SneakerBot Experience

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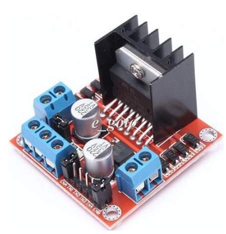
2018.07+

The ShoeBot, later the SneakerBot, was introduced by Raymond & Diane Brown ("R&D") in July of 2018 as an inexpensive, hands-on project to introduce newcomers, particularly Scouts, to the basics of robotics. People love to decorate and customize sneakers. How about one that was a robot and could run by itself? The project involved taking a cheap Radio Controlled car, mounting an inexpensive customizable sneaker on it, and replacing the RC receiver with a Raspberry Pi computer-on-a-card and a motor controller. It can then be programmed to be driven over WiFi from a PC. The logical extension is to add sensors or camera and some programming to make the SneakerBot semi-autonomous. The idea was to present the student with a pre-prepared shoe box containing a sneaker, the RC car, the Pi, motor controller, and necessary accessories.

Bill of Materials

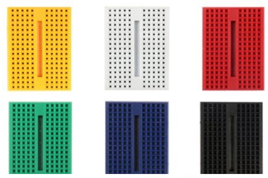
1) Inexpensive RC car
   1a) Five Below $ 5.00

2) Raspberry Pi Zero W
   Chosen because of less power demand & smaller size than Pi 3
   2a) From Adafruit with headers attached $14.00
   https://www.adafruit.com/product/3708?gclid=CjwKCAjw0JfdBRACEiwAiDTALvMpnbhv0SrZMu5mLDZUxCVH4qaakPuI4RWHWhhzy68tDUcDBPK91xoC7-kQAvD_BwE



3) L298N Dual H-Bridge Motor Controller
   3a) From NewEgg via slow boat from China, $1.89
   https://www.newegg.com/Product/Product.aspx?Item=9SIA7BF2YR6262&ignorebbr=1&nm_mc=KNC-GoogleMKP-PC&cm_mmc=KNC-GoogleMKP-PC-_-pla-_-Gadgets-_-9SIA7BF2YR6262&gclid=CjwKCAjw0JfdBRACEiwAiDTALip_9hiLZ9_nVRrjYj89eDjGpDJ9xPuuy6Zq8OImkmExiFFi20VEJxoC8SIQAvD_BwE&gclsrc=aw.ds

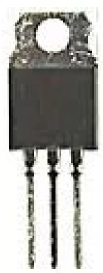
   3b) From Amazon, in stock $6.89
   https://www.amazon.com/Qunqi-Controller-Module-Stepper-Arduino/dp/B014KMHSW6/ref=asc_df_B014KMHSW6/?tag=hyprod-20&linkCode=df0&hvadid=167139094796&hvpos=1o1&hvnetw=g&hvrand=4223508469295216803&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9027584&hvtargid=pla-306436938191&psc=1



4) Mini Breadboard

4a) From Amazon $8.99/12 = 0.75ea

https://www.amazon.com/LampVPath-12Packs-solderless-breadboard-Arduino/dp/B01KKE602W/ref=sr_1_5?ie=UTF8&qid=1546820307&sr=8-5&keywords=mini+breadboard

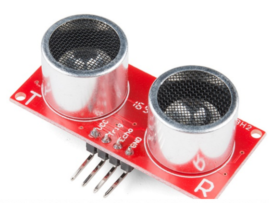


5) LM7805 5V regulator

(NOT NEEDED w/ Pi Zero W 4.5V configuration. Only if Vin > 5V)

5a) From Jameco, $0.29

https://www.jameco.com/z/7805T-Major-Brands-Standard-Regulator-5-Volt-1-Amp-3-Pin-3-Tab-TO-220_51262.html



6) Ultrasonic Sensor

6a) From Sparkfun $3.95

https://www.sparkfun.com/products/13959

7) Terminal Strip, 6 position

7a) From Digi-Key $1.12

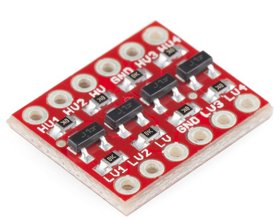
https://www.digikey.com/product-detail/en/phoenix-contact/1713075/277-13752-ND/2513984

8) Jumper wire assortment 10cm (3.9")

8a) From Amazon/COMeap $7.99/120pcs / 2 kits = $4.00/kit

More expensive but shorter leads for less clutter.

https://www.amazon.com/COMeap-120pcs-Female-Breadboard-Jumper/dp/B01MU0IMFF/ref=sr_1_5?ie=UTF8&qid=1537661515&sr=8-5&keywords=jumper+wire+male+female



9) Quad logic-level shifter (to convert sensor to Pi voltages.)

REQUIRES SOLDERING

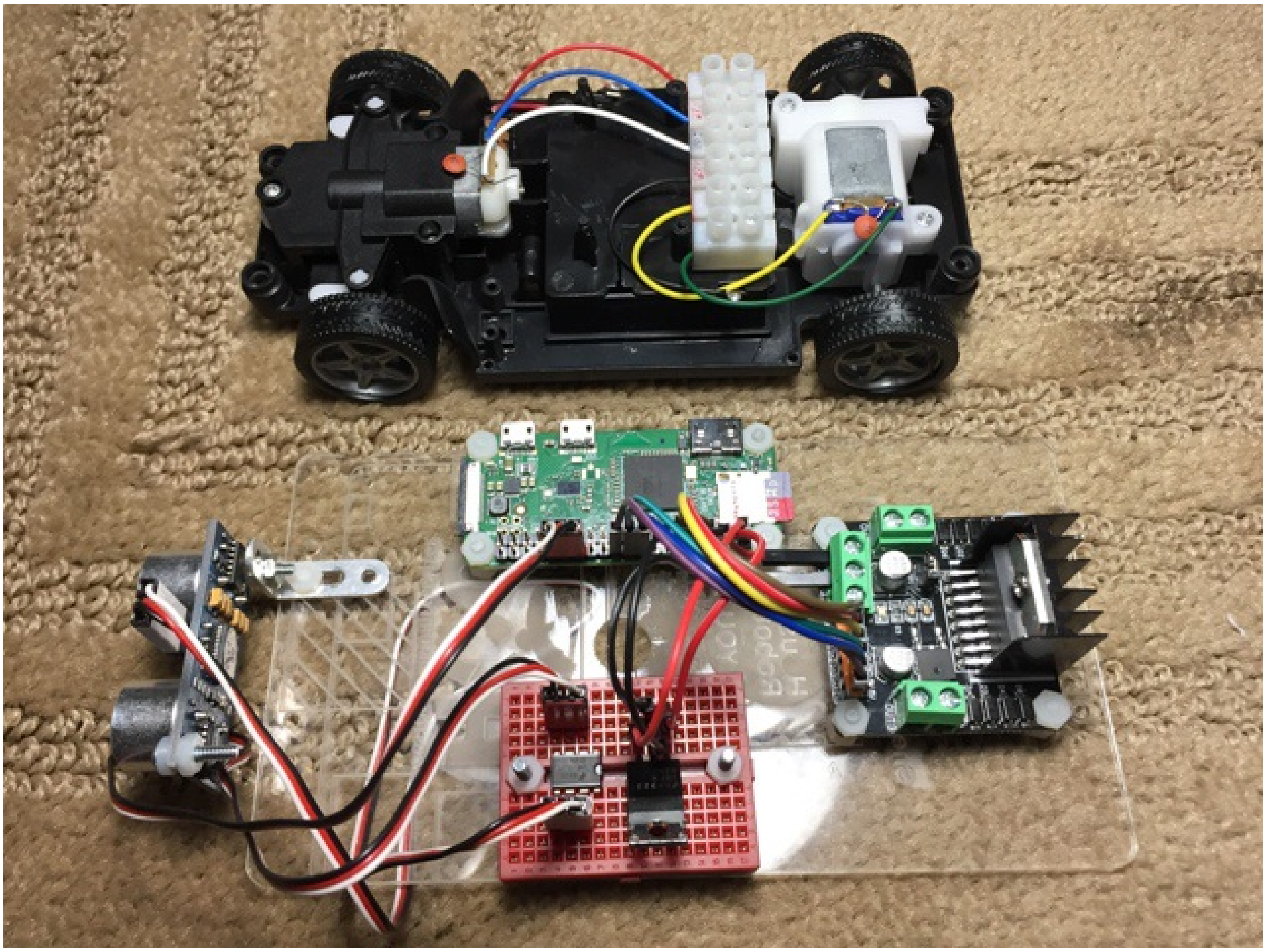
Solderless ie “Hammer Header” appear to only be available in 2x20 configuration. Sparkfun used to carry them but the product is “retired”

9a) From Sparkfun reliable $2.95

https://www.sparkfun.com/products/12009

9b) From Amazon / Cylewet questionable $9.99/10 = 1.00 ea

https://www.amazon.com/Cylewet-Channel-Converter-Arduino-CYT1070/dp/B073D4DJDC

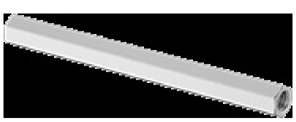


10) Custom laser-cut acrylic electronics / shoe platform 6.5" x 3.5"

10a) From Amazon / Mifflin 12"x24" $21.99 sheet / 9/sheet = $2.45 ea

(If were 6.5x3.375" and laser cutting was *perfect*, could get 10/sheet. Questionable!) Revised - instead of mounting holes (except for 4 uprights) etching would indicate position to tape components.

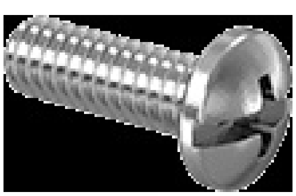
https://www.amazon.com/MIFFLIN-Plexiglass-Transparent-Acrylic-Plastic/dp/B078HX6ZLG/ref=sr_1_2?ie=UTF8&qid=1537709301&sr=8-2&keywords=clear+acrylic+sheet+1%2F8+12+x+24



11) M3 50mm Al F-F standoffs

11a) From McMaster-Carr $1.63 x 4 = $ 6.52

https://www.mcmaster.com/95947a502



12) M3 x 6mm screw

12a) From McMaster-Carr $5.31/100 = $0.06 ea x 4 = $0.24

https://www.mcmaster.com/92000a116

13) Angle mounting bracket

(Optional? Sensor *could* hang by pins from breadboard or use more foam tape. Positioning tricky)

13a) Parallax $0.50 x 2 = $1.00

https://www.parallax.com/product/720-00011

14) Foam mounting tape 2"/Pi, 2x1.5"/controller, 2x2.5"/shoe, ?/sensor, extra.

14a) From Amazon $4.99/150" = $0.033/in x 15" = $0.50
https://www.amazon.com/Scotch-4013-2-Inch-150-Inch-Mounting/dp/B003W0R4PE

Cost of Materials

$ 5.00	car
$14.00	Pi
$ 6.89	controller
$ 0.61	breadboard
$ 3.95	sensor
$ 4.00	jumpers
$ 1.12	terminal block
$ 2.95	level shifter
$ 6.52	stand-offs Al
$ 0.24	screws
$ 2.45	platform
$ 1.25	shoe
$ *1.00*	*bracket opt.*
$ 0.50	foam tape
$ **50.48**	**per kit**

Assuming tax-free 501c3. Some economy of scale may be gained
Assuming shoes come in 2 shoes/box & we only use 1 shoe/kit, where do we get the other shoe box?
Or, do we have sets of 2 kits: 1 box of shoes, 2 boxed RC cars, 2 SneakerBot kits in zip bag (add to cost)

Tools
Phillips head screwdriver, small
Flat blade screwdriver, small
Diagonal cutters
Wire strippers
Scissors (might get by with diagonal cutters or wire strippers for cutting foam tape)

The Process

Unboxing the car. Slip the RC car cardboard carrier from the box. The car should be attached from the bottom with two large plastic wing screws. Remove them. Note the car's antenna is held by holes in the carrier. Slide it out with caution. The RC transmitter should slide up. It's antenna is similarly restrained. Free it.

Installing batteries. Before committing to major modifications, make sure your car works. You'll need 5 x 1.5V AA batteries. Look at the bottom of the car. **Note the switch near the battery compartment. Be sure it's OFF. This will keep your car from running off until you're ready.** More on this below. Use a small phillips head screwdriver to remove the retaining screw from the battery compartment cover. Open the compartment. With the cover open, replace the screw all the way back in. You should be able to replace the cover & close it with perhaps a little help with the catch. This will keep you from having to unscrew the cover every time you want to access the batteries. Insert 3 AA cells into the car as indicated. Replace the cover. Perform a similar operation on the back of the transmitter, **leave the batteries out for now**, and replace the cover. If you're with a group project, be sure the frequency of your transmitter and car are the same, i.e. 27 or 49MHz. I think there are only those 2 frequencies so only two people can race at a time. This also means half the people in the group are likely to have the same frequency. Anyone playing with their transmitter could make half the cars within a few yards start running if the car's power switch is on! Since there's no power switch on the transmitter, it would be wise to leave the batteries out until you're ready to run.

Power on test. If in a group, announce "Preparing to transmit on 27MHz (or 49MHz) in 10, 9, 8...". While doing this, turn the car power switch ON. Being careful not to press any buttons on the front of the transmitter, insert its batteries. "...5, 4, 3, 2, 1." Place the car on a smooth, ie tile, floor and line it up with a line on the floor if possible. Find the FORWARD (left upper) button and push it for just one second. The car should zoom ahead. If if doesn't move, check that the power switch is on, all the batteries are fresh and properly in place, and that your transmitter and car are on the same frequency. If it still doesn't go, consider it broken and seek help troubleshooting. Then try running it backwards using the left lower button. Again note any failure or deviation. What's the speed of your car? How might you determne that?

Trimming the car. Assuming it ran, notice whether it goes exactly straight or veers to the right or left. If it goes straight, great! If not, look at the bottom of the car between the front wheels. There you'll see the trim setting. You'll see the letters R and L on the opposite of the expected side. This is because the car is upside down. If the car veered to the right, move the dial one click toward R. This will make the wheels turn a little to the left to compensate. If it veered to the left, move the dial one click toward L. Run the car as above again being careful not to cross-transmit. Adjust the trim until your car runs *reasonably* straight. It won't be perfect, it's just a cheap toy car!

Turning. Flip the car on its back so that, like a turtle, it can't go anywhere. Observe the front wheels while flicking the steering buttons (right side, right & left buttons) just briefly right and left. Unlike a car where you can control how sharp a turn you make, this car is "all or nothing." It doesn't matter how hard you push the turn button, just how long you hold it. As long as you hold the button, it will continue to turn and will go straight again once release. It only takes a brief flick of the button to veer sharply one direction or the other. But the turn button won't do anything except shift the front wheels unless the forward or reverse buttton is also pressed. What's the turning radius of your car? How might you determne that?

Play around. Play with the car and increase your skill until you're ready to hack it to the next step.

Hacking the car. Say goodbye to the RC function of your car. There may be a way to keep and switch between the RC function and the about-to-be-installed computer, but we're not going there. But if you were....? Take the batteries out of the transmitter and the car so as to not cause trouble. Set the transmitter aside. You can replace the battery compartment door. There are no screws to access through there. Now would be a good time to find a suitable, i.e. shoe, box to keep the "set asides" in.

Removing the body. There are 4 screws that attach the upper body to the chassis of the car. They're sunk deep into holes at the very front and back of the bottom of the car. Remove with a phillips head screwdriver & save them. [PHOTO] Then gently pry the body away from the chassis starting at the front bumper. Once loose there the rest usually slips off easily. Twist the body around as you remove it to allow the little loop at the end of the antenna to back out of the slot on the body. Put the screws back into the upper body and set aside.

Removing the antenna. In the middle of the chassis you'll note a small printed circuit board with the antenna and 6 colored wires attached to it. It's held in place with 2 screws and 2 posts. The antenna is attached by one of the screws at one corner of the PCB. Remove the screw and keep handy. Remove the antenna and set aside with the body and transmitter.

Removing the PCB. Remove the other screw releasing the PCB. Lift it off the pegs and move aside within the limits of the attached wires. Pt the screws back in the holes for safe keeping. You'll see 6 colored wires attacked to it: Red (power), Black (ground), Green & Yellow (drive motor) and Blue & White (steering motor). Being careful not to pull them away from their sources, use the diagonal cutters to cut each wire as close to the PCB as possible. Set the PCB aside also.

Prepare the wires. Again being careful, use the wire strippers to remove 1/4" of the insulation from the free end of each wire. Twist the strands to keep them together. *(OPTIONAL: If you're handy with a soldering iron, it would be a good idea to "tin" the stripped ends to keep the strands together and solid. Makes plugging them into the terminal strip much easier!)*

Mounting the terminal strip. Locate the multi-colored 6 position terminal strip. It should have colors to match the wire you just prepared. Using the flat blade of a screwdriver, bend the bottom pins down against the terminal strip. These are designed to go through holes in a printed circuit board and won't be used here. They'll just be in the way. You *might* be able to clip them off with the diagonal cutters but you don't want to nick the blade of the cutter or have flying clippings hit you in the eye! If in doubt, don't. Cut a piece of the foam tape to just shorter than the terminal strip leaving the covered side intact. We're not going to stick it down yet. Press the raw foam side centered into the bottom of the terminal strip. Start from the middle of the terminal strip and work outward. Press the release lever on the strip. Stick the corresponding colored wire into the strip so that it grips only bare wire, close to but not gripping the insulation. Release the lever. For each wire, aim for the most direct and neatest path from the source to the terminal strip. Check that all the wires are snugly gripped by the terminal strip. When satisfied, locate a spot between the 4 posts on the chassis to place the terminal strip crosswise such that you'll have easy access to the holes and levers. More wires are coming later! Pick the cover off the foam tape on the bottom and firmly press down the terminal strip in your chosen location. Now that the cars wires are secured, it's time to assemble the brains of the robot.

The Platform. The platform is the hub of the SneakerBot. It will be mounted on 4 upright standoffs using the same holes the body mounting screws came from. The electronics will hang below it. The sneaker will be mounted on top of it. Locate the platform. Also locate the 4 hex standoff uprights and 8 M3 6mm screws. The platform is 1/8" clear acrylic. It may have protective paper on one or both sides that needs to be peeled off. It was custom designed and laser cut in the Fab Lab of the Houston

Community College manufacturing campus in Stafford, TX. In addition to the 4 mounting holes and appropriate logos, it has etched into it the template for mounting the electronics. The etching will be rough on the "bottom". Orient it so you can clearly read the etching through the smooth "top". Note the front end with the narrow holes and the back with the wider set holes. Mount the 4 hex standoffs to the "bottom" of the platform with the M3 screws. Place the standoffs on the chassis where the body attachement screws used to be at the front and back of the chassis. No need to screw them in at this time. With the platform raised above the chassis on the standoffs, be sure the etching is clear through the top. Rest the sneaker on the platform pointing forward. This is just to give you an idea of the finished SneakerBot. Set the sneaker aside.

The motor controller.

The Raspberry Pi Zero WH.

Wiring the motor controller.

Wiring the control pins.

Installing & configuring Rasbpian Stretch
download image of raspbian stretch
burn to SD card
put in a full-size Raspberry Pi, i.e. 3b
boot up w/ monitor, keyboard & mouse
configure for ssh
install incoming remote desktop: $ sudo apt-get install xrdp
~~install git-hub app: $ sudo apt-get install git~~ comes pre-installed in raspbian stretch
$ git clone https://github.com/AlanKuist/Robot_Codes.git [copied from git hub clipboard]

Powering the Pi.

Testing the Pi and motor controller from the keyboard.

The breadboard.

The sensor.

The logic level shifter.

Wiring the logic level shifter to the sensor and the Pi.

Testing the sensor.

Mounting the platform.

Mounting the sneaker.

Letting it loose.

Jan 2019
Ordered parts from various sources, see above, for at least 5 SneakerBots. Some part quantities exceeded this & will be stock for future production.