Ricochet Systems Ltd

Hockey Puck Tracking System

ENSC 305/440

Ashkan Tehrani-Nejad
Imran Dewji
Kelsey James Regan

Simon Fraser University
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Today's Agenda

- Group introduction
- Project overview
- Puck Subsystem
- Receiver Subsystem
- Software Subsystem
- Business Case
- Experimental Results
- Conclusion

Ricochet Team

Ashkan Tehrani-Nejad (CEO)

Imran Dewji (COO)

Kelsey James Regan (CTO)

Project Overview

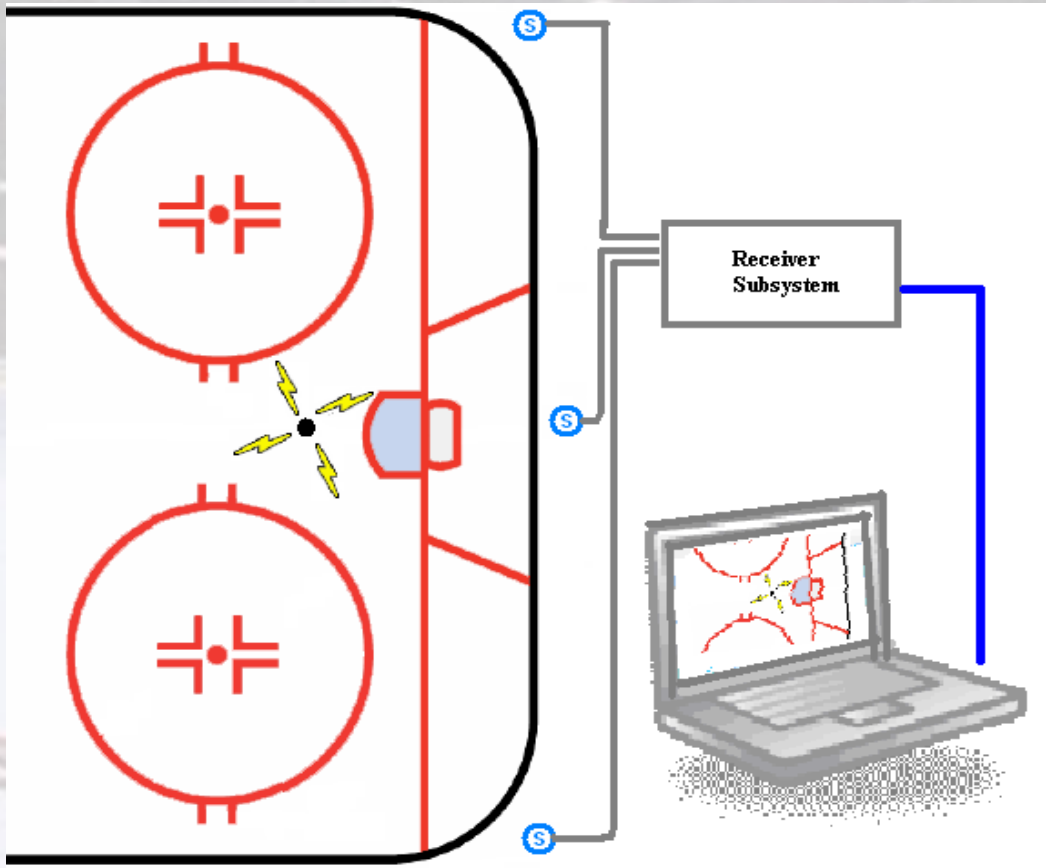
- A ultrasonic tracking system designed for hockey puck.
- Aimed to detect passing of the puck over the goal line.

Why Ricochet Tracking System?

- Inconclusive goals
- Inconsistent goal judgments
- Wasted time for goal judgments
- Added broadcast features
- Happier fans

Ricochet Subsystems

- Puck
- Receiver
- Software

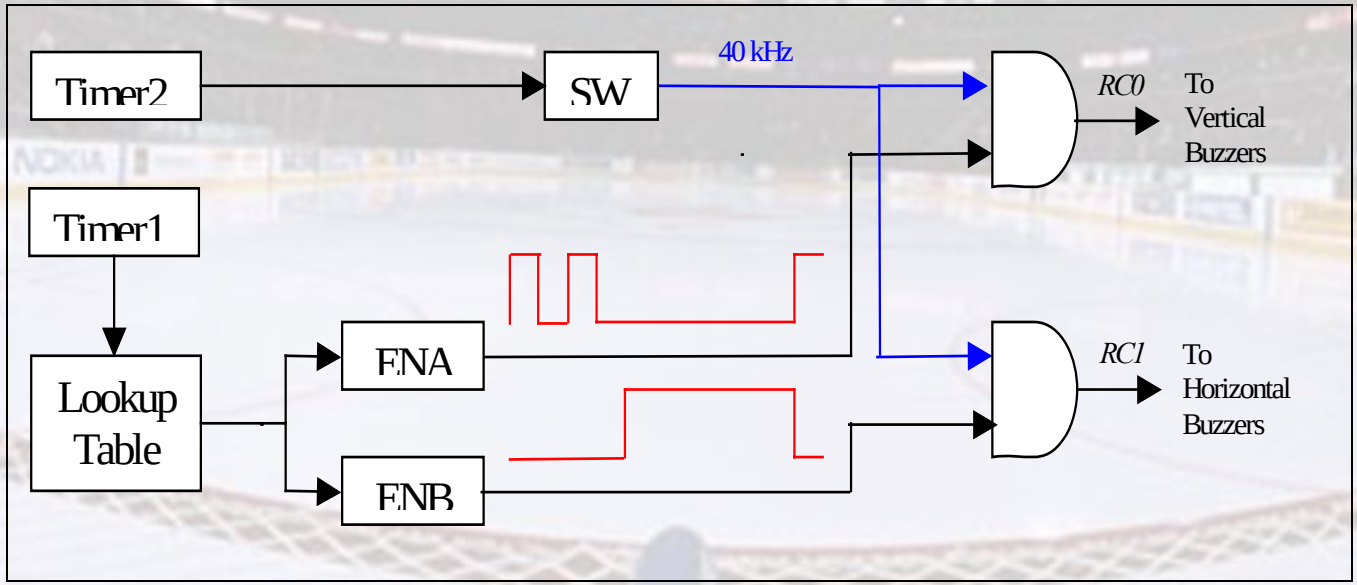


Puck Subsystem

- Generating Signal
- Circuitry Housing
- Prototype Puck

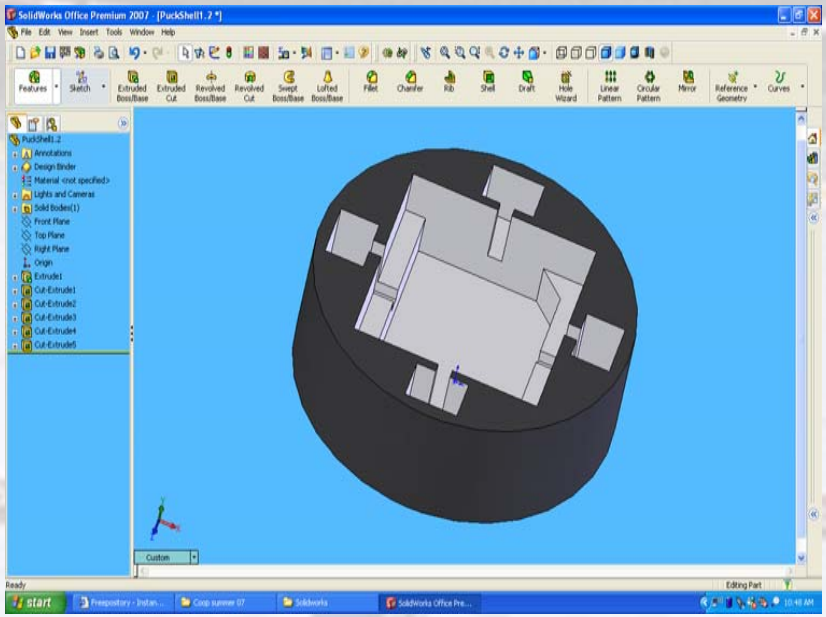
Generating Signal

- PIC microcontroller to create periodic ultrasonic bursts.



Circuitry Housing

- SolidWorks design
- CAMworks to generate NC machine code

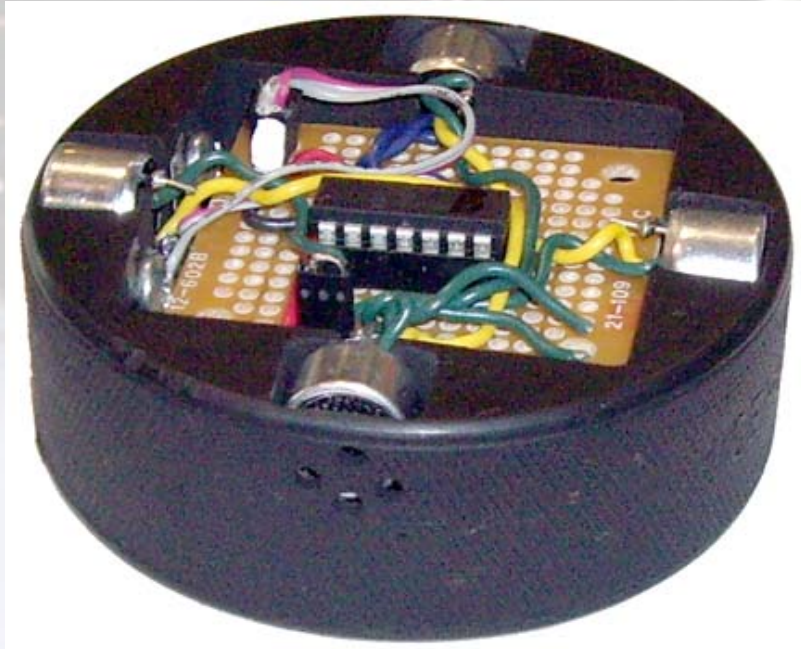


Circuitry Housing

- Milling an official hockey puck

Prototype Puck

- PIC Microcontroller
- Battery
- Ultrasonic Buzzers

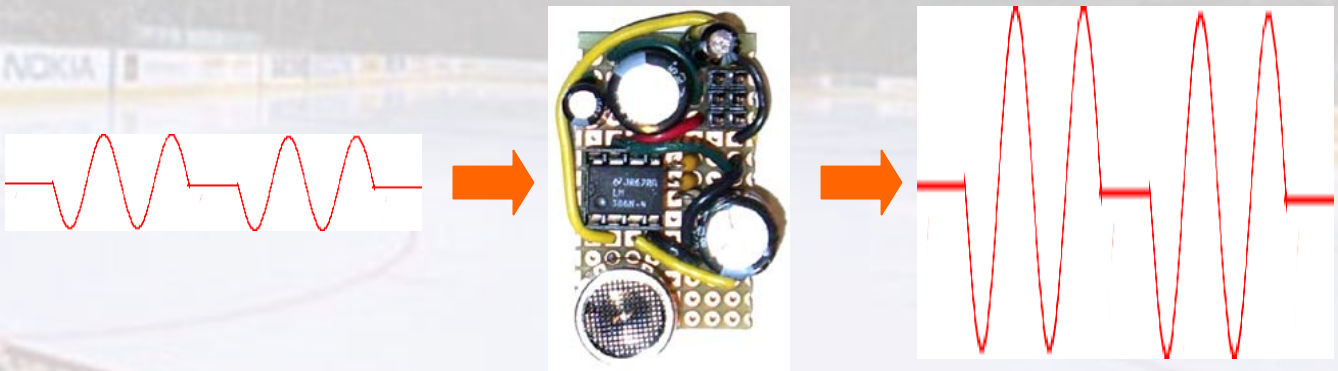


Receiver Subsystem

- Collect Transmitted Signal
- Filtering and Data Recovery
- Time of Flight Measurement

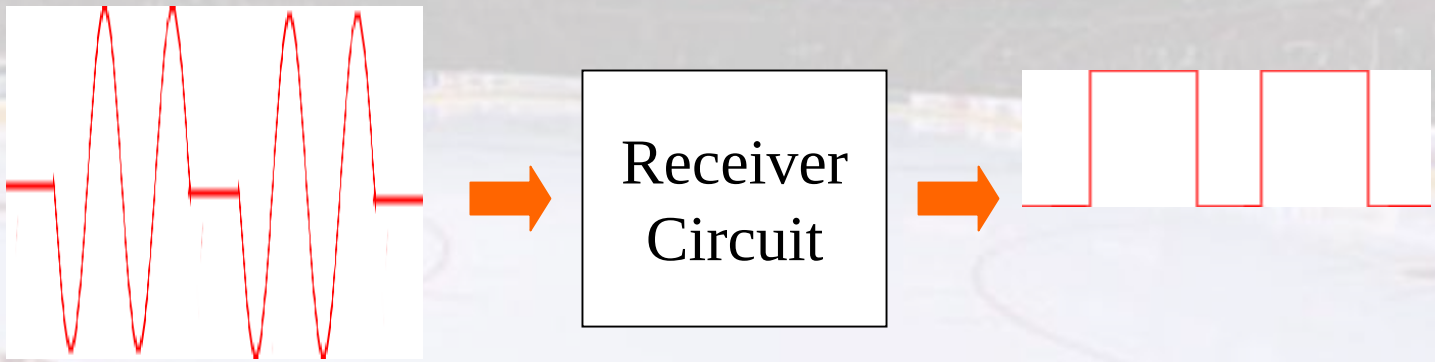
Collect Transmitted Signal

- Reverse the operations of the transmitter
  - First collect the ultrasound signal



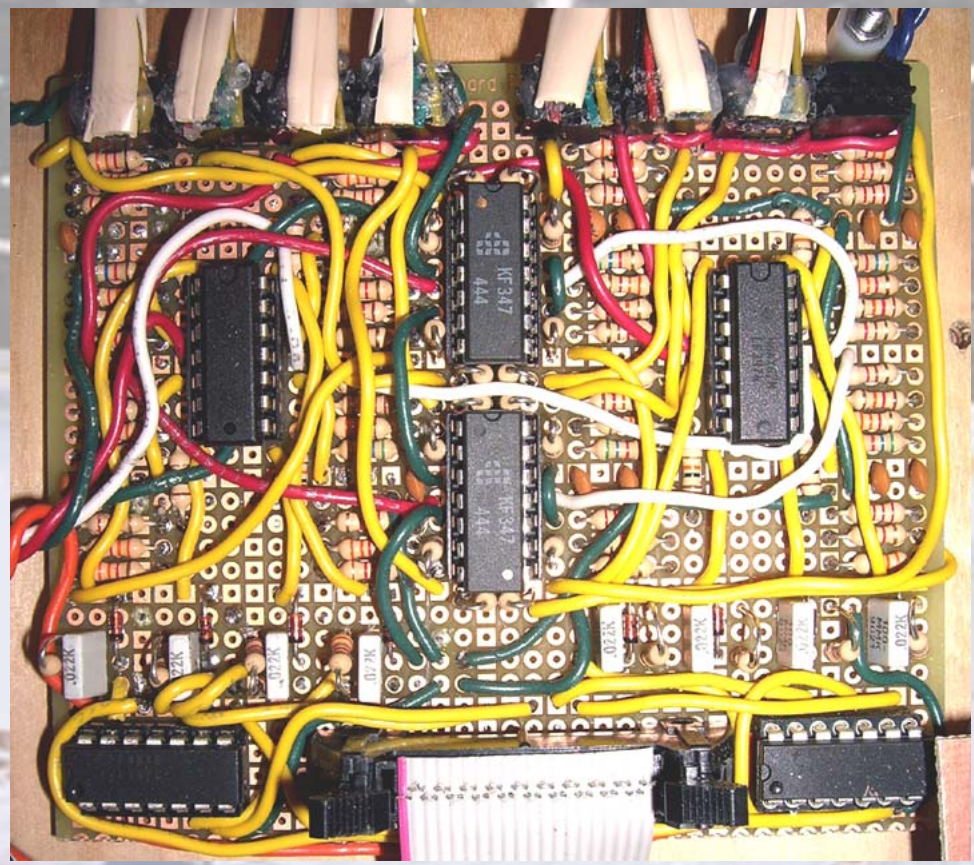
Filtering and Data Recovery

- Reverse the operations of the transmitter
  - Then filter out noise, and recover the pulses



Filtering and Data Recovery

- The receiver circuit
  - 88 resistors
  - 24 capacitors
  - 16 op-amps
  - 12 inverters
  - 8 diodes
  - 90 cm^2



Time of Flight Measurement

- Now measure the time of arrival on each sensor
  - HC12 has eight Input Capture channels, we are using seven
  - Interrupt driven, plus a data transfer routine
  - Data transfer via serial port

Software Subsystem

- Serial Communication
- Calculating Position
- Graphical User Interface

Serial Communication

- Data is communicated from the HC12 board
- Sent to the PC via RS232
- RS232 to USB converter is used on laptop
- Decoded on the PC for sensor measurements

Serial Communication

- Message
  - The message begins with a ‘$’ character
  - Each data segment is sent in binary and is decoded on the PC as a double
  - The data segments are then separated by commas to be parsed by the PC
  - Message format:

$,<data1>,<data2>,<data3>,<data4>,<data6>,<data7>

Calculating Position

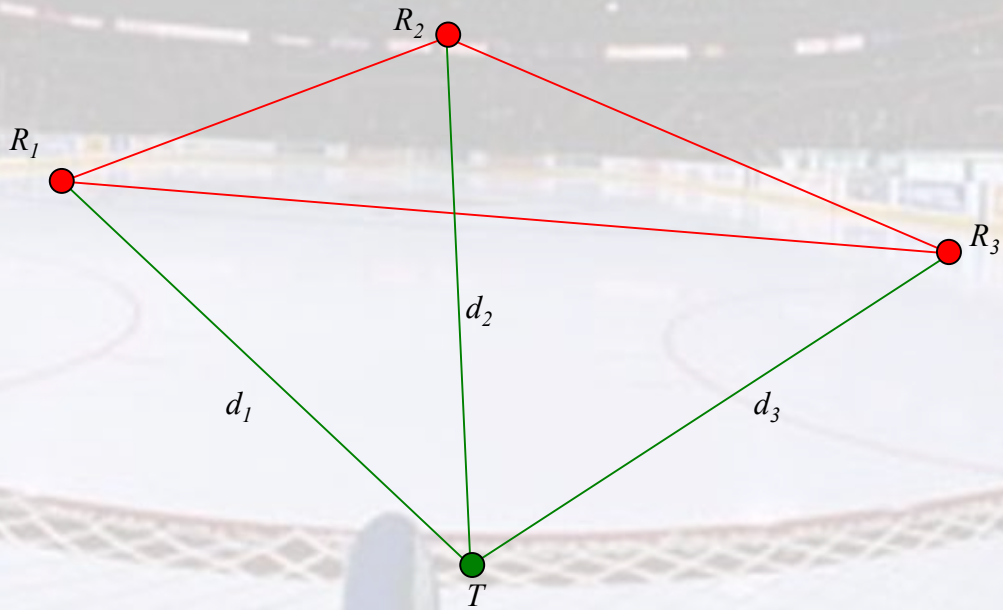
- Multilateration (hyperbolic positioning)
  - A method of locating an object by computing the time difference of arrival (TDOA) of an emitted signal from three or more sensors.
  - Different form triangulation which used the absolute times of arrival.

Calculating Position

- Data is sent relative to the shortest time of arrival
- The shortest time received is sent as a zero
- Why?
  - Slight drift in crystal synchronization
  - Makes for a more robust system
  - Removes any error consistent with all sensors

Calculating Position

- The problem:

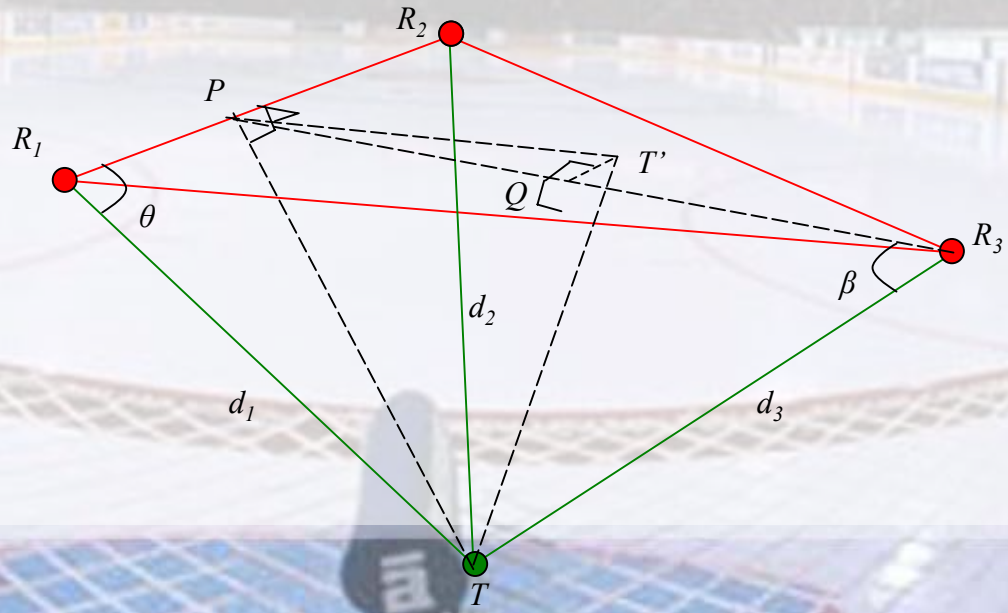


Calculating Position

- Firstly, three sensors are taken into consideration, then
- A value is added to each of the measurements so that there is a solution, and from this
- A solution is calculated.
- This is repeated for another group of three sensors and the results are compared
- The difference is applied to the algorithm to reiteratively improve the result.

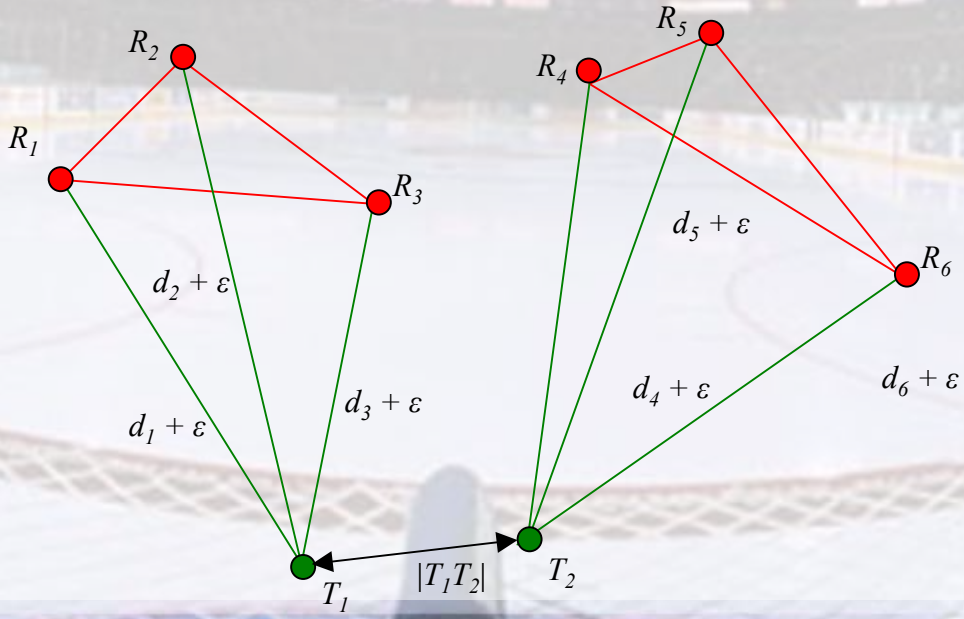
Calculating Position

- To calculate the position of the puck from three sensors, a vector analysis is done on the figure below:



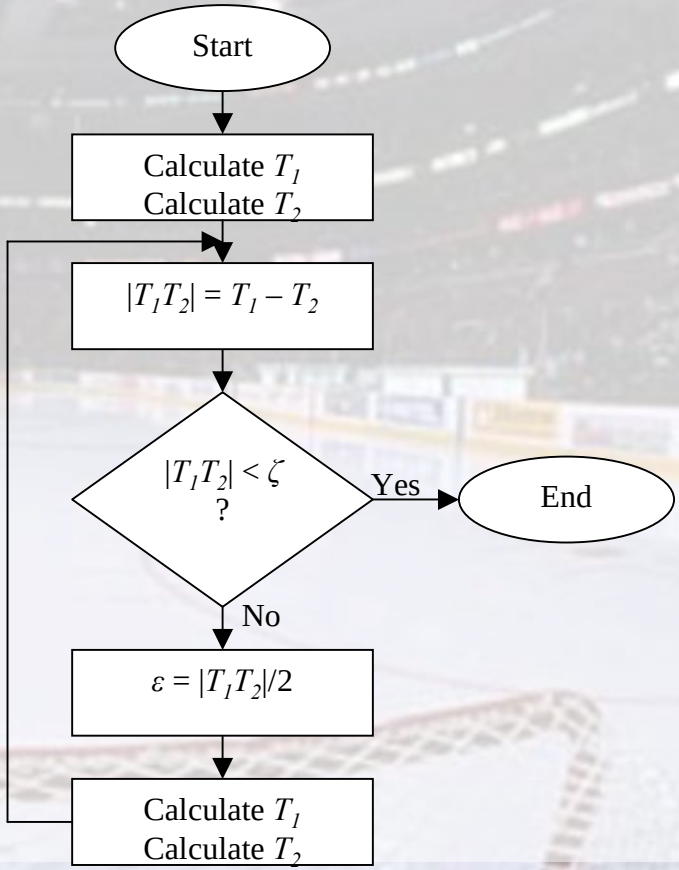
Calculating Position

- To improve the accuracy, the difference of two results is analyzed:



Calculating Position

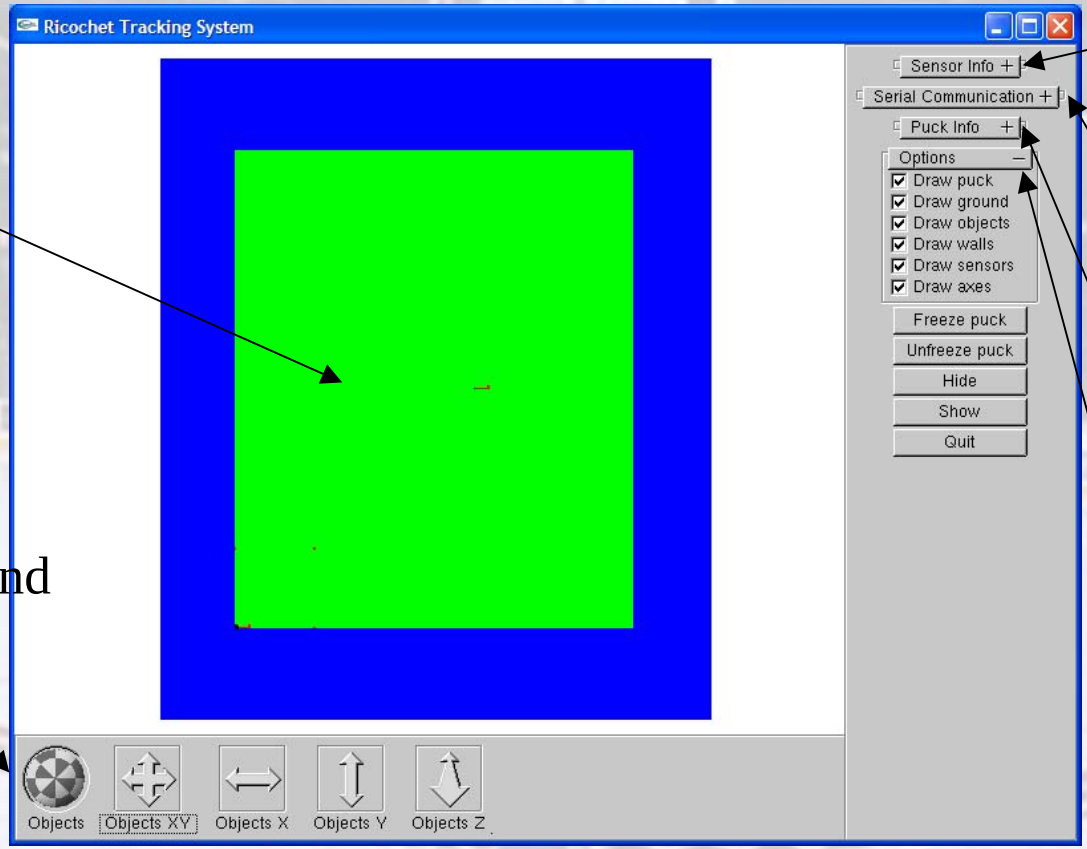
- Algorithm:
- As stated before:
  - Two positions are calculated
  - The error is checked against a threshold
  - The error is then applied to the measurements and the process is repeated



Graphical User Interface

- Done in OpenGL
- Allows user to view the movement of the puck
- The position, velocity and acceleration are readily available
- The camera can be adjusted to any angle, zoom or position

Graphical User Interface



Display

Rotation, panning and zoom

Sensor info

Serial control

Puck info

Various options

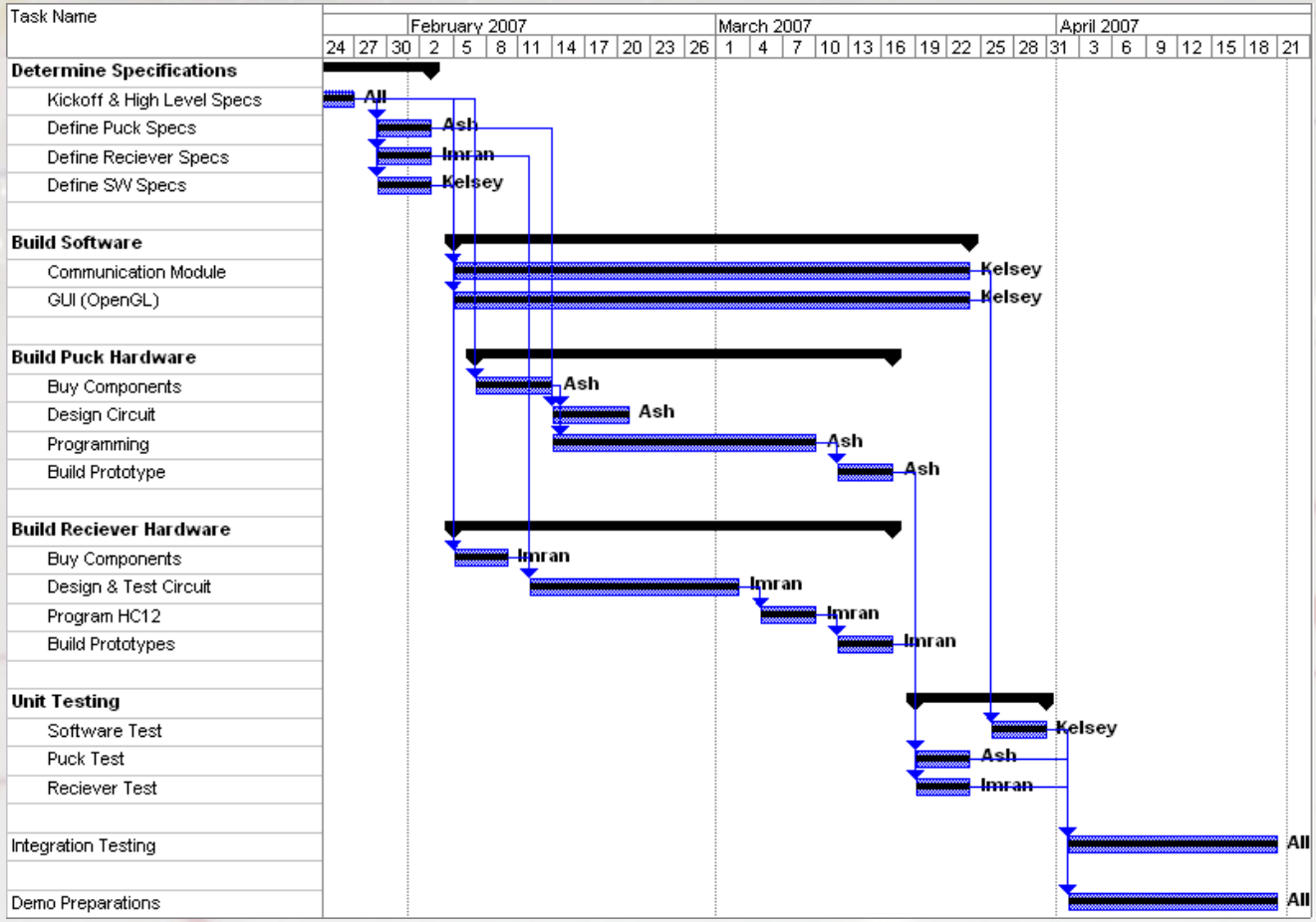
Business Case

- Positional tracking a desired technology
- Other applications:
  - Other sports applications such as football and soccer.
  - Indoor tracking applications.
- Low cost tracking system

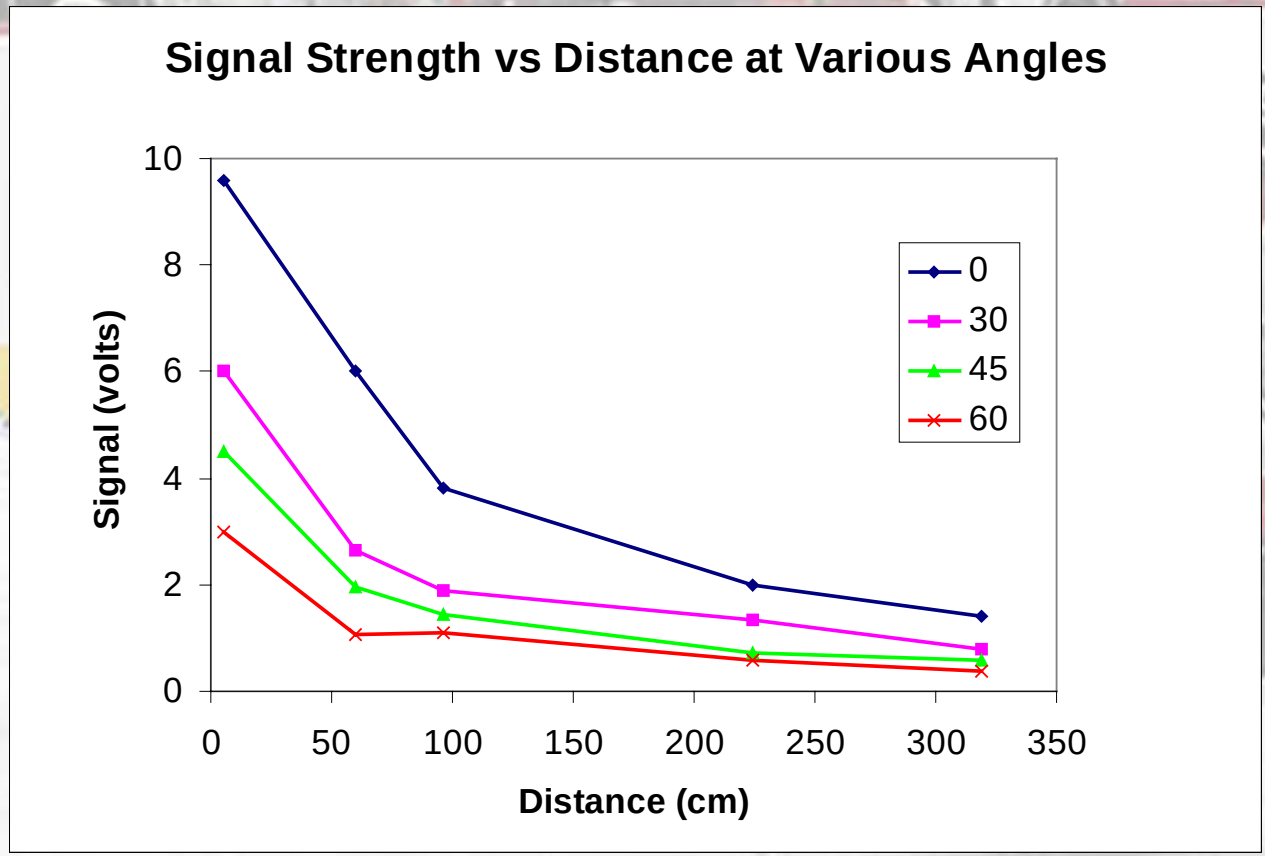
Budget & Expenses

Item	Budget	Actual
Accelerometer	$60	-
Ultrasonic Transmitter & Receiver	$150	$84.30
Circuit components	$50	$33.90
Miscellaneous	$30	$15.25
Total	$290	$133.45

Schedule


Task Name
February 2007
March 2007
April 2007
24 27 30 2 5 8 11 14 17 20 23 26 1 4 7 10 13 16 19 22 25 28 31 3 6 9 12 15 18 21
Determine Specifications
Kickoff & High Level Specs
Define Puck Specs
Define Reciever Specs
Define SW Specs
Build Software
Communication Module
GUI (OpenGL)
Build Puck Hardware
Buy Components
Design Circuit
Programming
Build Prototype
Build Reciever Hardware
Buy Components
Design & Test Circuit
Program HC12
Build Prototypes
Unit Testing
Software Test
Puck Test
Reciever Test
Integration Testing
Demo Preparations
All
Ash
Imran
Kelsey

Experimental Results



Difficulties encountered

- Hardware issues:
  - PIC limitations
  - HC12 limitations
  - Circuit issues
- Software issues:
  - Complex mathematics

Acknowledgements

Our special thanks to:

- Lucky One and Steve Whitmore
- Gary Houghton, Fred Heep and Gary Shum
- Our TAs Vinay, Brad and Amir
- And all the companies that sent us free samples

Conclusion

- If Luongo is in goal, there is no need for Ricochet Tracking System.
- Otherwise, due to frequent goal disputes, NHL requires a tracking system for hockey puck.
- Through this project we have recognized a need for tracking in sports.
- We have demonstrated that such system can be implemented using ultrasound.


Questions?


Demo time!