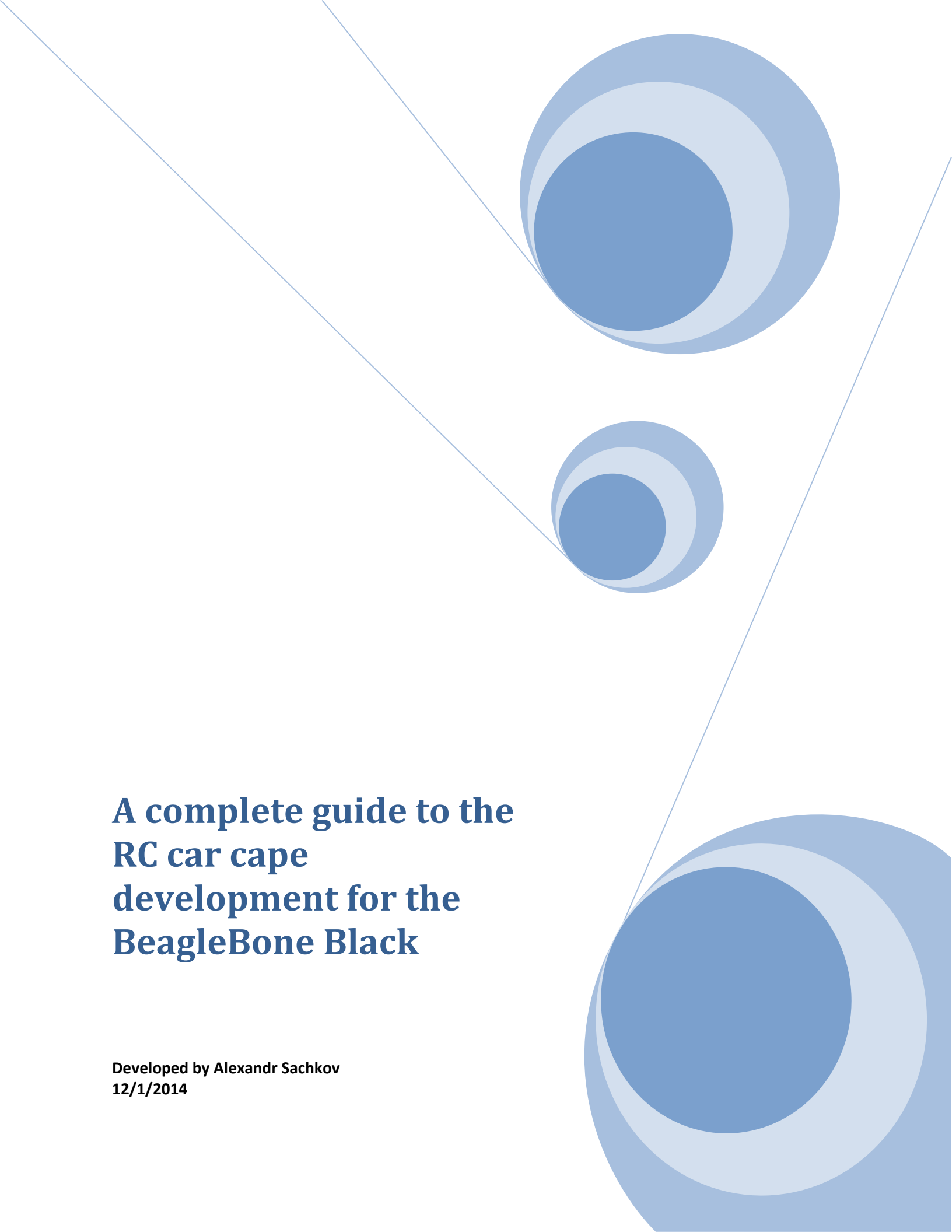

A complete guide to the RC car cape development for the BeagleBone Black

Developed by Alexandr Sachkov
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Introduction

Originally developed for
Project RIDN

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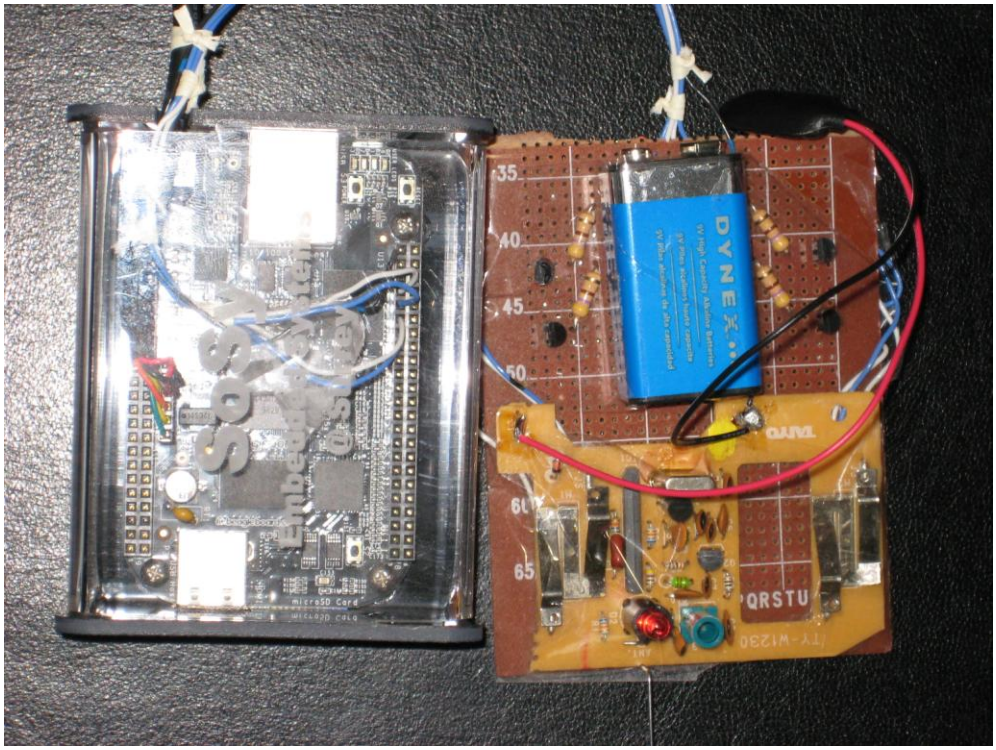
If you ever wanted an RC car that could be driven programmatically or if you are just looking for a cool project for your BeagleBone Black, then this guide is for you.

In just a few easy steps, we will create a custom cape to interface BeagleBone Black with any commercially available RC car. This guide assumes some previous knowledge of the BeagleBone Black and embedded Linux as well as some ability to solder.



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Tools and Materials:

- BeagleBone Black
- RC car of your choice (and its remote control)
- Breadboard or, for a more permanent solution, a Proto board
- Soldering Iron with a fine tip
- Solder
- Flux or Flux-Core solder (not required but it improves the quality of your solder joints)
- Spool of wire (20 - 22 gauge)
- Philips screw driver
- Wire strippers (or a knife)
- 2N3904 transistors x4
- 470 Ohm resistors x4

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Build procedure:

Step 1: Soldering connections onto the car's remote control

Remove the batteries from your RC remote control, extract all the screws and open the back cover. Carefully extract all the screws holding the circuit in place, and remove the circuit (Be very careful not to damage any components). Remove the analog sticks if they are still attached to the board.

You will have to solder some wires to this board. Prepare 5 wire slices long enough to reach from the RC circuit to your Breadboard, and strip both ends by about 1/8 inch. Leave some slack as you can always trim them later.

Examine the RC circuit and find the 2 locations where the analog sticks used to be attached. Each analog stick controls the direction of rotation of one of the motors, so after examining their locations, you should notice that each one contains two analog switches where the front-most switch spins the motor forward, and the other, in reverse.

It's time for some circuit tracing. Pick a switch, then flip over the board and find the two contacts that connect to it. The trace for one of the contacts will lead to a wider trace running along the outer perimeter of the circuit which by convention is ground. You want the other contact. Dip one end of a wire into flux and solder it to the contact. Be careful not to overheat the board and do not let the solder flow over multiple traces. Now repeat the process for the other 3 switches, and make sure to label the wires with their corresponding switch locations.

Find the battery clip contacts on the board and solder the fifth wire to the negative contact. Reinsert the circuit into the bottom half of the remote control as we will still need its battery back to power the remote.

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Step 2: Build the transistor switching circuit

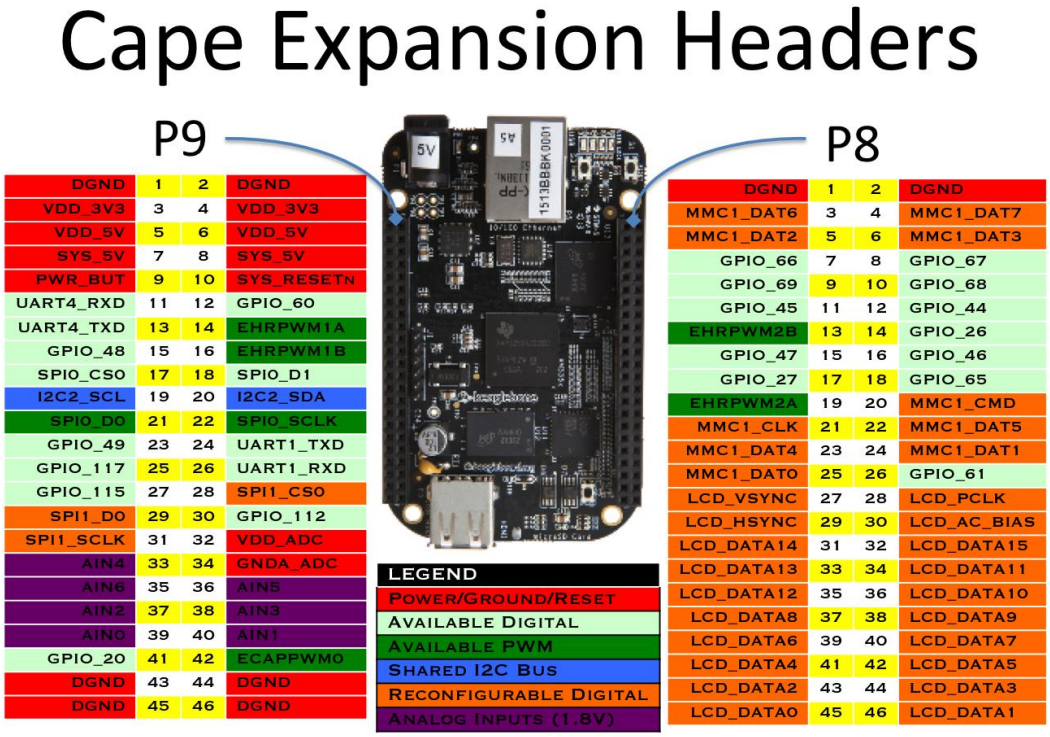
It is time to build the switching circuit for your RC remote.

1. Insert the four 2N3904 transistors into the Breadboard so that their labels are facing you.
2. Insert the four 470 Ohm resistors with one end connecting to the center pin of each transistor. Leave the other end disconnected for now.
3. Connect the left-most pin of each transistor to the ground rail on the Breadboard.
4. Connect the motor control wires to the right-most transistor pins, one wire per transistor. These transistors will act as electronic switches for the motor controls.
5. Connect the battery clip wire to the ground rail on the Breadboard.

Prepare 5 wire slices long enough to reach from your Breadboard to the cape expansion headers on the BeagleBone. Connect one end of each wire to the other end of each resistor. Then connect the fifth wire to the ground rail.

Now check with the BeagleBone cape extension header pinout diagram and find 4 available GPIO pins (they are highlighted with a light green color). Connect your 4 transistor wires to GPIO pins. Note which GPIO pin each switch is connected to. Connect your ground wire to any pin labeled DGND.

Congratulations! You are all done with the cape hardware!



P9			P9
DGND	1	2	DGND
VDD_3V3	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETn
UART4_RXD	11	12	GPIO_60
UART4_TXD	13	14	EHRPWM1A
GPIO_48	15	16	EHRPWM1B
SPI0_CS0	17	18	SPI0_D1
I2C2_SCL	19	20	I2C2_SDA
SPI0_D0	21	22	SPI0_SCLK
GPIO_49	23	24	UART1_TXD
GPIO_117	25	26	UART1_RXD
GPIO_115	27	28	SPI1_CS0
SPI1_D0	29	30	GPIO_112
SPI1_SCLK	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
GPIO_20	41	42	ECAPPWM0
DGND	43	44	DGND
DGND	45	46	DGND

P8			P8
DGND	1	2	DGND
MMC1_DAT6	3	4	MMC1_DAT7
MMC1_DAT2	5	6	MMC1_DAT3
GPIO_66	7	8	GPIO_67
GPIO_69	9	10	GPIO_68
GPIO_45	11	12	GPIO_44
EHRPWM2B	13	14	GPIO_26
GPIO_47	15	16	GPIO_46
GPIO_27	17	18	GPIO_65
EHRPWM2A	19	20	MMC1_CMD
MMC1_CLK	21	22	MMC1_DAT5
MMC1_DAT4	23	24	MMC1_DAT1
MMC1_DAT0	25	26	GPIO_61
LCD_VSYNC	27	28	LCD_PCLK
LCD_HSYNC	29	30	LCD_AC_BIAS
LCD_DATA14	31	32	LCD_DATA15
LCD_DATA13	33	34	LCD_DATA11
LCD_DATA12	35	36	LCD_DATA10
LCD_DATA8	37	38	LCD_DATA9
LCD_DATA6	39	40	LCD_DATA7
LCD_DATA4	41	42	LCD_DATA5
LCD_DATA2	43	44	LCD_DATA3
LCD_DATA0	45	46	LCD_DATA1

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Step 3: Writing the driver for the RC cape

The cape hardware is built but we still need a driver to control it which we will write using BoneScript.

BoneScript is a Node.js library that comes preinstalled on the BeagleBone and provides a simple interface to control GPIO. It also makes it easy to interface with a Node.js server in case you want to control the car remotely.

First of all, we will write some code to control a single car motor.
Create a new file called "rcmotor.js" and add the following code to it:

```
var b = require('bonescript');

function RCMotor(fwdPort, rvsPort){
	var fwdPortNumber = fwdPort;
	var rvsPortNumber = rvsPort;

	b.pinMode(fwdPortNumber, 'out');
	b.pinMode(rvsPortNumber, 'out');

	var off = 0;
	var on = 1;

	this.fwd = function(){
		b.digitalWrite(rvsPortNumber, off);
		b.digitalWrite(fwdPortNumber, on);
	};

	this.rvs = function(){
		b.digitalWrite(fwdPortNumber, off);
		b.digitalWrite(rvsPortNumber, on);
	};

	this.off = function(){
		b.digitalWrite(fwdPortNumber, off);
		b.digitalWrite(rvsPortNumber, off);
	};
}

module.exports = RCMotor;
```

The above code creates an object called RCMotor which takes two parameters fwdPort and rvsPort. These parameters are the GPIO pin numbers that you connected your transistor wires to. The forward port refers

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to the wire that drives the corresponding motor forward, and the other in reverse. Make sure that the two wires drive the same motor, or otherwise, your build will misbehave.

RCMotor has 3 public functions to drive it forward, in reverse, and stop.

Next, we will write some code that builds on the motor code and represents the RC car as a whole. Create a file named "rccontroller.js" in the same directory as the "rcmotor.js" and add the following code to it:

```
var RCMotor = require('./rcmotor.js');

function RCController(){
	var leftMotor = new RCMotor("P8_8", "P8_10");
	var rightMotor = new RCMotor("P8_12", "P8_14");

	var no_direction = 0;
	var fwd_direction = 1;
	var rvs_direction = 2;

	var current_direction = no_direction;

	this.stop = function(){
		console.log("stopping.");
		leftMotor.off();
		rightMotor.off();
	};

	this.stop();

	this.fwd = function(){
		console.log("driving forward.");
		leftMotor.fwd();
		rightMotor.fwd();
	};

	this.rvs = function(){
		console.log("driving in reverse.");
		leftMotor.rvs();
		rightMotor.rvs();
	};

	this.left = function(){
		console.log("turning left.");
		leftMotor.off();
```

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```
        rightMotor.fwd();
    };

    this.rotateLeft = function(){
        console.log("rotating left.");
        leftMotor.rvs();
        rightMotor.fwd();
    };

    this.right = function(){
        console.log("turning right.");
        leftMotor.fwd();
        rightMotor.off();
    };

    this.rotateRight = function(){
        console.log("rotating right.");
        leftMotor.fwd();
        rightMotor.rvs();
    };


}

module.exports = RCController;
```

The above code creates an RCController containing two motors that are passed their corresponding GPIO pin numbers. In this example, I am using pins 8, 10, 12, and 14 on the P8 expansion header where:

- pin 8 drives the left motor forward
- pin 10 → left motor in reverse
- pin 12 → right motor forward
- pin 14 → right motor in reverse

The public interface contains 7 intuitive functions to control the car.

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Step 4: Testing!

Congratulations, you made it this far!

It is time to test the build. Double check your wiring configurations and stick the batteries back into the RC remote.

Create a file called "rctest.js" in the same directory as the "rccontroller.js" and add the following code to it:

```
var RCController = require('./rccontroller.js');
var controller = new RCController();

controller.fwd();
setTimeout(function(){
        controller.rvs();
        setTimeout(function(){
                controller.stop();
        },3000);
}, 3000);
```

The above code will make your car drive forward for 3 seconds followed by reversing for 3 seconds.
If your RC remote contains an LED indicator, then you can leave your car off.
Run the above code using the following command:

 # nodejs rctest.js
On some boards it is:
 # node rctest.js

You should see the controller LED light up and stay lit throughout the test. Once this test is passed, turn on your car and make sure that the car behaves as expected.

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Troubleshooting:

- Node.js or BoneScript is not installed:
  Install them. There are many online guides for this.

- GPIO pin **** is taken:
  This is caused by a bug in the BoneScript. Reconfigure to use different GPIO pins and try again. You could also upgrade to the later firmware image which fixes the bug.

- The controller LED does not turn on:
  Double check your wiring, make sure you reinstalled the battery into the remote control.
  If the problem persists, unplug the wires from the BeagleBone GPIO header and touch them one at a time to the positive battery terminal on the remote control. The LED should light up each time. If the LED lights up, your problem is caused by the software configuration. Otherwise, check your Breadboard connections and solder joins on the remote control circuit.

- The car drives in mysterious ways:
  Check for proper configurations one motor and direction at a time. Determine which motor/direction is malfunctioning, then check its corresponding wiring and GPIO configurations.

For further support, please contact me at **alexsachkov@hotmail.com**

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