FIRST ANNUAL CSU IEEE-HKN OPEN DESIGN COMPETITION

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Official Component Retailer
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Project Overview

One of the challenges within engineering as a whole is getting students actively engaged in their curriculum, their community, and striving to improve the technological environment around them. In response to this, team members Austin Steingrube and Eve Klopf created and organized the first annual Colorado State University IEEE-HKN Open Design Competition. It focused on getting students involved in their engineering community, local industry, and keeping students interested in their major with hands-on electronics.

Background

The idea for the design competition was conceived as of an effort to get students involved on many different levels. A nationwide trend over the last ten years saw a rise in the percentage of electrical engineering students that changed their major in favor of another. As a way to try to inspire students to "stick with" their major, the Electrical and Computer Engineering Department at Colorado State University created a focus group and brought the topic to the minds of local industry and research companies. Three of the reasons that stood out over weeks of discussion and brain storming, was 1) students were becoming disillusioned by strenuous study loads, 2) they had few hands-on projects outside of lab, and 3) student involvement, compared to past years, has declined.

Colorado State University's student chapters of IEEE and Eta Kappa Nu (Delta Pi Chapter) came together to tackle these issues. By getting students to become actively involved in student activities and organizations, we found that they would also become more involved with their peers, their industries, and would be a lot less likely to become disheartened by a heavy study load. Several ideas were thought about, from mini-project and pizza nights to bowling nights and various other get-togethers, but the idea that stuck out was to create a design competition that geared towards the students from the ground up.

Structure of Competition

Unlike a traditional design competition where a prompt is given, participants work on a design, and return a few months later with their project, the CSU IEEE-HKN Open Design Competition was structured quite differently. There were no specified prompts, community workshops were created to help students with circuitry, program, and design, and a new judging scheme was put in place to make the competition as friendly as possible.

No prompts

The focus of organizing the design competition was to get students engaged in engineering. We felt that having a specific prompt was limiting to our goal in many different reasons. A prompt would prevent some students from participating if they didn't find the prompt interesting. Depending on the depth of the prompt, it might discourage younger students who have a more limited knowledge base due to their class rank. And, should a group of students take the challenge of a prompt and find they didn't do very well, it may dishearten them and have the opposite effect we were looking to achieve.

By having an open call for project ideas, students are able to find an area of interest that suits them, learn more about it, and then challenge themselves by creating an electronic project. The result is that the competition would create an immersive learning and thinking environment for everyone who participated. In terms of organizing the competition itself, this is a win-win situation; the students are learning and becoming inspired while that same interest drives up participation numbers.

Even though we didn't have a prompt, we did choose to have real engineering constraints. The students were asked to keep their bill of materials under $150, they were all asked to use the same open-hardware microcontroller, and were asked to use the same IDE to program that microcontroller. The constraints had dual purposes: 1) they forced the students to think as engineers and find a solution that will best suit the situation and 2) they created a level playing field to allow a basis of judging to be formed.

Workshops

Learning is one of the most integral parts of engineering as a whole. A good engineer takes small snippets of information, combines it with previous knowledge, and uses that to form a new solution. As a large number of the participants of the competition would be underclassman with a more limited knowledge base, the workshops were developed to teach them the base skills they would need to create a fully functional project. As the promotional flyers said, "At the end of the competition, even an English major could make a robot."

Austin Steingrube teaching a workshop

The workshops provided the students necessary skills and background in digital I/O, programming, circuitry, project synthesis, and more. So that the workshops could be as effective as possible and were to promote a high level of hands-on learning, the microcontrollers and many electrical components were provided for the students by the generous contributions from Wolf Robotics, LLC in Fort Collins, CO and the IEEE Standards Education Mini-Grant program.

To complement the workshops and resources given at the workshops, most of what was discussed was posted and elaborated at csuieeedesign.blogspot.com and csuieeedesignresources.blogspot.com for easy reference of the students.

The first workshop looked at programming basics and digital I/O. At the end of the first workshop, students were able to use programming libraries, use a few advanced programming techniques, read and write to pins, and handle various types of input. They walked away with from the workshop having made an electronic version of the "High-Low" card game that used LEDs, switches, and some advanced programming techniques.

The second workshop was centered on analog circuits, sensors, and using PWM to simulate analog conditions with passive components. At the end of the second workshop, students knew how to read analog values into their microcontroller and scale the input to real voltages, wire different sensors and devices (such as a potentiometer) as inputs, and various other important circuit applications like the voltage divider and current limiting resistors. At the end of the workshop, students made an electronic version of the "Wheel Of Fortune" spin wheel using a potentiometer, several LEDs, and a speaker. The faster the potentiometer is spun, the faster the LED representation of the wheel would "spin" until they slowed and settled on one of the LEDS in a circle.

Students helping each other with a workshop

The third workshop featured "circuit bending", also known as electronics "hacking", which is repurposing electronic devices for a new use. The idea was to get students thinking about all of the engineering around them, how it works, and how they may change it to work for a new use. Very often, it is more cost and time effective to use what is available than it is to make a device from scratch. At the end of the workshop, students were equipped with the knowledge of how to find useful devices, "hack" them, and repurpose them to work with a new device. The project for the night was to hack an old PS2 keyboard to allow their microcontrollers to easily accept text input without a terminal connection.

Due to a heavy testing schedule, the fourth workshop was recorded via "screencast" and then published online. The idea was that the students could view the workshop they had time and focus on tests when they didn't. The workshop was based on conceptualizing an idea, looking at various aspects, features and uses of the device that would stem from the idea, and then actually realize it in the physical world. A concern that was widespread amongst many participants was that they didn't know where to start when it came to their project. This workshop helped many of them get on the right track.

The last workshop and most highly anticipated workshop focused on electromechanical movement and IEEE standards (discussed in great detail within in the **Teaching IEEE Standards** section). Students were given an engineering challenge that required them to create a communication standard to get several servos to move in sync over a large network.

Judging

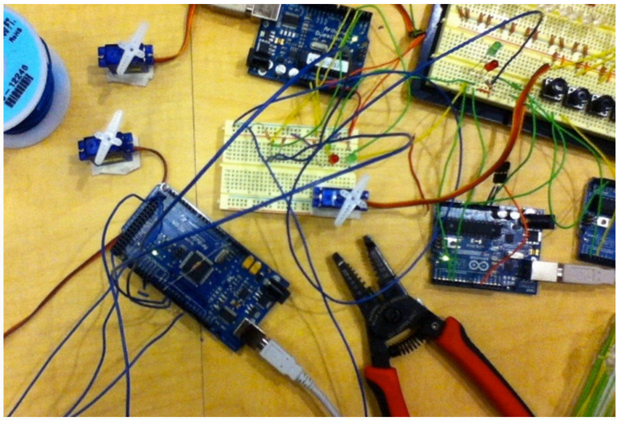
Due to the open nature of the competition, the concept of judging must be dramatically changed compared to that of a traditional design competition. There is simply no way to gauge the fastest, most accurate, or best designed project with such an unlimited variety of possible gadgets that could have been made. All of the projects were designed and created with different goals and constraints in mind, making traditional judging guidelines null. With respect to this fact, projects were judged on four common and unifying categories: Originality of Concept and Design, Technical Engineering Skills, Programming Methodologies and Execution, as well as End Functionality. To help the younger students, a small number of bonus points were awarded to teams that consisted of lower class years as well.

The award distribution was inspired by a dog show. "Best Of Show" and top cash prize of $300 went to the project with the highest total score. Four smaller prizes of $50 were distributed to the teams with the highest total scores in the categories described above. Custom-made trophies, created by Mr. Steingrube, in addition to the cash prizes provided Wolf Robotics LLC and the IEEE Standards Education Mini-Grant, were given to the 5 winning teams.

Teaching IEEE Standards

While immensely important in the engineering world, learning about standards of any kind can often seem dull and uninteresting from a student's perspective. Given their inherent value and importance, we set out to form a solution to this particular problem by creating a hands-on workshop. The workshop was brought to life using microcontrollers, servos, and a fun engineering challenge.

In order to understand the technical side of IEEE Standards workshop, the students would need a basic working knowledge of servomotors and electromechanical devices. It was very likely that many of the teams would use servos in their project, which is why they were chosen for this workshop. They are also relatively inexpensive and ubiquitous throughout the consumer and industrial electronics world.

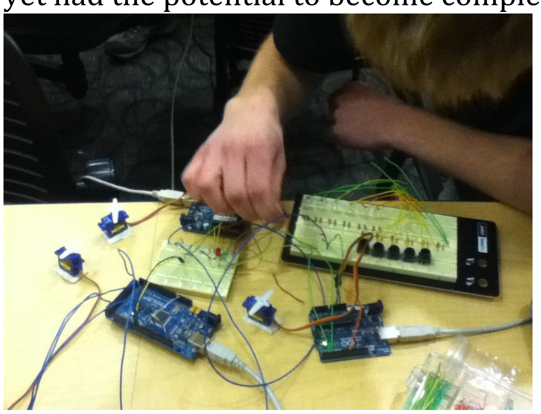


To learn the ins and outs of servo control, they all wrote a simple program that would sweep the servo arm the full range of the servo and then a program that would move the servo to randomly selected angles at regular time intervals. After the first 25 minutes of the, the students had gained an understanding of how a servo works, how it is controlled, and how it may be applied to a project or device.

Teaching Standards in an Immersive Environment
The next two hours were devoted to learning about IEEE standards and to doing the hands-on “standards challenge”.

To understand the importance of standards, we discussed a several companies whose product lines didn’t conform to any IEEE, de facto or industry standards. A common trend was that most of the product lines, and sometimes entire companies, went out of production. By not conforming to standards, the products had limited functionality when interfacing with other devices, making them undesirable and sometimes worthless to a technology driven society. The point of the beginning discussion was to address the following idea: “If you make a device, it needs to work well with supporting technology. If there were no standards, few things would interoperate, and no things would interoperate well.”

Having an idea of why standards are in important in daily life, the students looked at how standards are formed and what types of considerations are brought to the table when proposing them. These concepts were brought to clear focus by the standards design challenge created for the workshop: *Create a communication protocol between microcontrollers that moves multiple servo motors, in sync, to predetermined angles.* Another way to say it is that when a master controller moves its servo to a position, the rest of the microcontrollers move their servos to the same position at the same time. The challenge itself was simple so that it could be completed during the time we had to do the workshop, yet had the potential to become complex and difficult depending on how far it was taken.



To fulfill the challenge, students looked at a few key points and decided that their system and protocol must be expandable, as simple as possible, and reliable. After a few minutes of discussion, the students chose how they would address the prompt: all of the problems would be handled by a real-time binary serial interface. The main microcontroller would choose one of four predetermined angles for its servo and then broadcast that angle using a set of three wires – one ground, the other two representing the two binary bits. Every combination of the binary bits corresponded to one of the predetermined angles. Each slave would then take that signal, broadcast it to the next microcontrollers, and then move its servo accordingly. Should extra angles be needed, another wire could be added to increase the number of angles by a factor of two.

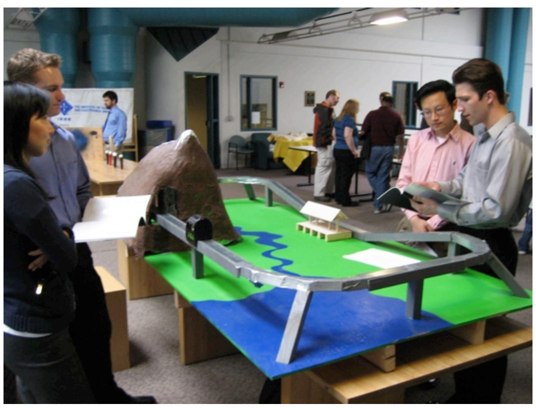
By the end of the workshop, the students picked apart a problem, thought about its future potential, and then created a standard that addressed the current problem as well as ones that might occur in the future.

<u>The Judged Event</u>

To judge the competition were 7 members of industry, research, and academia. Over the course of 2 hours, they talked to the students about their projects, asking them about the engineering challenges they conquered, the ideas that they had, and what interesting things they did. They were scored to a rubric the looked at the four categories of Originality, Technical Skill, Functionality, and Programming, each holding a total of 10 points. Bonus points of up to 4 points per rubric were given to younger classman and smaller teams. Deductions for going over budget were to be given to teams that went over the budget, although none of the teams did.

While 15 teams signed up for the competition and attended the workshops, only seven teams competed in the judged event. From talking to the teams who chose not to participate, the common theme was that school projects and tests simply got in the way – something that was expected to happen when first organizing the competition. One of our participants also suffered a terrible snowboarding accident and was hospitalized as well.

The entered projects are (in no particular order):



"JNJ Railway" ~ A Solar Powered Train with Regenerative Breaking
By Justin and Joseph Kopaz (EE and ME respectively)
The Kopaz brothers created an energy friendly train set that used solar panels and regenerative breaking to power an engine over a homemade track. They spent a great deal of time searching for an efficient yet powerful motor, creating and simulating the battery charging circuits, and milling their parts to fit their specifications.

Camera Intervalometer featuring Infrared Communication
By Justin Haze (EE)
Justin Haze created a timing system for time-lapse video photography. Through research, he found the infrared protocol for his particular model of camera. The resulting system could be inexpensively used to capture spectacular videos of nature, urban areas, and many other amazing shots.

Ghost Trap retrofit – Electomechanical Ghostbuster Movie Prop upgrade
By Devin Dyke and Nathan Reynos (both ME)
Devin Dyke and Nathan Reynos created a working model of the famous "ghost trap" as seen in the 1984 classic movie, Ghostbusters. The project featured a board to control a music player for sound effects, servomotors to open and close the unit, bright display LEDs to accurately emulate the film prop, and pressure switches for the foot activation pedal.

OBDII (On Board Diagnostics) Interface
By Tyler Kron and Tucker Kern (both EE)
Tyler Kron and Tucker Kern used an existing OBDII hand-held computer to reverse-engineer the protocol to communicate with a car's on board computer to get numbers for engine speed, oxygen intake, and various other engine data. The information was shown on an LCD character display and navigated with tactile switches.

Chromatic Synthesizer
By Christopher Robbiano and Amy Standley (EEs)
Running with the "circuit bending" workshop, Robbiano and Standley found a child's piano toy and used it to create a chromatic synthesizer. Using various parts of the piano connected to a resistor ladder, the team was able to determine the key presses via a single analog port, allowing for expansion of various other sensors and capabilities on other pins.

Ground Tracking LED Lighting System featuring Magnetic Encoder
By Austin Steingrube (EE)
Austin Steingrube designed and created the world's first longboard that uses live data from a magnetic encoder to create a visual display with 60 LEDs along the board. Among them the illusion of a light pattern that seems to float stationary over the ground as the board moves over it. The custom designed magnetic encoder used a latching hall effect sensor and permanent magnets.

Gravity Ball
By Casey Anderson (EE)
Casey Anderson reinvented the classic "Gravity Ball" game with an electronic scoring system. The goal of the classic game was to guide a ball into one of several targets. Casey added sensors, a bright LED display, and sound effects to make the classic game a home run.

Electromechanical Shooting Target
By Kevin Premo (EE)
This project featured a moving target, and was made using an electric screwdriver controlled by the Arduino.

Results of the competition:

The youngest participant, Casey Anderson, won the competition with his Gravity Ball game. It was very well made, designed, and programmed, making the end product spectacular. Tyler Kron and Tucker Kern won Best of Technical skill for their work with the OSBII interface. Devin Dyke and Nathan Reynos won Best of Functionality for their Ghostbusters prop. Austin Steingrube won Best of Originality for his ground tracking longboard system. The Kopaz brothers took Best of Programming for their JNJ Railway.

Conclusion

The competition went very well. There was a high turn out for the first year it was done and in coming years, it will increase to even more. We had great support from local industry and IEEE as well as from professors and faculty at Colorado State University. From what we learned organizing the design competition this year, in coming years a few we do plan on changing a few things: the workshops will be started earlier in the year to allow for more in-depth subject to be talked about, plans will be made with local industry members to come in and interact with students and their projects, and we will look for more funding to get even better components and devices for the workshops.