AC 2010-1281: INTERNATIONAL COLLABORATION THROUGH THE SWISS DARWIN21 DESIGN COMPETITION

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International Collaboration through the Swiss Darwin21 Design Competition

Abstract:

The Swiss Darwin21 design competition is sponsored by companies related to the Swiss automation industry, and is run on a two-year cycle in Switzerland. It involves most of the Universities of Applied Sciences in Switzerland, and for the 2009 competition, included one international Swiss-USA team comprised of students from the electrical, mechanical and industrial design departments of the Lucerne University of Applied Science and Arts – Engineering & Architecture (LUASA), as well as the Electrical and Computer Engineering Technology department of Purdue University.

Students and faculty from Lucerne University traveled to Purdue University in the fall of 2008 to meet and to determine assignments for the design and construction aspects of the project. After both teams worked on the project during the fall, and winter of 2008 and the spring of 2009, the Purdue team then traveled to Lucerne, Switzerland, in May 2009 for two weeks to work on the integration of the hardware and software aspects of the project. This project served as the capstone senior design experience for the students from Purdue University.

The student's were required to: obtain the competition design specifications, which were performance-only specifications and made no attempt to define the electrical or mechanical technologies to be used, submit a proposal, including a preliminary budget, obtain funding for both the cost of the project as well as the costs of travel and lodging, and design and create the competition entry. This paper describes the overall project including the competition, the communications issues faced and solved by the two parts of the team, and the results of the project.

Introduction:

As we continue to merge into a global market, it is imperative that we prepare our students to operate in a global work force environment [1]. Moreover, it is increasingly important for engineering and technology students to have an international experience, both technical and cultural, as part of their undergraduate education [2]. The Internet has the capability to allow students separated by great distances and diverse cultures to successfully participate in joint projects [3].

Darwin21 is a joint venture of the industrial automation sector in Switzerland. Approximately 50 companies, associations and educational institutions are engaged in the project. The goal is to disclose the attractiveness of careers in technology and inspire young people [4]. The challenge for the competition covered by this paper was to develop a body that is able to express five different types of emotions on demand like salutation, relaxing, making an impression, and reacting to acoustical signals. The project teams work on their solutions over a time period of

one year. At the end of this period a jury awards prizes in different categories. Afterwards all products will be displayed on a road-show like exhibition across Switzerland.

The objective was to setup and implement an interdisciplinary team of students between Purdue University and Lucerne University within the scope of the "darwin21" initiative. The goal of partnership was to motivate the students to gather experience in interdisciplinary work within an international project environment, provide the students the opportunity to build up cross-cultural competence, and strengthening the affiliation on the basis of the "Student Exchange Agreement" between the Universities.

Each project team in the darwin21 contest is sponsored by an educational institution and supported by a private company from the Swiss automation industry. The educational institution usually appoints an advisor to coach the project team. The supporting company may provide technical material at beneficial prices to the team if desired. However, it is expected that each team of students will complete at least 75% of the project work and is required to sign a code of honor stating compliance to this requirement.

The project is required to be housed in a floor-standing enclosure, similar to this sketch shown below in figure 1. The enclosure will be approximately 2 feet wide, 4 feet long, and about 7 feet tall.

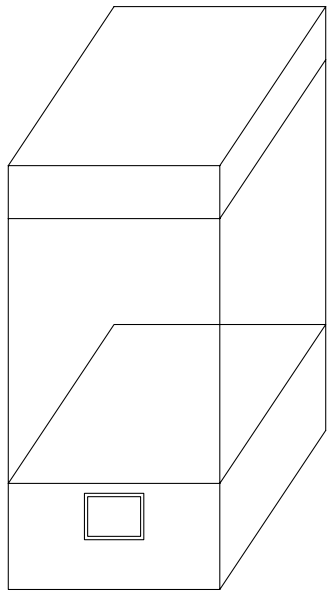

Figure 1 – Sketch of Enclosure

The top section of the enclosure provides space to place items such as circuit boards, power supplies, interface modules, etc. The bottom of the enclosure will also allow additional items to be housed including an industrial PC, additional interface modules and/or circuit boards, power supplies, etc. The enclosure will also be supplied with 230VAC, an air supply, an air pressure regulator and on-off air valves. These supplies will be provided by the industrial partner in the competition along with sound-recognition software and a variety of Windows OS with real-time capability. The team has the option to utilize all or none of the items provided.

Team Formation:

The Purdue University team was established by recruiting students from the second semester, junior level team project course ECET 396 Project Development and Management. Each student enrolled in the course was sent an email indicating the possibility to join the team. The students interested in the project attended a preliminary meeting which identified seven individual students that would participate in the project.

In a manner similar to that at Purdue, students at Lucerne University are required to take a final "Diploma Thesis Project" in the last year of their program. The darwin21 project was offered as one project which could fulfill this requirement. The four Lucerne students chose the darwin21 project as their final project.

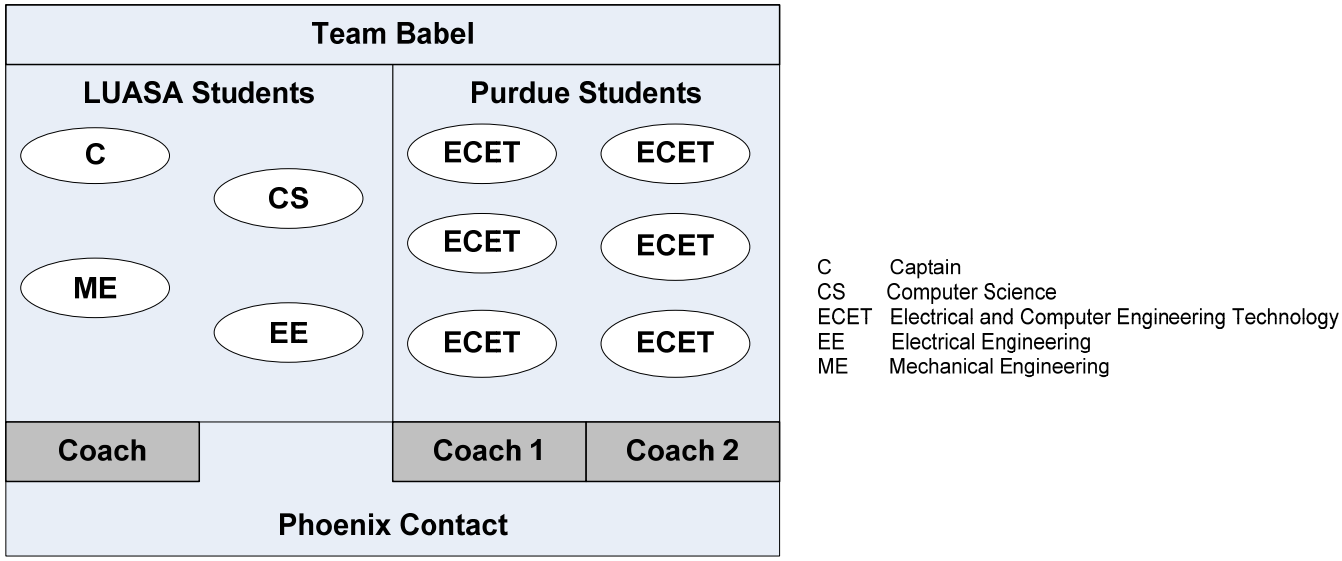

Figure 2 – Team Formation Distribution

Initial Team Meeting:

Once the students were identified, the students from Lucerne University traveled to Purdue University during September of 2008 to hold a kick-off meeting. The team members were introduced to each other and the associated captains associated with the team. The team members were given multiple opportunities to socialize outside of the traditional confines of the University setting. This allowed the team members to progress through the initial phases of team formation. It is commonly accepted that teams go through a five step process that includes: forming, storming, norming, performing, and finally adjourning [5]. Under this model, the team formation stage is characterized by a climate where the team members do not know each other, the roles within the team are not well defined, and the objectives of the team are also not well defined. The initial team interaction included an American style cookout and other social activities that allowed the team members to get to know each other and learn about the unique skill sets of each member. One of the initial challenges that the team had to overcome was the language barrier: the American team all spoke English while the Swiss students all spoke German as their primary language with English as a secondary language.

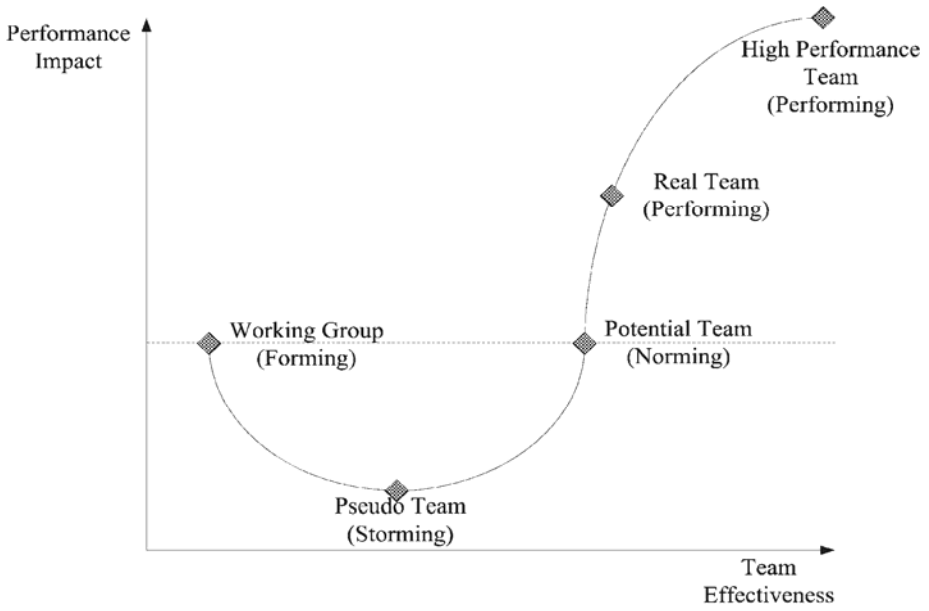

Figure 3 - Team Performance Curve
(image from: Design for Electrical and Computer Engineers [5])

Once the team members had an opportunity to get to know each other, the real team work began. The team held a formal meeting in one of the Purdue University Electrical and Computer Engineering Technology laboratories that was equipped with a chalk board, multiple computers and an overhead computer projector. This environment allowed the students all the resources that they needed to exchange ideas, create diagrams, and perform research. The faculty coaches of the team outlined the Darwin21 challenge and rules, and then provided some initial guidance to the student group. From that point forward, the team of students took control of the meeting.

The students were initially challenged with picking both an overall team captain, and then individual team leaders for the individual schools. With team leaders in place, the team next had to decide on a name for the team. Under the rules of the competition, each team was to have a name that started with the letter 'B'. The team started by generating a list of possible names but unanimously chose the name "Babel" due to the language barriers that they had already encountered and would continue to encounter through the project.

The next, and perhaps biggest challenge for the team, was to brainstorm overall concepts for the Babel team entry. Individual team members took turns articulating ideas which were presented through several methods including: illustrations on the chalk board, hand gestures to illustrate movement, and research on a computer to show various existing models and techniques that could be employed. Once a significant number of concepts had been generated, the team utilized formal methods such as concept tables and decision matrixes, along with simpler techniques like strength and weakness comparisons to ultimately decide the overall concept for the design: a six-legged hexapod that would be able to freely walk around inside the formal enclosure, paired with a cable and pulley system that would attach to the hexapod from each of the four corners of the enclosure allowing the robot to be manipulated in 3-demionational space, a lighted "disco" floor made up of individual elements that could be illuminated to virtually any color, all controlled by a touch-screen computer system.

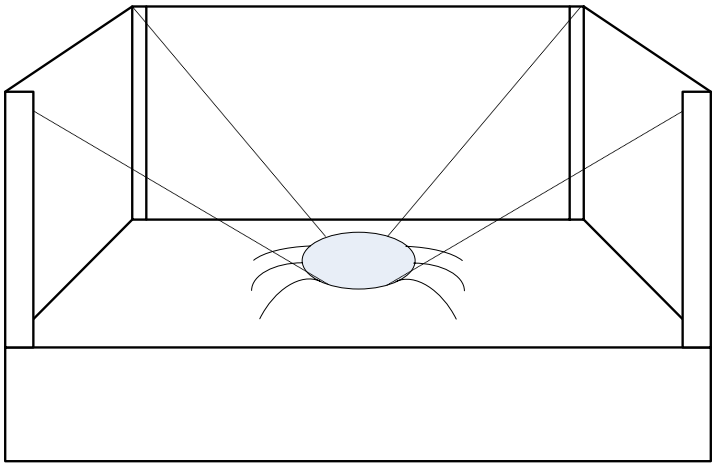

Figure 4 – Overall Concept

Once the overall concept was selected, the individual sub-systems of the design were determined through functional decomposition. The team members determined the following sub-systems for the design: touch-screen computer and user interface, hexapod controller and mechanical design, lighted floor, pulley system, and power supply. Additional conversation among the team led to the decision to design the system in a distributed network fashion creating the need for an additional network controller.

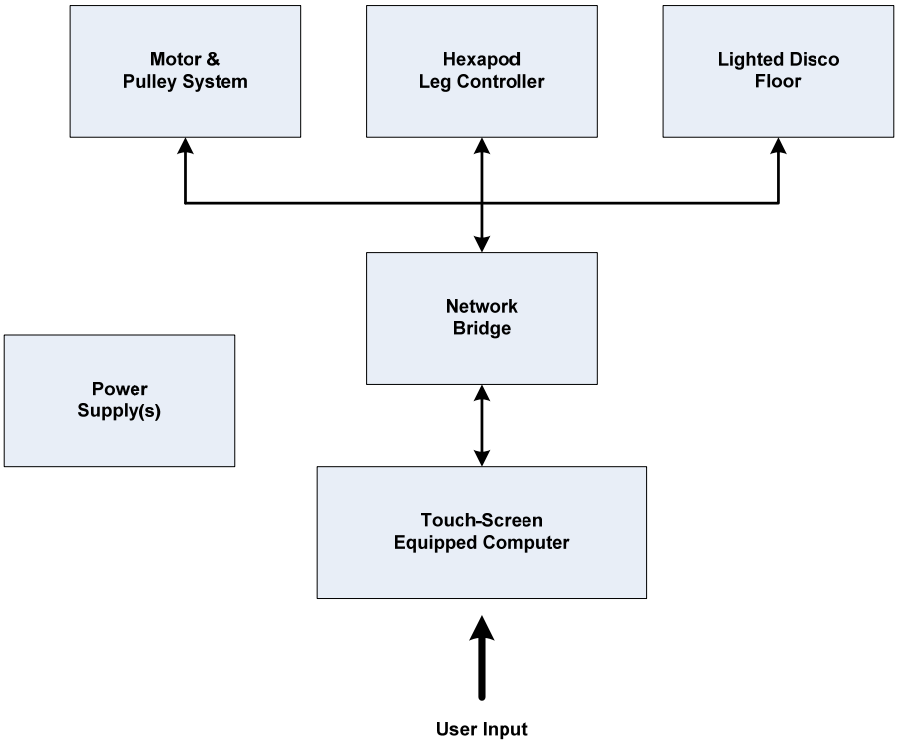

Figure 5 – Overall System Diagram

Once the individual sub-systems were determined by the team, individuals within the team volunteered for design responsibility for the individual systems. In the end, the Purdue University team had design responsibility for the power supply, lighted floor, electronics for the hexapod robot, the pulley system, and the network controller. The Lucerne University team had design responsibility for the mechanical design of the hexapod, and the touch-screen computer user interface.

Once the division of labor had been established, additional meeting between the students helped to further define the scope of work that would be required by each member of the team. Upon completion of these meeting, the individual team members had a clear understanding of their design responsibilities and expectations. The team also agreed upon In addition, it was determined that the team leaders would routinely utilize Skype to communicate about the individual team progress throughout the development cycle.

Upon the conclusion of the initial meetings between the two teams, the individual students would have until the end of May 2009 to complete their individual responsibilities. In June of 2009, the Purdue University team would travel to Lucerne University for two weeks to complete the integration of the individual sub-systems into one overall project.

Individual Implementation:

Once the initial team meeting was over, the students were required to take the information from the meeting and create a formal proposal that described their individual contributions to the overall project. Along with the proposal, the students were required to generate a detailed project timeline or Gantt chart. With the formal proposal written and Gantt chart developed, the students were then required to create a functional prototype of their individual sub-system. For the Purdue University students, their participation in the group project fulfilled the bulk of the requirements for their team project course. The objectives for the team course are as follows: 1 - state the goals and risks of working in a team, 2 - from problem definition, define a workable plan to create a design to solve that problem, 3 - evaluate customer needs as part of the definition of the solution to a problem, 4 - evaluate alternative designs to solve a problem, and then decide on the most appropriate design to pursue, 5 -complete a working project by application of design and construction methods appropriate to prototype development, 6 -construct and follow a Gantt chart for a project, 7 - write a formal technical proposal for a project, 8 - write a formal technical report on the results of the project, 9 - define a problem, and propose a solution to be carried through in their capstone senior design course. At the end of the team project course, the students took the information learned through the prototypes they developed and then proceeded to carry out a full project implementation in their individual capstone senior design course.

System Integration:

The overall system integration occurred in a two week period at the end of May, 2009, in Switzerland, at the beginning of which the Purdue students and one of the faculty coaches traveled to Lucerne. It should be noted that the Purdue University students were promised at the beginning of the project that the costs for travel and lodging would not come out of their pockets.

So there was a serious fundraising effort which took place in the fall of 2008 and spring of 2009, just as the recession took hold!

Lucerne University had committed laboratory space to the darwin21 project for its duration, and most work was done there with the assistance of the in-house machinist. To begin the integration, the Captain of the Lucerne University team, with the assistance of all members of the team, developed all the foreseen duties that each member would have in order to have a functional entry by the end of the two week period.

As would be expected, there were many engineering and software issues that arose that had not been foreseen, but this became part of the students project experience. This paper will not attempt to enumerate those issues as that is not its purpose. As each issue arose, the team made decisions on who would handle it and if assistance was needed from other team members. The time plane was adjusted accordingly. At the end of the two weeks, the project was not 100% functional, but was about 85% functional and could be demonstrated to Lucerne University faculty and Swiss industry sponsors.

The Swiss members of the team and their coaches continued to solve problems after the Purdue University team returned home. As a result of their work "Babel" was ready for entry into the darwin21 competition in the fall of 2009. Additional information about the darwin21 competition can be found at the following web site: www.darwin21.ch.

Overall Results:

In all, 13 teams of students and apprentices of technical disciplines participated in the competition. The Babel Pioneers, comprised of students from the department of engineering management and electrical engineering student from Lucerne University together with six electrical and computer engineering technology students from Purdue University comprised the only bilingual and international team in the competition.

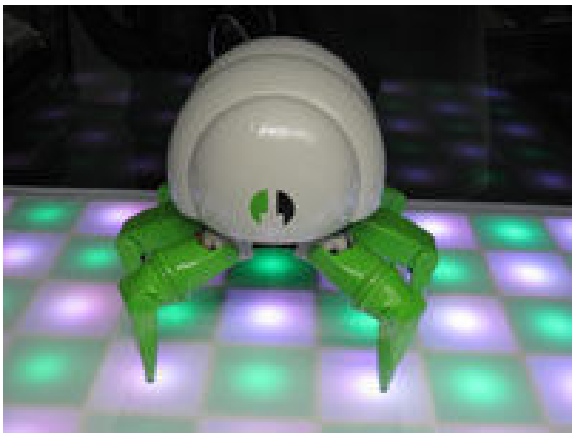

Figure 6 & 7 - Images of the Actual Hexapod in Action

Figure 8 – User Control over the Robot

On September 3, 2009 the awarding ceremony took place. The team comprised of Purdue University and Lucerne University students placed first among all university teams in the Darwin21 design competition. The Babel Pioneers took second place in the expert category which included teams with industry & university members. The jury of experts acknowledged the professional design concept and the attractive appearance of the six-legged robot along with the fact that the robot was developed in close cooperation with the team members from the USA.

Acknowledgements:

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