A Cross-Disciplinary Study via Animatronics

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Background

This paper presents the authors' attempts and consequent challenges in developing a true cross-disciplinary study for undergraduate engineering, technology and art students. The development process was initiated to enhance the Mechatronics and Robotics Program at Ohio Northern University (ONU) Technological Studies Department resulting in development of an honors course. HONR 218 - Animatronics was developed and offered in Winter Quarter of 2003/04 academic year. Animatronics is the art of bringing inanimate objects to life through computer technology, cable control, remote control or hand puppetry[1]. Unlike biomimetics, animatronics is not purely based on various technologies and art is an important component because of the imitation factor leading to creativity and problem solving skills. In a well-blended cross-disciplinary setting, animatronics encompasses a wide span of areas limited by diverse subjects such as biomechanics, controls, costuming or manufacturing processes.

The immediate goals of the development attempts were:

- Attracting good and interested students into the inter-disciplinary fields of mechatronics or robotics
- Capturing and maintaining students' interest through design of life-like entertainment robots or toys in a fun and creative team environments
- Utilizing emerging technologies such as muscle wires, air muscles, micro- and nano-controllers

Initially ONU technology and engineering student body was chosen as the main target audience since the focus areas were mechatronics and robotics. However, art majors and minors did show strong interest during promotional activities. They were subsequently recruited. Students who are not in the honors program were also allowed to register depending on the number of available seats within fifteen seat capacity limit of the Honors Program.

This paper elaborates on the HONR 218 – Animatronics course through its description, objectives, curriculum, and delivery structure including laboratory assignments. Examples of student work are also presented. This paper introduces the outreach activities driven by the same methodology on which HONR 218 is based. Conclusion talks about student response and some of the major challenges the authors faced in execution of the methodology.

HONR 218 - Animatronics

HONR 218 is a 4 credit hour course which is to be offered during winter quarters of alternating years[2]. It is available for students from all four ONU undergraduate colleges including business and pharmacy due to honors program requirements. Its main audience is second year honors students with at least the introductory honors course (HONR 100 - The Discipline of Reason) under the belt. Topics are covered through lectures (40% of course time) complemented by reading assignments and homeworks, laboratory assignments and a quarter-long design project (60% of course time). Students are evaluated on their attendance and participation to class activities, their performances on homeworks and laboratory assignments, a paper that activates the students' imagination and creativity, and a successful completion and presentation of an open-ended quarter-long design project.

Upon successful completion of HONR 218, the students will gain:

- Understanding of inter-disciplinary engineering and artistic design processes in a cross-disciplinary environment
- Strong knowledge on articulated robot and toy design
- Strong knowledge of various technical and non-technical fields mentioned below in the curriculum.

The curriculum includes the following content in the following sequence[3]:

- Introduction to Animatronics and Robotics
- Engineering Design and Product Development Process:
    - Methodology involved in engineering and product design processes including problem definition, alternative design production, analysis and decision making, prototyping and testing stages
    - Concurrent engineering and DFMA (design for manufacture and assembly)
    - Industrial design
    - Product-life cycle and continuous improvement
- Project Management and Team Work Basics
    - Resource management and scheduling of activities
    - Team dynamics, leadership, communication and other interpersonal skills
- Concept Development and Artistic Design
    - Concept development
    - Artistic design via various type art drawings and story-boarding
    - Modeling with clays to be utilized as visual aids or patterns for molding
- Mold Design and Fabrication
    - Sand-casting
    - Plastics processing including injection molding, gravity based molding processes using various materials including Plaster of Paris or Urethane
    - Shell fabrication by use of Rubber Latex and soft plastics
- Mechanism Design and Armature Fabrication
    - Joints

    - Mechanisms - Continuous and Intermittent
    - Power Transmission and related components such as drives and gears
    - Metal removal, NC laser cutting, and forming processes in shaping links, linkages and structural components
- Costuming through
    - Fabrics
    - Soft Plastics
    - Painting
- Actuators and Sensors
    - Fundamentals of Electricity and Electronics
    - Electric motors (DC, RC, servo or stepper), switches, sensors
- Controllers and Programming
    - RC or autonomous systems and Interactive C programming
- Future of Animatronics in Human Life
    - Animatronics in Entertainment or Daily Life

As mentioned previously, HONR 218 was offered for the very first time during Winter Quarter of 2003/04 academic year. Nine out of the ten students enrolled for the course were in the Honors Program eight of which being engineering, technology and art students. Yet, a pharmacy and a business major also took the course.

Various tools and delivery methods were utilized to enhance the learning experience during lecture periods:

- Power point presentations complemented with hand-outs as reading assignments
- Videos and computer animations
- Demonstration of animatronic toys, working mechanisms, and materials samples

Laboratory demonstrations were used in explanation of the procedures that students have to follow during laboratory or project activities. They also replaced some of the laboratories due to time constraints. Students completed various laboratory projects including:

- Concept Design - Figure 1
- Modeling - Figure 2
- Molding - Figure 3
- Reverse Engineering - Figures 4 and 5
- Mechanism Design - Figure 6
- Sensors, Actuators, and Controllers
- Integration – Figure 7

Students enrolled in HONR 218 converted their ideas into sketches during the concept design experience as shown in Figure 1, created 3D models as visual aids as shown in Figure 2, utilized some of the models as patterns in mold making as shown in Figure 3, studied mechanisms and joints through Reverse Engineering as shown in Figures 4 and 5. respectively, build mechanism components using an NC laser cutter and other equipment and assembled them as shown in Figure.6, deformed welding wire or wire mesh to obtain body parts or shell of the animatrons in

armature fabrication, assembled their designs in the final integration stage as shown in Figure 7. Students were exposed to basic electricity and electronics concepts that included sensors, actuators, and RC and micro-controllers through a set of fixed-goal laboratories and demonstrations.

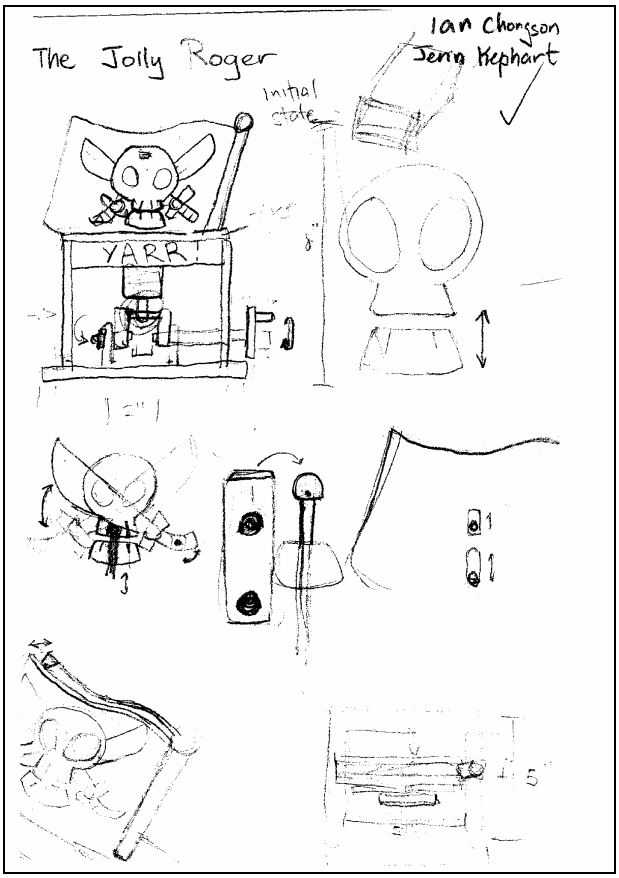

Figure 1: Concept design

Figure 2: Modeling with polymer based clays

Figure 3: Using earth clay patterns in making plaster molds

Figure 4: Reverse engineering a toy monkey

Figure 5: Study of joints through reverse engineering

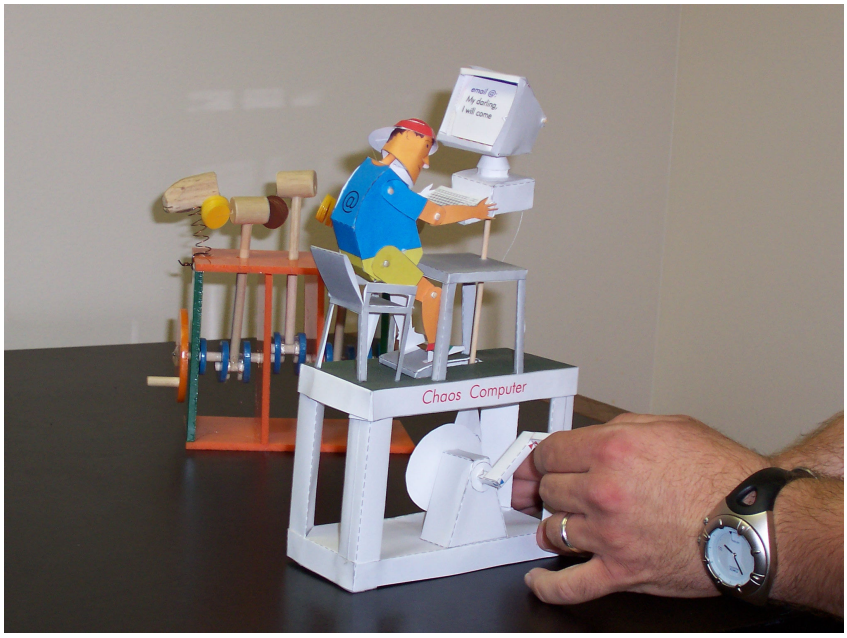

Figure 6: Mechanism design

Figure 7: Integration

Students experimented with a wide range of materials varying from acrylic to metals and with adhesives and fasteners. They also learned mechanisms by evaluating various joints as shown in Figure 5 and linkages or drives as shown in Figure 4. They selected appropriate materials and mechanisms for realization of their concepts. Time constraints limited the design experience and prevented the actuators and the controls from being included within the designs. Students used manual means such as cranks or puppet wire to drive their mechanisms. Yet, the student feedback was positive and constructive. Students emphasized that they had learned a lot working in this fun and creative cross-disciplinary team environment while managing their projects.

After taking the course, students remained in touch with the faculty members. One of the students studied shape memory alloys (SMA's) and built a robotic bug that is driven by shape memory alloys as shown in Figure 8 as an Honors Contract Course project.

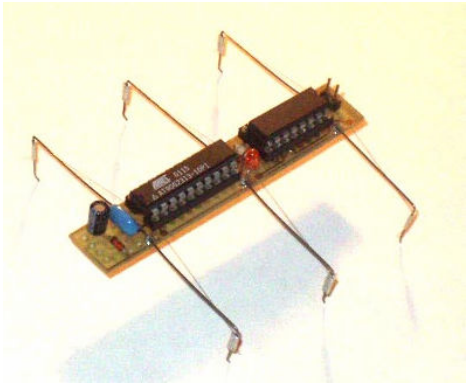

Figure 8: SMA driven robotic bug

Outreach

With the completion of the honors course, authors developed an NSF (National Science Foundation) proposal based on the same approach utilizing animatronics for a grades 7-12 project[4]. It is a weekend program complemented by a summer capstone experience. Even though the program was not funded, it allowed authors to develop a better course plan to be reflected upon two levels, college and secondary education. Since then the authors has gained recognition and partners leading to funding of two small projects by Ohio Northern University and a major summer program for gifted and talented secondary school students by Ohio Department of Education. A three-day summer camp was also designed and successfully executed with participation of four local middle school students from the gifted and talented program. During the development stage, authors have interacted with an art professor to strengthen the art component of the program. With the help, new modeling materials such as oil based clays were purchased in addition to the polymer and earth based clays that were being utilized. Molding capabilities were also enhanced. Materials such as urethane and other polymers were acquired. Authors are currently working with the local schools to take part in a national toy design competition.

Conclusions

The experience was very rewarding due to the open-ended nature or creativity factor. The approach employed here is based on following the actual product design sequence in a real cross-disciplinary setting. In the process, students no matter what level they are, are exposed to the real-life experience of developing unique animatronic structures in a job shop environment or encouraged to follow the product design process in toy making. Recruitment of college and secondary students to the mechatronics and robotics fields is the critical goal for this project. The project also assists in retaining students due to the fun, creativity, and realistic learning components.

Designing a cross-disciplinary program with cohesive components is a difficult task. The transition between the subjects must be carried out smoothly. The authors had to work hard to explain the students that they were following a sequence that has been used by the product developers. Combining multi-disciplinary teams for a project with short span is a major challenge by itself. However, art students, the business and the pharmacy major did have some technical background easing the issue of catching up to the levels of engineering and technology students. At times since the project was being in its infancy, a hobbyist approach rather than the engineer's way was followed. Trial and error in cases of laser cutting of new materials or assembly process also tighten the time constraints on the participants and the authors. However, problems were dealt with simple intelligent solutions leading to an interesting learning environment which lead to an honors contract course and a capstone project for two of the enrolled.

Bibliography

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Biography

ARIF SIRINTERLIKCI is a faculty member at Ohio Northern University. He holds a Ph.D. in Industrial & Systems Engineering Program from the Ohio State University and M.S/B.S. in Mechanical Engineering from Istanbul Technical University, Turkey. His previous work experiences included appointments/ projects in Mechanical and Manufacturing Engineering. He is a member of various societies and a Certified Senior Industrial Technologist.

JOHN MATIVO teaches Materials and Product Manufacturing courses at Ohio Northern University. His university teaching experience totals of ten years six of which he served as Department of Technology Chair at the University of Eastern Africa, Baraton. He is currently a consultant for the Ohio Department of Education. His Doctorate is from the University of Georgia. He is a member of Sigma Xi, Epsilon Pi Tau, Phi Kappa Phi, and Phi Beta Delta.