This brainboard uses the popular and powerful Microchip PIC16F877A microcontroller (included!) to take over the functions of the Discrete Brain that comes with your Sumovore.

The PIC16F877A is part of a very popular family of microcontrollers, and is programmable in an ever-growing list of languages (some free!).

It’s fast, inexpensive, and very powerful. An ideal mate to the Sumovore!

[Sumovore Sumo robot kit and DB25 printer cable/connector req’d]
We strongly suggest you inventory the parts in your kit to make sure you have all the parts listed. Use a pen, pencil, pricked finger, chocolate bar - anything to mark off the items. If anything is missing, contact us for replacement parts information.

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Looking for a more flexibility out of your Sumovore? Well, we come to the PIC 16F877A Brainboard - the 16F877A. The ‘877 offers an impressive list of features, including (but not limited to):

- 20MHz /4 MIPS processing speed
- 33 programmable Input/Output (I/O) lines (that’s a lot!)
- Eight 10-bit analog-to-digital converters (ADCs)
- Two Pulse-width modulation (PWM) channels
- Only 35 instructions (good for you assembler masochists)
- Two analog comparators
- In-circuit programmable (which we make use of)
- 8kB flash memory, 368 bytes RAM, and 256 bytes EEPROM

We’ve barely made a dent in what the ‘877 is capable of, and there’s lots more you can do with it. Being a PIC microcontroller which have been around for quite a while, there is a considerable amount of information and software for it on the Internet.

**This is **not** a kit for a microcontroller beginner. Anybody using this brainboard should have the appropriate skills, or be ready to learn the techniques that make a microcontroller... microcontroller!**

This kit lets you swap out the default discrete brainboard for a programmable version. If you run into any problems, it’s a simple process to swap a different brain back in. Didn’t you ever have days where that’d be a handy feature for you to have? (umm...for the robot, we mean).

This kit features:

- Microchip PIC 16F877A microcontroller
- 5 indicator LEDs
- RJ11-5 (telephone jack) and 5-pin programming headers
- Three servo (or similar peripheral) headers
- Extra breadboarding space and hard-point mounts
- Microprocessor Reset Switch

We designed the breadboarding space to accommodate extra ICs and support electronics, or simply as a place to mount a servo with double-sided sticky tape! It’s a flexible area - use it for whatever strikes your fancy.

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**Step 1 - ‘877 Carrier:** Everybody wants to start with the most important-looking parts. Well, tough - you can’t. You keep your paws off that pretty PIC until the end, as the whole point of the carrier is to protect the chip from seeing any potential ESD (static electricity) which could damage it. So, the next best thing to attack is installing the carrier itself.

Note that there is a notch on one end. Although not critical, it’s nice to keep the notch aligned with the notch drawn on the printed circuit board (PCB) so you’re sure to install the microcontroller properly when the time comes.

**Step 2 - 10k Resistors (Brown / Black / Orange):** Pretty easy stuff here. Use your considerable soldering experience (you built the Sumovore yourself, right?), and install these resistors into positions ‘R1’, ‘R2’, ‘R3’, ‘R4’, ‘R5’, and... ‘R12’? (Gotta have a talk with the guy who designed this PCB. R12 - sheesh! Yes, install one into ‘R12’ as well.

**Step 3 - 1k Resistors (Brown / Black / Red):** Just like the 10k, but in the group at the bottom in positions ‘R6’, ‘R7’, ‘R8’, ‘R9’, ‘R10’, and ‘R11’.
Step 4, 5 & 6 - Tiny LEDs, Capacitor, and Resonator: Although not critical to the performance of your Sumovore PICBrainy, blinky lights are always helpful. Trust us. Install them into locations ‘L1’, ‘L2’, ‘L3’, ‘L4’, and ‘L5’. Note that the LED has a white stripe that indicates the lead to be inserted into the square pad, old?

The 0.1μF “decoupling” capacitor is installed into position ‘C1’, in any orientation you prefer. Good for keeping the microcontroller power clean!

The 20MHz resonator is installed into position ‘Xtal’ (which is short-hand for crystal, which a resonator contains). This device isn’t polarity-sensitive either.

Step 7, 8 & 9 - Transistor, 3-Pin Headers, and Diodes: The transistor installs into position ‘Q1’, with the curved surface facing to the right. You can just see a small part of the curve on the PCB surface to help you identify the correct orientation. This transistor powers the three auxiliary ports (usually used for servos), and isolates them from the batteries when the main power switch is turned off.

The three 3-pin headers are installed at the positions indicated [which should be labeled left-to-right ‘S’ , ‘S2’, and ‘S3’. Sorry!]

The diodes are installed at positions ‘D1’ and ‘D2’. Watch that the band orientation matches what’s printed on the PCB!

Note: The three 3-pin headers are driven through the ‘Q1’ transistor from the unregulated 6V provided by the quad-AA pack on the Sumovore body. We designed it this way to offer more power to any larger accessory loads like servos that can run at higher voltages than the regulated 5V.
Step 10, 11, & 12 - 5-Pin Header, RJ-11, and Reset Switch: The 5-pin header is most likely going to be your primary method of programming your ‘877. Install it at location ‘P5’. The RJ11 socket is another popular way of connecting the ‘877 to a programmer, and it’s installed at location ‘RJ11-6’.

Note: You don’t have to install both if you know how you’ll be interfacing the microcontroller. We supply you two methods for maximum flexibility.

Step 11: RJ11

The single-pole, single-throw (SPST) microcontroller reset switch is installed at location ‘SWT1’. Nothing to mysterious here!

Step 12: Reset Switch

Step 13 & 14 - Pin Installation, continued: Remember, install these pins on the underside of the PCB, soldering only one pin per strip initially. This lets you eyeball and adjust them so they’re straight up-and-down, which is important so they can mate with the sockets on the Sumovore.

Pin strip installed crooked - good thing you soldered only one pin, so you can re-emit the connection and make it stand straight up!

Remelt solder on top pin, and re-adjust pins so they sit properly, then solder the rest of the pins.

Finished pin installation, all nice and neat!

Step 13 & 14 - 4-Pin and 8-Pin Connector Strips: Let’s start by making this very clear: These parts are installed on the underside of the PCB. Not this side. Ok? Alright? Kapeesh? Ok - carry on.

See the next page for details on how to get these lined up jeeuudst right!

Install all pin headers on UNDERSIDE of Brainboard!

Step 13: 8-Pin Connectors

Step 14: 4-Pin Connectors

Step 15 & 16 - 16F877A Chip Preparation and Installation: Ever notice how most IC chips have their legs splayed out a bit? This is for machine-installation, where the grab the chip by the sides of the legs, squeeze them in a bit, put them into the holes, and release. When the legs relax back out, the hold the chip in place. Unfortunately for us humans, this is not as easy so you’ll have to manually bend the legs if enough so you can easily insert the ‘877 into the socket.

We really, really recommend you do this on a metal surface, while some part of your skin is touching a ground connection. Like near the kitchen sink, while you’re resting a bare elbow on the sink edge. This grounds you, draining off any potential static electricity. Even better if you perform the bend on some aluminum foil also touching the metal sink edge.

With a firm grip on the chip, lay one side on the surface, and bend the chip over until the legs are sitting at a 90 degree angle to the chip. Repeat for the other side.

Starts like this…

(do for each side)…ends like this!

Step 15: Bending the Leads inward

Step 16: Install PIC. Note notch location!
Step 18 - Installing the 5th line sensor: Yank the edge-sensor board out of your Sumovore, and install the included line sensor in position ‘Edge3’, just like you did when you originally built your Sumovore. You don’t have to do this, but if you want to make the best use out of your Brainboard, it’d be a good idea!

Other Brainboard Points-of-Interest: “Leftovers, get yer leftovers!”

The ’877 comes with 8 ADC (analog/digital converters) in the chip’s port ‘E’, of which we’re using five for the edge sensors. The leftover three are grouped near the middle of the chip, labeled as ‘E0’, ‘E1’, and ‘E2’.

Practically all of port ‘B’ has been left untouched, with the exception of the necessary links to ‘B3’, ‘B5’ and ‘B7’ which are used by the programming cable. If you use these three pins, make sure they’re for high-impedance usage only. Avoid using them if you can.

If you need raw 6V from the quad AA pack, ‘TP1’ is your pal. Useful for driving servos, or other high-load circuitry. The three servo headers are driven via this raw 6V through the ‘Q1’ transistor.

There is also a spare I/O pin available from the PCB underside below the ’877 - port ‘RA4’. Look, you’ll see it...

There are a wide variety of ways to program a PIC microcontroller, from expensive powerful commercial units, to bare-bones next-to-no-parts-needed circuits. What we’ve got for you here is a bit better than the bare-bones approach, and will work on pretty much all computers. It’s derived from a programmer designed by David Tait, and will accommodate serial ports that don’t quite have enough voltage (like most laptops) to properly program the PIC.

We’re showing you both versions of the circuit, so you can try the original or our modified version of the programmer. Of course, if you already own a commercial microcontroller programmer (like a PICStar Plus, ISP-Pro or Warp13a), you’re good to go!

The RJ11-6 jack on this brainboard is configured to work with the ISP-Pro programmer, which is one of the PIC programmers we use in-house at Solarbotics.
This is the default code that your PIC 16F877A ships with. If you mess something up, you can either re-download it from our website or type it in from what you see here (ug!).

There are a great many languages to pick from to program in, some of which we’ve linked to on our website. Some are free, some not - it depends on what suits you best.

We’ve decided to code our default program in JAL ("Just Another Language"), which is a free GPL programing environment developed by Wouter van Ooijen. It’s more like PASCAL than C, but it’s still pretty easy to work with. Check out the resources page for this brainboard on the Solarbotics website for full documentation.

There are three major sections to the code, being the startup routine, the Sumo routine, and the Line-follower routine. If you start your Sumovore on a black surface (like a sumo ring), the startup routine reads the low inputs from the edge sensors and determines that it should start the sumo routine. When on a white surface (like line-follower usually is), with a black electrical tape line), then the startup routine kicks the Sumovore into ‘running the line-follower routine.

Both of these programs are pretty decent, but there is much more room for creative optimizing. Feel free to modify and hack this code - we’re presenting it to you as a good starting point.
For those of you wanting to do more customizing to your PIC 16F877a Brainboard, here are the microcontroller pin assignments and the PCB schematic.

With all the extra I/O available to you with this microcontroller, you should have no problem in adding in a multitude of modifications to make your PIC-powered Sumovore even more competitive!

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