ENPRO 355: Augmented Reality Technologies

Tyche Technologies
Spring 2008

Project Plan

Submitted by: ENPRO 355

Date: February 22, 2008

1. OBJECTIVES

In the construction industry, safety is obviously a big concern. Companies take many precautions to reduce the number of incidents that occur to reduce costs and save lives. As one of these precautions, construction companies purchase extra safety equipment to save the lives of workers to supplement regular required products such as hard hats. However, despite all of the safety equipment that is used, accidents still occur. For example, there was a flood in Chicago in 1992 which cost more than two billion dollars in reparations because a worker placed a wooden piling into the wrong place.

Tyche Technologies will solve this problem by providing accident prevention technologies that use augmented reality (AR) to enhance the awareness of the construction worker. This additional information will let the worker know where key construction hazards are, such as the location of pipes and cables that run underground. Our team will develop a business plan and a prototype to demonstrate the feasibility of this project and attract potential sponsors/investors. The business plan will outline the market and financial feasibility of this product as well as any other problems/concerns that we foresee. The prototype will demonstrate how an AR environment can be created and relevant information uploaded and displayed to a user.

Our team is split into two sub-teams and both have specific objectives:

Business Team

- Determine market feasibility after conducting in-depth market research.
- Create a viable business plan for the development of actual product.
- Evaluate potential ethical and legal issues with relation to the project.
- Establish and build relationships with representatives from potential project sponsors such as Caterpillar and Komatsu.

Technology Team

- Acquire hardware required for the creation of the prototype and learn to interface it with the computer
- Develop software to utilize positioning and orientation data from various hardware devices
- Integrate data from electronic sources such as CAD drawings to display a virtual image over the real environment
- Build a proof of concept prototype that will demonstrate the viability of AR in safety equipment.

2. BACKGROUND

Tyche Technologies was created in the IIT Stuart School of Business undergraduate program in the fall semester of 2006. It was developed for a semester-long project in which the student team members researched and produced a business plan for a new and innovative product under the advisement of Dr. David Pistrui. This plan was entered into the New Idea Generation Challenge (NIG) and took second place. By achieving such an honor, the idea was allowed to become an ENPRO project in the fall of 2007.

Last semester, Tyche identified three potential target markets for an augmented reality device- large cities, theme parks, and major sporting events at selected sporting venues. As Tyche Technologies was developed in Chicago, Illinois, the target markets were chosen to give significant benefits to Chicago and other large cities. Commuters in large cities would have information such as traffic reports, weather, and maps displayed within their field of view. City parks would provide tourism, concert, and event information to users. The Sports Arena market would focus on stadiums throughout the United States. These stadiums frequently hold MLB, NBA, NFL, and NHL games during the season. During the off season, these arenas hold a variety of concerts, conferences, and trade shows that generate a significant amount of revenue. The users would see stadium-generated ads, sports statistics, concession information, and restroom or other venue information streamed directly to them. This was considered to be a promising market as the increase in utility to the user could result in higher ticket sales.

The sports and metropolitan markets were large and sustainable. However, this semester, we analyzed our previous target markets and came to the conclusion that these markets were too broad for a product that is very new and expensive. Consequently, we decided that we should target a market that would focus on situations that are unique and require very professional work to be performed. After discussing several alternatives, we decided to target construction companies in order to fill a critical gap in the safety equipment used in construction. This project intends to solve problems and concerns that exist in the construction industry regarding the use and operation of heavy machinery through a novel approach: an augmented reality system. An augmented reality system is a device that overlays virtual reality images showing safety information onto the real world in order to prevent accidents and collision of heavy machinery with each other, people, buried utilities and various other work site objects. This equipment will be able to import construction plans from common construction programs such as CAD and display it to the user with AR and GPS integration.

Our goal is to create a device that is easy to use and control; a technology that works in open fields, in dark basements, through physical obstacles and is deployable in a variety of places. Our focus is to make the product reliable and able to function under the harsh conditions encountered in the construction industry.

Those who use our product will benefit through cost savings from avoiding accidents, productivity enhancement and unification of construction plans, possible tax and insurance savings for money spent on safety equipment. We anticipate that our product will be able to interface with current computer vision systems.

Historical successes addressing safety issues in the past include the usage of mirrors in earth movers and bulldozers, flags and sprays to mark buried utilities, back-up warnings for vehicles, fluorescent safety vests, hard hats, and more. Along with the successes, there have been many failures in the past where there has not been adequate safety equipment to prevent workers from damaging themselves, other or property. For example, in 1992, a flood occurred beneath the Chicago River while working on the Kinzie Street Bridge. There was an abandoned Chicago Tunnel Company tunnel beneath the river that had been used in the early twentieth century for the transportation of goods and coal. A piling was driven into the bottom of the river alongside the north wall of the old tunnel. This caused an increas in pressure that cracked the wall which resulted in mud oozing in. After a few weeks, enough mud entered to open a leak, causing a flood. The basements of several office buildings and shopping areas were flooded, shutting down the loop for three days. The cost of cleanup was in the billions of dollars, and a key commerce area was shut down, furthering losses. Had the worker been equipped with one of our augmented reality systems, this accident could have been avoided through increased awareness of key utilities or by shutting down the machinery driving the pilings.

We researched Caterpillar and found that they are already in the process of giving more awareness to users to address safety concerns in the use of their products. For example, a system called Work Area Vision System (WAVS) can be installed into the cab of a machine. This system consists of three cameras that survey the blind spots for the operator and display them onto an LCD screen in the cab. This allows the operator to have a wider field of vision and monitor the work site for any potential danger that would otherwise be unknown to him without the help of other crew members.

Since we are now focusing on a different market, we must now begin to consider ethical, moral, cultural or scientific issues at the moment. For example, will workers find it acceptable if the system shuts down a piece of equipment because the system believes the user will damage a key utility or other structure? What if the user must use on of these machines in order to prevent damage, but the system believes that he or she will cause damage and locks the user out – should the user be able to override the system? Most issues that may arise in this project will stem from the area of technical development. It appears at this juncture that augmented reality (AR) is plausible and viable for a wide variety of applications including augmented construction equipment operations system. As electronics progress, advances in miniaturization, cost reduction and accuracy of location awareness will only widen possible uses and reduce the barriers to development.

As currently envisioned, the device will deliver real-time pertinent safety data to personnel operating large heavy machinery on a work site. Currently, this data will be displayed through a hardened screen in the machine cab, but it will eventually deliver this information through a head mounted display to better overlay the data onto the real world. The device will be aware of its current position in the real world at all times through high accuracy GPS data in the form of a WAAS receiver and an electronic dead-reckoning system. Together, the two technologies will give the position of the device regardless of external conditions such as GPS outages or compounding errors. The device will be capable of overlaying utility information that has been collected by a service such as JULIE.

Previously, Tyche had potential partners such as Microvision, Intersense and Garmin. However, these partnerships did not benefit the team very much. Currently we do not have any partners or sponsors and will be working on the prototype with our IPRO budget. Further, we are developing an exit strategy, including the possibility of partnering with or acquisition by companies such as Caterpillar or Komatsu.

3. METHODOLOGY

A. Problem
  - Accident prevention technology in the construction industry is slow and mostly passive due to the lack of effective warning technologies
  - Augmented Reality(AR) is unused due to its current limitations and high cost
  - A method of conveying construction and architectural plans to the workers in the field in an effective way does not exist

B. Solution
  - Our team will create a product that integrates construction and architectural plans to a worker’s field of vision, or equivalent, using AR technology in order to prevent accidents from occurring in the work place.
  - We have split up the team into two subgroups that will be performing tasks throughout the semester to develop a solution.
  - Technology
    1. The technology team will develop a prototype product that will integrate construction and architectural plans with positioning technologies to create an AR environment that will be displayed on a screen by focusing on the following tasks:
       a. Use WAAS, dead-reckoning, and other positioning technologies to determine where user's vehicle is located
       b. Combine position data with compass / tilt sensor data to display a virtual structure as it would be seen in the real world
       c. Take 2-D utility information on buried power lines, etc., and integrate with display
       d. Determine relative position of active tool (shovel, plow) to vehicle to alert user if there is risk of damaging a utility

- Business
    1. The business team will develop the idea into a viable business plan by focusing on the following tasks:
        a. We will develop a business model that will generate positive cash flows and create value for its shareholders
        b. We will research our market to determine the best entry strategy
        c. We will develop a winning business model

C. Testing

- The technology team will be testing the concept at key steps in the development of the prototype:
    1. Test each component directly to gain a basic understanding of the fundamentals of each technology
    2. Learn to interface each component with the computer (through a microcontroller if necessary) so data can be analyzed
    3. Learn to interpret data from each component so data can be put into algorithms to determine position, heading, etc.
    4. Test the accuracy of each technology by taking a short walk and comparing the recorded results of each technology with the actual results
    5. Combine position and orientation data to change perspective of 3-D object
- The team will perform primary and secondary research to determine the most viable business plan
    1. Primary Research
        a. Conduct interviews with professionals and professors in the construction industry
        b. Speak with safety personnel/buyers at construction firms to determine the marketability of our product
    2. Secondary Research
        a. Research current accident prevention equipment used by construction firms
        b. Determine accident rates and the cost of accidents in the construction industry
        c. Research substitutes to our product

D. Documentation

- Results will be documented through team notes and reports such as:
    1. Presentations from both sub-groups at the scheduled team meetings
    2. Meeting minutes from team and sub-groups
    3. IPRO deliverables
- All results and research will be digitally documented and posted on iGroups.

E. Analysis

- After knowledge is shared through various methods such as presentations and group discussions, ideas will be analyzed and proper actions will be taken to incorporate new findings into the business plan.

F. IPRO Deliverables
   - The IPRO deliverable will be delegated by the team leader in a manner that is reflective of their skills and fair to the team:
     1. Each member will be assigned work which he/she is expected to complete by the deadlines set by the team leader and submit findings to the respective sub-group leader
     2. Sub-group leaders will compile information received and submit to team leader
     3. Team leader will receive sub-group reports and compile the final report which will be available to whole team for examination. Team leader will delegate tasks pertaining to:
        a. Project Plan
        b. Mid-Term Report
        c. Meeting Minutes
        d. Final Report
        e. IPRO Day

4. EXPECTED RESULTS

The expected outcomes for this semesters work can be summarized best by dividing them by the goals of each sub-team:

Business Sub-Team:

- Research compatibility between the product and the construction market
- Communicate our project to potential investors
- Build a business model to support the design of the technology
- Complete a professionally written and executable business plan

Technology Sub-Team:

- Develop a working prototype to help convey our vision to others and prove the project's viability
- Be capable of overlaying a virtual object onto real-world imagery, based on the current user position
- Maintain versatility of the system to permit other uses
- Research and implement two positioning technologies for the project for redundancy and error control
- Ensure that the designed system is reliable and rugged.

5. BUDGET

Item	Quantity	Price
Photocopying	200 copies	$20.00
Paper		$30.00
Mailing		$20.00
Transportation		$25.00
WAAS receiver	1	$210.00
3-Axis accelerometer	1	$50.00
Tilt sensor	1	$30.00
Compass sensor	1	$40.00
Contingency fund		$75.00
TOTAL		**$500.00**

Lab Space Requirements

- Room at least 10’x 12’
- Room will be used for storage of our acquired materials, so we will have to be able to lock it and limit access.
- The minimum size is important so we can move around the room and gauge the responsiveness of the sensors.
- Room must have grounded sockets for equipment
- Room must have proper ventilation for soldering (a window will work)
- Internet access (wireless or wired) will also be necessary for team communications.

6. SCHEDULE OF TASKS

		Task Name	Duration	Start	Finish	Predecessors
1		**ENPRO 355**	**94 days?**	**Tue 1/22/08**	**Fri 5/2/08**	
2		**Technology Team**	**44 days?**	**Fri 2/22/08**	**Sun 4/13/08**	
3		**Administrative**	**21 days?**	**Fri 2/22/08**	**Thu 3/13/08**	
4		Approval and Purchasing	1 day?	Fri 2/22/08	Fri 2/22/08	
5		Mid-Term Report	7 days	Fri 3/7/08	Thu 3/13/08	
6		**Software**	**40 days?**	**Tue 2/26/08**	**Sun 4/13/08**	
7		Software Framework Development	9 days	Tue 2/26/08	Wed 3/5/08	
8		API Review	9 days	Tue 2/26/08	Wed 3/5/08	
9		Learning Ruby	16 days?	Tue 2/26/08	Wed 3/12/08	
10		Data Intergration	20 days	Tue 3/25/08	Sun 4/13/08	
11		**Research**	**30 days?**	**Tue 2/26/08**	**Thu 4/3/08**	
12		Intergrate J.U.L.I.E. Data with Software	21 days?	Thu 3/6/08	Thu 4/3/08	
13		Algorithm Development	9 days	Tue 2/26/08	Wed 3/5/08	
14		**Hardware**	**40 days**	**Tue 2/26/08**	**Sun 4/13/08**	
15		Component Testing	7 days	Thu 3/6/08	Wed 3/12/08	
16		Componenet Interfacing	20 days	Tue 3/25/08	Sun 4/13/08	
17		Documentation Review	9 days	Tue 2/26/08	Wed 3/5/08	
18						
19		**Business Team**	**81 days**	**Tue 1/22/08**	**Sat 4/19/08**	
20		**Research**	**80 days**	**Tue 1/22/08**	**Fri 4/18/08**	
21		**Primary Research**	**35 days**	**Sun 2/24/08**	**Sun 4/6/08**	
22		Questionaire Development	7 days	Sun 2/24/08	Sat 3/1/08	
23		Professors	14 days	Sun 3/2/08	Sun 3/23/08	22
24		Professionals	14 days	Wed 3/5/08	Wed 3/26/08	
25		Purchasing & Safety Managers	14 days	Fri 3/7/08	Fri 3/28/08	
26		Representatives	14 days	Mon 3/10/08	Mon 3/31/08	
27		Construction Crew	14 days	Mon 3/24/08	Sun 4/6/08	
28		**Secondary Research**	**70 days**	**Tue 1/22/08**	**Tue 4/8/08**	
29		Library	70 days	Tue 1/22/08	Tue 4/8/08	

28		**Secondary Research**	**70 days**	**Tue 1/22/08**	**Tue 4/8/08**
29		Library	70 days	Tue 1/22/08	Tue 4/8/08
30		Internet & Other	70 days	Tue 1/22/08	Tue 4/8/08
31		Finalize Research	10 days	Wed 4/9/08	Fri 4/18/08
32		**Finance**	**12 days**	**Tue 4/8/08**	**Sat 4/19/08**
33		Financial Models & Analysis	12 days	Tue 4/8/08	Sat 4/19/08
34		Buyer Models & Analysis	12 days	Tue 4/8/08	Sat 4/19/08
35		**Marketing**	**9 days**	**Wed 4/9/08**	**Thu 4/17/08**
36		Marketing Analysis	7 days	Wed 4/9/08	Tue 4/15/08
37		Market Models & Positioning	7 days	Thu 4/10/08	Wed 4/16/08
38		Competitors & Environment Analysis	7 days	Fri 4/11/08	Thu 4/17/08
39					
40		**IPRO Deliverables**	**55 days**	**Sat 3/1/08**	**Fri 5/2/08**
41		**Mid-Term**	**14 days**	**Sat 3/1/08**	**Fri 3/14/08**
42		Ethics Report	7 days	Sat 3/1/08	Fri 3/7/08
43		Mid-Term Report	7 days	Sat 3/8/08	Fri 3/14/08
44		Mid-Term Presentation	5 days	Sat 3/8/08	Wed 3/12/08
45		**IPRO Day**	**49 days**	**Fri 3/7/08**	**Fri 5/2/08**
46		Final Report/Business Plan	16 days	Thu 4/17/08	Fri 5/2/08
47		Abstract	8 days	Fri 4/18/08	Fri 4/25/08
48		Poster	10 days	Wed 4/16/08	Fri 4/25/08
49		Presentation	12 days	Mon 4/14/08	Fri 4/25/08
50		CD	4 days	Tue 4/29/08	Fri 5/2/08
51		iKNOW Upload	2 days	Thu 4/17/08	Fri 4/18/08
52		Prototype	2 days	Fri 3/7/08	Sat 3/8/08
53		Exhibit Requirements & Set-up	7 days	Sat 4/26/08	Fri 5/2/08
54		IPRO Day Skills Session	2 days	Fri 4/11/08	Sat 4/12/08
55		Meeting Minutes	5 days	Mon 4/14/08	Fri 4/18/08

7. INDIVIDUAL ASSIGNMENTS

EnPRO 355

Team Leader: Devaraj Ramsamy

Advisors:

Jim Burstein

John Stoner

Business Sub-Team

Leaders: Savina Jose & Vlad Rusz

Savina Jose – 3^{rd} year, Marketing & Human Resources. Specialty is marketing research. Will focus on investigating primary and secondary research methods.

Devaraj Ramsamy – 4^{th} year, Finance. Specialty is financial analysis. Will contribute in the business and financial models. Also will provide guidance for the entire team as team leader.

Vlad Rusz – 3^{rd} year, Finance & International Business. Specialty is in finance and entrepreneurship. Will apply his skills in building financial model and statement as well as providing administrative support for IPRO Day.

Meng Zhang – 4^{th} year, Information Technology & Management. Minute taker. Has both technology and business backgrounds. Will focus her efforts on marketing research and analysis as well as helping communication between the two sub-teams.

Technology Sub-Team

Leader: Jeffrey Mizek

Adam Bain – 4^{th} year, Computer Engineering & Computer Science. Specialty is in software development. Will focus his efforts on taking sensor data and using to reposition camera in 3-D environment.

Maximillian Estrada – 3^{rd} year, Aerospace Engineering. Sub-team secretary. Will focus efforts on working with 3-D CAD environment and integrating utility information.

Timothy Madsen – 4^{th} year, Applied Mathematics. Specialty is in math. Will use his skills to develop algorithms to determine position.

Jeffrey Mizek – 3^{rd} year, Electrical Engineering. Specialty in hardware electronics. Will use his skills to interface sensors with microcontroller and microcontroller with PC.

8. DESIGNATION OF ROLES