CHAPTER 1.

INTRODUCTION

A smart mirror is a mirror that has been enhanced by technology. It is a very simple concept that is illustrated in figure 1.1. A screen is placed behind a two-way mirror 1. By using a black and white graphical user interface (GUI) only the white colors will penetrate the mirror, resulting in an effect that makes it appear as if the mirror itself is a screen. The idea of an intelligent mirror is to further this enhancement to include artificial intelligence as well.

Fig 1.1 Prototype

The ideas as to what an intelligent mirror could encompass is vast. It could encompass anything related to intelligence. It could be a mirror that recognizes people, talk to people, learns a person's habits, it could be used as a component in activity recognition as part of a smart home. Or as it is ultimately a tool used by people to see their own reflection - it could be used to analyze the emotions of the person in question. This could further be used as input for a machine learning algorithm to predict the person's current level of happiness. Or even monitor his emotions over an extended period of time to detect mental illnesses. Because a mirror is naturally used by most people at least twice a day (morning and night), it would be able to continuously monitor people's faces without requiring any explicit input. The major advances done in the fields of computer vision in recent years makes the acts of facial recognition easily available to any software developer through frameworks.

1A two-way mirror is a mirror that does not reflect 100% of the light. In other word a mirror that can be seen through. More on this is chapter 5

The resurgence of neural networks has played its part; allowing previously complex computational methods to be used by cheaper hardware available to the general public.

As such the aim is to build an intelligent mirror that can recognize people and use this to tailor the experience for each individual user. In this iteration of the project the goal is to create a user recognition system that will show a different user interface for each user.

The Raspberry Pi (RPI) will be used as an embedded device to capture video from a camera hidden behind the mirror. Further we will explore if it is possible to build a user recognition system that can run at a satisfactory level on the RPI. Alongside that a remote processing architecture will be proposed in case running the user recognition system locally on the RPI does not produce satisfactory results.

Finally, a physical prototype of the intelligent mirror will be built.

CHAPTER 2.

HARDWARES

2.1 TWO WAY MIRROR

Two-Way Mirror is the third studio album of the band Crystal Antlers. It was released by Recreation Ltd. on July 12, 2011. Former albums of the band were released by Touch and Go Records.

Features

- Flatter than the acrylic.
- 1 side reflective, other side is transparent.
- Temper able to increase its strength by 10x.
- Lead time: 1 day until shipped if 65″ x 96″ or smaller
- Durable coating can be with standard glass cleaner.
- 70% Reflective, 11% transparent for optimal privacy
- Add window tint to non-reflective side to increase privacy.

Advantages of Glass Two Way Mirror

The appearance of a glass two-way mirror depends on which side you are looking through–it is only reflective from one side. With lighting darker on the observation side, the observer is able to see straight through it, but from the other side all you see is a regular mirror. We can temper the glass to increase its strength by tenfold. The glass is rated for both indoor and outdoor use and has a highly durable coating which can be cleaned with standard glass cleaner and paper towels.

How Do Two-Way Mirrors Work?

It's a familiar scene from every police procedural: In one brightly lit room, a perp is being questioned. In an adjacent room, officers watch the proceedings in near darkness, downing cup after cup of coffee. Between the rooms is a two-way mirror, which allows the officers to watch the suspect's questioning without being seen. But how is that even possible?

(i) Traditional vs. Two-Way

Traditional mirrors are created using a process called silvering, in which a coating of a reflective material (such as silver, tin or nickel) is applied to the back of a pane of glass. After a layer of copper is added to prevent oxidation of the metal, a layer of paint is applied. It serves two purposes: to protect the reflective coating,

and to ensure that all light is reflected forward to the person standing in front of the mirror—which means that it's impossible to look through a regular mirror.

The trick of the two-way mirror is accomplished through manufacturing and lighting. To make this type of mirror (which are also sometimes referred to as one-way mirrors), a thin layer of metal—usually aluminum—is applied to the front of a pane of glass. The layer is so thin that only half of the light that hits it is reflected back; the rest goes through the pane.

(ii) Let There Be Light

In order for the mirror to work properly, one side—the interrogation room, for example—must be very bright, while the other side—the police observation room—must be dark. The bright light in the interrogation room reflects back off the mirror's surface; all a criminal sees when he looks at it is his own reflection. The observation room, meanwhile, is kept dark so that very little light is transmitted into the interrogation room. The large amount of light coming from the criminal's side is what allows the detectives to observe his activity as if they were looking through a regular tinted window. Make the light levels the same in both rooms, however—either by turning the lights in the observation room on or switching the lights in the interrogation room off—and the people in each room will be able to see into the other.There are many uses for two-way mirrors besides interrogation rooms, including teleprompters, scientific and marketing research, security cameras, and to create various stage effects.

2.2 TFT TECHNOLOGY

Thin Film Transistor (TFT full form) monitors are now popular in Computers, TV, Laptops, Mobile phones etc. It gives enhanced quality of images like contrast and address-ability. Unlike the LCD monitors, TFT monitors can be viewed from any angle without image distortion. TFT display is a form of Liquid Crystal Display with thin film transistors for controlling the image formation. Before going into the details of TFT technology, let us see how the LCD works.

Figure 2.2.1 TFT Prototype

The LCD contains Liquid crystals which is a state between liquid and solid. That is the matter can change its form from liquid to solid and viceversa. The liquid crystal flows like a liquid and it can orient to form the solid crystal. In the LCD displays, the liquid crystals used have the property of light modulation. The LCD screen do not emit light directly but it has a number of pixels filled with liquid crystals that pass light. These are arranged in front of a Back light which is the source of light. The pixels are distributed in columns and rows and the pixel behaves like a capacitor. Similar to a capacitor, the pixel has a liquid crystal sandwiched between two conductive layers. The images from The LCD may be Monochrome or colored. Each pixel is connected with a switching transistor.

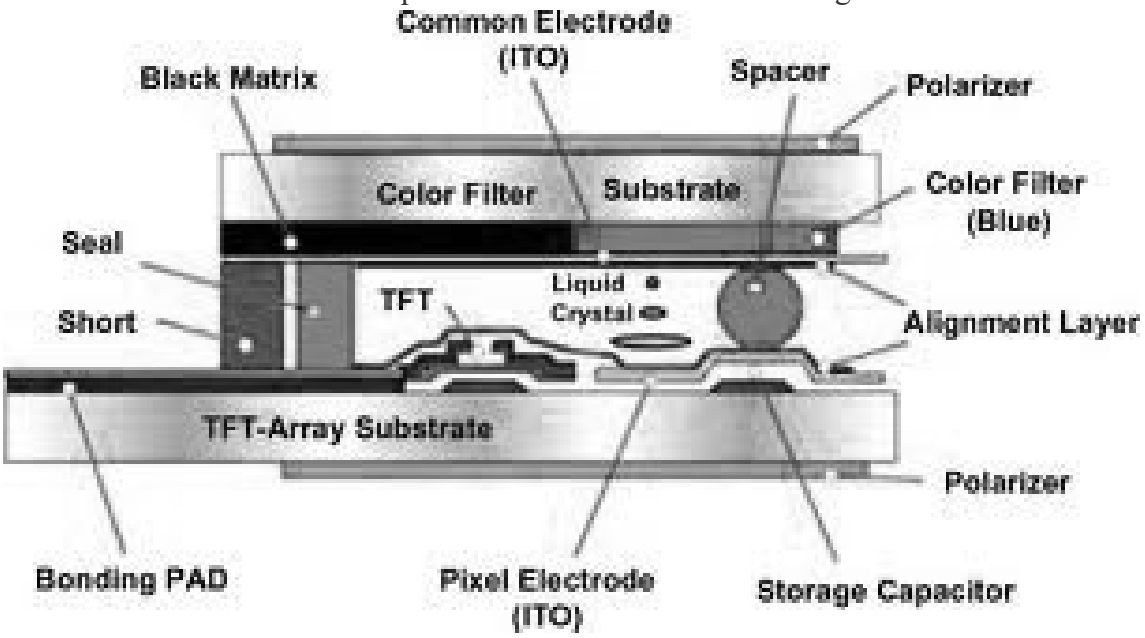


Figure 2.2.2 TFT working diagram

When compared to the ordinary LCD, TFT monitors give very sharp and crisp text with increased response time. The TFT display has transistors made up of thin films of Amorphous silicon deposited on a glass using the PECVD technology. Inside each pixel, the transistor occupies only a small portion and the remaining space allows the passage of light. Moreover, each transistor can work off at the expense of very little charge so that the image redrawing is very fast and the screen refreshes many times in a second. In a standard TFT Monitor around 1.3 million pixels with 1.3 million thin film transistors are present. These transistors are highly sensitive to voltage fluctuations and mechanical stress and will be damaged easily leading to the formation of Dots of colors. These dots without the image are called as Dead pixels. In the Dead pixels, the transistors are damaged and cannot work properly.

The Monitors using TFT are known as TFT-LCD monitors. The display of TFT monitor has two Glass substrates enclosing a layer of liquid crystal. The Front glass substrate has a color filter. The Back glass filter contains the thin transistors arranged in columns and rows. Behind the Back glass substrate, there is Back light unit that gives light. When the TFT display is charged, the molecules in the liquid crystal layer bend and allow the passage of

light. This creates a pixel. The color filter present in the Front glass substrate gives the required color to each pixel.

There are two ITO electrodes in the display to apply voltage. The LCD is placed between these electrodes. When a varying voltage is applied through the electrodes, the liquid crystal molecules align in different patterns. This alignment produces both light and dark areas in the image. This kind of image is called as Grey scale image. In color TFT monitor, the color filter substrate present in the front glass substrate gives color to the pixels. The color or grey pixel formation depends on the voltage applied by the Data driver circuit.

The Thin film transistors play an important role in pixel formation. These are arranged in the Back glass substrate. The pixel formation depends on the On/Off of these switching transistors. The switching controls the movement of electrons into the ITO electrode region. When the millions of Pixels are formed and alighted according to the switching of the transistors, millions of liquid crystal angles are created. These LC angles generates the image in the screen.

2.2.1 ORGANIC ELECTRO LUMINESCENT DISPLAY

Organic Electro Luminescent Display (OELD) is the recently evolved solid state semiconductor LED having a thickness of 100-500 nanometers. It is also called as Organic LED or OLED. It finds many applications including the displays in mobile phones, digital camera etc. The advantage of OELD is that it is much thinner than the LCD and consumes less power. OLED is composed of aggregates of Amorphous and Crystalline molecules which are arranged in an irregular pattern. The structure has many thin layers of organic material. When current passes through these thin layers, light will be emitted through the process of Electrophosphorescence. The display can emit colors like Red, Green, Blue, White etc.

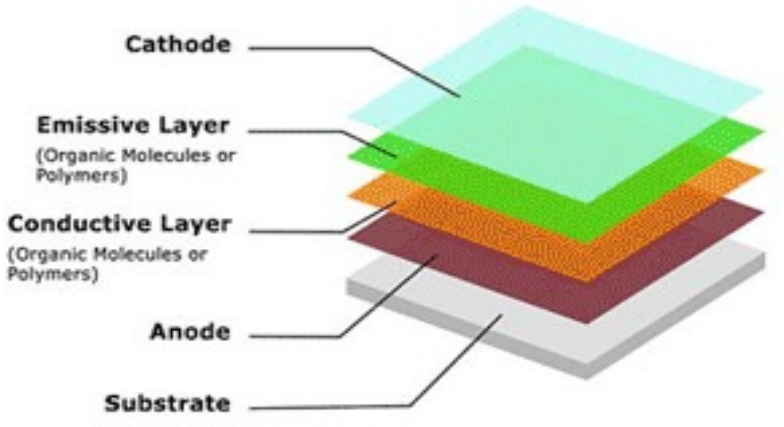


Figure 2.2.3 OLED Working Diagram

Based on the construction, OLED can be classified into

- Transparent OLED- All layers are transparent.
- Top emitting OLED – Its Substrate layer may be either reflective or non-reflective.
- White OLED – It emits only White light and makes large lighting systems.
- Foldable OLED – Ideal to make Cell phone display since it is flexible and foldable.
- Active Matrix OLED – The Anode is a transistor layer to control the pixel. All the other layers are similar to the typical OLED.
- Passive OLED – Here the external circuitry determines its pixel formation.

In function, OLED is similar to an LED but it has many active layers. Typically, there are two or three organic layers and other layers. The layers are Substrate layer, Anode layer, Organic layer, Conductive layer, Emissive layer and Cathode layer. The substrate layer is a thin transparent glass or plastic layer that supports the OLED structure. Anode later is active and removes electrons. It is also a transparent layer and is made up of Indium Tin Oxide. The organic layer is composed of Organic materials.

Conductive later is an important part and it transports the holes from the Anode layer. It is made up of organic plastic and the polymer used are Light Emitting Polymer (LEP), Polymer Light Emitting Diode (PLED) etc. The conductive layer is electroluminescent and uses the derivatives of p-phenylene Vinylene (Poly) and Ploy fluorene. The Emissive layer transports electrons from the Anode layer. It is made up of Organic plastic. The Cathode layer is responsible for the injection of Electrons. It may be either transparent or opaque. To make Cathode layer, Aluminum and Calcium are used.

OLED gives excellent display than the LCD and the pictures can be viewed from any angle without distortion. The process of light emission in the OLED involves many steps. When a potential difference is applied between the Anode and Cathode layers, current flows through the Organic layer. During this process, the Cathode layer emits electrons into the Emissive layer. The Anode layer, then releases electrons from the conductive later and the process generates holes. At the junction between the Emissive and the conductive layers, the electrons combine with the holes. This process releases energy in the form of Photons. Color of the Photon depends on the type of material used in the Emissive layer.

2.2.2 IN-PLANE SWITCHING (IPS)

In-plane switching was developed by Hitachi Ltd. in 1996 to improve on the poor viewing angle and the poor color reproduction of TN panels at that time. Its name comes from the main difference from TN panels, that the crystal molecules move parallel to the panel plane instead of perpendicular to it. This change reduces the amount of light scattering in the matrix, which gives IPS its characteristic wide viewing angles and good color reproduction.

Initial iterations of IPS technology were characterized by slow response time and a low contrast ratio but later revisions have made marked improvements to these shortcomings.

Because of its wide viewing angle and accurate color reproduction (with almost no off-angle color shift), IPS is widely employed in high-end monitors aimed at professional graphic artists, although with the recent fall in price it has been seen in the mainstream market as well. IPS technology was sold to Panasonic by Hitachi.

Safety

Liquid crystals are constantly subjected to toxicity and eco-toxicity testing for any hazard potential. The result is that:

- wastewater from manufacturing is acutely toxic to aquatic life.
- but may have an irritant, corrosive or sensitizing effect in rare cases. Any effects can be avoided by using a limited concentration in mixtures,
- are not mutagenic – neither in bacteria (Ames test) nor in mammalian cells (mouse lymphoma assay or chromosome aberration test),
- are not suspected of being carcinogenic?
- are hazardous to aquatic organisms (bacteria, algae, daphnia, fish).
- do not possess any significant bioaccumulation potential,
- are not easily biodegradable.

The statements are applicable to Merck KGaA as well as its competitors JNC Corporation (formerly Chisso Corporation) and DIC (formerly Dainippon Ink & Chemicals). All three manufacturers have agreed not to introduce any acutely toxic or mutagenic liquid crystals to the market. They cover more than 90 percent of the global liquid crystal market. The remaining market share of liquid crystals, produced primarily in China, consists of older, patent-free substances from the three leading world producers and have already been tested for toxicity by them. As a result, they can also be considered non-toxic.

The CCFL backlights used in many LCD monitors contain mercury, which is toxic**.**

Feature

Features of TFT Displays. TFT stands for thin-film-transistor, which is a variant of liquid **crystal display** (LCD). TFTs are categorized as active matrix LCDs, which means that they can simultaneously retain certain pixels on a screen while also addressing other pixels using minimal amounts of energy.

2.3 RASPBERRY PI

Figure 2.3.1 Raspberry Pi 3 Model B+

Also known as	R Pi
Release date	29 February 2012; 7 years ago
Introductory price	US$35
Operating system	FreeBSD, Linux, Net BSD, Open BSD, Plan 9, RISC OS, Windows 10 ARM64, Windows 10 IOT Core
System-on-chip used	Broadcom BCM2837B0
CPU	1.4 GHz 64/32-bit quad-core ARM Cortex-A53
Memory	1 GB LPDDR2 RAM at 900 MHz
Storage	Micro SDHC slot
Graphics	Broadcom Video Core IV 300 MHz/400 MHz
Power	1.5 W (average when idle) to 6.7 W (maximum under stress)

TABLE 2.3.1 Raspberry Pi 3 Model B

The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote teaching of basic computer science in schools and in developing countries. The original model became far more

popular than anticipated, selling outside its target market for uses such as robotics. It does not include peripherals (such as keyboards and mice) and cases. However, some accessories have been included in several official and unofficial bundles.

The organization behind the Raspberry Pi consists of two arms. The first two models were developed by the Raspberry Pi Foundation**.** After the Pi Model B was released, the Foundation set up Raspberry Pi Trading, with Eben Upton as CEO, to develop the third model, the B+. Raspberry Pi Trading is responsible for developing the technology while the Foundation is an educational charity to promote the teaching of basic computer science in schools and in developing countries.

According to the Raspberry Pi Foundation, more than 5 million Raspberry Pis were sold by February 2015, making it the best-selling British computer. By November 2016 they had sold 11 million units, and 12.5m by March 2017, making it the third best-selling "general purpose computer". In July 2017, sales reached nearly 15 million. In March 2018, sales reached 19 million

Most Pi s are made in a Sony factory in Pen coed, Wales; some are made in China or Japan.

Generations of released models

Figure 2.3.2 The Raspberry Pi Zero, a US$5 model first introduced in 2015

Several generations of Raspberry Pi s have been released. All models feature a Broadcom system on a chip (SOC) with an integrated ARM-compatible central processing unit (CPU) and on-chip graphics processing unit (GPU).

Processor speed ranges from 700 MHz to 1.4 GHz for the Pi 3 Model B+; on-board memory ranges from 256 MB to 1 GB RAM. Secure Digital (SD) cards in Micro SDHC form factor (SDHC on early models) are used to store the operating system and program memory. The boards have one to four USB ports. For video output, HDMI and composite

video are supported, with a standard 3.5 mm tip-ring-sleeve jack for audio output. Lower-level output is provided by a number of GPIO pins, which support common protocols like I²C. The B-models have an 8P8C Ethernet port and the Pi 3 and Pi Zero W have on-board Wi-Fi 802.11n and Bluetooth. Prices range from US$5 to $35.

The first generation (Raspberry Pi 1 Model B) was released in February 2012, followed by the simpler and cheaper Model A. In 2014, the Foundation released a board with an improved design, Raspberry Pi 1 Model B+. These boards are approximately credit-card sized and represent the standard *mainline* form-factor. Improved A+ and B+ models were released a year later. A "Compute Module" was released in April 2014 for embedded applications. The Raspberry Pi 2, which added more random-access memory, was released in February 2015.

A Raspberry Pi Zero with smaller size and reduced input/output (I/O) and general-purpose input/output (GPIO) capabilities was released in November 2015 for US$5. By 2017, it became the newest mainline Raspberry Pi. On 28 February 2017, the Raspberry Pi Zero W was launched, a version of the Zero with Wi-Fi and Bluetooth capabilities, for US$10. On 12 January 2018, the Raspberry Pi Zero WH was launched, a version of the Zero W with pre-soldered GPIO headers.

Raspberry Pi 3 Model B was released in February 2016 with a 1.2 GHz 64-bit quad core processor, on-board Wi-Fi, Bluetooth and USB boot capabilities. On Pi Day 2018 the Raspberry Pi 3 Model B+ was launched with a faster 1.4 GHz processor and a three-times faster gigabit Ethernet (throughput limited to ca. 300 Mbit/s by the internal USB 2.0 connection) or 2.4 / 5 GHz dual-band Wi-Fi (100 Mbit/s). Other features are Power over Ethernet (POE), USB boot and network boot (an SD card is no longer required).

Family	Model	Form Factor	Ethernet	Wireless	GPIO	Released	Discontinued
Raspberry Pi 1	B	Standard (85.60 × 56.5 mm)	Yes	No	26-pin	2012	Yes
	A		No			2013	Yes
	B+		Yes		40-pin	2014	
	A+	Compact (65 × 56.5 mm)	No			2014	
Raspberry Pi 2	B	Standard	Yes	No		2015	
Raspberry Pi Zero	Zero	Zero (65 × 30 mm)	No	No		2015	
	W/WH			Yes		2017	
Raspberry Pi 3	B	Standard	Yes	Yes		2016	
	A+	Compact	No			2018	
	B+	Standard	Yes			2018	

Table 2.3.2 RPI Model Description

The Raspberry Pi hardware has evolved through several versions that feature variations in memory capacity and peripheral-device support.

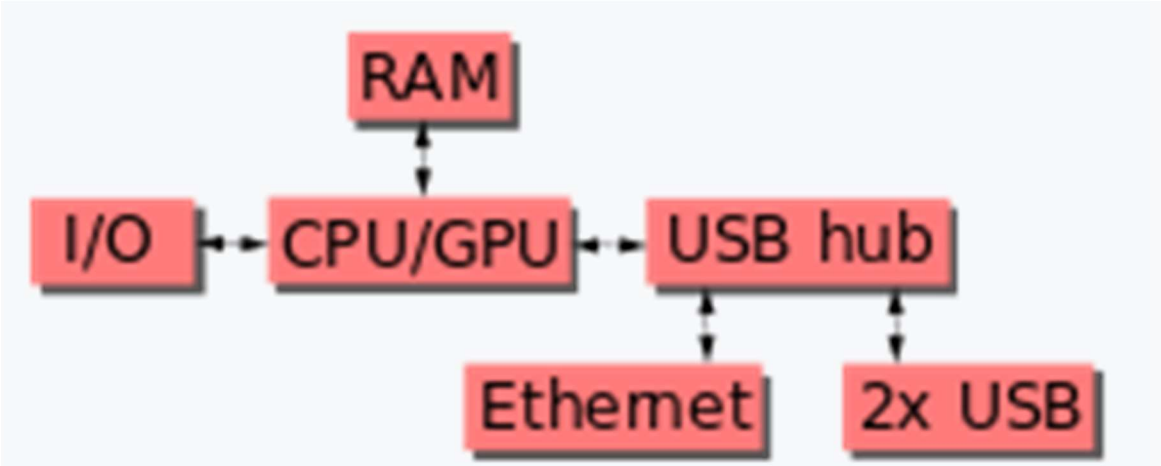


Figure 2.3.3 RPI B And B+ Block Diagram

This block diagram describes Model B and B+; Model A, A+, and the Pi Zero are similar, but lack the Ethernet and USB hub components. The Ethernet adapter is internally connected to an additional USB port. In Model A, A+, and the Pi Zero, the USB port is connected directly to the system on a chip (SOC). On the Pi 1 Model B+ and later models the USB/Ethernet chip contains a five-port USB hub, of which four ports are available, while the Pi 1 Model B only provides two. On the Pi Zero, the USB port is also connected directly to the SOC, but it uses a micro USB (OTG) port.

Processor

Figure2.3.4 Raspberry Pi 2B uses a 32-bit 900 MHz quad-core ARM Cortex-A7processor.

The Broadcom BCM2835 SOC used in the first generation Raspberry Pi[20] includes a 700 MHz ARM11 76JZF-S processor, Video Core IV graphics processing unit (GPU),[21] and RAM. It has a level 1 (L1) cache of 16 KB and a level 2 (L2) cache of 128 KB. The level 2 cache is used primarily by the GPU. The SOC is stacked underneath the RAM chip, so only its edge is visible. The 1176JZ(F)-S is the same CPU used in the original iPhone, although at a higher clock rate, and mated with a much faster GPU.

The earlier V1.1 model of the Raspberry Pi 2 used a Broadcom BCM2836 SOC with a 900 MHz 32-bit, quad-core ARM Cortex-A7 processor, with 256 KB shared L2 cache. The Raspberry Pi 2 V1.2 was upgraded to a Broadcom BCM2837 SOC with a 1.2 GHz 64-bit quad-core ARM Cortex-A53 processor, the same SOC which is used on the Raspberry Pi 3, but under clocked (by default) to the same 900 MHz CPU clock speed as the V1.1. The BCM2836 SOC is no longer in production as of late 2016.

The Raspberry Pi 3+ uses a Broadcom BCM2837B0 SOC with a 1.4 GHz 64-bit quad-core ARM Cortex-A53 processor, with 512 KB shared L2 cache.

Performance

While operating at 700 MHz by default, the first generation Raspberry Pi provided a real-world performance roughly equivalent to 0.041 GFLOPS. On the CPU level the performance is similar to a 300 MHz Pentium II of 1997–99. The GPU provides 1 Gpixel/s or 1.5 G texel/s of graphics processing or 24 GFLOPS of general purpose computing performance. The graphical capabilities of the Raspberry Pi are roughly equivalent to the performance of the Xbox of 2001.

Raspberry Pi 2 V1.1 included a quad-core Cortex-A7 CPU running at 900 MHz and 1 GB RAM. It was described as 4–6 times more powerful than its predecessor. The GPU was identical to the original. In parallelised benchmarks, the Raspberry Pi 2 V1.1 could be up to 14 times faster than a Raspberry Pi 1 Model B+.

The Raspberry Pi 3, with a quad-core ARM Cortex-A53 processor, is described as having ten times the performance of a Raspberry Pi 1. This was suggested to be highly dependent upon task threading and instruction set use. Benchmarks showed the Raspberry Pi 3 to be approximately 80% faster than the Raspberry Pi 2 in parallelised tasks.

Overclocking

Most Raspberry Pi systems-on-chip could be overclocked to 800 MHz, and some to 1000 MHz. There are reports the Raspberry Pi 2 can be similarly overclocked, in extreme cases, even to 1500 MHz (discarding all safety features and over-voltage limitations). In the Raspbian Linux distro the overclocking options on boot can be done by a software command running "sudo raspi-config" without voiding the warranty. In those cases the Pi automatically shuts the overclocking down if the chip temperature reaches 85 °C (185 °F), but it is possible to override automatic over-voltage and overclocking settings (voiding the warranty); an appropriately sized heat sink is needed to protect the chip from serious overheating.

Newer versions of the firmware contain the option to choose between five overclock ("turbo") presets that when used, attempt to maximise the performance of the SOC without impairing the lifetime of the board. This is done by monitoring the core temperature of the chip and the CPU load, and dynamically adjusting clock speeds and the core voltage. When the demand is low on the CPU or it is running too hot the performance is throttled, but if the CPU has much to do and the chip's temperature is acceptable, performance is temporarily increased with clock speeds of up to 1 GHz, depending on the board version and on which of the turbo settings is used.

The seven overclock presets are:

- none; 700 MHz ARM, 250 MHz core, 400 MHz SDRAM, 0 overvolting
- modest; 800 MHz ARM, 250 MHz core, 400 MHz SDRAM, 0 overvolting,
- medium; 900 MHz ARM, 250 MHz core, 450 MHz SDRAM, 2 overvolting,
- high; 950 MHz ARM, 250 MHz core, 450 MHz SDRAM, 6 overvolting,
- turbo; 1000 MHz ARM, 500 MHz core, 600 MHz SDRAM, 6 overvolting,
- Pi 2; 1000 MHz ARM, 500 MHz core, 500 MHz SDRAM, 2 overvolting,
- Pi 3; 1100 MHz ARM, 550 MHz core, 500 MHz SDRAM, 6 overvolting. In system information the CPU speed will appear as 1200 MHz. When idling, speed lowers to 600 MHz.

In the highest (*turbo*) preset the SDRAM clock was originally 500 MHz, but this was later changed to 600 MHz because 500 MHz sometimes causes SD card corruption. Simultaneously in *high* mode the core clock speed was lowered from 450 to 250 MHz, and in *medium* mode from 333 to 250 MHz.

The CPU on the first and second generation Raspberry Pi board did not require cooling, such as a heat sink or fan, even when overclocked, but the Raspberry Pi 3 may generate more heat when overclocked.

RAM

On the older beta Model B boards, 128 MB was allocated by default to the GPU, leaving 128 MB for the CPU. On the first 256 MB release Model B (and Model A), three different splits were possible. The default split was 192 MB (RAM for CPU), which should be sufficient for standalone 1080p video decoding, or for simple 3D, but probably not for both together. 224 MB was for Linux only, with only a 1080p framebuffer, and was likely to fail for any video or 3D. 128 MB was for heavy 3D, possibly also with video decoding (e.g. Kodi). Comparatively the Nokia 701 uses 128 MB for the Broadcom VideoCore IV.

For the later Model B with 512 MB RAM, new standard memory split files (arm256_start.elf, arm384_start.elf, arm496_start.elf) were initially released for 256 MB, 384 MB and 496 MB CPU RAM (and 256 MB, 128 MB and 16 MB video RAM) respectively. But a week or so later the RPF released a new version of start.elf that could read a new entry in config.txt (gpu_mem=*xx*) and could dynamically assign an amount of RAM (from 16 to 256 MB in 8 MB steps) to the GPU, so the older method of memory

splits became obsolete, and a single start.elf worked the same for 256 MB and 512 MB Raspberry Pis.

The Raspberry Pi 2 and the Raspberry Pi 3 have 1 GB of RAM. The Raspberry Pi Zero and Zero W have 512 MB of RAM.

Networking

The Model A, A+ and Pi Zero have no Ethernet circuitry and are commonly connected to a network using an external user-supplied USB Ethernet or Wi-Fi adapter. On the Model B and B+ the Ethernet port is provided by a built-in USB Ethernet adapter using the SMSC LAN9514 chip. The Raspberry Pi 3 and Pi Zero W (wireless) are equipped with 2.4 GHz Wi-Fi 802.11n (150 Mbit/s) and Bluetooth 4.1 (24 Mbit/s) based on the Broadcom BCM43438 Full MAC chip with no official support for monitor mode but implemented through unofficial firmware patching[41] and the Pi 3 also has a 10/100 Mbit/s Ethernet port. The Raspberry Pi 3B+ features dual-band IEEE 802.11b/g/n/ac Wi-Fi, Bluetooth 4.2, and Gigabit Ethernet (limited to approximately 300 Mbit/s by the USB 2.0 bus between it and the SOC).

Special-purpose features

The Pi Zero can be used as a USB device or "USB gadget", plugged into another computer via a USB port on another machine. It can be configured in multiple ways, for example to show up as a serial device or an ethernet device. Although originally requiring software patches, this was added into the mainline Raspbian distribution in May 2016.

The Pi 3 can boot from USB, such as from a flash drive. Because of firmware limitations in other models, the Pi 3 is the only board that can do this.

Peripherals

Figure2.3.5 The Model 2B boards incorporate four USB ports for connecting peripherals.

The Raspberry Pi may be operated with any generic USB computer keyboard and mouse. It may also be used with USB storage, USB to MIDI converters, and virtually any other device/component with USB capabilities.

Other peripherals can be attached through the various pins and connectors on the surface of the Raspberry Pi.

Video

Figure 2.3.6 The early Raspberry Pi 1 Model A, with an HDMI port and a standard RCA composite video port for older displays

The video controller can generate standard modern TV resolutions, such as HD and Full HD, and higher or lower monitor resolutions as well as older NTSC or PAL standard CRT TV resolutions. As shipped (i.e., without custom overclocking) it can support the following resolutions: 640×350 EGA; 640×480 VGA; 800×600 SVGA; 1024×768 XGA; 1280×720 720p HDTV; 1280×768 WXGA variant; 1280×800 WXGA variant; 1280×1024 SXGA; 1366×768 WXGA variant; 1400×1050 SXGA+; 1600×1200 UXGA; 1680×1050 WXGA+; 1920×1080 1080p HDTV; 1920×1200 WUXGA.

Higher resolutions, up to 2048×1152, may work or even 3840×2160 at 15 Hz (too low a frame rate for convincing video). Note also that allowing the highest resolutions does not imply that the GPU can decode video formats at these resolutions; in fact, the Pi s are known to not work reliably for H.265 (at those high resolutions), commonly used for very high resolutions (however, most common formats up to Full HD do work).

Although the Raspberry Pi 3 does not have H.265 decoding hardware, the CPU is more powerful than its predecessors, potentially fast enough to allow the decoding of H.265-encoded videos in software. The GPU in the Raspberry Pi 3 runs at higher clock frequencies of 300 MHz or 400 MHz, compared to previous versions which ran at 250 MHz.

The Raspberry Pi s can also generate 576i and 480i composite video signals, as used on old-style (CRT) TV screens and less-expensive monitors through standard connectors – either RCA or 3.5 mm phono connector depending on model. The television signal standards supported are PAL-BGHID, PAL-M, PAL-N, NTSC and NTSC-J.

Real-time clock

None of the current Raspberry Pi models have a built-in real-time clock, so they are unable to keep track of the time of day independently. Instead, a program running on the Pi can retrieve the time from a network time server or from user input at boot time, thus knowing the time while powered on. To provide consistency of time for the file system, the Pi automatically saves the current system time on shutdown, and re-loads that time at boot.

A real-time hardware clock with battery backup, such as the DS1307, may be added (often via the I²C interface). Note however that this conflicts with the camera's CSI interface, effectively disabling the camera.

Connectors

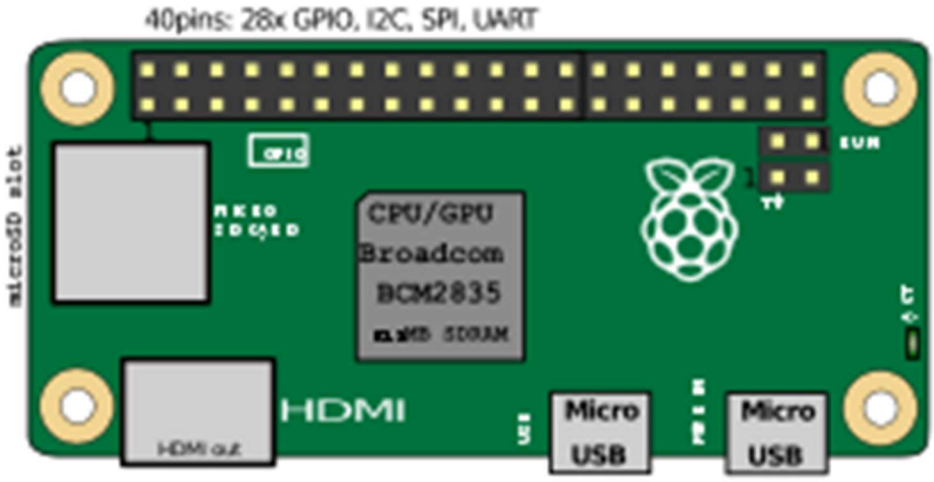


Figure2.3.7 RPI GPIO Diagram

General purpose input-output (GPIO) connector

Raspberry Pi 1 Models A+ and B+, Pi 2 Model B, Pi 3 Models A+, B and B+, and Pi Zero and Zero W GPIO J8 have a 40-pin pinout. Raspberry Pi 1 Models A and B have only the first 26 pins.

Table 2.3.3 Location of connectors and main ICs

GPIO#	2nd func.	Pin#	Pin#	2nd func.	GPIO#
	+3.3 V	1	2	+5 V	
2	SDA1 (I²C)	3	4	+5 V	
3	SCL1 (I²C)	5		GND	
4	GCLK	7	8	TXD0 (UART)	14
	GND		10	RXD0 (UART)	15
17	GEN0	11	12	GEN1	18
27	GEN2	13		GND	
22	GEN3	15	16	GEN4	23
	+3.3 V	17	18	GEN5	24
10	MOSI (SPI)	19		GND	

9	MISO (SPI)	21	22	GEN6	25
11	SCLK (SPI)	23	24	CE0_N (SPI)	8
	GND		26	CE1_N (SPI)	7
(Pi 1 Models A and B stop here)					
EEPROM	ID_SD	27	28	ID_SC	EEPROM
5	N/A	29		GND	
6	N/A	31	32		12
13	N/A	33		GND	
19	N/A	35	36	N/A	16
26	N/A	37	38	Digital IN	20
	GND		40	Digital OUT	21

Model B rev. 2 also has a pad (called P5 on the board and P6 on the schematics) of 8 pins offering access to an additional 4 GPIO connections.

Function	**2nd func.**	**Pin#**	**Pin#**	**2nd func.**	**Function**
	+5 V	1	2	+3.3 V	
GPIO28	GPIO_GEN7	3	4	GPIO_GEN8	GPIO29

GPIO30	GPIO_GEN9	5	6	GPIO_GEN10	GPIO31
	GND			GND	

Models A and B provide GPIO access to the ACT status LED using GPIO 16. Models A+ and B+ provide GPIO access to the ACT status LED using GPIO 47, and the power status LED using GPIO 35.

Accessories

- Gertboard – A Raspberry Pi Foundation sanctioned device, designed for educational purposes, that expands the Raspberry Pi's GPIO pins to allow interface with and control of LEDs, switches, analog signals, sensors and other devices. It also includes an optional Arduino compatible controller to interface with the Pi.
- Camera – On 14 May 2013, the foundation and the distributors RS Components & Premier Farnell/Element 14 launched the Raspberry Pi camera board alongside a firmware update to accommodate it. The camera board is shipped with a flexible flat cable that plugs into the CSI connector which is located between the Ethernet and HDMI ports. In Raspbian, the user must enable the use of the camera board by running Raspi-config and selecting the camera option. The camera module costs €20 in Europe (9 September 2013). It can produce 1080p, 720p and 640x480p video. The dimensions are 25 mm × 20 mm × 9 mm. In May 2016, v2 of the camera came out, and is an 8 megapixel camera.
- Infrared Camera – In October 2013, the foundation announced that they would begin producing a camera module without an infrared filter, called the Pi NoIR.
- Official Display – On 8 September 2015, The foundation and the distributors RS Components & Premier Farnell/Element 14 launched the Raspberry Pi Touch Display .
- HAT (Hardware Attached on Top) expansion boards – Together with the Model B+, inspired by the Arduino shield boards, the interface for HAT boards was devised by the Raspberry Pi Foundation. Each HAT board carries a small EEPROM (typically a CAT24C32WI-GT3) containing the relevant details of the board, so that the Raspberry Pi's OS is informed of the HAT, and the technical details of it, relevant to the OS using the HAT. Mechanical details of a HAT board, which uses the four mounting holes in their rectangular formation, are available online.

2.4 MIRROR FRAME

First, disassemble the door of the medicine cabinet, removing the mirror from the frame. The staples holding the frame together can be pulled out with needle-nose pliers.

Replace the mirror with the two-way acrylic and re-assemble the frame. (I was able to re-use the staples, but added some wood glue to be safe)

Next, tape over the bottom 1 3/4" of the back of the acrylic with electrical tape, masking off the area not covered by the monitor.

Figure 2.4.1 Prototype Frame

Add a strip of wood at the bottom of the frame to support the monitor. Attach an eye-hook to each end of the strip. Attach an eye hook in the top corners of the frame.

Figure 2.4.2 Original Frame

Also, you might want to drill ventilation holes. I added three to the top of the cabinet

Figure 2.4.3 Final Frame Structure

CHAPTER 3.

SOFTWARES

3.1 OPERATING SYSTEMS

Figure 3.1.1 Various operating systems for the Raspberry Pi can be installed on a Micro SD, Mini SD or SD card, depending on the board and available adapters; seen here is the Micro SD slot located on the bottom of a Raspberry Pi 2 board.

The Raspberry Pi Foundation provides Raspbian, a Debian-based Linux distribution for download, as well as third-party Ubuntu, Windows 10 IOT Core, RISC OS, and specialised media centre distributions. It promotes Python and Scratch as the main programming languages, with support for many other languages. The default firmware is closed source, while an unofficial open source is available.[112] Many other operating systems can also run on the Raspberry Pi, including the formally verified microkernel, seL4. Other third-party operating systems available via the official website include Ubuntu MATE, Windows 10 IOT Core, RISC OS and specialised distributions for the Kodi media centre and classroom management.

Other operating systems (not Linux-based)

- Broadcom VCOS – Proprietary operating system which includes an abstraction layer designed to integrate with existing kernels, such as Thread X (which is used on the VideoCore4 processor), providing drivers and middleware for application development. In case of Raspberry Pi this includes an application to start the ARM processor(s) and provide the publicly documented API over a mailbox interface, serving as its firmware. An incomplete source of a Linux port of VCOS is available as part of the reference graphics driver published by Broadcom.
- RISC OS Pi (a special cut down version RISC OS Pico, for 16 MB cards and larger for all models of Pi 1 & 2, has also been made available.)
- FreeBSD
- Net BSD
- Open BSD (only on 64-bit platforms, such as Raspberry Pi 3)
- Plan 9 from Bell Labs and Inferno (in beta)

- Windows 10 IOT Core – a no-cost edition of Windows 10 offered by Microsoft that runs natively on the Raspberry Pi 2.
- Haiku – an open source BeOS clone that has been compiled for the Raspberry Pi and several other ARM boards. Work on Pi 1 began in 2011, but only the Pi 2 will be supported.
- Helen OS – a portable microkernel-based multi server operating system; has basic Raspberry Pi support since version 0.6.0

Other operating systems (Linux-based)

- Android Things – an embedded version of the Android operating system designed for IOT device development.
- Arch Linux ARM – a port of Arch Linux for ARM processors.
- open SUSE
- SUSE Linux Enterprise Server 12 SP2
- SUSE Linux Enterprise Server 12 SP3 (Commercial support)
- Gentoo Linux
- Lubuntu
- Xubuntu
- Devuan
- CentOS for Raspberry Pi 2 and later
- Red Sleeve (a RHEL port) for Raspberry Pi 1
- Slackware ARM – version 13.37 and later runs on the Raspberry Pi without modification. The 128–496 MB of available memory on the Raspberry Pi is at least twice the minimum requirement of 64 MB needed to run Slackware Linux on an ARM or i386 system. (Whereas the majority of Linux systems boot into a graphical user interface, Slackware's default user environment is the textual shell / command line interface.[) The Flux box window manager running under the X Window System requires an additional 48 MB of RAM.[139]
- Kali Linux – a Debian-derived distro designed for digital forensics and penetration testing.
- SolydXK – a light Debian-derived distro with Xfce.
- Ark OS – designed for website and email self-hosting.
- Sailfish OS with Raspberry Pi 2 (due to use ARM Cortex-A7 CPU; Raspberry Pi 1 uses different ARMv6 architecture and Sailfish requires ARMv7.)
- Tiny Core Linux – a minimal Linux operating system focused on providing a base system using Busy Box and FLTK. Designed to run primarily in RAM.
- Alpine Linux – a Linux distribution based on musl and Busy Box, primarily designed for "power users who appreciate security, simplicity and resource efficiency".
- Void Linux – a rolling release Linux distribution which was designed and implemented from scratch, provides images based on musl or glibc.
- Fedora – supports Pi 2 and later since Fedora 25 (Pi 1 is supported by some unofficial derivatives, e.g. listed here.).

Driver APIs

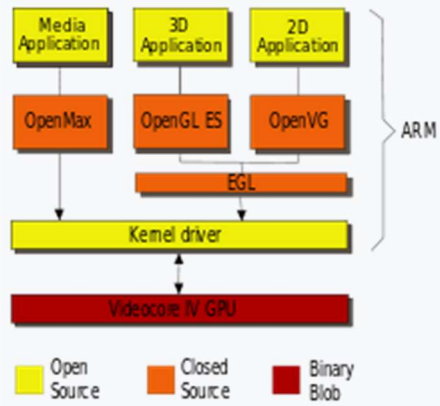


Figure3.1.2 Scheme of the implemented APIs: Open MAX, OpenGL ES and Open VG

Raspberry Pi can use a Video Core IV GPU via a binary blob, which is loaded into the GPU at boot time from the SD-card, and additional software, that initially was closed source.This part of the driver code was later released. However, much of the actual driver work is done using the closed source GPU code. Application software makes calls to closed source run-time libraries (Open Max, OpenGL ES or Open VG), which in turn call an open source driver inside the Linux kernel, which then calls the closed source Video Core IV GPU driver code. The API of the kernel driver is specific for these closed libraries. Video applications use Open MAX, 3D applications use OpenGL ES and 2D applications use Open VG, which both in turn use EGL. Open MAX and EGL use the open source kernel driver in turn.

Firmware

The official firmware is a freely redistributable binary blob, that is closed-source. A minimal proof-of-concept open source firmware is also available, mainly aimed at initializing and starting the ARM cores as well as performing minimal startup that is required on the ARM side. It is also capable of booting a very minimal Linux kernel, with patches to remove the dependency on the mailbox interface being responsive. It is known to work on Raspberry Pi 1, 2 and 3, as well as some variants of Raspberry Pi Zero. While it is in a working state, it is not actively developed, with last significant commits made around mid-2017.

Third party application software

- Astro Print – Astro Print's wireless 3D printing software can be run on the Pi 2.
- C/C++ Interpreter Ch – Released 3 January 2017, C/C++ interpreter Ch and Embedded Ch are released free for non-commercial use for Raspberry Pi, ChIDE is also included for the beginners to learn C/C++.

- Mathematica & the Wolfram Language – Since 21 November 2013, Raspbian includes a full installation of this proprietary software for free. As of 24 August 2015, the version is Mathematica 10.2. Programs can be run either from a command line interface or from a Notebook interface. There are Wolfram Language functions for accessing connected devices. There is also a Wolfram Language desktop development kit allowing development for Raspberry Pi in Mathematica from desktop machines, including features from the loaded Mathematica version such as image processing and machine learning.
- Minecraft – Released 11 February 2013, a modified version that allows players to directly alter the world with computer code.
- Real VNC – Since 28 September 2016, Raspbian includes Real VNC's remote access server and viewer software. This includes a new capture technology which allows directly-rendered content (e.g. Minecraft, camera preview and omxplayer) as well as non-X11 applications to be viewed and controlled remotely.
- User Gate Web Filter – On 20 September 2013, Florida-based security vendor Entensys announced porting User Gate Web Filter to Raspberry Pi platform.
- Steam Link – On 13 December 2018, Valve released official Steam Link game streaming client for the Raspberry Pi 3 and 3 B+.

Software development tools

- Arduino IDE – for programming an Arduino.
- Algoid – for teaching programming to children and beginners.
- Blue J – for teaching Java to beginners.
- Green foot – Green foot teaches object orientation with Java. Create 'actors' which live in 'worlds' to build games, simulations, and other graphical programs.
- Julia – an interactive and cross-platform programming language/environment, that runs on the Pi 1 and later. IDEs for Julia, such as Juno, are available. See also Pi-specific Git hub repository Julia Berry.
- Lazarus – a Free Pascal RAD IDE resembling Delphi
- Live Code – an educational RAD IDE descended from HyperCard using English-like language to write event-handlers for WYSIWYG widgets runnable on desktop, mobile and Raspberry Pi platforms.
- Ninja-IDE – a cross-platform integrated development environment (IDE) for Python.
- Object Pascal – an object oriented variant (the one used in Delphi and Lazarus) of Niklaus Wirth's original Pascal language. Free Pascal is the compiler in Lazarus
- Processing – an IDE built for the electronic arts, new media art, and visual design communities with the purpose of teaching the fundamentals of computer programming in a visual context.
- Scratch – a cross platform teaching IDE using visual blocks that stack like Lego, originally developed by MIT's Life Long Kindergarten group. The Pi version is very heavily optimised for the limited compute resources available and is implemented in the Squeak Smalltalk system. The latest version compatible with The 2 B is 1.6.
- Squeak Smalltalk – a full scale open Smalltalk.

- Tensor Flow – an artificial intelligence framework developed by Google. The Raspberry Pi Foundation worked with Google to simplify the installation process through pre-built binaries.
- V-Play Game Engine – a cross-platform development framework that supports mobile game and app development with the V-Play Game Engine, V-Play apps and V-Play plugins.
- Xojo – a cross-platform RAD tool that can create desktop, web and console apps for Pi 2 and Pi 3.
- C-STEM Studio – a platform for hands-on integrated learning of computing, science, technology, engineering, and mathematics (C-STEM) with robotics.

Community

The Raspberry Pi community was described by Jamie Ayre of FLOSS software company Ada Core as one of the most exciting parts of the project. Community blogger Russell Davis said that the community strength allows the Foundation to concentrate on documentation and teaching. The community developed a fanzine around the platform called *The Mag Pi* which in 2015, was handed over to the Raspberry Pi Foundation by its volunteers to be continued in-house.A series of community *Raspberry Jam* events have been held across the UK and around the world.

Use in education

As of January 2012, enquiries about the board in the United Kingdom have been received from schools in both the state and private sectors, with around five times as much interest from the latter. It is hoped that businesses will sponsor purchases for less advantaged schools. The CEO of Premier Farnell said that the government of a country in the Middle East has expressed interest in providing a board to every schoolgirl, to enhance her employment prospects.

In 2014, the Raspberry Pi Foundation hired a number of its community members including ex-teachers and software developers to launch a set of free learning resources for its website. The Foundation also started a teacher training course called Picademy with the aim of helping teachers prepare for teaching the new computing curriculum using the Raspberry Pi in the classroom.

In 2018, NASA launched the *JPL Open Source Rover Project*, which is a scaled down of Curiosity rover and uses a Raspberry Pi as the control module, to encourage students and hobbyists to get involved in mechanical, software, electronics, and robotics engineering.

Use in home automation

There are a number of developers and applications that are leveraging the Raspberry Pi for home automation. These programmers are making an effort to modify the Raspberry Pi

into a cost-affordable solution in energy monitoring and power consumption. Because of the relatively low cost of the Raspberry Pi, this has become a popular and economical alternative to the more expensive commercial solutions.

Use in industrial automation

In June 2014, Polish industrial automation manufacturer TECHBASE released Mod Berry, an industrial computer based on the Raspberry Pi Compute Module. The device has a number of interfaces, most notably RS-485/232 serial ports, digital and analogue inputs/outputs, CAN and economical 1-Wire buses, all of which are widely used in the automation industry. The design allows the use of the Compute Module in harsh industrial environments, leading to the conclusion that the Raspberry Pi is no longer limited to home and science projects, but can be widely used as an Industrial IOT solution and achieve goals of Industry 4.0.

In March 2018, SUSE announced commercial support for SUSE Linux Enterprise on the Raspberry Pi 3 Model B to support a number of undisclosed customers implementing industrial monitoring with the Raspberry Pi.

Use in commercial products

OTTO is a digital camera created by Next Thing Co. It incorporates a Raspberry Pi Compute Module. It was successfully crowd-funded in a May 2014 Kickstarter campaign.

Slice is a digital media player which also uses a Compute Module as its heart. It was crowd-funded in an August 2014 Kickstarter campaign. The software running on Slice is based on Kodi.

Astro Pi

A project was launched in December 2014 at an event held by the UK Space Agency. The Astro Pi competition was officially opened in January and was opened to all primary and secondary school aged children who were residents of the United Kingdom. During his mission, British ESA astronaut Tim Peake deployed the computers on board the International Space Station . He loaded the winning code while in orbit, collected the data generated and then sent this to Earth where it was distributed to the winning teams. Covered themes during the competition included Spacecraft Sensors, Satellite Imaging, Space Measurements, Data Fusion and Space Radiation.

The organisations involved in the Astro Pi competition include the UK Space Agency, UK space, Raspberry Pi, ESERO-UK and ESA.

Pre-launch

July 2011: Trustee Eben Upton publicly approached the RISC OS Open community in July 2011 to enquire about assistance with a port. Adrian Lees at Broadcom has since worked on the port, with his work being cited in a discussion regarding the graphics drivers.] This port is now included in NOOBS.

- August 2011 – 50 alpha boards are manufactured. These boards were functionally identical to the planned Model B, but they were physically larger to accommodate debug headers. Demonstrations of the board showed it running the LXDE desktop on Debian, *Quake 3* at 1080p, and Full HD MPEG-4 video over HDMI.
- October 2011 – A version of RISC OS 5 was demonstrated in public, and following a year of development the port was released for general consumption in November 2012.
- December 2011 – Twenty-five Model B Beta boards were assembled and tested[225] from one hundred unpopulated PCBs. The component layout of the Beta boards was the same as on production boards. A single error was discovered in the board design where some pins on the CPU were not held high; it was fixed for the first production run.]The Beta boards were demonstrated booting Linux, playing a 1080p movie trailer and the Right ware Samurai OpenGL ES benchmark.
- Early 2012 – During the first week of the year, the first 10 boards were put up for auction on eBay. One was bought anonymously and donated to the museum at The Centre for Computing History in Cambridge, England. The ten boards (with a total retail price of £220) together raised over £16,000,] with the last to be auctioned, serial number No. 01, raising £3,500. In advance of the anticipated launch at the end of February 2012, the Foundation's servers struggled to cope with the load placed by watchers repeatedly refreshing their browsers.

3.2 INSTALLING OPERATING SYSTEM IMAGES

This resource explains how to install a Raspberry Pi operating system image on an SD card. You will need another computer with an SD card reader to install the image.

We recommend most users download NOOBS, which is designed to be very easy to use. However, more advanced users looking to install a particular image should use this guide.

Download the image

- Official images for recommended operating systems are available to download from the Raspberry Pi website Downloads page.
- Alternative distributions are available from third-party vendors.
- If you're not using Etcher (see below), you'll need to unzip .zip downloads to get the image file (.img) to write to your SD card.

Note: the Raspbian with Raspberry Pi Desktop image contained in the ZIP archive is over 4GB in size and uses the ZIP64) format. To uncompress the archive, a unzip tool that supports ZIP64 is required. The following zip tools support ZIP64:

- 7-Zip (Windows)
- The Unarchiver (Mac)
- Unzip (Linux)

Writing an image to the SD card

- Before you start, don't forget to check the SD card requirements.
- You will need to use an image writing tool to install the image you have downloaded on your SD card.
- **Etcher** is a graphical SD card writing tool that works on Mac OS, Linux and Windows, and is the easiest option for most users. Etcher also supports writing images directly from the zip file, without any unzipping required. To write your image with Etcher:
- Download Etcher and install it.
- Connect an SD card reader with the SD card inside.
- Open Etcher and select from your hard drive the Raspberry Pi .img or .zip file you wish to write to the SD card.
- Select the SD card you wish to write your image to.
- Review your selections and click 'Flash!' to begin writing data to the SD card.

For more advanced control of this process, see our system-specific guides:

- Linux
- Mac OS
- Windows
- Chrome OS

3.3 INSTALL MAGIC MIRROR ON YOUR RASPBERRY PI

copy and paste the following into the Terminal:

```
bash -c "$(curl -sL
https://raw.githubusercontent.com/MichMich/MagicMirror/master/installers/raspberry.sh)"
```

If you get an error that says “Unable to install dependencies!” you have to install an older version of Electron:

```
sudo npm install -g electron@1.7.6
```

The installer will ask if you would like to use pm2 to automatically boot up into the Magic Mirror dashboard. type in y and press enter to confirm, since we want to make the mirror start up automatically if the power goes out, for example.

Now you’re ready to start up your Magic Mirror, so type in the following:

```
cd ~/MagicMirror

DISPLAY=:0 npm start
```

7. Make Magic Mirror automatically start when the Pi boots up

We want Magic Mirror to start up automatically, so type in the following command:

```
pm2 startup
```

A different command will appear. Run that command also.

Now create a shell script for startup. Open up the built-in text editor on the Pi by typing in:

```
cd ~
nano mm.sh
```

The lower line basically means, “open up a file called mm.sh in the nano text editor.”

When the text editor has opened, add this to the mm.sh file:

```
cd ~/MagicMirror
DISPLAY=:0 npm start
```

Exit the editor by pressing ctrl+x and type in *y* to save the file.

Make your shiny new script executable by typing in:

```
chmod +x mm.sh
```

Now start up Magic Mirror and make it start up on boot:

```
pm2 start mm.sh

pm2 save
```

Now, reboot your Pi by typing in

```
sudo reboot
```

Additional steps:

Rotate the display to portrait mode if your mirror isn't landscape:

```
sudo nano /boot/config.txt
```

Add the following line to the file:

```
display_rotate=1
```

Keep the screen from going to sleep:

```
sudo nano ~/.config/lxsession/LXDE/autostart
```

Add the following lines to that file:

```
@xset s noblank
@xset s off
@xset -dpms
```

Press ctrl+x, save the file and reboot your Pi. If all went well, Magic Mirror should start up after about 1-2 minutes. If it doesn't allow you to save, try opening the file again without the "sudo" command.

You will have to edit your config file to set up weather, calendar and other stuff.

Additional settings for best experience (optional)

Here are some additional settings you can use if your smart mirror project needs them. Just copy/type them into the terminal like before.

Rotate the screen (if you have a portrait oriented mirror):

1. edit /boot/config.txt:

```
1 sudo nano /boot/config.txt
```

2. Add the following lines to the config file:

```
1 display_rotate=1
2 avoid_warnings=1
```

3. Reboot the Raspberry pi:

```
1 sudo reboot
```

Set the mouse cursor to auto-hide mode:

Install the unclutter utility:

```
1 sudo apt-get install unclutter
```

3.4 MAGIC MIRROR MODULES

There are a *lot* of 3rd party modules available for the Magic Mirror platform that runs on the Raspberry Pi. The platform has hundreds of users that have contributed many great modules that you can add easily to your Magic Mirror. Here are 10 handpicked Magic Mirror modules that can make your life easier or just look cool on your wall. I personally use many of these ony my mirror, but not all of them.

3.4.1. MMM-SCROBBLER

Displays the music you are currently listening to, if you are using last.fm (Which I recommend as a data nerd)
This is an extension for the Magic Mirror. It displays your currently playing music. To use this module you need to have a Last.fm account and scrobble your music.

Installation

1. Navigate into your Magic Mirror's modules folder and execute git clone https://github.com/PtrBld/MMM-Scrobbler.git.

2. A new folder will appear. That's all :)

##Configuration You can scrobble all your music with Last.fm.

1. Create an account

2. Create an API key

3. Configure your client to scrobble your music. How To: Scrobble to Last.fm from iTunes, Spotify, and more

##Module Usage The entry in the module array in your config.js can look like the following. Only username and API key are mandatory fields. All other fields have default values.

```
{
        module: 'MMM-Scrobbler',

        position: 'top_right',
        config: {

                username: 'Last.fm username',

                apikey: 'Last.fm api key',

                //time interval to search for new song (every 15 seconds)
                updateInterval: 15 * 1000,
                //how often should we try to retrieve a song if not listening
                delayCount: 5,
                //time interval to search for new song if the 5 times not listening is received.
                //set this to the same number as updateInterval to ignore this option
                DelayInterval: 120*1000,
                animationSpeed: 1000,
                showAlbumArt: true,
                showMetaData: true,
                //Determines the position of the meta text. Possible values: top, bottom, left, right
                alignment: "bottom",
                }

}
```

3.4.2 PHONE NOTIFICATIONS

Show your phone notifications on your mirror.

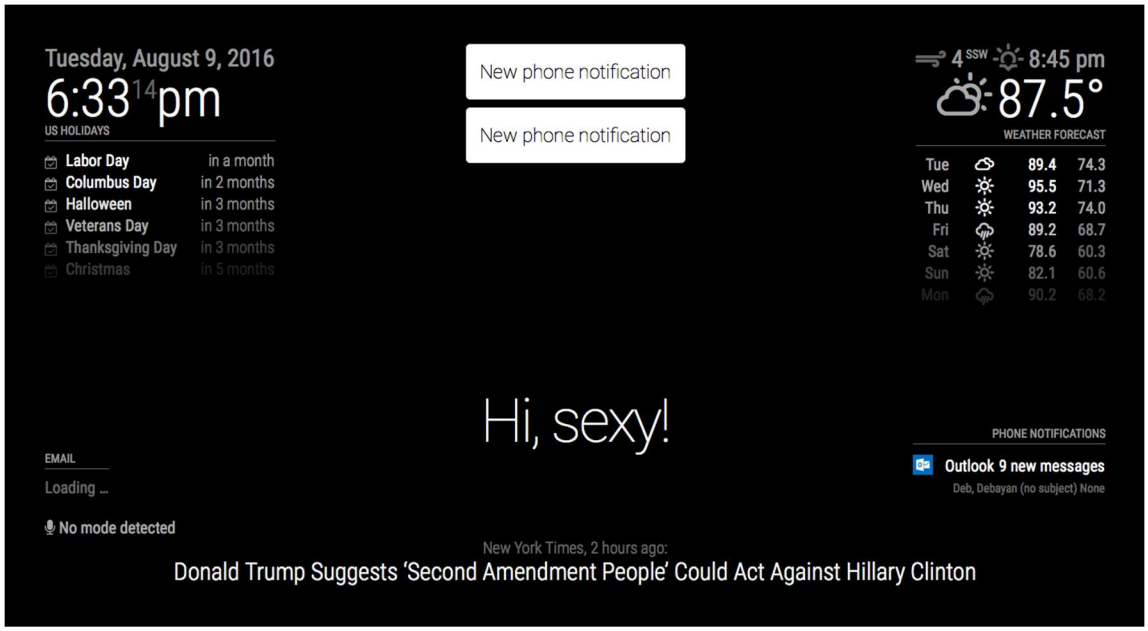


Figure 3 .4.2.1 Phone notification Prototype

Getting Started

Firstly, a Push bullet app is required on the phone. After downloading and installing the application on your phone, get a Push bullet Access Token from your Account Settings.

Installing the module

To install the module, just clone this repository to your **modules** folder: git clone https://github.com/ronny3050/phone-notification-mirror.git phone_notification. Then run cd phone_notification and npm install which will install the dependencies.

Using the module

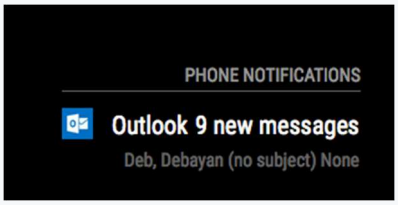
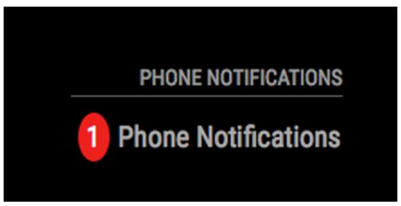
To use this module, add it to the modules array in the config/config.js file:

```
        {
                module: 'phone_notification',
    position: 'bottom_right',
    header: 'Phone Notifications',
    config:{
      access Token: 'YOUR_ACCESS_TOKEN',
      number Of Notifications: 5,
      display Notification Icon: true,
```

```
        display Message: true,
        display Count: false,
        alert: false,
        fade: true,
        max Characters: 50
    }
      },
```

Configuration options

The following properties can be configured:

Option	Description
Access Token	Your Push bullet Access Token
Number Of Notifications	Number of notifications to display at a time **Default value:** 5 If set to 0, no notification messages will be displayed.
Display Noticiation Icon	Display app icon that generated the notification **Possible values:** true or false **Default value:** true
Display Message	Display body of the notification **Possible values:** true or false **Default value:** true 
Display Count	Display notification count **Possible values:** true or false **Default value:** true 

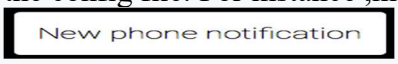
Option	Description
alert	Show alerts on new notification **Possible values:** true or false **Default value:** true Please note that this requires the alert module to be present in the config file. For instance ,modules: [{ widget: 'alert' }] 
Fade	Fade older notifications to black. (Gradient) **Possible values:** true or false **Default value:** true
Max Characters	Number of characters to display per notification body **Default value:** 50

Table 3.4.2.1 Phone Notification Module setup

3.4.3 MMM-NOWPLAYINGONSPOTIFY

A module for the Magic Mirror project by Michael Teeuw displaying the song currently playing on Spotify.

How it works

After installing the module and configuring and setting up the Spotify app the module displays the song you are currently listening to on Spotify. It shows on which of your devices you're playing the song. If you like you can also display the album cover.

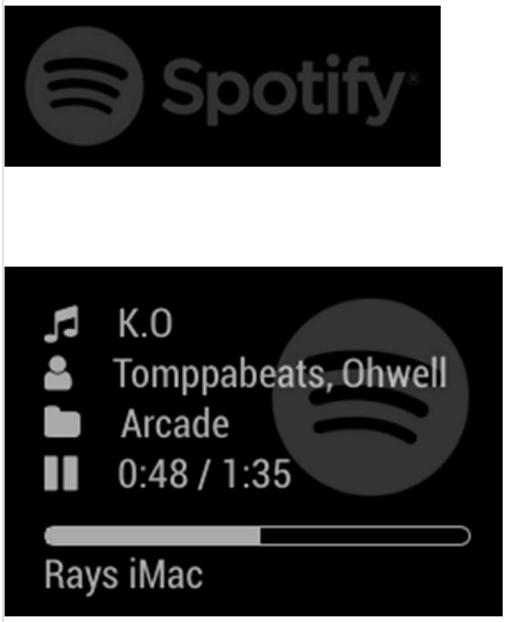
To be able to display your currently playing song the module must connect to the Spotify service and query your private data. For obvious reasons this is not possible for arbitrary apps – or for that matter Magic Mirror modules. There are third party solutions which will enable access to your Spotify data. This module is designed to be independent from third party services. Everything you need is in this module respectively is created by yourself.

Preconditions

- MagicMirror[2] instance
- Node.js version >= 7
- npm
- a Spotify account

Installing

Installing the module is quite straight forward. Getting it to display your playing songs requires a bit more work.



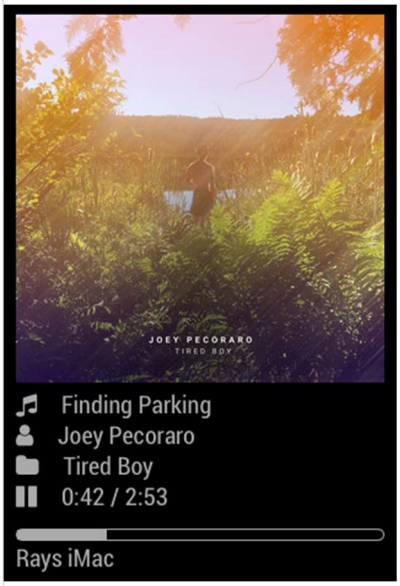


Figure 3.4.3.1 Spotify Module

Step 1 – Install the module

In your Magic Mirror directory:

```
cd modules
git clone https://github.com/raywo/MMM-NowPlayingOnSpotify.git
cd MMM-NowPlayingOnSpotify
npm install
```

Step 2 – Create and authorise a Spotify app

In order to be able to connect to the Spotify API you need to create an app in the Spotify developer area. Then you need to authorise the app to access your personal data. Et voilà!

The module provides you with a special app which describes all the necessary steps and which guides you through the whole process. To use this app change into the authorization folder and start the app by typing node app.

```
cd authorization
node app
```

When the app is running you can access it by opening localhost:8888 in your browser. Provided you are doing this directly on your Raspberry Pi. If you want to access the app remotely just type the ip address or the name of your Raspberry like so for instance: http://raspi:8888. Then you should see the authorisation app like below.

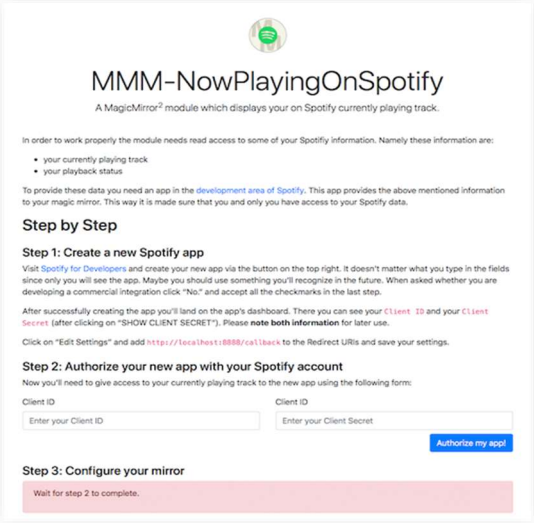


Figure 3.4.3.2 Spotify Authorisation App

Now just follow the steps described there. After successful authorisation the app will display a code snippet under the heading **Step 3: Configure your mirror**. Copy that snippet and paste it into your mirror's config.js. Configure the rest to your needs and you're good to go.

Updating

Go to the module's folder inside Magic Mirror modules folder and pull the latest version from GitHub and install:

```
git pull
npm install
```

Configuring

Option	Description
Show Cover Art	A Boolean value describing whether an album cover photo should be displayed or not. **Type:** Boolean **OPTIONAL** **Example:** false **Default Value:** true
Updates Every	An integer determining the interval for display updates. **Type:** integer **OPTIONAL** **Example:** 5 **Default Value:** 1 **Note:** With the default setting the display is updated every second. So when you skip to the next song it is virtually immediately visible. Also the progress bar runs smoothly. If you increase the value you may relieve the strain on your Raspberry's processor but your display will not be as up-to-date.
Client ID	A string describing the clientID of your Spotify app. **Type:** string **REQUIRED** **Example:** "acecg8a4..." **Default Value:** none **Note:** The easiest way to get that value is by copying the code snippet from step 3 in the authorisation app.
Client Secret	A string describing the client Secret of your Spotify app. **Type:** string **REQUIRED** **Example:** "87978346..." **Default Value:** none **Note:** The easiest way to get that value is by copying the code snippet from step 3 in the authorisation app.
Access Token	A string describing the access Token of your Spotify app. **Type:** string **REQUIRED** **Example:** "WaIO1987..." **Default Value:** none **Note:** The easiest way to get that value is by copying the code snippet from step 3 in the authorisation app.

Refresh Token	A string describing the refresh Token of your Spotify app. **Type:** string **REQUIRED** **Example:** "HIuLH798..." **Default Value:** none **Note:** The easiest way to get that value is by copying the code snippet from step 3 in the authorisation app.

Table 3.4.3.1 Spotify Cofiguration Table

There is not very much to configure but here are the options:

Here is an example for an entry in config.js

```
{
   module: "MMM-NowPlayingOnSpotify",
   position: "top_right",

   config: {
      showCoverArt: false,
      clientID: "<YOUR_CLIENT_ID>",
      clientSecret: "<YOUR_CLIENT_SECRET>",
      accessToken: "<YOUR_ACCESS_TOKEN>",
      refreshToken: "<YOUR_REFRESH_TOKEN>"
   }
}
```

Special Thanks

- Michael Teeuw for inspiring me and many others to build a Magic Mirror module.
- The community of magic mirror. builders for help in the development process and all contributors for finding and fixing errors in this module.

CHAPTER 4.

CONFIGURATION & API CODES

```
var config = {
address: "localhost", // Address to listen on, can be:
                // - "localhost", "127.0.0.1", "::1" to listen on loopback interface
                // - another specific IPv4/6 to listen on a specific interface
                // - "", "0.0.0.0", "::" to listen on any interface
                // Default, when address config is left out, is "localhost"
port: 8080,
ipWhitelist: ["127.0.0.1", "::ffff:127.0.0.1", "::1"], // Set [] to allow all IP addresses
                                        // or add a specific IPv4 of 192.168.1.5 :
                                        // ["127.0.0.1", "::ffff:127.0.0.1", "::1",
"::ffff:192.168.1.5"],
                                        // or IPv4 range of 192.168.3.0 --> 192.168.3.15 use
CIDR format :
                                        // ["127.0.0.1", "::ffff:127.0.0.1", "::1",
"::ffff:192.168.3.0/28"],

language: "en",
timeFormat: 12,
units: "metric",

modules: [
{
module: "clock",
position: "top_left"
},
{
module: "calendar",
header: "Indian Holidays",
position: "top_left",
config: {
calendars: [
{
symbol: "calendar-check",
url: "https://www.calendarlabs.com/ical-calendar/ics/33/India_Holidays.ics"
},
{
symbol: "my calendar",
url:
"https://calendar.google.com/calendar/ical/mailsaurabhvermasrb%40gmail.com/private-
8c6e93a21bdfc95e4d46dbb942a247e0/basic.ics"
}
```

```
]
}
},
{
module: "currentweather",
position: "top_right",
config: {
location: "Prayagraj",
locationID: "1278994",  //ID from http://bulk.openweathermap.org/sample/; unzip the gz file and find your city
appid: "b62c0eabef68fbe3be18633b50c13f19"
}
},
{
module: "weatherforecast",
position: "top_right",
header: "Weather Forecast",
config: {
location: "Prayagraj",
locationID: "1278994",  //ID from https://openweathermap.org/city
appid: "b62c0eabef68fbe3be18633b50c13f19"
}
},
{
module: "newsfeed",
position: "bottom_bar",
config: {
feeds: [
{
title: "The Hindu",
url: "https://www.thehindu.com/news/national/feeder/default.rss"
}
],
showSourceTitle: true,
showPublishDate: true
}
},
{
  module: "MMM-NowPlayingOnSpotify",
  position: "top_left",
  config: {
    clientID: "7093de9c8a9b4eca9ec9c3a075ceafba",
    clientSecret: "403d20c3c4464c1d8ef9a0f0acf4d458",
    accessToken: "BQCBxv4AGY0hrycKye1At-2ksE7W2SfkulGrj_o4jjs5R4uhpp5ekxUfRkqnlboA-FCA2rTAE-
```

```
6CDvwAS7_mP87pmCmepDlsiV98zsA9f7mxjOibirq1V0W8d3Z1DYqoFywwkLaa1xX
B0fnh688oPro_Tr2rrqbUhAaSWH8GQfH4",
   refreshToken: "AQAuqoA4D36Wq-gnt8K-baxcr-
X0n_tV8sWHWSp_Z5YYRiiftUEQaShLHag4oJH4-
VueUrT_pKNCm8cSBgH5XgWiCisOZQdulNhH2cw03R-
IV14UQnK2NSqDD29Tp6JpzcfXTg"
  }
},


]

};

/*************** DO NOT EDIT THE LINE BELOW ***************/
if (typeof module !== "undefined") {module.exports = config;}
```

CHAPTER 5

CONCLUSIONS & FUTURE WORK

We have designed an intelligent mirror keeping in mind the up-coming future advancement in the field of home automation environment. The prototype of the magic mirror is powered and controlled by the Raspberry Pi 3 and all the final output in form of real time data feeds are displayed on LED screen fixed with a two-way mirror. We have built a working model to demonstrate various functionalities of the mirror using voice commands. It gives a layout that can be extended in future to accommodate even more functionalities.

In our future work we will try to add advanced gesture controls, automated salutation using face recognition of the end user and also understand that how advanced artificial intelligence can be implemented to the mirror so that it can automatically take care of all the requirements of the end user.

FUTURE WORK AND RECOMMENDATIONS

Successful implementation of voice control was achieved. The progress made can be leveraged to incorporate more variety of voice commands.

Similarly, the research, tests and development made for the face recognition aspect can be used to to incorporate face recognition, and other functionality such as multiuser capability into the system.

It is also possible to realise the ultimate aim of the project which is to integrate the device into a smart home system.

REFERENCES

[1] K.Ashton, “That 'Internet of Things' Thing” RFID Journal, July 22, 2009. (*references*)

[2] M. S. Raisinghani, A. Benoit, J. Ding. M. Gomez, K. Gupta, V. Gusila. D. Power, and 0. Schmedding. Ambient intelligence: Changing forms of human computer interaction and their social implications. Journal of Digital Information, 5(4),

2004.

[3] F. Bomarius, M. Becker, and T. Kleinberger. Embedded intelligence for ambient-assisted living. ERCIM News, 67:19-20, 2006.

[4] P.L. Emiliani and C. Stephanidis. Universal access to ambient intelligence environments: Opportunities and challenges for people with disabilities. IBM SystemsJournal, 44(3):605-619, 2005.

[5] M. Friedewald, 0. Da Costa, Y. Punie, P. Alahuhta, andS. Heinonen. Perspectives of ambient intelligence in the home environment. Telematics and Informatics, 22(3):221-238, 2005.

[6] Nest Labs Thermostat,”Programs itself, Then pays for itself”, 2010 https://nest.com/thermostats/nest- learning-thermostat/overview/

[7] Derrick Gold, David Sollinger, and Indratmo. SmartReflect: A Modular Smart Mirror Application Platform. IEEE Journal, Nov 2016.

[8Philips Homelab. http:// www.research.philips. com/ technologies/misc/homelab/index.html