AC 2011-12: PARAMETRIC MODELING, RAPID PROTOTYPING, AND A WALKER ROBOT

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Randy Shih is a Professor in the Manufacturing and Mechanical Engineering and Technology Department at Oregon Institute of Technology. He worked as a design engineer in the automobile sector prior to starting his teaching career in 1984. He has over 25 years of experiences in the areas of CAD/CAE; and he is the author of fifteen CAD/CAE textbooks that are currently being used by many universities and colleges in North America.

Parametric Modeling, Rapid Prototyping and a Walker Robot

Abstract

Computer-aided-engineering tools, such as CAD, FEA and CAM, are becoming to be the essential tools to the engineering practices in industry. This paper describes the development of an applied Parametric Modeling course that is being offered by the Manufacturing and Mechanical Engineering and Technology (MMET) department at Oregon Institute of Technology (OIT) .

Parametric Modeling technology is a new breed of Computer Aided Design (CAD) technology that can be used to aid the creation of better Designs. The Parametric Modeling technology was first introduced back in 1989; and with the additional developments through the years, we now see very exciting changes in how an engineer perform his/her daily tasks in industry.

Since 1996, the MMET department at OIT has incorporated the parametric modeling software in the ME, MET and MFG programs. In April of 2008, the MMET department at OIT also purchased a Rapid Prototyping (RP) machine. The combination of these new technologies has enabled many of our students to be much more creative and productive in doing design works.

During the Winter term of 2009, an elective course (ME 475 Applied Parametric Modeling) containing all the above mentioned elements, was developed and offered. The course has been offered every year since then.

The two main objectives of the course are to both teaching the students to use a commercially available parametric software and to have the students go through the complete design process. The students are given a specific design task; the main design task has been to build a walker robot. The course objectives have been established as follows:

- To learn the basic concepts and procedures associated with using a commercially available Parametric Modeling package.
- To understand and the use of 3D Printing and Rapid Prototyping technology .
- To gain hands-on experience by going through a design process.
- To learn and perform 2D and 3D kinemtaic analysis using modern computer software.
- Apply the techniques and skills taught to related problems in follow-on courses.

This paper describes the changes and results of the Applied Parametric Modeling course offered by the Manufacturing and Mechanical Engineering and Technology Department at Oregon Institute of Technology.

Development of the Applied Parametric Modeling course at OIT

Parametric Modeling technology is a new breed of Computer Aided Design (CAD) technology first introduced in 1989. The Parametric Modeling Technology revolutionized the CAD industry as it can be used to aid the creation of better designs. In 1994, with the help of several education grants from industries, the OIT-MET department started a two year research on incorporating the leading edge Computer Aided Engineering technology into the MET and MFG programs at OIT. As a result of that research, a series of computer aided engineering (CAD/CAM) courses were developed and incorporated into the two programs. In 1996, the MET department at OIT offered their first Parametric Modeling course; the course was a required course for both the MET and MFG programs. The course replaced the previously required Solid Modeling course, the new course emphasizes more on the design aspects of Mechanical Designs and also the hands-on experience in using a commercially available Parametric Modeling package.

In April of 2008, the MMET department purchased a Rapid Prototyping (RP) machine and a 3D scanner. The combination of these new technologies has enabled most of our students to be more creative and productive in doing design works. The faculty of the MMET department at OIT felt it is also necessary to expose students to the different flavors of available Parametric Modeling packages. Through the help of several education grants from industries, the following parametric modeling packages are now available in the OIT CAD/CAE Labs: Pro/Engineer, Autodesk Inventor, SolidWorks and Unigraphics NX series. In the Winter term of 2009, an elective course, ME 475 Applied Parametric Modeling, containing all the above mentioned new technologies, was developed and offered. The course has been offered every year since 2009.

The main emphases of the course are placed on both teaching the students to use a second commercially available parametric software and to have the students go through the complete design process. The students are given a specific design task; currently the design task has been to build a walker robot.

Course Description

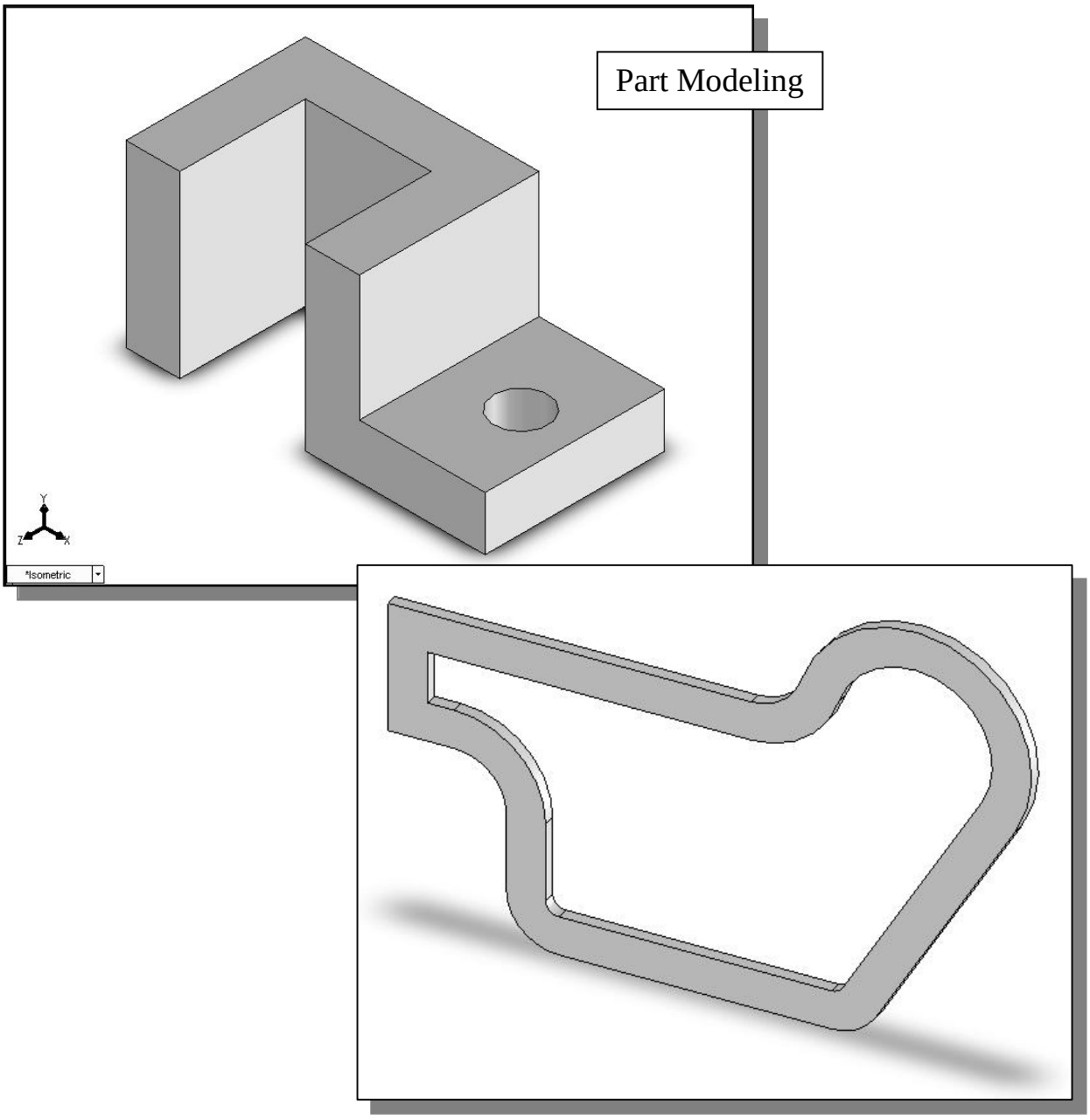
The current format of the course contains three components: (1) The use of a commercial Parametric Modeling package. Currently the SolidWork software is used. (2) An understanding of the available new technology, such as using a Rapid Prototyping (RP) machine and using a 3D scanner. (3) The designing and building of an actual product to further reinforces the concepts and principles learned. By integrating the project into the 2nd half of the course, the insights and strengths of using the available new technologies can be better observed.

The course is structured in a 2-3-3 format (2 hours lecture, 3 hours lab, 3 credit hours) and the class meets for 5 hours per week. A typical week consisted of about 2 hours of classroom time and 3 hours in the computer labs. The class also has access to a classroom, a Rapid Prototyping lab, and a computer lab. Activities of the ten weeks term includes the discussions of the basic parametric design techniques, paralleled by using a commercial parametric modeling software to aid the design task. Currently the design task has been to convert a remote controlled car into a walker robot. As an assessment tool, students are also required to take the Certified SoldWorks Association (CSWA) Examination.

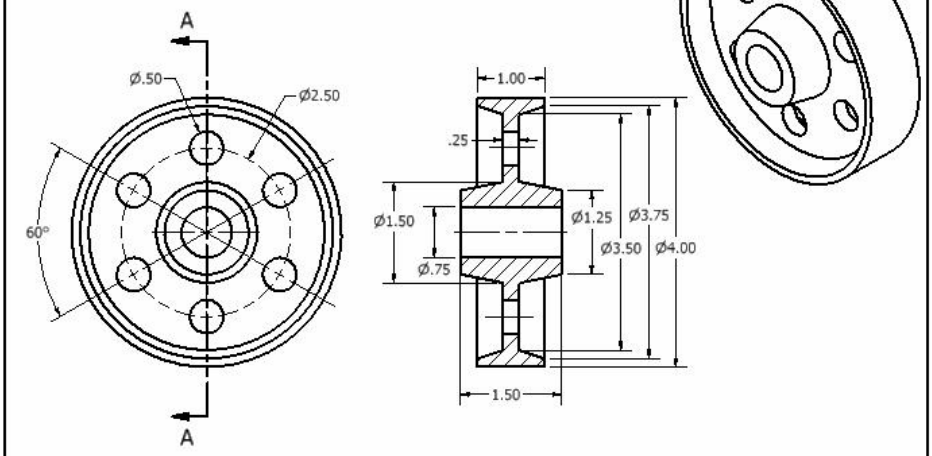
The course objectives have been established as follows:

- To learn the basic concepts and procedures associated with using a commercially available Parametric Modeling software.
- To understand and use of 3D Printing and Rapid Prototyping technology .
- To gain hands-on experience by going through a design process.
- To learn and perform 2D and 3D kinemtaic analysis using modern computer software.
- Apply the techniques and skills taught to related problems in follow-on courses.

The course begins by covering the three basic components of a parametric modeling software: Part Modeling, Creating 2-D multiview drawings from 3-D models, and Assembly Modeling. The typical assignments are as shown in the below figures :



2-D Drawings



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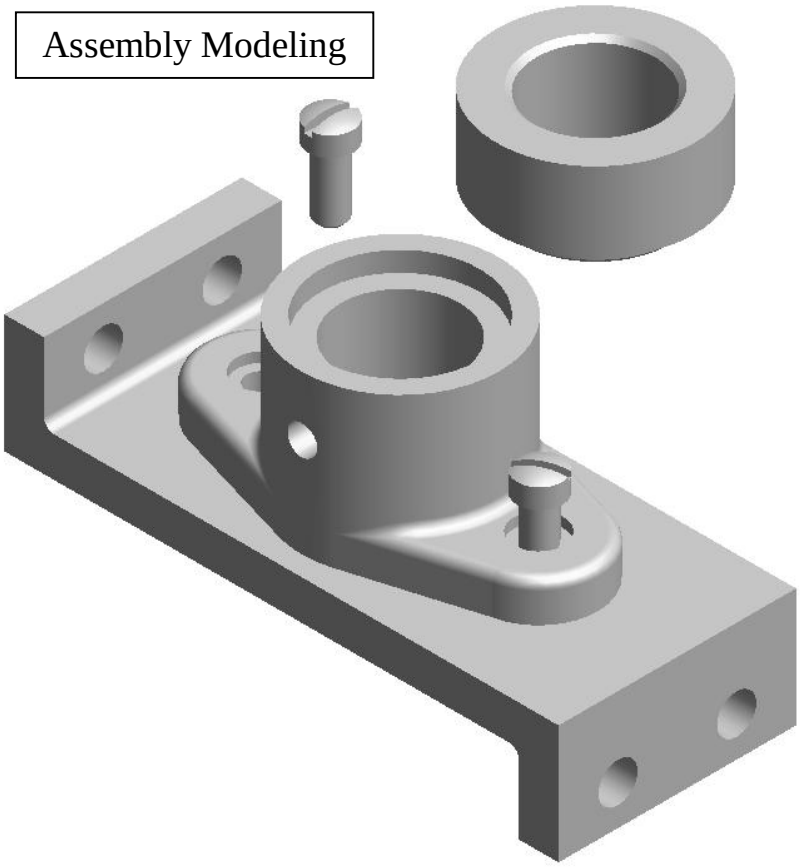
Assembly Modeling



In the second half of the course, the concepts and principles related to the 3D printers and Rapid Prototyping technology are first discussed; the class is then divided into four to five design teams, with three to four members in each team. Currently, the design task is to build a walker robot; each team is also given a remote control car kit.

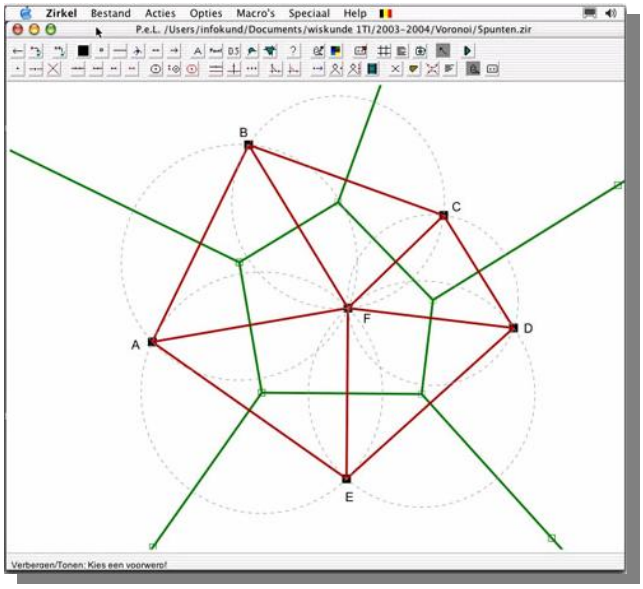
Project Objective: To build a walker robot by performing the necessary analyses and computer simulations.

Project requirements: The walker robot must have at least two legs as the main motion generator; and be able to travel a straight line distance of ten feet and also walk back to the starting point with the remote control. Modeling parts and analysis/simulation using the C.a.R program and the Solidwork software are required. A written report documenting the design process is to be submitted at the completion of the project.

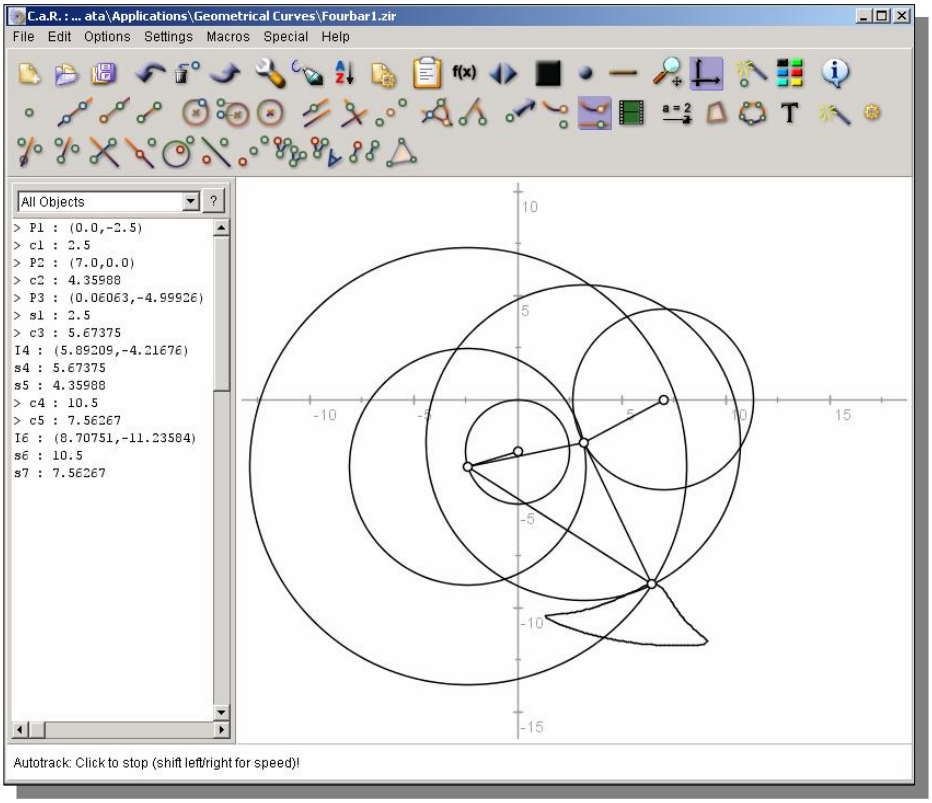
Guidelines for the project:

1. **Research & Discovery**: Spend adequate time thinking about the purpose of the project, along with coming up with feasible basic ideas and concepts.
2. **Competitive Analysis**: Looking at pre-existing ideas and executions created by peers and/or competitors. Competitive analysis identifies the strengths and weaknesses of those existing designs. It can reveal gaps which still need to be filled and shortcomings which should be met.
3. **Conceptual design and analyses**: Perform the related analyses and/or computer simulations to confirm the feasibilities of possible solutions.
4. **Prototyping & Basic Testing**: Create a prototype, full size or scaled down version of the design to begin the refinement of the design.
5. **Finalize the design**.
6. **Timeline**:
   3D printing: Feb. 18, Feb. 25 and March 4.
   Final Design Validation and Report: March 11

The C.a.R software is a dynamic geometry program simulating **compass and ruler** constructions on a computer. The software is designed and maintained by Professor René Grothmann of Catholic University of Eichstätt, Germany. The C.a.R software runs on Java as a local appication or as an applet in a browser. The free and open source program includes docuementation and tutorials. The program currently support several platforms and also available in many languages.

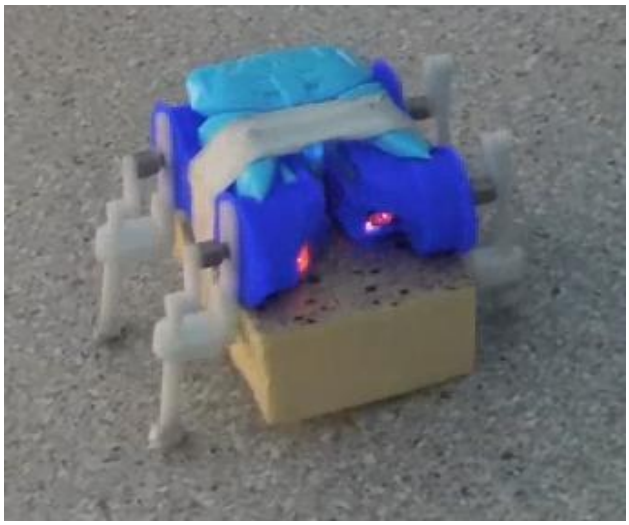


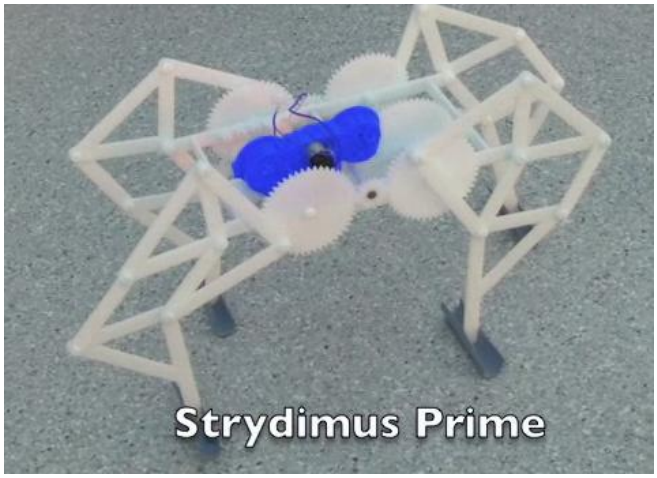
Although the C.a.R software is a 2-D geometry software; it provides two main features suitable for kinematics analysis purpose: **Motion simulation** and **Loci tracking**.



Validation of designs

During Winter term 2009, the five design teams came up with five very different and interesting designs:





Conclusions

In the past 20 years, the advancements in CAD (computer aided design) and RP (Rapid Prototyping) technologies are truly amazing. The Engineering/Engineering Technology Students today are very fortunate to have all these very powerful tools to aid theie career as an engineer; but at the same time, the students also have to devote themselves and be proficient in using these tools.

In this course, students are required to use most of the subjects they have learned, such as machine designs, electronic fundamentals, CAD and Solid Modeling. The elements associated to the course provide activities that are very challenging, but the results are also very rewarding.

The course was first taught during Winter 2009, with 15 students enrolled; with three students in a team, five teams were formed. As the project proceeded, students learned the importance of the finer details involved in designing walking robots, for example, measuring the motor speed and adjusting the gear ratio to provide proper motions and also the importance in providing enough frictions at the feet.

The applied parametric modeling course was offered again during Winter 2010 and with a slightly different approach. Several existing designs, including the designs from the previous year, of walker robots were discussed first. Three teams were formed, but students all went with the same design that were successful from the previous year.

This paper has presented the undergraduate course of an applied parametric modeling course offered by the OIT-MMET department during winter term 2009. The course provided students with very practical hands-on experience of the modern technology tools available for product design. The course also requires the students to apply the knowledge they have acquired in previous courses they have taken. The success of the course showed that the modern technology tools can help in enhancing the design process in many ways. Variations of this course can be implemented by changing the requirements of the project while maintaining the use of the tools.

Bibliography

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