Spring 2011

UICC IEEE Magazine

SPARK

Follow Up!
The Bridge to China & iGEM Team, Part 2

What's Happening
Engineers Without Borders in Nigeria, the SigArt team, and AIAA Make a Difference

Meet the Spark Team!

One-on-One
with Professor Mark Hasegawa-Johnson

Group photo: Nancy (left), Mahir (center), and Sujeeth (right)

About the Spark Team

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Nancy Chang, a senior in Electrical Engineering at UIUC, is a co-founder of Spark! and has been working on the magazine since her sophomore year. She is the current Vice-President of IEEE and Student Ambassador Lead of ECESAC.

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Sujeeth Bharadwaj, a first-year graduate student at UIUC, is a co-founder of Spark! and has been working closely with Mahir and Nancy since his sophomore year. He will remain actively involved with Spark! in the semesters to come.

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Bridge to China and Spark team photographs courtesy of Jake (Zhe) Zhao.

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Interview with a Professor: Mark Hasegawa-Johnson

When people ask me my religion, I tell them I'm Bayesian"

Tell us a little bit about your early days – where you grew up and how you became interested in mathematics and the sciences.

I was an academic lad. My dad was a professor—he taught at several universities including Purdue, Whitworth (WA), and Cal Poly. I was initially interested in being a science-fiction writer, and so I was interested in the sciences from the very beginning.

What did you father teach?

Inorganic chemistry and he switched entirely to organic chemistry when he started working at Boeing.

So what got you interested in engineering and computer science?

When I was in sixth grade, I learned how to program and I really enjoyed it. My friend said if you're good at math and love to program, you should be an engineer. I said what's an engineer? At that point, my dad also confessed to actually being an engineer.

So you've been around the country. Where exactly did you go to college?

I lived in Washington. In my neighborhood, you either went to MIT, Ivy League, or the University of Washington. I managed to get into MIT.

You stayed there for three degrees. How was the MIT experience?

I liked it a lot. As an undergraduate I lived off campus in a fraternity. As a graduate student, I was much more involved with the campus—basically lived in my lab.

Which fraternity were you part of?

Theta Xi. It's the only social fraternity founded by engineers, I think. Like all other social fraternities, it had its own distinct character. It was an artsy fraternity, which involved going to museums and doing art-related things. My freshman year roommate took vinyl records, splatter painted them and hung them on the ceiling to emulate night sky.

So what made you go to graduate school?

I got my bachelors and masters at MIT in 5 years because of a joint program. I wanted to either start a company or get a JD. During my junior year though, I got interested in Japanese. Instead of doing either of those, I went and worked in Japan at a Fujitsu lab in Kawasaki. I realized doing independent research was so much more fun than taking classes so I applied to MIT again for the doctoral program.

Was this before or after you added the Hasegawa to your name?

This was before. I became Hasegawa-Johnson when I got married. I met my wife within two weeks after returning for doctoral studies. I was at a party and I had forgotten how to socialize in English. Japanese have rules with different responsibilities for the guests and hosts. There were people at a corner saying something in Japanese, so I decided to go and talk to them. The woman who became my wife was recruiting people to teach programming to high school teachers in developing countries such as Thailand, Ghana, and Zimbabwe. This was long enough ago that those countries did not have many computers. It was an interesting enough conversation that I maintained contact and married her five years later.

So how good would you say your Japanese is?

I can hold a conversation with anybody willing to talk to me. I read a grant proposal and discovered my Japanese was not as good

as I thought it was. My Japanese is at second or third grade level; based on the Magic Tree House series I've started reading.

How do you find yourself spending time with family, writing grants, advising students, and teaching classes?

Time management is important. I have used every calendar aid available since the palm pilot for the simple purpose of time management. If you want to maintain an active research program, and to teach good classes, and have time for your children, you need to know when they get out of school, pick chunks of time and make it available for them—ideally every day. But that doesn't happen when we have to write grants. I wasn't this way as a student though. I was obsessed with a particular topic I was interested in and devoted most of my time to it. Of course, I saved some for social life as well.

What made you choose U of I over the other top tier schools?

Many factors. The biggest one was the Beckman Institute. At least since I started my doctoral research, I've worked with linguists and speech scientists. I was fascinated with the idea that there's a building dedicated to interdisciplinary study.

What types of research is your group engaged in?

My group is working primarily on speech and non-speech processing, which is a tongue and cheek way of dividing it. We work on audio and speech user interface for which we need to know a lot about the users and a lot about the signals. That means really a mathematical component and a scientific component. Mathematical component is machine learning. When people ask me my religion, I tell them Bayesian. If you want to understand why people act the way they do, you should look at the probability distribution and people act in a way to maximize their gain. Signals are also probabilistic agents. Outside of Matlab, no two signals are the same. The math is primarily machine learning and information theory. The scientific component involves understanding what it is humans know they do. In the cortex they have some representation of all languages they speak. What is it that humans get from the signal? We use mathematical models to capture this.

Are you open to undergraduate students?

I usually have one or two undergraduate students. Advising them is a fair amount of work. I treat each like a graduate student. I work out a research project that will leverage that student's knowledge and interest; ideally something that hasn't been done before stems out of it.

What courses would you recommend for someone interested in this field of study?

At least ECE 313 and ECE 410. Something like 417 or 534 is even better. No matter what your background is, you'll have to spend time learning and reading relevant papers.

Students are often confused about grad school versus finding a job. How do you think they should go about making the decision?

I've always enjoyed it so much that I haven't analyzed it carefully. If you really enjoy research, you should go to grad school. Figuring out whether you will enjoy research or not is not so obvious. To be good at research is kind of like an elaborate game of multiplayer chess. People all over the world are trying to devise better algorithms and better explanations for reality. When you look through the literature and can understand what they're saying and if you can say this is a cool idea, it's possible that you have the obsession.

Undergraduate students have to make similar choices regarding grad school. What kinds of things should they look for?

I got my masters from the same place as my undergraduate institution. When I applied for doctoral studies, I already knew I was interested in speech processing. I looked through the literature and people at UC Santa Barbara and MIT seemed to be doing the most relevant things. I got into both, talked to the professors, and picked MIT. Obviously, the ranking had something to do with it, but I read the publications and talked to research groups before deciding.

Bridging the Divide in Yunnan, China

The first edition of Spark! showcased the survey report of the Illinois Bridge to China (BTC) team; after a semester full of challenges ranging from technical concerns to financial issues, BTC now presents the completed footbridge of Paomaping Village, China.

The Illinois Bridge to China team is the first international chapter of the well-established Wu Zhi Qiao Charitable Foundation (WZQCF), an organization dedicated to the construction of footbridges in impoverished villages across mainland China. Three semesters ago, five engineering students from the University of Illinois took their technical skills to lend a hand to less fortunate people around the world.

In Paomaping, Yunnan, a flooded river once stood between a village and their ability to perform daily duties—children were isolated from their schools and farmers were prevented from reaching their own fields. In Spring 2010, a class of thirty UIUC students set forth to design a bridge that best suited the needs of Paomaping, Yunnan Province.

Later that fall, four students continued this process and made a trip to Paomaping to see their bridge to completion. Tasks ranged from wiring cages filled with large stones for the foundation to more demanding jobs such as laying down the foundation. Through the combined efforts of the village and students from UIUC and partnering universities such as Chongqing University and the Chinese University of Hong Kong, the construction of the bridge was transformed into an enjoyable, yet significant community event. Three hundred fifty people now cross this bridge daily.

"Learning the technical aspects of bridge design was good; interacting with the locals was even better, but the impact our projects have had on these people is most rewarding," states Jake Zhao, one of the founders of the Illinois chapter and a project manager of the class.

The Illinois team is constantly expanding and has recently formed ties with Bridges to Prosperity, an Iowa based group with the same mission. Twenty-three students are currently enrolled in the class this semester and are in the process of designing a suspension bridge for a different location in China. The key to BTC's success is their welcoming nature and openness to new faces and ideas. Feel free to contact any of the members to see how you can contribute.

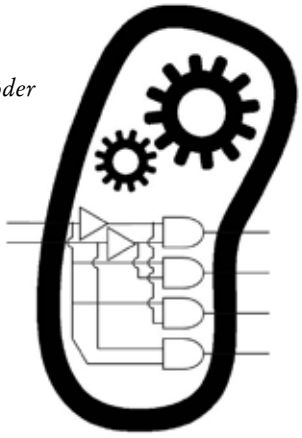
The Illinois Genetically Engineered Machines

Illinois iGEM 2010

This is the third year that the University of Illinois has been host to a team of highly motivated undergraduate researchers. The International Genetically Engineered Machines (iGEM) Competition is the premier undergraduate Synthetic Biology competition. It is held annually at the Massachusetts Institute of Technology and provides a venue for student creativity and ingenuity. The 2010 competition included over 130 teams from countries as diverse as Panama, Japan, Germany, and South Africa.

What is synthetic biology and how does it relate to Engineering?

In a sentence, synthetic biology is the application of engineering principles, particularly standardization and abstraction, to biological systems. The basis for developing biological systems is on the level of individual DNA base pairs. However, working with individual base pairs would be like writing code in binary. Thus, different DNA sequences such as genes, promoters, ribosome binding sequences, etc. have been abstracted into parts. Indeed, much of iGEM is founded on this idea, and a Registry of Standard Biological Parts has been developed. Each iGEM team is given a kit of these parts, or BioBricks, at the beginning of the summer, and these are used to design new parts and build novel biological systems over the course of the summer. The other essential part of engineering biology is standardization. iGEM has worked to develop several standards that allow for the easy combination of parts. Using the same restriction sites to surround a BioBrick part on a standard plasmid backbone is comparable to using the same size and angle grooves on a standard size screw. Standards such as these allow all sorts of parts, including BioBricks, to be easily interchangeable.



Bacteria and Decoder

Using these techniques iGEM teams have come up with many cool projects ...

The UIUC 2010 team was actually divided into two groups: a "wet-lab" or Bioware team which developed new functions within bacteria and a "dry-lab" or Software-Tools team which created new software tools to make biology easier to engineer. The Bioware team project has two main components: development of bacteria capable of bioremediation and refinement of a 2 to 4 bacterial decoder developed by the 2009 Illinois iGEM team. The bioremediation portion focused on using E.coli to bind and sequester toxic metals from their environment. The bacterial decoder portion was designed to produce one of four possible outputs (different fluorescent proteins) based on two distinct chemical inputs. This was implemented using small RNAs as a novel genetic regulatory mechanism to control a system of logic gates which made up the decoder. http://2010.igem.org/Team:UIUC-Illinois

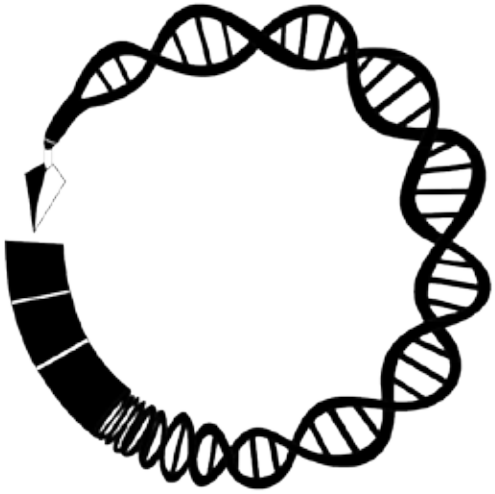
The Software-Tools team has created the tool suite known BioMortar which automates plasmid design for novel metabolic processes and models cell growth. Plasmids are circular pieces of DNA often containing several BioBricks. BioMORTAR designs and displays the advised, usable plasmid(s) for a requested metabolic process. Finally, the program

models the growth of the organism, with the addition of the new metabolic pathway(s). By automating the design process, BioMORTAR streamlines the process of designing bacteria with new metabolic processes. http://2010.igem.org/Team:UIUC-Illinois-Software

There have been many other intriguing iGEM projects including making bacteria smell like mint, designing bacteria that can survive in a mammalian blood stream, and making bacteria produce different visible color reporters. In working on these projects, we have faced the central question that iGEM first presented to the world: "Can simple biological systems be built from standard, interchangeable parts and operated in living cells? Or is biology simply too complicated to be engineered in the way that mechanical and electrical systems are designed and constructed?" Considering the success of our project and that of many other iGEM teams, we believe that designing biological systems is a reality that has already shown proven benefits. In fact, researchers have gone as far as creating bacteria to produce artemisinin, a substance that is used to cure malaria.

Successes and Future Plans

In 2009, the UIUC Software-Tools team won Best Software-Tool, and in 2010 the Bioware team received a gold medal for their work. We are looking forward to the 2011 project. The 2011 UIUC iGEM team will combine both Bioware and Software-Tools into one. The project is already underway and the team is currently researching ideas for the competition. For more information, check out http://openwetware.org/wiki/IllinoisSyntheticBio or e-mail us at Illinoisigem@gmail.com.



Engineers Without Borders: Bringing Water to Adu Achi, Nigeria

by Joe Sawa

Community Based Water System for Rural Nigeria

While most Americans enjoy access to convenient, safe, and consistent water sources for everyday use, approximately one sixth of world's people lack adequate access to water. Statistics are even worse for nations such as Nigeria, where around half of the country's 150 million people suffer from deficient water supply. The people in the village of Adu Achi, which lies in Oji River L.G.A., Enugu State, in Southeast Nigeria, previously fetched water for domestic use from a distant and contaminated surface water source. The water borne-illnesses caused by consumption of this water were a significant contributor to physical and psychological stresses and the need to make multiple four mile round trips per day to the stream source occupied much of women and children's days. These ailments and burdens often prevented the pursuit of educational, economic, and social opportunities.

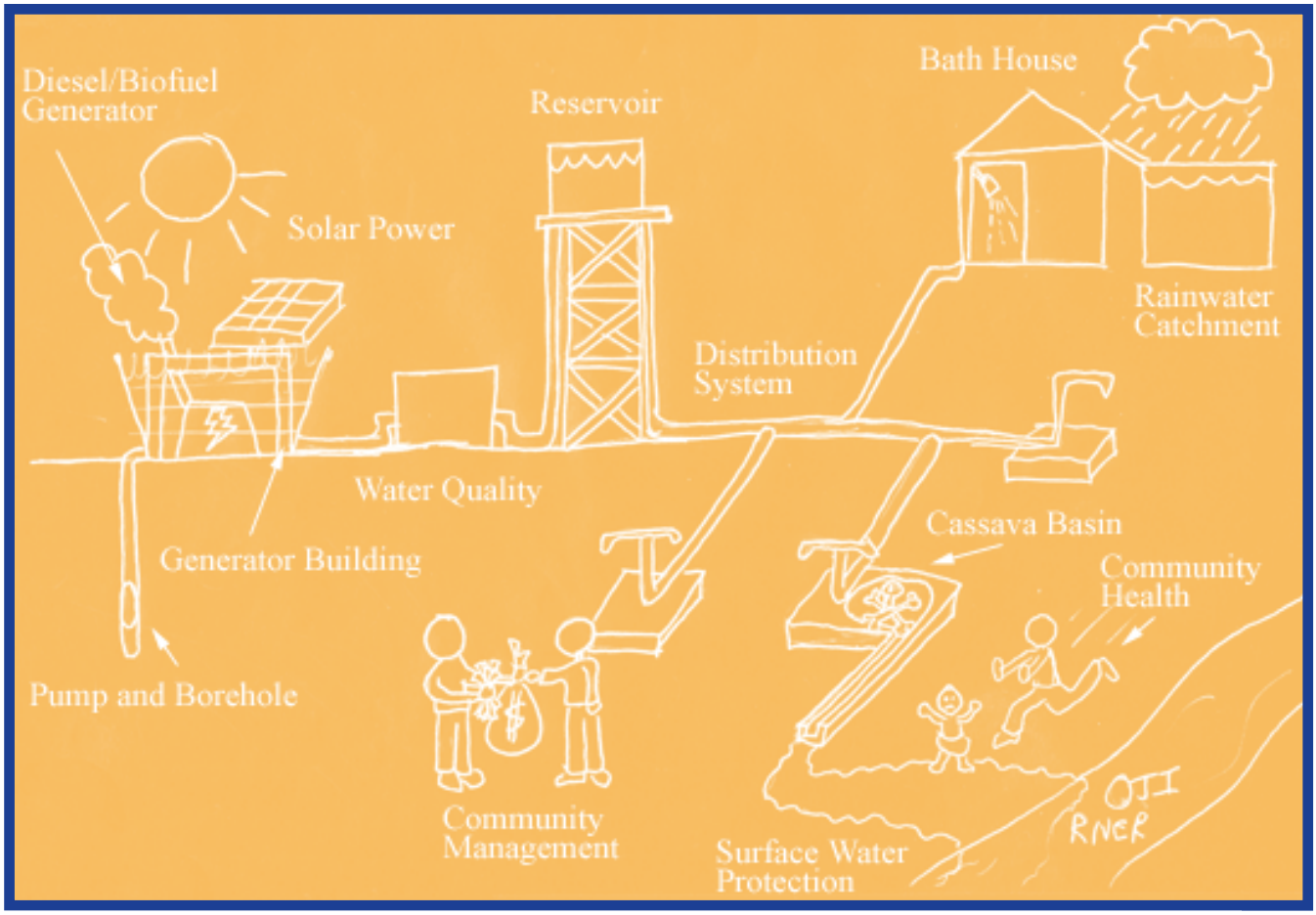
Now a priest in Canada, Stan Chu Ilo grew up in Adu Achi and experienced his community's need for water first hand. In 2004, Stan and the NGO Canadian Samaritans for Africa submitted a proposal to EWB-USA for the provision of adequate water supply in the village. The proposal was accepted by EWB-USA, and the EWB-UIUC team took over the project in late 2005 and has been working since to provide sustainable water supply.

The team first travelled to Nigeria during the summer of 2006 for a site assessment, which involved collecting preliminary water use and demand data, conducting elevation surveying and mapping, investigating potential sites for borehole and storage tank construction, and water quality testing at several local sources.

At this point, several plans for water provision were evaluated. Centralized treatment and point of use treatment for existing water sources were evaluated, but development of a well in a clean underground aquifer with an extensive distribution system proved to be the most feasible option for bringing water to Adu Achi. The system design called for a 500 foot deep borehole well with an electric submersible pump. The pump, powered by a diesel generator set, would pump water from the aquifer and uphill to reservoir tanks. The water would flow through four miles of gravity-fed distribution system to service the community at 10 public tap stands. Private house connections and a tanker truck filling station were also included in the design.

Travel safety questions and fundraising challenges kept the EWB team in the U.S. until late 2007. Two implementation trips during winter 2007-2008 and summer/fall 2008 saw the completion of two ferrocement reservoir tanks, with 23,000 gallons of storage capacity each. During this time, drilling and casing of the 500 foot borehole well was completed, 850 feet of distribution mains were installed, and two public tapstands were also constructed.

The third and most recent implementation trip began during the summer of 2009. During that summer, the submersible pump was successfully installed and a pumping test was performed. A generator set house was constructed to protect the 40kVA generator set and pump control panel that were then installed. When the rest of the team returned to the U.S. at the end of the summer, one UIUC graduate stayed in-country to continue work on the water system. He completed the electrical installations of the pump, pump control panel, and generator set. Under his management, around one mile of distribution system was installed, and two additional public tap stands were constructed by workers in the village. This pipeline now runs the length of the main road through the village and can service most of the village, including two primary schools.



During this trip, and since the trip's completion, extensive efforts have been made to establish and finalize the community management system that will ensure sustainability of the water system. A local Water Project Management Committee will oversee operations and maintenance, major repairs and expansions, and financial issues. The UIUC team has been maintaining communication with members of the water committee and others involved with the water project in Nigeria. Technical and managerial expertise is relayed to those in country to further develop the system and address any issues that may arise.

Looking toward the future, alternative management models, including those of social businesses, are being investigated for elements that may contribute to the sustainability of the water system. Additional projects in Nigeria and collaborations with Nigerian universities, women's groups, and NGO's are also being explored. Future travel to Nigeria will allow monitoring of the current water project and assessment and implementation of new projects during the same trip. With this model, knowledge and experience can be compounded to continue successful and efficient work in Nigeria.

Man vs. Machine: Exploring Wikipedia

Wikipedia Knowledge Extractor

It has been a longstanding goal of Artificial Intelligence to develop 'Strong AI' - the sapience of a machine with regards to a wide array of subjects. An essential step in this direction is the imbuing of such machines with elementary knowledge, in a format easily reasoned with. For example, a general-purpose planning algorithm supposed to make your breakfast might be greatly improved if it could obtain and manipulate the fact that the toaster must have a supply of electricity to prepare

your toast. A cleaning robot equipped with the commonsense fact that 'dirt is dark' might be able to selectively identify spots on a carpet requiring further attention, without explicitly hard-coding this behavior. Having a store of such knowledge would prove invaluable to a wide variety of applications, but the challenges of creating such a knowledge base are nontrivial.

With recent advances in Natural Language Processing, the wide-scale automated extraction of machine-readable facts has become more tractable. Such advances have driven the vision of the Semantic Web, the evolution of the web as a repository of structured data in which each resource defines its own type and content. In this manner, web services will be able to intelligently query each other as data will be tagged with meaning. The full scope of the vision of the Semantic Web has yet to be achieved. However, there are thoroughly established and developed precursors. One such resource is the well-known open encyclopedia Wikipedia. Wikipedia contains semi-structured data spanning across a varied multitude of domains of discourse, with great depth for a great deal of topics.

Given these motivating factors, we set out to create software that automatically harvests commonsense knowledge from Simple English Wikipedia, a project of Wikipedia developed for use by "people with different needs, such as students, children, adults with learning difficulties and people who are trying to learn English." Its articles are written primarily in Basic English and thus generally contain non-complex sentence structures, which are easier to parse with a computer. Furthermore, because the articles are concise, they typically present only basic, background or some might say commonsense knowledge regarding a subject. Our primary goal was to present a store of commonsense knowledge from which applications in disparate domains may draw world-knowledge.

Several related projects already existed before we begun work on ours. The most prominent being the Cyc project, a 25 year effort to codify comprehensive commonsense knowledge in a unified, consistent database. The primary difference between our knowledge extractor and Cyc is that the vast majority of facts stored in Cyc have been painstakingly entered into the database by hand, while we wish to automate the process. More recent developments have seen the rise of such commercial systems as True Knowledge, Powerset (which was acquired by Microsoft in 2008), Freebase, and Wolfram Alpha. There also exists the DBpedia project, a database of relationships between various concepts. These projects gave us hope that our idea was feasible, but did not precisely address the issue we hoped to tackle: automating the creation of a commonsense knowledge base using Wikipedia.

We began our project by downloading the entirety of Simple English Wikipedia as an XML file from Wikimedia. We then preprocessed the file using a simple regex-based heuristic to detect noisy sentences which were not in natural language, but instead pertained to tables or figures. The remaining sentences were deemed clean and entered into our database as raw sentences, along with the title of the article where each sentence was found.

To process the raw sentences, we used the Illinois Chunker, created by the Cognitive Computation Group here at the University of Illinois, to partition our sentences into semantic 'chunks' corresponding to various phrase types such as noun phrases (NP), verb phrases (VP), prepositional phrases (PP) and adjective phrases, among others. We were largely interested in obtaining only the subject,

object and relation terms from each sentence retaining as much information as possible while removing unnecessary noise, so we looked for (NP, VP, NP) patterns in our sentences, and used simple ad hoc rules for combining phrases that are not labeled as NPs or VPs. For example, if a PP (prepositional phrase) immediately followed an NP, we combined the two to retrieve our subject or object phrase. The rules used, though intuitive, were not perfect and often incorporated noise or lost valuable information. Refinement of these rules is definitely a potential area of improvement for future work.

Some of the sentences contained noise in the form of words in parenthesis. For example, one article starts with "Napoleon Bonaparte (French: Napolon Bonaparte), was ...", which we automatically reduced to simply "Napoleon Bonaparte." We then extracted the head word of each of our nouns and relations using the NounGroup parser that was developed for the YAGO-NAGA project. Finally, we used a lemmatizer from MontyLingua to reduce words to their simplest forms (lemmatization). Our database was then, theoretically, full of clean commonsense knowledge.

The final contribution of our system was a web interface written in Django, which allowed users to query a term and presented the facts available relevant to the queried term. It functioned both as a sample application and as proof that the data we had collected was useful. Our interface displayed the link structure graphs corresponding to articles from which the facts were retrieved.

Additionally, users could ask the system questions of the form "(Do) EntityX (Verb) EntityY?" and "(Be) EntityX EntityY?". Facts were chained together to arrive at a Boolean conclusion. Answers to the questions were displayed along with the facts that were used to determine the answer.

We used the question answering system to evaluate the quality of our data. Using 120 random commonsense facts, we posed yes/no questions about them to our system and TrueKnowledge. We discovered that TrueKnowledge does not perform well with this type of question, as it is tailored toward questions starting with "who" or "which". Our system, on the other hand, performed favorably, returning correct positives 44% of the time and correct negatives 77% of the time, compared to True Knowledge's 30% (positives) and 48% (negatives).

We would like to give a special thanks to Eyal Amir for his support throughout this project. We would also like to thank Sam Johnson for his help at multiple points throughout the implementation phase of the project, especially with regards to the XML parsing and his suggestions for using Django as the web interface. And finally, we would like to give a special thanks to Juan Mancilla for his involvement of the project and for basing his "Turing Game" application on our data, which was well received.

About the Project Participants

The Wikipedia Knowledge Extractor is brought to you by Bobak Hadidi (bhadidi2@illinois.edu), Nikhil Johri (njohri2@illinois.edu), Darin Pantley (pantley2@illinois.edu), Abhishek Pradhan (apradha2@illinois.edu), and Felix Wang (fywang2@illinois.edu). Bobak, Nikhil, Darin, and Abhishek are students of the Department of Computer Science and Felix Wang is a student of the Department of Electrical and Computer Engineering at the University of Illinois in Urbana-Champaign.

Meet the Society: The American Institute of Aeronautics and Astronautics

The American Institute of Aeronautics & Astronautics (AIAA) is the world's largest professional society devoted to the progress of engineering and science in aviation, space, and defense. The purpose of the society is "to advance the arts, sciences, and technology of aeronautics and astronautics, and to promote the professionalism of those engaged in these pursuits." Here at the University of Illinois at Urbana-Champaign, the AIAA Student Chapter is an organization that accomplishes these goals through on-campus activities as well as off-campus excursions. We sponsor talks about current research in aerospace, graduate school and undergraduate research opportunities, as well conduct field trips to companies (Boeing in St. Louis, for example) and museums (Wright-Patterson AFB). We try to create activities and an atmosphere that encourages involvement in aerospace engineering and that also promote interaction between students.

The American Institute of Aeronautics and Astronautics at UIUC has a technical project team that focuses on showing members what their studies will hopefully lead them towards. The projects are designed to reflect the elementary versions of what the aerospace courses eventually strive to teach students, such as the basics of rocketry and airfoils, among other things.

Currently we have two separate projects going on during the semester. The first rocket is a small rocket with a swing-wing, the purpose of which is to help in the descent. The wing will be deployed from its original position when the rocket reaches its zenith, and will slow the rocket to a reasonable gliding speed. This project challenges the design skills of our members, showing the basics of assembling a rocket, as well as interjecting aspects of airfoil theory.

The second project comprises of two identical rockets. Each rocket will be attached to a steel wire cable, and will race each other side by side during the upcoming Engineering Open House 2011. As there will be little stability or control concerns with the rockets, being guided by the cables, the project is more focused on the structural integrity of the rocket and aerodynamics of the exterior. The rockets will also feature exchangeable motors, which will introduce the aspect of reusability as a factor for students to think about when designing rockets.

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