronics. The application of this device can be found everywhere. From the name plate display to the train number display.
2. The power consumption is 70% less than the primitive displays.
3. Another advantage of this display is that the information displaying on the display can easily be changed by changing the program in the microcontroller.
4. Even animation and 3D displays are possible. It is undoubtedly acceptable worldwide.
5. It is cost effective. The LED in this device is red LED having a wavelength of 660nm. Hence the messages displayed can be seen from large distances.
6. Propeller clocks can be displayed on airports, railway-stations with lesser cost and lesser hardware.
7. If Persistence of vision is used in education field it will provide a better way for interactive education. Many concept need to be explained in three dimension view that can be easily demonstrated by the help of this persistence of vision.

## VI. CONCLUSION

This project has taught both of us how to construct creative attracting displays using Arduino hardware and software more than what we expected. We also learned how to save and use efficient supplies to stay on a reasonable budget. But most of all when we ran into many issues and problems, time management did come into play and I believe we dealt with the management in a reasonable manner. The whole project itself helped improve our mechanical and electrical skills in various ways. The persistence of vision taught us how the technology works since we never made anything in the past related to POV. The POV display can be mostly used for many entertainment purposes such as displaying time and date or name of a logo or motto or even an image of decorating lights.

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## Future scope

1. An innovative evolution of POV display known as JANUS display is the advancement in POV display. It is being developed by “Design media and HCI labs of KAIST in Darjon, South Korea aims to expand upon both the functionality and practicality of these devices.
2. The present POV display features a single LED array facing towards one viewer is potentially problematic for any one viewing the image from the other side- it will appear inverted. The JANUS display includes a secondary arm on the opposing side of the device which allows for two viewers to observe the image from either of the sides.
3. JANUS display also includes direct interaction by placing two sheets of plexiglass between the observer and the blade so this evolves a new development- one might even go so far as to say that it is holographic imager. This advanced implementation of present POV display is certainly a unique concept, one can come up with plenty of interesting ideas to take advantage of it and this may lead to future of display technologies.
4. Ultra low cost solar rechargeable POV display this produces a bright and eye catching display to write text and small images through the air. It has built in RC clock and uses a small rechargeable battery and solar cell which are typically pricey items, but currently there is a huge flood of keying-sized cheap solar powered torches from China.
5. Advancement of 7\*5 display is to develop 7\*8 LED display that spins to create 3D POV display. This display includes a hand full of pre-set images defined by user which could be enhanced with 3D visual effects like rotation. A GUI (Graphical User Interface) is created that allows the user to draw the image or text they want to show. It can also create static images and small frame animations by controlling the speed of display rotation

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