Building a USB DAQ System for a Championship Pumpkin Catapult

Introduction

In 2003, Team ETHOS (Experimental Torsion Hybrid Onager System) organized to compete in charity ‘pumpkin tossing’ events in the hopes of one day participating in the ‘World Championship Punkin Chunkin’ games (http://www.punkinchunkin.com). Annual regional events around the country challenge individuals and teams to build an apparatus to launch a pumpkin as far as possible.

Team ETHOS entered the competition selecting a type of catapult called an onager, a single-arm torsion catapult powered by a bundle of twisted rope. Originally used as artillery by the ancient Greeks, onagers were constructed of wood and iron and used sinew or horsehair torsion bundles. The team, under the leadership of David Mollenhauer, innovated on this ancient device by using modern materials and computer aided design and simulation tools. To secure an invite to the World Championships, the team needed to design and construct a machine to surpass previous records of throwing an 8 pound pumpkin over 2,000 feet.

After an initial period of design and analysis, the team constructed and tested a 1/10th scale model as a proof-of-concept. Starting with various kinds of rope materials, such as nylon and polyester, and assorted rope construction styles, such as twisted and double-braid, Team ETHOS tested methods for attaching the torsion bundle to the frame of the machine.

“The USB-2404-UI allowed us to monitor performance during the contest, allowing for real-time adjustments to increase our throwing distances.”

To build the frame of the machine, the team solicited donations and secured a number of large, heavy-duty fiberglass panels for the construction. Rope, glass cloth, graphite epoxy rods, and other materials were donated, as were hours of precision machining by a local machine shop. After optimizing the design using these materials, Team ETHOS constructed and successfully tested a 1/4th scale version of the catapult. Later that same year, the team embarked on building their full-sized competition machine and completed construction two years later.

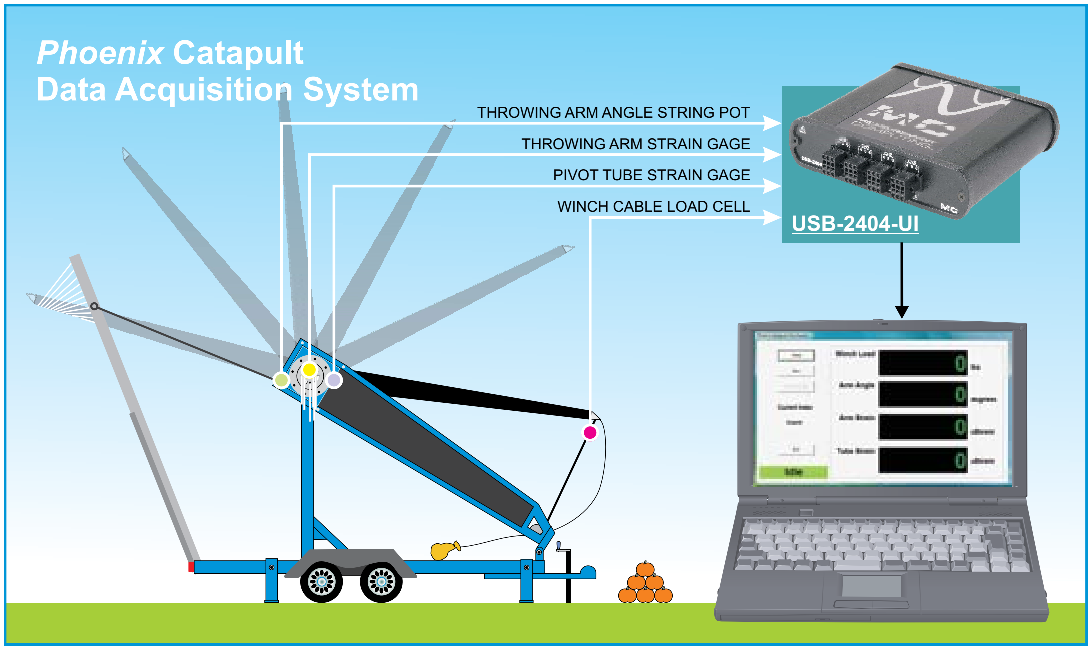
Team ETHOS engineers set up the data acquisition system as they prepare the Phoenix catapult for a series of field tests.

Challenge

In 2008, Team ETHOS qualified for the first time, to compete in the national competition. During round one of the competition, after a throw of 1,190 feet, the team’s distance secured a third place standing. After this initial launch, the team noticed that the ropes in the torsion bundle appeared to have slipped, and adjustments were made to prevent additional slippage.

During the draw-back for the second shot, disaster struck. The design loads of the frame exceeded, the frame of the machine failed, and the catapult collapsed. Fortunately, no one was hurt, and there was no significant damage to the critical parts, including the irreplaceable one-of-a-kind throwing arm. The team was unable to conduct additional launches and finished in fourth place out of six teams. Team ETHOS vowed to regroup, rebuild, and try again the following year.

After a year of work designing and building a new steel and carbon fiber composite frame and custom trailer, Team ETHOS headed to the national competition once again. With a newly designed machine, including a 12,000 pound winch, the team was confident in the construction, but still lacked certainty in the amount of pull-back torque being applied. The disaster



measured in fractions of a second. And because 'punkin chunkin' takes place in an outdoor field environment, portability of the data acquisition system was also a key requirement. Additional considerations such as size, ease of use, and USB bus-powered connectivity to a laptop were essential. With the national contest quickly approaching, the team needed to purchase, program, and deploy a monitoring system in less than four weeks.

just twelve months earlier was the catalyst for the redesigned machine, nicknamed '*Phoenix*,' and a data acquisition system with sensors to monitor the torque.

Sensors

ETHOS team member John Camping constructed and programmed the new sensor system. A load cell was added to the release trigger, monitoring the force created when the arm was pulled back into the shooting position. The 3/4-10 stud connecting the winch cable to the trigger was converted into a load cell by removing several rows of center threads, and applying strain gages to the area. Four strain gages in a full-bridge configuration were used to achieve maximum output.

Although the newly designed steel and carbon fiber composite frame was much stronger than the original fiberglass frame, possibilities existed in a high-load situation, for the apparatus to fail. The team also uncovered potential weaknesses in both the throwing arm and the pivot tube. A single strain gage was added to monitor these two components, and a stop process was implemented should either component near a critical threshold of failure. Finally, to calculate the overall performance of the machine, the team designed and constructed a string pot and installed it in the torsion bundle.

DAQ Requirements

Team ETHOS required a data acquisition system to handle signals from a combination of low-level and high-level sensors. The DAQ system needed to monitor the slower action of pulling back the catapult arm, measured in minutes, and much faster actions of the actual launch,

Solution

Team ETHOS selected the Measurement Computing USB-2404-UI, with universal inputs, for their project. The direct connectivity to all of the signals, the 100 Hz data rate, and simultaneous sampling exceeded the team's requirements. The team used Visual Basic® and the complimentary Universal Library™ programming software included with the USB-2404-UI device to develop the application.

Measurement Computing's USB-2404-UI: four-channel, 24-bit, universal analog input device with integrated signal conditioning

The USB-2404-UI monitored the performance of the machine during the contest, so that real-time adjustments could be made.

Result

With the help of the USB-2404-UI data acquisition system, and a respectable 2,088 foot pumpkin toss, Team ETHOS, captured a first place 2009 World Championship trophy in the Torsion Catapult Division.

Author

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