Undergraduate and M. Eng. Research Projects in The Robotics and Human Power Lab

Fall 1999

Faculty advisor: Andy Ruina

Kimball 306

Copies of this page and 6 more pages about the lab and how to apply are available from Nikki Lumbard in Kimball 212.

All projects concern the coordinated movement, particularly locomotion, of people, animals, or machines. There are several different projects involving construction and/or simulation of more-or-less human like walking robots. Other simulation projects include simulations of children's swings, Gibbon brachiation, human rowing, and extracting power from repeated jumping. Other construction projects include electrical and/or mechanical work on a machine for extracting power from a person, and building a rowing simulator. Other projects of mutual interest will be considered.

- Freshman/woman to M-Eng welcome.
- 3 credit minimum, 50 hours = minimum work per credit.
- Satisfies engineering writing requirement.
- Weekly meetings Wednesdays 3:25-4:20, Kimball 306. First meeting on Wednesday, September 1 1999
- You must have or develop some of the following skills: machining/construction, computer-simulation/math-modeling, data collection, oral communication, written communication.
- People interested in 2 semesters or more of lab involvement are most welcome.
- You must be highly self-motivated, persevering, tenacious, resourceful, independent, and responsive to guidance. You *will not* be told exactly what to do on a day by day basis but you will be expected to follow advice that is given.
- Grade will be based on weekly progress reports, weekly presentation, lab notebook, presentation quality, contribution to discussion, net result of semester's research, and mostly on the utility and clarity of the information in the final report. Note: the 50 hours minimum work is a requirement for a passing grade but hours are not correlated to your grade in any other way.
- You may also work for pay instead of credit.
- See full information sheet for application details. Applications are due Monday afternoon August 30 at 309 Kimball.

Information for Undergraduates/ M. Eng. Human Power and Robotics Lab

Faculty advisor: Andy Ruina, ruina@cornell.edu
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Possible projects

1) Tinker with Tinkertoys and the like. In May 1997 Mike Coleman and I made the interesting discovery that we could make a thing that could walk and couldn't stand still. It was made of Tinkertoys. We are working still to understand it. In the mean time, it would be nice to make it work better. Can you make a little toy that can walk, can't stand, is easy to make, and works more reliably than the Coleman's Tinkertoy walker? If so, it might make a marketable toy for the Nature Company or for science demonstrations. No computer skills needed and shop skills may or may not be needed. An ability to tinker patiently and productively is needed. Good progress might be made in one semester. Up to two people could work on this.

2) Make the quadripedal biped really have 2 legs. Our physical realizations of 2 dimensional walkers use 4 legs to keep them from falling over sideways. But they have knees and a more anthropomorphic motion than the Tinkertoy walker above. With appropriately shaped foot bottoms it might be possible to take off 2 of the 4 legs. This would make an appealing more anthropomorphic walking robot that would work using the old 2-D theory. This is the most likely route to quickly making a much more appealing looking walking machine. In the fall of 1998, Martijn Wisse, a Dutch graduate student visiting Cornell built a machine as described above. It walked very nicely, but only one time that we know of. Martijn's design is an excellent start but needs to improved upon. No computer skills necessary. Shop skills will be needed. Good 3-dimensional visualization ability is needed. Patience with tinkering will be needed. With luck and hard work two people might be able to get this working in one semester. Two semesters is a more realistic estimate.

3) Powered walking. Our working walking machines all walk downhill. According to theory, similar designs should work on the level with power. Some design work has been done. But a working prototype is not yet in sight. Success at this project needs construction and electronics (simple logic circuits) skills. Simulation would be useful if not necessary (for which A+ level of understanding of TAM 203 is needed). Two to four people could work on this project. The first robust prototype will likely take two semesters. Currently, Yan Yevmenenko is working on the project for his Master's in Engineering.

4) Simulate rowing. Two previous student projects have developed a simple computer model of rowing (as in college racing). With a little more model refinement and some good library research this work could turn into a journal article. The model helps explain, in terms of mechanics principles, what is the reason for the complex sequencing of motions used by racing rowers. Rowing is a simple sample system that is easier to understand in some ways than, say, walking. Thus one is able to better understand energetic issues in coordination. 'A' level understanding of TAM 203 is needed as well as comfort with MATLAB. Students should know or learn about rowing technique. One to two people could work on this project. Tidy completion is possible in one semester, but two semesters are probably needed.

5) Build a rowing simulator. When they can't go on the water rowers practice on rowing machines. We have an idea for a rowing machine that will give a much more realistic simulation of rowing. A good machine would likely be used by Cornell

teams (an earlier version has been so used for years) and could lead to a product. A prototype has been built but is not sufficiently sturdy. This project requires *good* construction and machining skills. One or two skilled people should be able to make a good prototype in one semester.

6) Human power extractor. Maybe we can get more power out of a human body than is possible with rowing or cycling. Several promising but too flimsy prototypes have been built. A newer sturdy prototype is nearly complete but needs some final design and construction, some safety features, and some electronics/computer work. Up to 4 people could work on this project of which at least one needs to be good at machining and at least one needs to be capable of dealing with electronic transducers one way or another.

7) Mechanics of windmill sailing. In principle it is possible to make a sail boat that can sail downwind faster than the wind. Help write up a description of the mechanics of this boat. This boat depends on basic mechanics ideas that are misunderstood by many people. The goal is a journal submittable paper in one semester. The one student working on this must be interested in the theory of how things work, good at library work, writing, and organizing ideas. You will work closely with me (Andy).

8) Mechanics of swinging. Why do kids pump swings in the way they do? Theories of swinging explain how swinging works in a general way. But there is no theory (yet) that explains the timing and phasing of what all kids do in about the same way. I have an idea that might explain this and other more complex coordination strategies of people. Swinging provides one simple test case (as does rowing, (4) above). The one (possibly two) people working on this project must have (or get) an A+ level understanding of TAM 203 and be (or get) comfortable with MATLAB. The project could be completed in one semester and can end with a journal submittable paper. The project involves theory and/or experiment. Currently there is an experimental set-up in the lab interfaced with a computer that can measure force in the swing chains and the swing orientation. Currently, Dave Cabrera, a Ph. D. student in TAM, is working on the modeling of swinging.

9) How do monkeys swing? Gibbons, for example, get from one place to another by swinging from branch to branch. Some of the ideas we are developing for walking apply for swinging. We think it is possible to design a brachiating (swinging) robot that can move with arbitrarily small energy cost (in the same way that rolling wheels involve arbitrarily small energy cost). This project would involve computer/math modeling. It will take a full school year for one or two people with A+ level of understanding of TAM 203.

10) Constrained bicycle pedal. A previous student group designed and built a constrained bicycle pedal. A possible improvement on conventional pedals. The implementation was not good enough to test whether or not the idea is good (efficient, comfortable). The design needs to be rebuilt and tested with human subjects. One or two people who are good with construction and able to learn any needed machining could make progress in one semester.

11) Power from jumping. In 1967 it was proposed that human powered flight might be powered by jumping. Now you can buy a human powered hydrofoil that is indeed powered by jumping. Can we figure out a good way to do this? Math-modeling and computer simulation for one semester by one student with A level understanding of TAM 203 is needed.

12) A project you define that is consistent with the overall lab goals and is of mutual interest.

Applying

Applications are due Monday afternoon August 30 at 309 Kimball Also, two copies of your applications are due at 3:25 PM on Wed, September 1, 1999 at the first lab meeting. Your application should include the following information (1-15) in approximately the order described, either typed or clearly printed.

1. Your full name
2. Your email address, local address, local phone number.
3. Your permanent (family) address and phone number.
4. (optional) Your sex and ethnic background. Special funding (from GE) is available for woman and minorities intending careers in research.
5. Citizenship
6. Social Security # and student ID #.
7. Expected graduation date.
8. Present major field of study.
9. Overall and major field GPA.
10. The name, phone number, and email address (if possible) of one or two people who can serve as a reference for you. This should be a person who can best judge your potential for productive research. Describe the relation of the person to you.
11. An essay describing your academic strengths and weaknesses, why research interests you now, and how undergraduate or graduate research fits into your academic and career goals, your work and project experience (volunteer or paid work, academic projects, etc.), and any management experience. This essay should be from 1/2 to 2 pages long.
12. Which project(s) are you interested in (describe it/them by name). Do you have any intended partners for this project?
13. Reporting agreement. Please copy the statement below and sign below it.

    I have read the 3 pages about how the lab works and agree to follow the directions there. I understand that the report should conform to ordinary good practices for technical reports, and that it will be bound and placed in the Engineering Library for public viewing.

15. A copy of of your college and university transcripts. Unofficial photocopies are acceptable.

How the Lab Works

Joining the lab:

1.) Come to the first meeting (see front page).
2.) Submit an application (see details above).
3.) If your project is accepted see Nikki Lumbard (212 Kimball), and tell her you are taking T&AM 491 for n credits. The S/U option is available.

Work load:

Successful projects only happen when people work consistently hard for the whole semester. Last minute rushes have never saved a lagging project.

Final Report:

Your final report should be written to communicate clearly what you were trying to do and what you succeeded at doing. It should also include useful information you have collected or developed so that future students can learn from your work. One section of the report should detail all spending (what purchased, where, and for how much money).

The first draft is due Wednesday, November 3. Second draft due Wednesday, November 24, and the final report is due Wednesday, December 15.

Save a copy of the report for your records and hand in 2 or 3 copies: one for Andy and one for the lab for future students.

The cover of your final report should have a title, the names of all your co-workers, the date of the report, your local address and phone number, your permanent address and phone number, your year in school and your department, the number of credits you are earning for the project.
With your final report also hand in a) copies of the transparencies you used for your weekly reports and the transparencies you used in your final presentation, and b) your lab notebook.
Allow at least 1 week for grading of the final report. Discussing drafts of the final report well before the end of the semester is advised.

Final Presentation

At the end of the semester each person will give a prepared presentation of 15 to 20 minutes of length about their semester's work. This will use overheads and any other appropriate media.

Dean's Presentation

In the spring you may be asked to give a talk and/or a poster demonstration of your work in progress to the Dean and to funders of undergraduate research.

Safety First.

•Wear safety goggles, ear protection, etc. when working with power tools that require them. Always wear safety goggles when working with power tools.
•Unlock doors into the lab if you are working with power tools or other dangerous equipment. This may mean blocking the door open.
•Special permission is needed to use the T&AM Machine Shop (319 Kimball).

Keep neat

Keep things neat every time you use the lab. Plan to spend time every week maintaining and improving the lab in ways that are not necessarily connected with your project. •return all tools to their proper location,

•return all hardware and scrap material to its proper place,

•vacuum and/or dust up debris.

•Any shelf, tabletop, or system of storage that is in disorder should be arranged as it was intended, or improved.

•Any lab tool should be engraved with the words 'Ruina Lab' and have a yellow stripe painted on it. If it's not labeled, label it.

No borrowing

No tools, supplies, books or reports can be borrowed without the specific verbal permission of Andy Ruina. After permission, it must be signed out.

Lab key

Don't give the lab key to anyone. You should know everyone you see in the lab and they should know you. If you don't know them, tell them who you are, what you are doing and ask them the same. Do not assume that everyone in the lab belongs there. Over the years the lab has been abused many ways. If anyone abuses the lab in a way that you could have prevented you are responsible.

Lab notebook

Buy a lab notebook. Write your name, home and campus addresses, and home and campus phone numbers on the cover. Keep track of lab activities in this notebook. Each time you work in the lab write the date and times worked entry with a brief description of what you did and what your plans are.

Your space

Make yourself a drawer or shelf space in the lab. Put your name and campus phone number on the outside as well as your project. Store your lab notebook and other project materials as needed in this place.

Weekly meetings

will be for an hour each week. Each week you will give a short description of your progress for the week and some weeks you will give a longer presentation about your work, both written and orally. Attendance required. For the oral presentations buy some sheets of overhead-transparency plastic and some colored (permanent ink) pens. A bottle of rubbing alcohol and some Q-tips are also recommended. Computer generated presentations are OK, but take more time to prepare. Many students have greatly improved their oral communication skills through the practice they get at these meetings.

How to buy things

If you need tools or materials that are not in the lab for a project, you are responsible for finding and getting them yourself. A record of what you purchased, where, and for how much will be part of your final report. Purchases of $20 or more should be cleared through Andy Ruina. To make a purchase, you can: A) make a purchase at the Campus Store, any of the stockrooms on campus, or General Stores (5-5121) by giving the appropriate account number and the lab's location and phone number: 306 Kimball, 5-0824. B) For orders from local businesses or mail orders from companies, the process is more complicated. For details and any other purchasing questions, consult "Purchases" on the bulletin board: Who to ask for purchasing help? •Other workers: everything.
•Peter Brown (210 Kimball): Department Business, Building issues.
•Maureen Letteer (212 Kimball): Pay, etc., Purchasing.
•Dan Mittler (Kimball 212): Electronics, computers.

Questions?

If you have a question- ask! help is available if you look hard enough for it. If there is a problem, bring it up in a lab meeting.