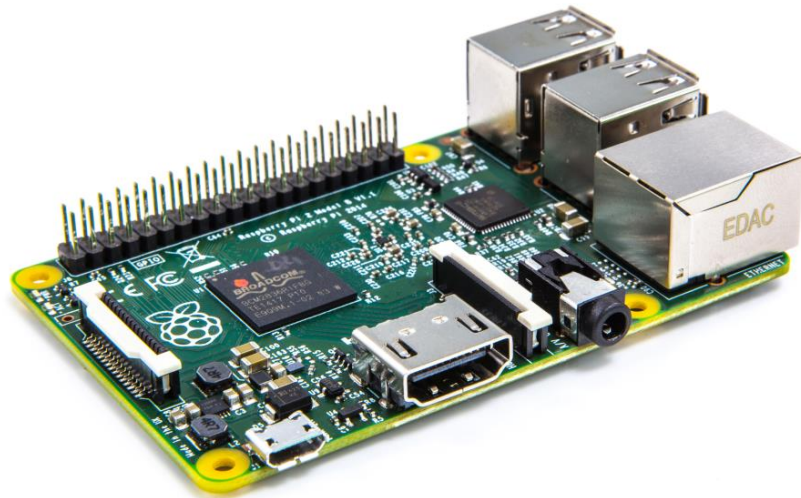


Using the Raspberry Pi in Robotics Projects

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I. Introduction and Overview of the Raspberry Pi

At DeWitt Perry Middle School we have started a Raspberry Pi project to build autonomous robots from the small, inexpensive Raspberry Pi. The Raspberry Pi is an inexpensive credit-card sized single-board computer released by the Raspberry Pi foundation in 2012 with the express intent of getting kids to program. Ebon Upton, the founder of the Raspberry Pi Foundation noticed that computers today differ from computers of the 70's, 80's and early 90's in that they do not come with a default, built-in development environment and the complexities of programming in a multi-tasked GUI environment can overwhelm new programmers and therefore, kids were not getting in to programming.

The Raspberry Pi runs a version of the Linux OS and has a bank of general-purpose IO pins (GPIO) available for the user to program. These GPIO pins can control external circuitry such as simple LEDs or motor driver IC's. All of the models have HDMI video out, USB ports and work with standard USB mice and keyboards.

There are many models of the Raspberry pi and are summarized in the table below (from <http://www.makershed.com/pages/raspberry-pi-comparison-chart>).

				
Raspberry Pi:	Model A+	Model B	Model B+	2, Model B
Price:	\$19.99	\$39.99	\$29.99	\$39.99
Availability:	Add to Cart	Add to Cart	Add to Cart	Add to Cart
Quick summary:	Cheapest, smallest single board computer.	The original Raspberry Pi.	More USB and GPIO than the B. Ideal choice for schools	Newest, most advanced Raspberry Pi.
Chip:	Broadcom BCM2835			Broadcom BCM2836
Processor:	ARMv6 single core			ARMv7 quad core
Processor Speed:	700 MHz			900 MHz
Voltage and Power Draw:	600mA @ 5V			650mA @ 5V
GPU:	Dual Core VideoCore IV Multimedia Co-Processor			
Size:	65x56mm	85x56mm		
Memory:	256 MB SDRAM @ 400 MHz	512 MB SDRAM @ 400 MHz		1 GB SDRAM @ 400 MHz
Storage:	Micro SD Card (not included)	SD Card (not included)	Micro SD Card (included)	Micro SD Card (not included)
GPIO:	40	26	40	
USB 2.0:	1	2	4	
Ethernet:	None	10/100mb Ethernet RJ45 Jack		

The best models to use for robotics are the model B+ and the Raspberry Pi 2 Model B. Both of these models have lots of GPIO pins, 4 USB ports, built in Ethernet and are useable as a stand-alone computer. The RPi 2 Model B has a faster quad-core processor and double the amount of RAM of the model B and is therefore much faster, almost 6X faster in some applications. However, the Model A+ is a very capable system for an embedded robot. Although it is not as fast and it does not have the memory or ports of the others the Model A+ is only \$20.00 and can easily be accessed via SSH and VNC with an added Wi-Fi adapter.

II. Advantages of Using the Raspberry Pi

The Raspberry Pi has many advantages, making it a suitable choice for a small mobile robot platform.

1. The Raspberry Pi is cheap, even the most expensive models can be had for around \$40.00. Most people already have a suitable mouse, keyboard and monitor. You may have to buy a cheap WiFi dongle (\$12.00) and a micro-SD card(\$6.00).
2. The Raspberry Pi is small, only about the size of a credit card and easy to integrate and mount into a robotics project.
3. There is a very large, very active and very helpful community around the Raspberry Pi. If you are stuck or need help, chances are, someone out there has already done it and has a website or forum post about it.
4. The Raspberry Pi has Python built in and a large number of Python libraries available.
5. The Raspberry Pi runs Linux, a free and open-source operating system.
6. The Raspberry Pi is a fully networked computer allowing us to remotely use the system and communicate with our robot anywhere in the world that has an internet connection.
7. The Raspberry Pi can be made to interface with Botball sensors.
8. Because the user must build a robot from discrete components and program the interface between the Raspberry Pi and the user you can learn much more about programming and electronics than using a turn-key solution.

III. Disadvantages of Using the Raspberry Pi

1. The Raspberry Pi is not a turn-key general purpose robotics controller (but it can be made into one) and is therefore hard to use.
2. The Raspberry Pi has no built in DC motor drivers or servo motor drivers.
3. The Raspberry Pi only has one PWM generator which affects our ability to generate signals to drive motors and servos accurately.
4. The Raspberry Pi has no built in analog sensing capability.
5. The Raspberry Pi runs Linux which may be unfamiliar to many people.
6. The Raspberry Pi has no built in sensor ports making interfacing any sensors more difficult.
7. Dealing with power issues can be complicated

IV. Equipment and Parts Needed

Since the Raspberry Pi is a bare-board controller, in order to build a robot around the Raspberry Pi you will need more equipment and parts than building a standard Botball robot. Most of the items can be obtained fairly inexpensively either online or at local electronics shops. Many companies sell “starter” packs with most of the required items in them.

Solderless Breadboard
Jumper Wire
Wire strippers and cutters
A collection of ¼ watt resistors
A collection of capacitors (primarily .1uF ceramic and 220uF – 1000uF radial)
22AWG solid core wire in various colors
Motor driver IC's (SN754410)
Analog input ICS (MCP3008)
Digital input IC's (MCP23008)
Various button, LED's etc.....

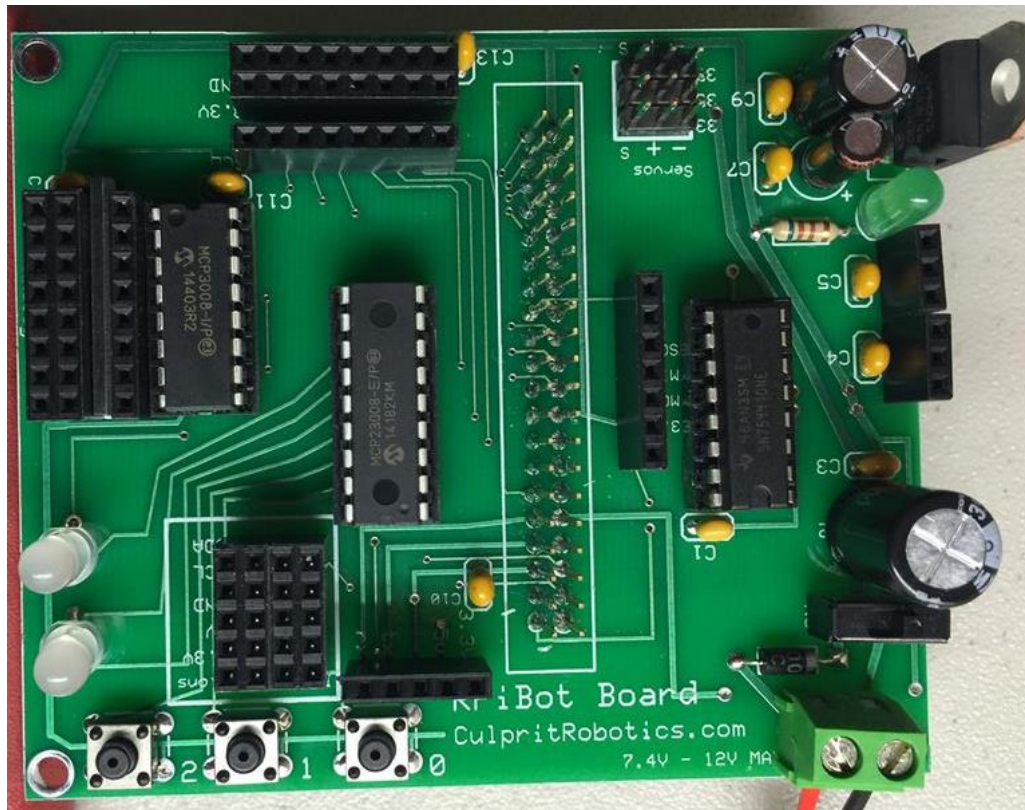
V. Our Experiences at Perry

The Raspberry Pi is an amazing machine, especially when you consider the price vs. performance and the small size. However, we ran into some problems and issues:

- The Raspberry Pi is an alien device to many kids. It runs an OS they are not familiar with and takes time to get used to.
- The Raspberry Pi is more difficult to program than a dedicated robot controller. Because you must manipulate the individual GPIO pins to control external circuitry that you build yourself, it takes more time!
- Learning basic circuit design, even for extremely intelligent middle school students took more time than planned.
- Because the Raspberry PI's were not part of the school infrastructure, we had to unplug monitors, keyboards, mice and network cables every time we needed to use them and then plug everything back together. This wasted time, a lot more time than you would think.

Most of these issues can be solved by simply dedicating more time to the problem. We met once every couple of weeks for about an hour and half and this simply wasn't enough time.

VI. The Final Product



In the end, I ended up designing a snap-on robot controller and writing a simple library of control functions in Python and the kids designed robots around it. The capabilities of the controller are:

- 2 DC Motor ports (6-9 volt motors)
- 3 Servo ports
- 8 Digital inputs and outputs
- Digital inputs can be used as simple or quadrature encoder inputs
- 8 Analog inputs
- 3 User controlled buttons
- 2 User controlled bi-color LEDs
- 1 UART
- I2C header with 4 ports
- SPI connector
- Most Botball sensors work without modification on the controller

I will continue to develop the board with future enhancements including more servos (up to 16) and 4 DC motors instead of just 2.