# Twin Tweaks


## THIS MONTH:

## Super Robonova

This month we will present the new Robonova-1 from Hitec. The Robonova-1 is a new "edutainment" robotics kit, and it can be acquired in the fully assembled "ready to walk" condition or, as we prefer it, in pieces. The Robonova comes with 16 servo motors, a plethora of prefabricated aluminum body pieces anodized in a slick copper tone, a comprehensive instruction manual, a complete software suite including RoboBASIC V2.5 and Roboscript, a serial cable for programming, an infrared remote control that would be easy to confuse with the one for your TV, and a battery charger.

The Robonova is billed as an "edutainment" robot, and while any robot that can do somersaults is bound to be entertaining, it does not come with any type of canned curriculum like some educational kits do. But how can a bipedal servo walker not teach you something?

## Gulliver in a Land of Tiny Screws

Building a walking robot from scratch is sure to be an educational experience, even as just a way to see what goes into making a bipedal servo walker. In the case of the Robonova, that's mostly a great number of very tiny screws.

Assembling the Robonova was a bit like playing Dr. Frankenstein. The robot was assembled in a piecemeal fashion; a leg here, an arm there, and finally the body. The instructions were unclear and frustrating at times, but the physical assembly was not terribly vexing. Each servo had a conveniently labeled clock of sorts on the driven servo horn to ensure that each limb would have a full range of motion without tricky guess work and estimations on behalf of the builder as to the location of the center of rotation.

The trouble with the instructions was an infectious strain of inconsistency — some pictures would block out the servos (which were conveniently numbered) for a particular limb in a certain order, but then another picture of the actual assembled piece would label them in a different order (not so convenient). We eventually came to the conclusion that some of the pictures were simply not meant to be taken literally, but

*The Robonova Kit.*


*Robonova Before.*


*The Programming.*

they were a hassle nonetheless.

While a nimble mind could sort out the troublesome instructions, sometimes even the nimblest fingers could have trouble with the fasteners of choice for the Robonova — micro mini screws. The screws, dubbed PH/M and PH/T by the kit and distinguishable only by the coarseness of the threads, could sometimes be so squirrelly to handle that perhaps the best recommendation to any builder would be to lay off of the nail clippers for a few days before attempting to assemble the Robonova. And make sure you have a tiny Phillips head screwdriver ...

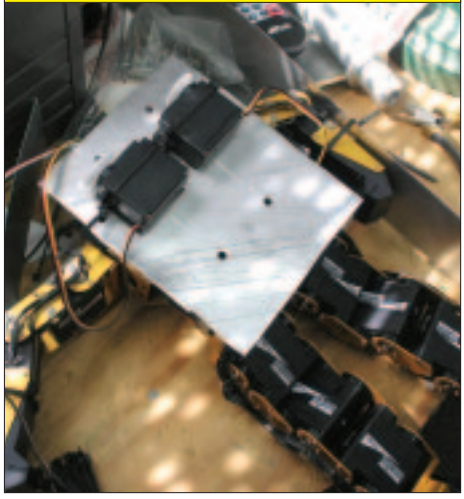
Once all of the screws are securely in place (over 100!), the Robonova is ready to be wired up. Thankfully, the instructions become a bit clearer at this point, and the kit includes plastic wire clamps to make routing the wires from 16 servos not quite as tedious a task as it might seem to be. Once all 16 wires are connected to their respective pins on the Robonova's compact circuit board, all that is left to do is attach the body panels. Looking at the mess of wires protruding from the Robonova's back, it's really quite amazing that the back panel fits on, but fit it does.

The Robonova does not come with any preprogrammed modes that allow it to amaze you with its acrobatic ability immediately after construction, but the software CD does come with a cornucopia of template programs ready for downloading. The program that caught our eye was one that allowed the remote control (or Roboremocon, as it's called in the kit) to command the Robonova with a variety of preprogrammed moves, ranging to the most functional task of walking to a very entertaining ballet move where the bot balances on one leg and flaps its arms around as if to imitate a bird.

Of course, the part about installing the infrared sensor to make the Robonova responsive to the remote control only comes after the point where you're told to close the bot up, but it's really no trouble at all to pop it back open and hook up one more wire. One caveat about the infrared sensor, though: the instructions encourage mounting the sensor to the top of the Robonova's head, and while this is the logical place to put the receiver to ensure that you get a clear shot with the remote control, it does seem like a dangerous place for a delicate sensor on a robot that does somersaults and handstands. A protective visor was put on the list of modifications.

For any last aesthetic touches (not that this slick looking bot necessarily needs any), a full suite of decals are included so you can give your own special touch to your creation.

*The Panel.*

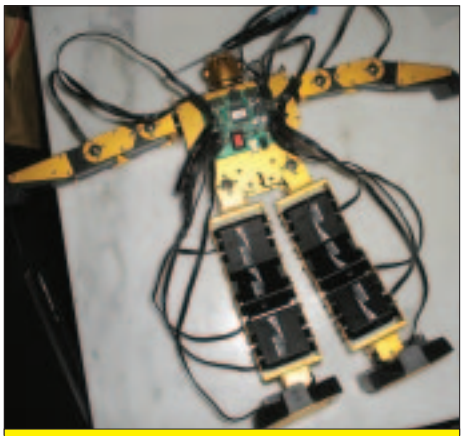


*Showin' a Little Leg.*

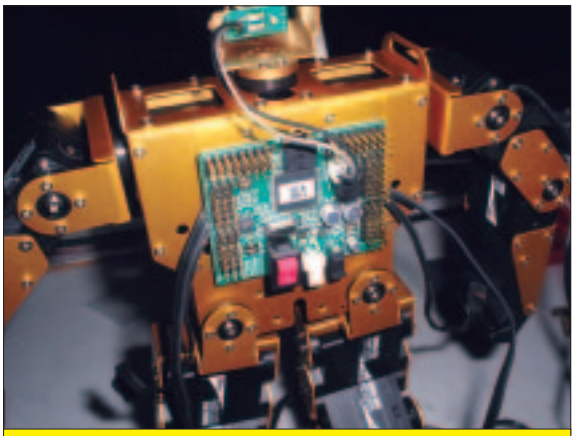
## RoboBASIC Basics

The Robonova comes with its very own programming language, Robo BASIC. RoboBASIC is really very much like any other form of Basic, but just with some special commands thrown in specifically tailored for the Robonova.

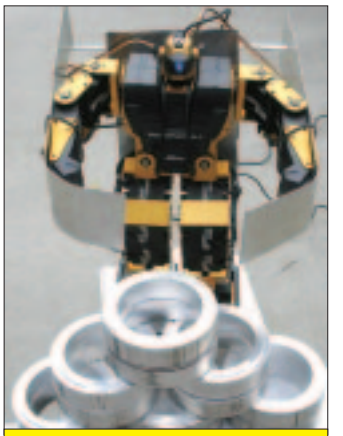
The software CD that comes with



Robonova Wiring.



The Electrical Setup.



Cylinder Stacking.

the Robonova includes a detailed manual on programming in RoboBASIC. The manual includes a brief overview of each command, the syntax of the command, and an example of how the command is used. The manual is logically ordered, starting off with major topics like servo control and then branching out later to more periphery matters like gyros that could be added onto the stock Robonova. The organization of the programming manual even struck as curriculum-like in a sense, or at least there was the potential there to turn the manual into an effective teaching tool to fulfill the "edu" half of "edutainment."

The only possible shortcoming of the programming guide is the lack of comprehensive examples to illustrate the implementation of the various commands in the context of a complete program, but other than that, even programming novices should be well equipped to start coding after leafing or clicking through the manual.

Another helpful software tool is RoboScript. RoboScript is an application that allows for a visual manipulation of the servos for programming — gauges representing each servo are displayed, and adjustments can be made by clicking and dragging. The great part is that once you have crafted a position with this graphical user interface of sorts, the actual RoboBASIC code will be written for you and inserted into your program. It's a great tool for anyone apprehensive about diving straight into RoboBASIC or for someone trying to get over a phobia of analog gauges.

Other cool software tools are some applications that read information directly from the Robonova. After reading the settings of the servos, you can manipulate them one by one on a type of computer waldo that allows the programmer to see exactly what value on a servo corresponds to what position clicking on the dial on the computer picture of the Robonova will cause a corresponding move in the actual robot. This is a great way to take the guesswork out of choreographing motions for the Robonova. A similar tool allows you to reset the zero point of the servos, in case the Robonova ever gets a little off balance in its neutral position.

## Tipping the Scales

The bipedal form of the Robonova is already so diverse in its abilities that it was a challenge to think of a way to augment those abilities. Really, what is there to do to improve upon a robot that can already walk (forwards and backwards), do somersaults, execute karate moves, balance on one foot, and do a passable impression of a graceless servo-powered bird?

Leafing through a *SERVO Magazine*, it's actually quite easy to find a way to augment the motion and abilities of the human form. The Tetsujin competition is all about augmenting human motion and abilities with exosuits, so why couldn't we design a mini exosuit for the humanoid Robonova?

For those of you not familiar with the competition (if this is your first issue of *SERVO Magazine*, or if you just fell off the turnip cart yesterday), Tetsujin 2006 will be comprised of three separate challenges: the walking race, weight lifting, and cylinder stacking. These challenges are designed to test everything from strength to mobility to dexterity, and all of them involve the difficult task of designing a mechanical unit to fit around the human body. While increased strength and mobility can easily be achieved for a mechanical unit like the Robonova by just doing something like giving it stronger servos or overvoltaging the bot, a bipedal servo walker could possibly serve as an effective scale model to test designs for an exosuit.

And so we had our challenge. Scale down the Tetsujin challenges and create a mechanical exoskeleton for the Robonova. The first step that we took was to make a comparison between the height and weight of the Robonova and a human being. The height of the robot was easy to measure — about 12.375 inches. The weight was made a little difficult to measure by the fact that we didn't have a decent scale at Robot Central (our garage at home).

Thankfully we go to UCSD, a top research institution with an excellent engineering school, so we were bound to find a scale somewhere. We eventually found a triple beam balance in one of the physics labs and we subsequently found the weight of the

Robonova to be 1.3327 kilograms, or 2.938101 pounds, since we like to use USCS units. That means the Robonova is about a foot tall and three pounds, so using some very rough estimation that means the Robonova is ten times lighter than a person of comparable height.

## Prince Myshkin

We were ready to start hacking into the Robonova to equip it with a mechanical exoskeleton, but a mysterious problem hindered our progress. Whenever the Robonova is turned on, it assumes the neutral standing position, but after a few days of operating normally, the Robonova would kick out its left leg defiantly, rendering it unable to stand. Thankfully the software comes with a way to reset the zero point on the servos, but the Robonova's leg eventually kicked out so far that the zero point couldn't even be reset to the point where the Robonova stood upright again. Sometimes the Robonova would even fall victim to inexplicable seizures of uncontrollable motion that earned it the name Prince Myshkin. We were baffled by this problem and eventually settled on the less than ideal solution of reattaching the left hip servo turned slightly backwards so that when the leg kicked out, it actually allowed the Robonova to stand straight up. This made it so the Robonova no longer had the full range of motion in its left hip, but it was worth it to get the bot back its good posture.

## Turning the Tables

The first challenge that we would take on with the Robonova would be the cylinder stacking task, a test of dexterity. We're all about giving credit where it's due, and the exosuit design that we'll use for the Robonova is actually a solution for the cylinder stacking task that our dad came up with. The design basically comes in two parts: a turntable to allow for safe turning while carrying a heavy load and arm attachments to help in the lifting itself.

This is a design that was meant for the actual size challenge, but it is actually nicely suited to the Robonova, as well. The idea behind the turntable is to allow safe, ergonomically correct turning. When you're carrying a heavy load (like a 70 pound concrete cylinder), it's very unsafe to turn in the waist because of the heavy load. The turntable would do the dangerous turning instead, allowing the operator to focus on the heavy lifting.

The idea was that the operator would actually stand on top of a large turntable of sorts to achieve this safe turning, and the increased height of the operator might also come in handy while stacking the cylinders into a tall pyramid. This design also works nicely for the Robonova since it can't turn in the waist, and shuffling its feet to turn while holding a scaled down heavy cylinder is iffy at best, certainly prohibitively dangerous when applying such a maneuver to human motion.

An actual size turntable would likely use some powerful motor with crazy gearing, but we didn't have any crazy-strong, crazy-tiny motors for the Robonova's turntable. What worked out nicely for hacking into the Robonova, though, was that the Robonova's board had plenty of open ports for hacking. There were plenty of servos in the garage available for hacking as well, so we picked out a few choice pieces from former FIRST Edurobot kits and proceeded with those. One of our initial ideas with the Robonova's exosuit was that the suit might require a separate brain, but by wiring the extra servos directly to the Robonova, the suit was very much an extension of its "operator" (keeping in the spirit of the Tetsujin mission).

There was plenty of scrap aluminum to craft a turntable out of in Robot Central, so after mashing together a servo from the Edurobot, gears from the VEX Robotics Design System, and discarded aluminum from Cosworth, Inc., we had a working turntable for the Robonova's exosuit. Some possible future modifications include physically bracing the Robonova onto its turntable to help with the torque created by the heavy cylinders, but first we had to get some more of the suit done so we would

*The Turntable.*

*Glamour Shot!*

*Road Trip!*

even have torque from a lifted cylinder to worry about in the first place.

## If You're Happy and You Know It

The second half of the design would involve strength augmenting arm extensions to help with the actual heavy lifting involved in the cylinder stacking challenge. The idea for the actual size design would be to have arm extensions extend from beyond the hands of the operator to beyond the shoulders of the operator. The extension beyond the hands of the operator would do the actual lifting of the cylinder — this eliminates the risk of any pinching of fingers by allowing the suit (not the driver) to hold on to the cylinders.

The extension beyond the shoulders of the operator would connect to the mechanism that drives the arms and hopefully make them stronger than the operator would be normally. The idea for the actual size design would be to have some kind of large pneumatic or hydraulic piston to power the arm extensions. The idea is to have the piston mounted horizontally between the arm extensions, so that when the piston extends the arms close, and when the piston retracts, the arms open. Not only is this motion clean, simple, and appropriate to the task, but it made the Robonova look like it was clapping when it was not picking up cylinders. Like a toy monkey with cymbals, but a robotic monkey with augmented abilities.

Anyway, we didn't have a pneumatic cylinder small enough for the Robonova, so we decided to use two servos, once again generously donated by the Edurobot, in place of it. While this certainly wouldn't be as strong as high pressure pneumatics, the Robonova was merely a model for the design anyway, and according to our high school physics teacher Vera Korchak — "there are no right or wrong models, just more accurate and less accurate ones." Our design might be less accurate in modeling the actual size design that inspired it, but we were sure that we would still be able to strengthen the Robonova with the mini exosuit. The arm extensions were also particularly useful for the Robonova since the bot had no end effectors besides its plastic fists, and those did not seem well-suited to gripping heavy objects. So the servo powered arm extensions were here to stay.

Of course, lifting a heavy cylinder at the end of the arm extensions could cause a potentially unbalancing torque from the weight of the cylinders, but some more additions to the suit could fix this problem. Some kind of leg braces could keep the operator from tipping over, and some springs of some sort could help in the lifting itself. If there were springs under the arms of the suit, they could compress as the arms are lowered and then help the operator lift the heavy cylinders as they decompressed. Of course, pneumatics or hydraulics might be better suited to an actual size design, but some extra springs from the FIRST kit of parts are perfectly sized for the Robonova.

Numerous tie wraps went into attaching the Robonova's exoskeleton, but other than the fact that the Robonova had to be cut out of its suit, tie wraps seemed to be a good approximation of being strapped into the exosuit. After being strappd into its suit, the Robonova certainly looked stronger ...

## Mini Tetsujin, Big Challenge

We know what you're thinking. Oh no, there's so much left to do — testing the cylinder stacking suit and two other challenges altogether, how can they wrap it all up in a few paragraphs? A combination of many factors, including the Robonova's strange erratic behavior, winter quarter finals at UCSD, and the indomitable march of time, fabricating the Robonova's exosuit was simply too ambitious a project to finish all at once. Scaling down the grand challenge of Tetsujin simply cannot be done justice in a single article anyway, so the Super Robonova will be back next time to test its strength, dexterity, and mobility.

Will the Robonova be able to stack heavy cylinders as easily as a magician stacks a house of cards? What exciting designs are there in store for the other two Tetsujin challenges? Will the Robonova develop any other strange afflictions that warrant an allusion to classic Russian literature? All questions and more will be answered in the next installment of Twin Tweaks, so until then, keep tinkering.

To be continued ... SV