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September 2010

HOVER BOTS

**Wheels?
We Don't
Need No
Stinking
Wheels!!**



♦ **GEERHEAD**
TITAN - Guitar Hero
Playing Robot From
Lee's Summit West HS
TITANIUM Robotics Team

U.S. \$5.50 CANADA \$7.00





PAGE 11

Departments

- 06 Mind/Iron
- 20 Events Calendar
- 21 Showcase
- 22 New Products
- 26 Bots in Brief
- 64 Menagerie
- 74 SERVO Webstore
- 82 Robo-Links
- 82 Advertiser's Index

Columns

- 08 **Robytes**
by Jeff Eckert
Stimulating Robot Tidbits
- 11 **GeerHead**
by David Geer
Titan, Baddest Guitar Hero Playing Humanoid on the Planet
- 15 **Ask Mr. Roboto**
by Dennis Clark
Your Problems Solved Here
- 67 **Twin Tweaks**
by Bryce and Evan Woolley
13 Years Under the Sea
- 77 **Then and Now**
by Tom Carroll
Robot Manipulators

PAGE 67



PAGE 35

The Combat Zone...

Features

32 PARTS IS PARTS:
Let's Roll — Wheels for
Combat Robots

35 MANUFACTURING:
Creating Composite
Combat Bots

**38 Combat Zone's
Greatest Hits**

Events

**38 Results/Upcoming
Events**



PAGE 52

40 The NXT Big Thing #2

by Greg Intermaggio

This time we get touchy-feely by first learning how the computer software included in the kit works. Then, we'll use our first sensor to navigate our robot around a room.

47 Tool Time With the Versapak Smart Charger

by Richard Spelling

Whether you have Versapak tools or not, this circuit can be used to charge any NiCd or NiMH battery pack and can restore what you may have thought was lost (battery wise, that is).

52 The Wasp Embedded Processor Takes the Sting Out of C

by Fred Eady

If you're already a C expert, you'll be interested in the hardware discussed here. If you're a hardware guru and want to know more about how C and an AVR microcontroller can work together for your robotic projects, there's something for you too.

59 "Roll" With the HoverBot

by L. Paul Verhage

Wheels? We don't need no stinking wheels with this unique bot that's lighter than air.



GEER HEAD

by David Geer

Contact the author at geercom@windstream.net

Titan, Baddest Guitar Hero Playing Humanoid On The Planet



The complete Titan Guitar Hero playing robot system with speaker system, television, web camera, DVD media player, the robot with laptop head, hand actuators, and guitar.

A high school robotics team is tasked to solve complex programming and design problems in robotics to achieve a worthwhile goal for their age group in popular culture. Their resolution: a humanoid robot that effectively competes in a significantly high percentile in the Guitar Hero video game, defeating most opponents.

Titan just may be the most “legit” (i.e., coolest) non-commercial robot rocking the Internet today. This music-savvy mechatron has the licks to rock expert level on Guitar Hero, playing songs with the difficulty of Iron Maiden’s “The number of the Beast” or Eric Johnson’s “Cliffs of Dover.”

Decked out with a laptop head, black PVC construction, and brand name chest plate, Titan — named for the mascot of Lee’s Summit West High School which produced

the robot’s creators — was inspired by another Guitar Hero robot that the high school team discovered in an exhibit.

Team Titanium came up with the idea for their robot at the 2009 FIRST Robotics Championships in Atlanta. “As a major FIRST sponsor, National Instruments had a big presence there, including a large booth area with various demos and seminars. All of the FIRST participants there were mesmerized by a very cool project they were showing



The web camera mounted in front of the TV where the notes are displayed.

translating the notes into instrumentation by the robot's hands.

The team would have to use an inexpensive web cam and a common laptop instead of the costly, high frame rate camera and high speed controller device used by NI. The students were concerned the camera might not be fast enough to pick up all the notes and that the laptop might not be fast enough to process the vision task and control the robot's fingers (guitar actuators).

Fortunately, Team Titanium was able to use NI's LabVIEW industrial control software which helped the team in producing their FIRST competition robots. The software includes video and vision tools and libraries, but would that be enough to create sufficient programming to recognize all the notes and outgoing signals for each note?

A Glimmer of Hope

Within a few short hours of tinkering, the team's software writer had a program running. The web cam was watching the TV screen, the game was running, and the program was flashing lights on the LabVIEW interface in tandem with the notes on the screen. "We did not know if the results were good enough to play the game well, but it was clearly good enough that we knew the vision task was within reach," remarked Spatz.

Moving on to the robot's construction, the team quickly decided to create a standing, humanoid robot with arms and legs that would approximate a real person playing the game. It would even be able to compete with real people.

This way, the robot would demonstrate the team's capabilities, help recruit future team members, and perhaps even help raise money for the team.

The actuators would need to function similarly to hands and fingers. They would need to attach to the guitar and be connected back into the robot's system. This way, the guitar and strap could hang on the robot just like on a real rock star, making the robot look more lifelike. "We decided to use simple solenoids for low cost and simplicity. We purchased a few 12 volt cylindrical solenoids, and tinkered with various finger designs to actuate the buttons on the guitar neck and toggle the strummer on the guitar. These two tasks were completely different design projects, but we were able to do both with the same solenoids," says Spatz.

The team also wanted the robot to employ the guitar's whammy bar which is similar to the hardware on a real electric guitar used to stretch and release the strings for special sound effects. An

The robot's laptop head runs the LabVIEW-based interface and program for playing Guitar Hero.

off: a Guitar Hero playing machine," says Jeff Spatz, head coach of the high school Team Titanium.

The NI system used an industrial machine vision camera, a high speed controller, and a complex pneumatics system to play the plastic guitar as part of the famous video game. The NI robot used the camera to read the notes rolling off the TV screen so the robot could play them — and play them quite well.

Building a robot better than that of NI posed several problems. Cost was a factor, since the high school robotics team operated on a very limited budget. During the first stage of development, the team focused on duplicating the robot's real-time vision task: seeing, transmitting, and



The robot's power supply, relay board, and control panel on the back of the robot.

additional actuator was adapted to that task.

"Using the Autodesk Inventor CAD that we used to design our competition robots, we designed hand assemblies that matched what we learned from our prototypes, and started to fabricate hand parts. After much tinkering, we had two hand mechanisms that could attach to and operate the guitar," Spatz explained.

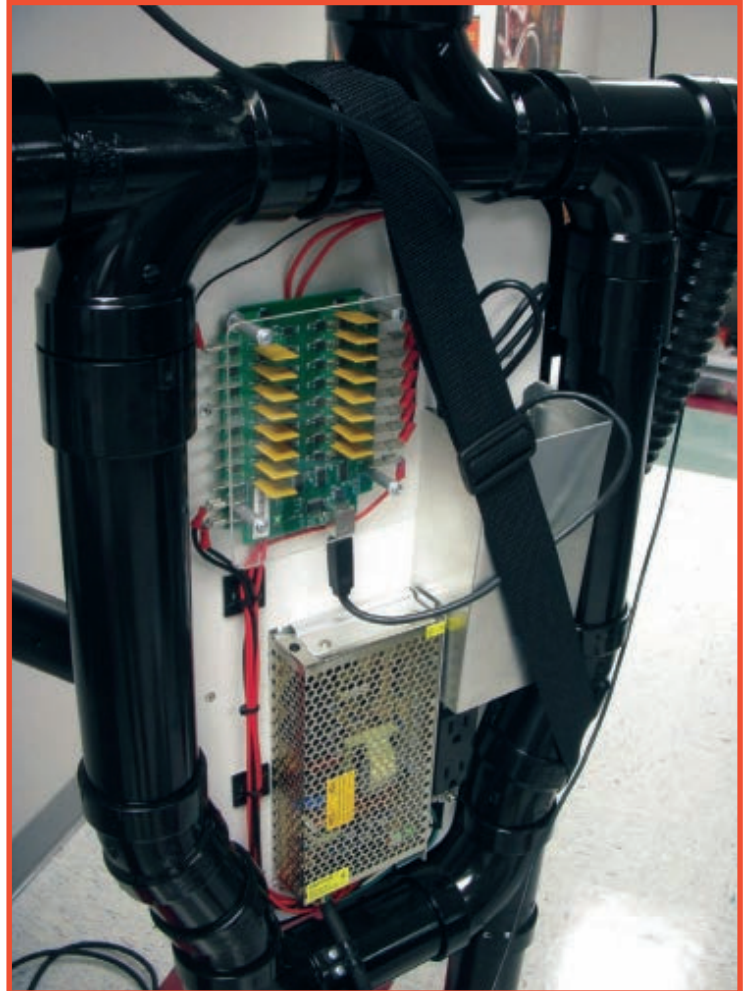
Once the vision and control software were completed on the laptop, and the hand mechanisms were ready to play the guitar, the team simply needed to create an I/O link between them. "We were hoping to find an inexpensive, all-in-one solution to go directly from the USB port on the laptop to the 12V high current signals we needed to drive our solenoids (the hand actuators). After much searching, we found it at a small irrigation controls company on the web called Bibaja," Spatz continued.

Bibaja's I/O solution used a small, cheap controller board designed for controlling irrigation systems. It translated the USB data into 16 channels of 12 volt output, Spatz commented. "We got the board, wired up the system, and were quickly playing Guitar Hero even better than we expected. There was still much experimenting and improving to do, but we knew we were in the ballpark," Spatz conveyed.

Using multiple variables in the programming, the team was able to make many adjustments. They were able to adjust the screen size, the locations for the camera and system to watch, the brightness level and duration of the light required to indicate a note, the ranges that occurred between notes, the time delay allowable between seeing a note and playing it on the guitar, the length of the output signal to the solenoid actuators and the length of other signals, and the length of the note required to activate the whammy bar, listed Spatz. With hours of practice and adjustment, they arrived at the best settings for the robot to play at the most expert level that it could.

Body and Soul

Next, the roboticists constructed Titan's body on which they mounted everything. They made it out of PVC pipe, with a glossy black



Close-up of the robot as its actuators play the guitar.



Close-up of the right hand strumming the guitar.



Close-up of the left hand fingering the fret board.

coating of paint.

They used vacuum hose to create the flexible arms, so they could connect them to the hand assemblies and use them to hide the wiring.

A 12 volt power supply mounted near the relay board

and power outlets on a control panel formed the electronics in the robot's back. "It was clear that the controlling laptop computer should be his head, so we added a platform on which it sat. We added colored LEDs to his fingers which flash as each finger is actuated. This made him much more interesting to watch," Spatz detailed.

To round out the self-sufficient, portable robot system, the team added a Wii console, guitars, a flat screen TV, and a speaker box with car speakers and amplifier, as well as wheels on which it could travel.

The robot currently scores in the 90s in the expert level of Guitar Hero for most songs it plays. Kids love to watch the robot at exhibits and demonstrations. "Many young Guitar Hero aces challenge him, but very few can beat him. We have added the ability to set him to play at any difficulty level (easy, medium, hard, or expert) so that he can play along with any level of challenger. He has become a great ambassador for our team, and quite the celebrity in our community," Spatz mused.

The team has put Titan on display at sports events, science fairs, camps, school assemblies, street fairs, and FIRST Robotics regional tournaments. "He even performed before a crowd of 2,000 Cerner Corporation employees at their annual convention at Kemper Arena in Kansas City. He has become popular on the Web, and we have received comments about him from all over the world," concluded Spatz.

Resources

Titan, original introductory video
www.youtube.com/watch?v=VLQhX0nZV6I

Titan, video playing "Cliffs of Dover" expert
www.youtube.com/watch?v=0mWHVvKb1hM

Titan, featured on Kansas City TV channel
www.youtube.com/watch?v=7uTnSHbRjF4

Titan, performing for Cerner Corporation convention
www.youtube.com/watch?v=zUEVzjbzjD4

Titan, story from school TV channel
www.youtube.com/watch?v=5Yx-JYXEqh8

Kansas City TV feature story about the student who programmed Titan
www.youtube.com/watch?v=iu2OcJ82zQg

National Instruments interviews with the student who programmed Titan
www.youtube.com/watch?v=kYhJMB8irhw&playnext_from=TL&videos=tUbZF0gNknk and
www.youtube.com/watch?v=ievSpmNU1fw&playnext_from=TL&videos=Ca72RhQ7zj4

NI LabVIEW software used with Titan
www.ni.com/labview

Bibaja's I/O technology
www.bibaja.com/products/index.php?page=iopoint_usb

Final Notes

Titan achieved all expectations as an attractive, highly accomplished humanoid, Guitar Hero playing robot. Team Titan also uses the robot as a fundraiser, charging a small fee to those who want to challenge the robot in Guitar Hero. The robot has been a great addition to the robotics team's PR efforts, striking a deep chord with the community. **SV**