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# Persistence Of Vision Display- A Review

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***Abstract:*** *Persistence of vision technology has gained immense popularity in the field of electronics due to its wide range of applications and ease of usage. Persistence of vision (POV) refers to the phenomenon of the human eye in which an afterimage exists for a brief time. A POV display exploits this phenomenon by spinning a one dimensional row of LED's through a two dimensional space at such a high frequency that a three dimensional display is visible. The LED matrix is connected to the Raspberry Pi, which is fast & programmable credit card sized computer. The display is user-friendly when interfaced with a touch pad compatible with the Raspberry Pi. The touch pad ensures that no programming has to be done at a user level and so the device gives rise to a very new, hassle-free type of display devices.*

***Keywords:*** *Persistence of Vision (POV), Raspberry Pi(R-Pi), RGB LEDs, Python, Slip Rings*

## I. Introduction

Persistence of Vision is a kind of optical illusion in which the human mind combines a series of images into one motion picture[1]. The human eye has a capability of retaining an image for $1/16^{th}$ of a second. If the images are displayed at a faster rate than what the human eye can retain, then the eye converges all the images into one moving object. It is the way in which the human eye blends the image of the things happening now with what had occurred a fraction of second ago.

Display devices acts as an interface between hardware/software components and viewers. It is an important parameter determining the effectiveness of machine component based on user reviews, thus interconnecting user with machine.POV display device is one among those ; it projects a 2D image into a 3D figure by use of RGB LED'S and Raspberry pi which has changed the outlook of perceiving things. Use of R-pi and RGB LED'S has made the entire process efficient. It captivates the attention of viewers by projecting a seemingly difficult concept in visual form. It is based on an age old concept of POV with varied futuristic application

## II. Hardware Components

### 1.1 Brushless DC Motor

It makes the entire operation more efficient, effective and less noisy as compared to brushed DC Motor. They are comparatively lighter for the same power output developed. The Brushes wear out during prolonged usage and thus are not reliable, thus BLDC is the suitable alternative. In BLDC the rotor acts as an permanent magnet and stator windings as the electromagnet. Soon as the current is passed through the coils of stator it becomes an electromagnet and thus operation of BLDC is based on interaction between permanent magnet (rotor) and electromagnet (stator).

The rotation is controlled by energizing the respective coils of the stator winding so as to maintain constant torque requirement. In order to control the energizing of coils a Hall Effect sensor cum controller is used.

### 1.2 Framework

The framework mostly consists of a base onto which the entire setup is mounted and a vertical bar serving as the axis to the rotating Printed Circuit Board on which LED'S are placed. The vertical bar contains the R-PI along it length. The framework ensures sufficient rigidity to absorb the vibration due rotation of rings at high rpm. Thus framework functions as the supporting structure to make it sturdy and also ensures safe operation within prescribed limits.

### 1.3 Slip Rings

Slip rings or Rotary actuators are used to transmit electrical signals from stationary (Frame) to rotating structure (Printed circuit board), thus establishing an electrical connection rotating assembly. It consists of a stationary graphite or metal contact (brush) which rubs on the outside diameter of a rotating metal ring. As the metal ring turns, the electric current or signal is conducted through the stationary brush to the metal ring making

the connection. This simple design has been used for decades as a method of passing current into a rotating device reason being it's simplicity of operation and cost effectiveness.

### 1.4 RGB LEDs

An RGB LED is capable of generating any colour. The LED comprises the basic primary colours namely red, green and blue LEDs each of which can be controlled by a Raspberry-Pi. It is a four terminal device with one terminal being the common terminal and the other terminals belonging to the respective Red, Green and blue colours. Since the two legs on the LED that supply the power are connected to the R-Pi and not the LED elements a current limit resistor is not required.

The R-Pi is able to turn each of the colours on or off, so if the red LED is turned on then the output from the colour changing LED is red. When the blue LED is turned on it is blue, if both the blue and red LEDs are turned on then the colour changing LED is a shade of purple (called magenta). Similarly combining red with green gives yellow and blue & green gives cyan. Although the colour changing LED uses the six colours mentioned above, it slowly changes from one to another. This is still done using the three basic red, green & blue elements. Thus it is possible to generate any desired colour by changing voltages across the RGB terminals of the LED.

### 1.5 Optocouplers

An opto-coupler contains a source of light or LED (emitter) which emits infrared light. This LED converts the incoming electrical signals into the infrared light. The opto coupler also contains a photo detector or an infrared detector which on receiving the infrared light from the transmitter, generates an electrical pulse thereby acting like a light to electric pulse convertor. The photo detector can be any device like a photo transistor, photo diode, SCR or triac etc. As LEDs can emit as well as receive the light they are suitable for designing symmetrical, bi-directional opto-couplers.

### 1.6 Power Supply

The power supply used is a regulated power supply which is capable of giving two different voltages for the DC motor and the Raspberry Pi and LED circuitry respectively. The specifications of the power supply are:

1.6.1 Input supply: 230V AC, 50Hz supply.
1.6.2 Output 1: 5V DC.
1.6.3 Output 2: 12V DC.

The 5V supply is required for the Raspberry Pi and the 12V DC is required by the DC motor.

### 1.7 Raspberry PI

The Raspberry Pi shown in Fig. 1 is a series of credit card-sized single-board computers. The Raspberry Pi is based on the Broadcom BCM2835 system on a chip (SoC), which includes a 700 MHz ARM1176JZF-S processor, VideoCore IV GPU, and RAM. It has a Level 1 cache of 16 KB and a Level 2 cache of 128 KB.

The Level 2 cache is used primarily by the GPU. The video controller is capable of standard modern TV resolutions, such as HD and Full HD, and higher or lower monitor resolutions and older standard CRT TV resolutions; capable of the following: 640×350 EGA; 640×480 VGA; 800×600 SVGA; 1024×768 XGA; 1280×720 720p HDTV[2].

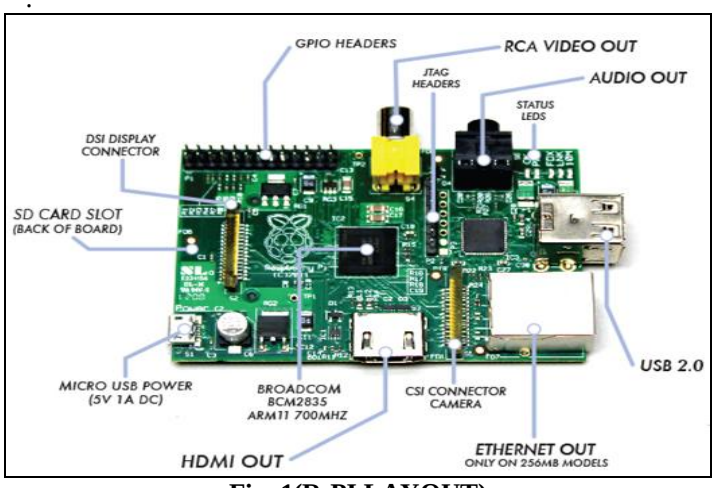


**Fig. 1(R-PI LAYOUT)**

### 1.8 Python Programming

The Python programming language is an Open Source, cross-platform, high level, dynamic, interpreted language. The Python 'philosophy' emphasises readability, clarity and simplicity, whilst maximising the power and expressiveness available to the programmer. The ultimate compliment to a Python programmer is not that his code is clever, but that it is elegant. For these reasons Python is an excellent 'first language', while still being a powerful tool in the hands of the seasoned and cynical programmer. Python is a very flexible language.

Python programs are just text files that contain instructions for the Python interpreter. You can create them with any text editor (including notepad), or a programmer's text editor called an IDE: Integrated Development Environment. IDEs for Python will often have useful built in tools like syntax checkers, debuggers, code browsers and much more.

## III. Working

When the power is turned on it is transmitted to the DC motor and to the Raspberry pi via the slip rings. In the slip rings there is a stationery graphite brush which rubs on the outer diameter of the rotating metal ring. When the graphite brush gets the supply, it transfers it to the rotating PCB structure on which the LEDs are soldered.

When the main circuit containing the raspberry pi gets the power supply, it turns on the opto-coupler. The Opto-couplers are used to count the rotation and they are used to determine as to which LED should turn on at what time and should be in "On" state for how much time. The opto coupler has two parts; the transmitter and the receiver. The transmitter is fixed on the stationery rod that is used to give support to the entire display and the receiver part of the opto-coupler is placed on the rotating PCB. The opto-coupler transmitter starts transmitting the IR signals as soon as the display starts rotating.

The advantage of using a PCB to mount LED matrix instead of an aluminium ring is that the weight of the whole structure is reduced and the amount of wiring required to connect each row of LED is also reduced as the PCB has printed copper tracks on it. This reduction in the wiring allows the structure to rotate freely due to the reduced wind resistance. Thus, using a PCB increases the stability of the display.

In order to make the device user-friendly we have made use of a touch screen panel and Raspberry-Pi, the user has to just draw the pattern directly on the touch pad and it will be converted by the R-pi and it will get displayed on the display device. The touch pad is already divided into an array of several pixels. Each pixel in the array corresponds to an LED in the display matrix. When a pattern is drawn on the touch pad, the R-Pi checks each pixel for any pattern on it if it finds any then that corresponding LED is switched on for that moment depending position of that LED on the rotation of the display.

Each LED on the display is on for a specific time and then switched off. The on and off time is decided according to the pattern to be displayed. So for the Processor to know about the exact location of the LED, the opto-coupler plays a very crucial role. Without it the pattern will get distorted as the proper location will not be received by the processor.

Therefore the only program that is to be stored in the memory of the Raspberry-pi is the program to convert the pattern on the touch pad onto the display and to count the rotations of the display using the opto-coupler so that the R-pi can know the exact location of the particular LED on the LED matrix.

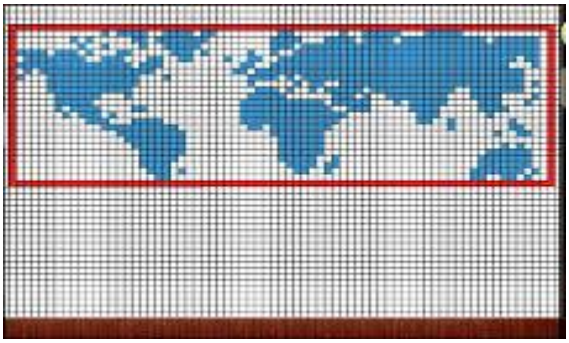

**Fig. 2(Mapping of Pixels on Touchpad)**

The Raspberry Pi can give video outputs only in two forms one is the normal VGA form and the other being HDMI format. But the LED POV display is not capable of processing the HDMI output signals, so a FPGA Decoder is used to convert these HDMI signals into suitable format which can be displayed using the RGB LEDs. The opto-couplers are integral to the Display as they give the raspberry pi the accurate position of each of the LEDs.

## IV. Applications

The POV Display is basically a display device so it finds applications in the field of computing, information exchange and entertainment[3].

4.1 The Display can be used as an interactive medium to make students learn about various concepts in educational institutions, that is, they can be used in e-class or e-learning. As this display has the ability to display images in a 3 dimensional manner, they can be used in educational institutions for better understanding and higher imagination.

4.2 The Raspberry Pi is directly interfaced with the touchscreen peripheral. This touchscreen peripheral can be connected to the GPIOs pins of the raspberry pi as shown in Fig.3. Once this touchscreen is interfaced it can be used for displaying any pattern directly on the POV display by merely drawing it on the touch screen. This touch screen has many advantages that will save the memory usage on the raspberry pi as the pattern to be generated need not be stored beforehand. It will also become easy for the consumers to use the display as no prior knowledge about programming is needed, as the pattern can be directly drawn.

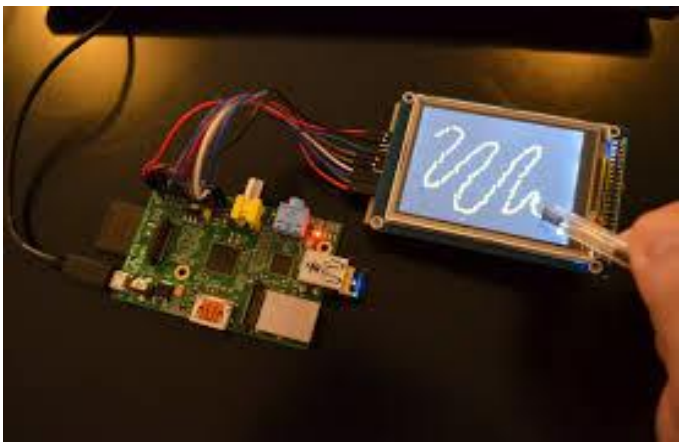

**Fig. 3(Interfacing R-pi with Touchpad )**

4.3 Along with the LEDs a row of proximity sensors will allow the consumers to actually pinpoint location or images on the display. As the display will be continuously rotating therefore touching it directly is not possible, so the use of proximity sensors can greatly help the viewers to enhance their viewing experience. For example, if we display a globe and want the information of a specific place on the globe then we can just pinpoint the location and the information about that place can be displayed.

4.4 The POV Display can act as an emulator screen. Emulators are used to run older devices in the newer devices. Due to its attractive display technique the globe can be used as a display device for various emulators and different gaming consoles so as to increase the gaming experience as shown in Fig.4. As it can display 2D images as 3D, the POV display will become an ideal display device for such types of consoles.


**Fig. 4(Gaming emulator)**

4.5 The POV Display can be interfaced with a wireless transmitter and the receiver[3]. The advantage of using this wireless transmitter and receiver will be that the number of wires will be reduced on the board due to which the weight and the obstruction to the flow of air in the rotating display will become less and there will be less air resistance. So the touchscreen will be connect to the transmitter side and the receiver will be inside the rotating ring with the raspberry pi. This will become more user friendly.

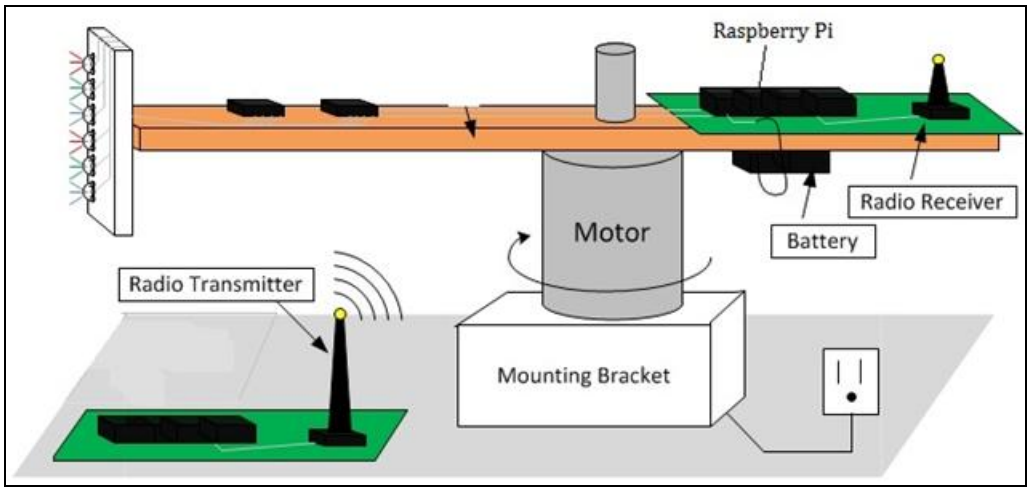


**Fig. 5(Schematic arrangement of POV display)**

## V. Advantages

**5.1** The POV Display is effective in attracting viewers with its visualization technique.
**5.2** When interfaced with a Touch screen, programming is not required as the pattern drawn on the touch pad is directly projected making it user friendly
**5.3** The proximity sensors ensure better interactive communication between the viewer and the display device.
**5.4** The ability of the display to show a 2D image in 3D is very advantageous for students to learn new concepts and understand the concept in depth.
**5.5** The display devices feature to be used as an emulator screen gives it an upper hand over conventional display devices because it increases the gaming experience due its unique way of displaying images.
**5.6** It requires a less voltage source compared to conventional display devices like CRT which requires 250V AC supply; instead the POV display requires a DC voltage of 5 V for the Raspberry PI and 24 V for the DC motor.

## VI. Disadvantages

**6.1** The stability of the POV display is very important and has to be carefully maintained. Framework must be robust and sturdy.
**6.2** As the Display is rotating it needs to be kept in a protective box to avoid any kind of disruptions to the rotating display.

## VII. Conclusion

This display device is a step into the future technology. It not only provides with a better viewing experience but it also opens new ways to change the way one has been seeing display devices. The proximity sensors can be added with each LED so as to pinpoint locations on the display without hampering the rotating ring. The touchscreen can be added in order to reduce complexity and to make it user friendly for the general public who do not possess knowledge of programming .Thus the POV devices can set up a benchmark for upcoming neoteric technologies.

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