Pandora Vision

Presents…

Augmented Reality Telepresence System

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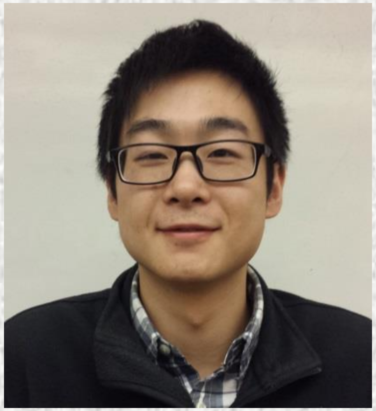

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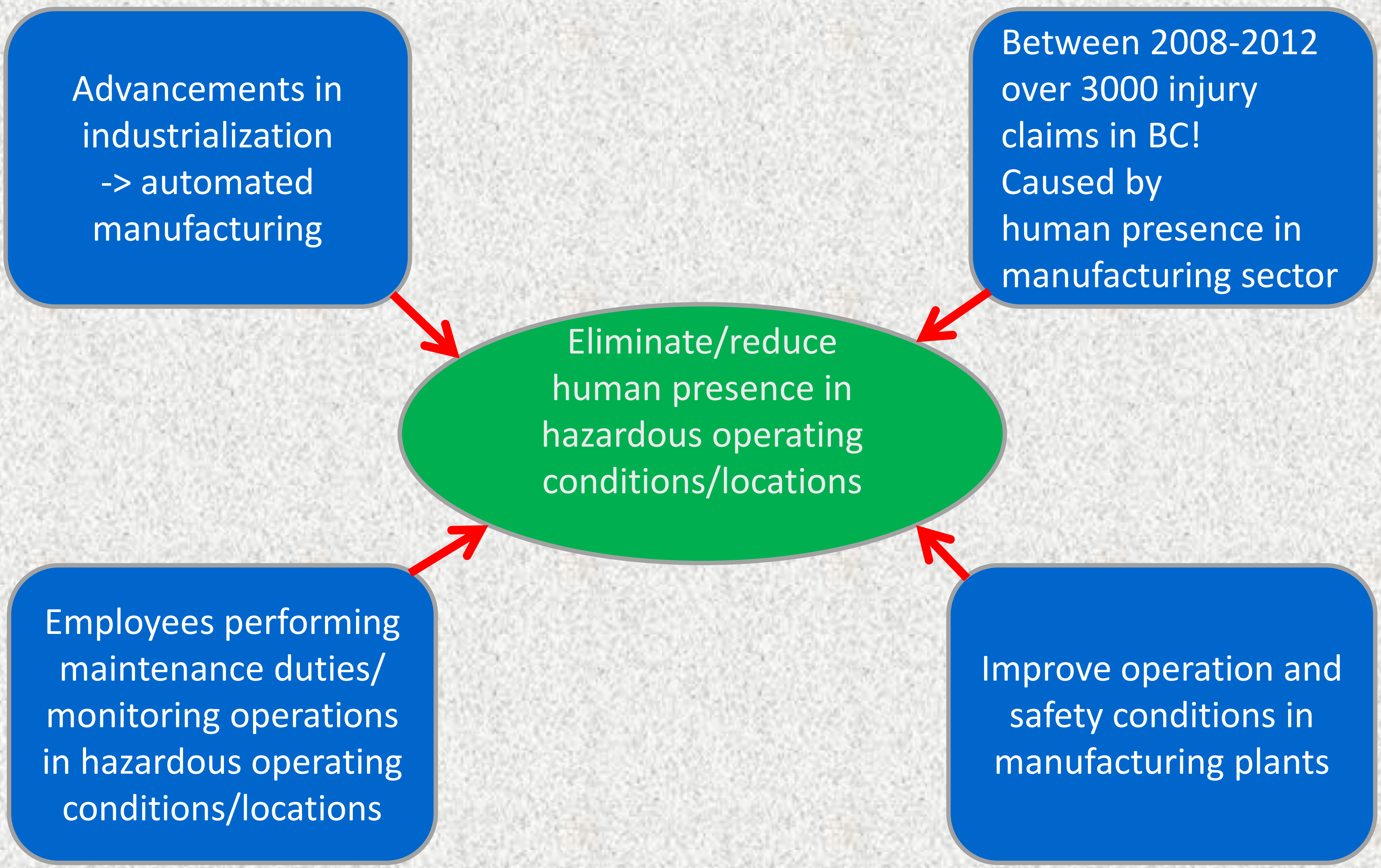
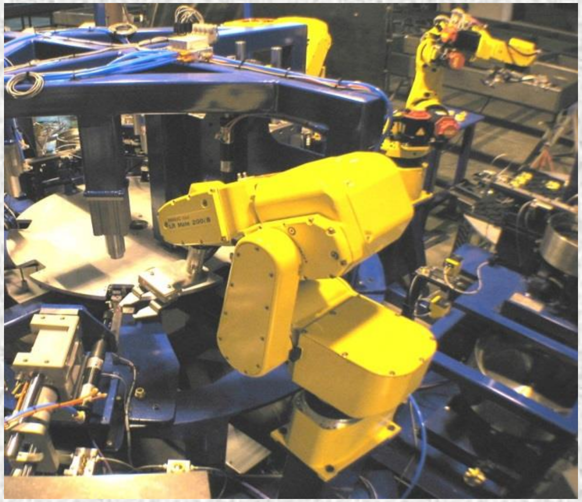
Presentation Outline

- Motivation
- Introduction
- System Overview
  - Head-Controlled Stereoscopic Camera (HCSC) Sub-System
  - The Control System
  - Head-Mounted Display
  - Integration/Interconnection
- Design Challenges/Modifications
- Project Timeline
- Finances
- Future of the ART System
- Conclusion

Motivation- Social Benefit



Motivation – Social Benefit



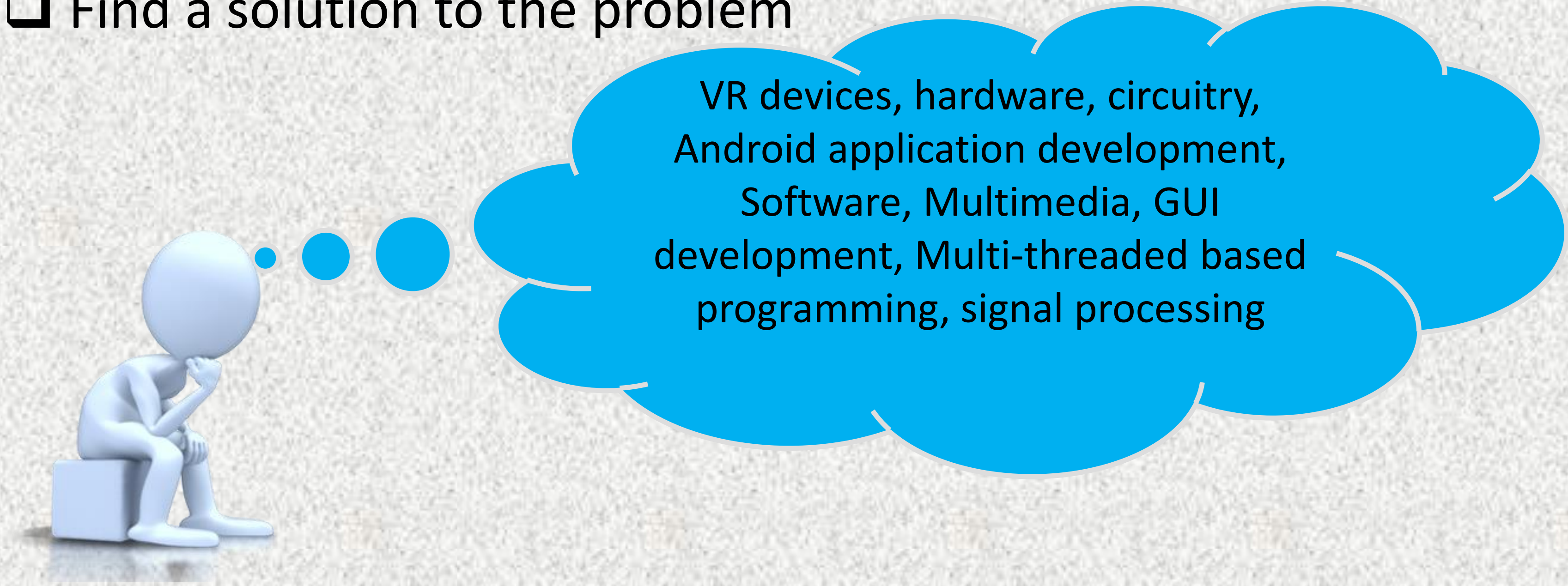
Motivation – Market

- Viable solution: Virtual Reality (VR) to create a sense of physical presence
  - Recent increase in research and investment in VR
    - Oculus Rift purchased for $2 billion dollars by Facebook in 2014
- Samsung Project Beyond, Google Cardboard, GoPro 3-D Hero System
- Potential in the market for a surveillance system which uses VR as an enhancement

Motivation – Market

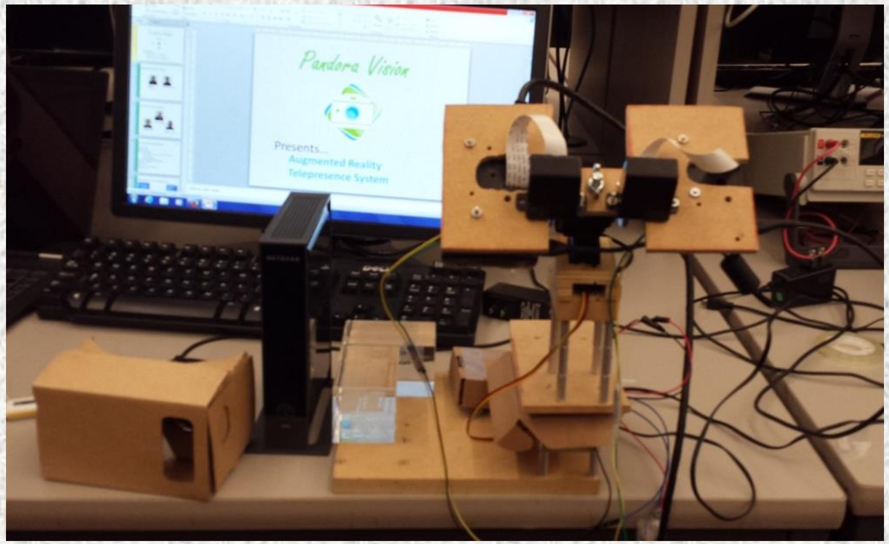
Motivation – Curiosity

- ENSC440/305 Project- a perfect opportunity to explore
  - Given the technology available to us(cost permitting), our knowledge and technical skills, what can we “engineer”?
- Find a solution to the problem



Introduction – Proposed Solution

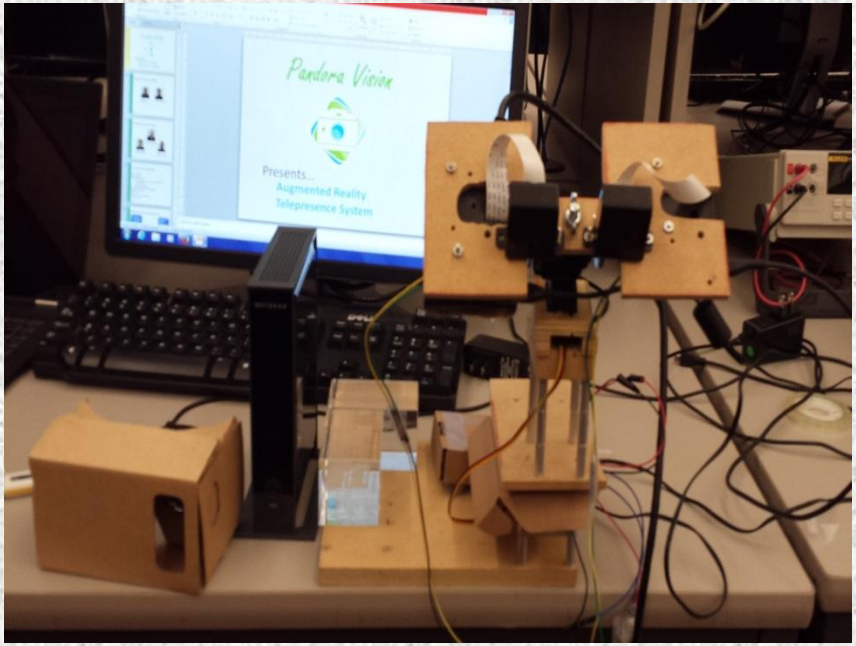
- **Augmented Reality Telepresence System**



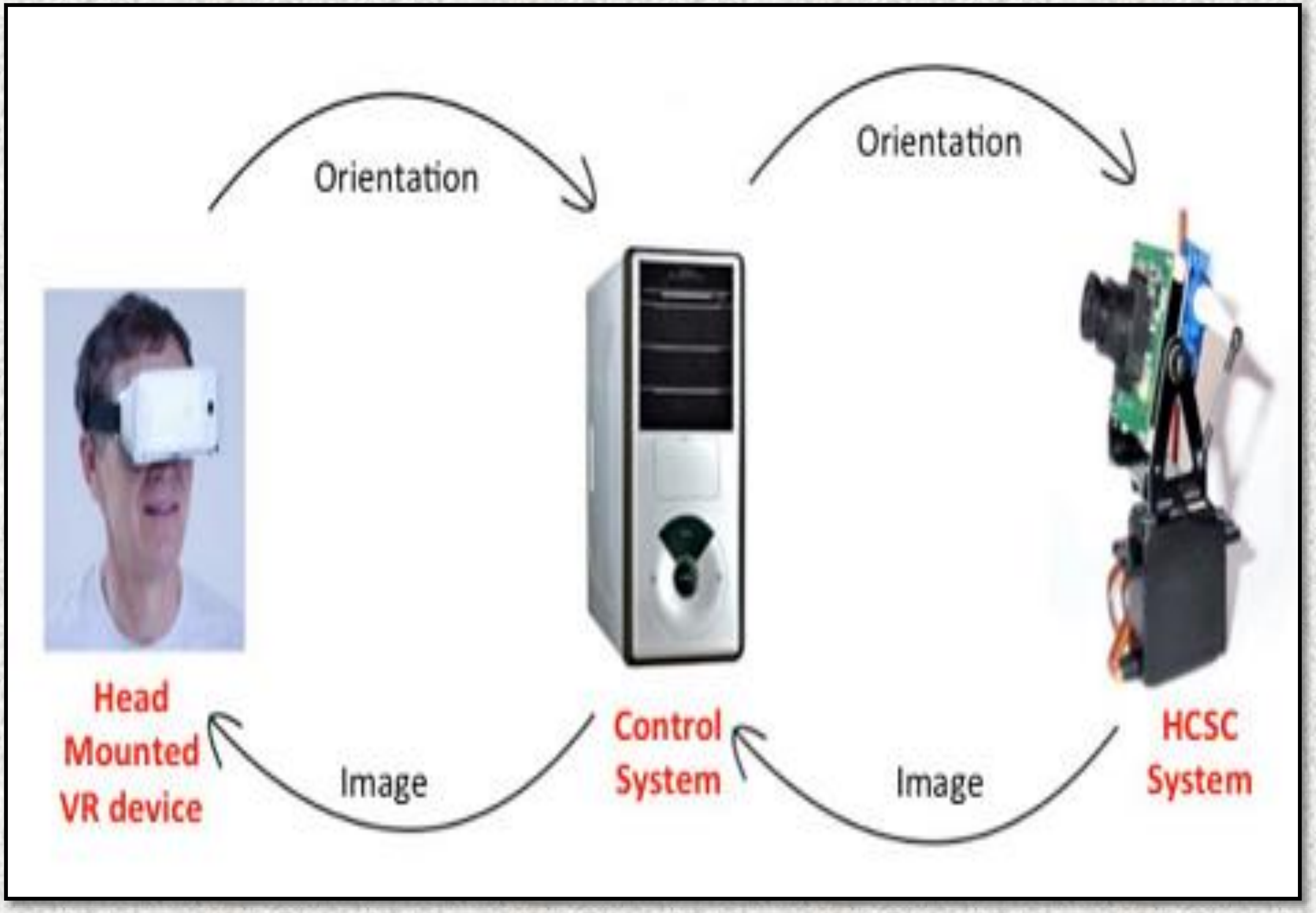
- Purpose
  - Camera system in a remote location providing real-time video feedback
  - Use VR as a tool to transform received video feedback into a stereoscopic video = create sense of physical presence
  - Maneuver the camera system to change the field of view

Introduction

- System characteristics:
  - Camera system with approximately 180 degrees range of motion in yaw and pitch axes in a remote location
  - Real-time stereoscopic video feed received by the user
  - Head-mounted display (VR device) to maneuver camera system's field of view and receive real-time stereoscopic video feedback
  - Android application to communicate with the camera system
  - Simple GUI for user interaction with the system



The ART System Block Diagram



System Overview

❑ System breakdown

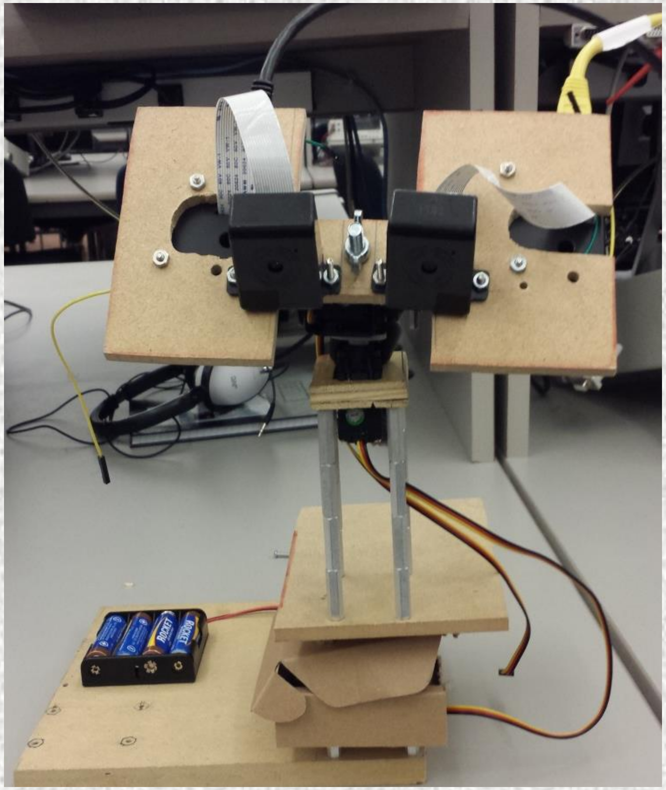
- Two sub-systems:
  - Head-Controlled Stereoscopic Camera (HCSC)
  - Control System
- Head-mounted display (VR device)
- GUI
- Android App

❑ Main functions

- User receives real-time stereoscopic video feedback of the remote location
- Communication between two sub-systems
- HCSC mimics user’s head movement
- Maneuvering of the HCSC by the head-mounted display
- A functional GUI that enables user interaction with the system

Head Controlled Stereoscopic Camera (HCSC) Sub-System

- Purpose:
  - Receive head-orientation data from control system and change field of view of the cameras accordingly
  - Capture and send video from the cameras to the control system
- System components:
  - Two Raspberry Pis (Rpi)
  - Two camera board modules
  - Two servo motors
  - Pan tilt mount
  - Power supply



Head Controlled Stereoscopic Camera (HCSC) Sub-System

- Why RPi?
  - H.264 hardware encoder
  - Small/lightweight
  - Cheap (approx. $50)
  - General Purpose Input/Output(GPIO) pins
    - Head-orientation data
    - Pulse Width Modulator(PWM)
    - Control servo motors
  - Camera Serial Interface (CSI) connector port
    - Ideal for streaming video
    - Camera board modules

Head Controlled Stereoscopic Camera (HCSC) Sub-System

- Why RPi camera board modules?
  - Small/lightweight
  - Cheap (approx. $30)
  - CSI cable (very high transfer rate)
  - Video format: raw H.264 (accelerated)
  - Designed for interaction with RPi
  - Ideal resolution and data transfer rate specifications

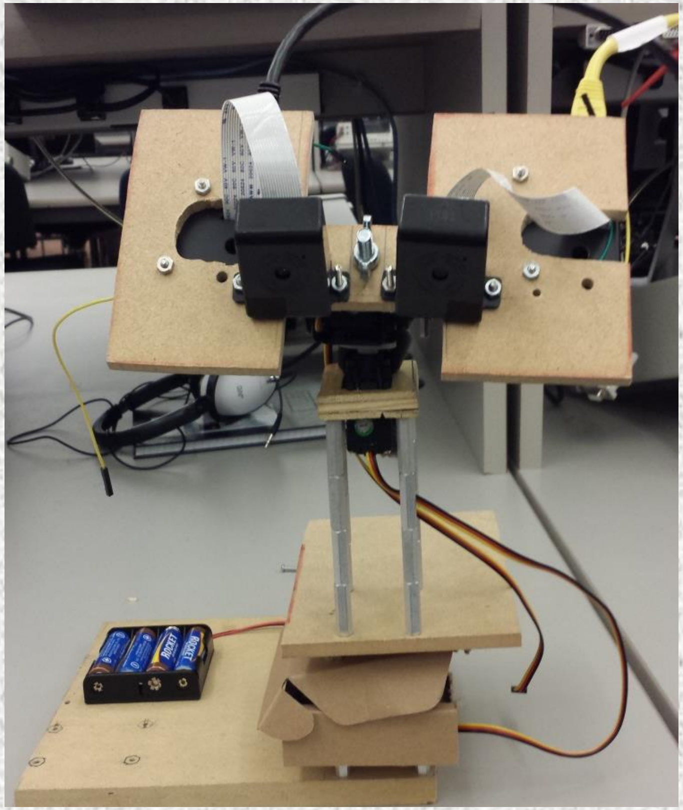
Field of View (inches)	Still Image Capture Resolution	Video Capture Resolution		
		@90 fps	@60 fps	@30 fps
194 (wide) 195(distance)	5 MP (2592x1944)	640x480p	720p, 640x480p	1080 HD, 1080p

Head Controlled Stereoscopic Camera (HCSC) Sub-System

- Why Lynxmotion servo motors?
  - 180 degree rotation along yaw and pitch axes
  - Small/lightweight
  - Capable of lifting up to 3.3 Kg
  - Standard mounting apparatus
  - PWM- easy control

Head Controlled Stereoscopic Camera (HCSC) Sub-System

- Mechanical Design
  - Weight per servo <3.3Kg
  - RPi and camera boards secured in casing
  - Minimizes strain on CSI ribbon cable
  - Clearance during Yaw and Pitch movements

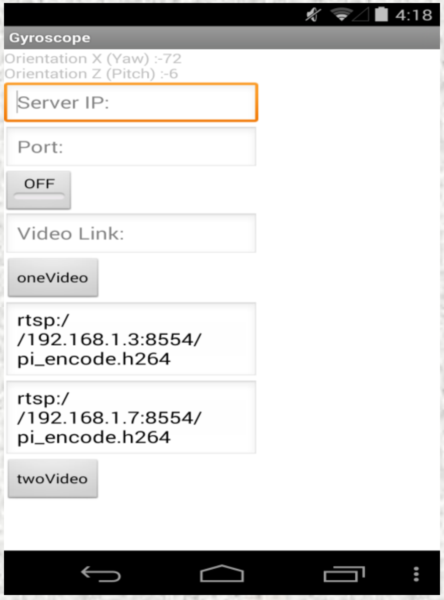


The Control Sub-System

- Purpose:
  - Measure and send user's head-orientation data to the HCSC system
  - Receive real-time video feedback from the HCSC
- System components:
  - Android phone
  - PC
  - Google Cardboard/Oculus Rift

The Control Sub-System

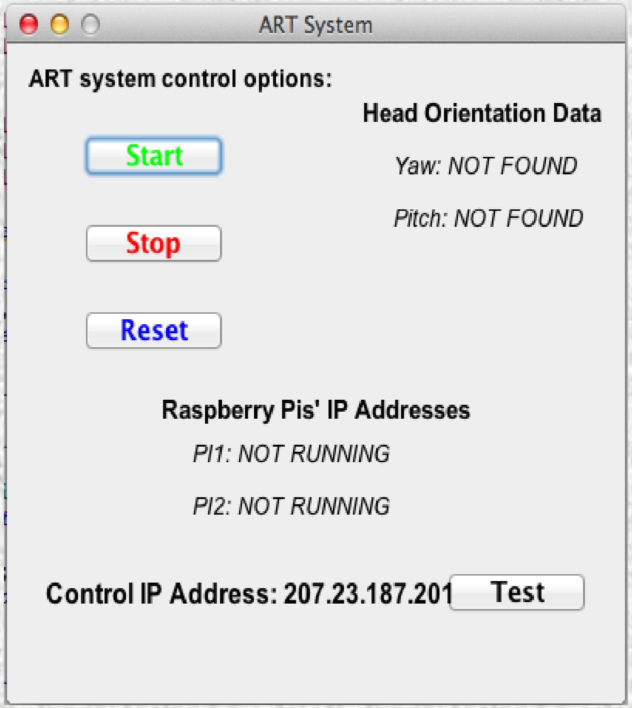
- Android App
  - Purpose:
    - measure head-orientation and send to control PC
    - Receive video feedback display
- Real Time Streaming Protocol (RTSP), Google API for RTSP
- User enters IP address of control PC and port #



The Control Sub-System

❑User Interface Functionality

- Display IP address of control PC
- Display IP addresses of the RPis in HCSC and connects to them automatically
- Initializes the ART system: transfer of head orientation from Android app to RPis



Head-Mounted Display

❑Purpose:

- VR- Create sense of physical presence
- Measure and track head-orientation data

Integration/Interconnection

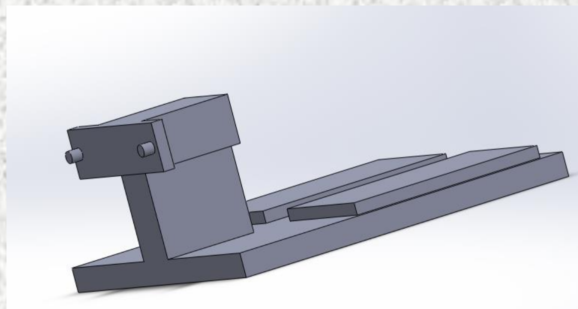
- Communication between HCSC and Control System
- Stereoscopic video feed- how we achieve this
- Powering the systems
- Compatibility

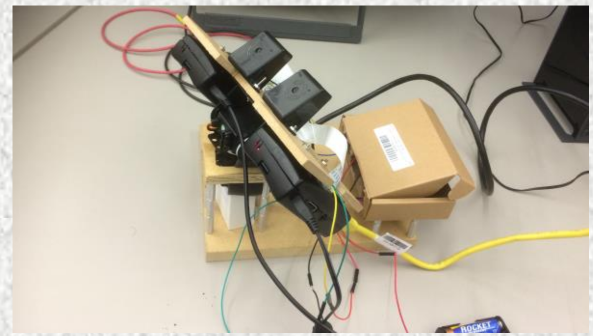
Design Challenges/Modifications

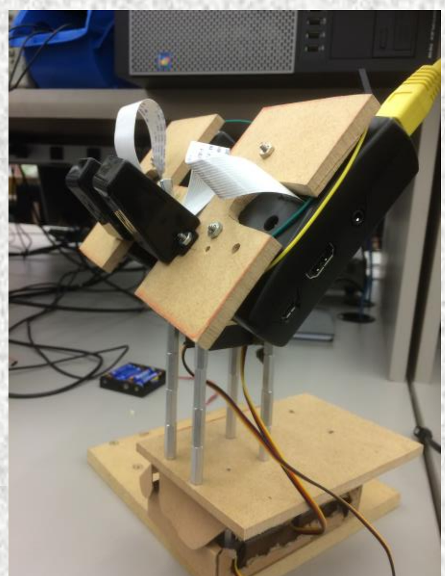
- Original design vs current design
- Servo motors:
  - jitter caused by gyro drift and noise of output signals of accelerometer/magnetometer
  - https://www.youtube.com/watch?v=Pwirwv5bagc&index=4&list=PLMzS6u2NrDl_UCI-Q849feATfaBKyh2hs
  - Solution: Sensor Fusion Algorithm via Complimentary Filter
- Video streaming:
  - Incompatibility between Gstreamer and Android application
  - https://www.youtube.com/watch?v=9XF7iQT6dFI&index=1&list=PLMzS6u2NrDl_UCI-Q849feATfaBKyh2hs

Design Challenges/Modifications

- ❑ Mechanical Design of HCSC



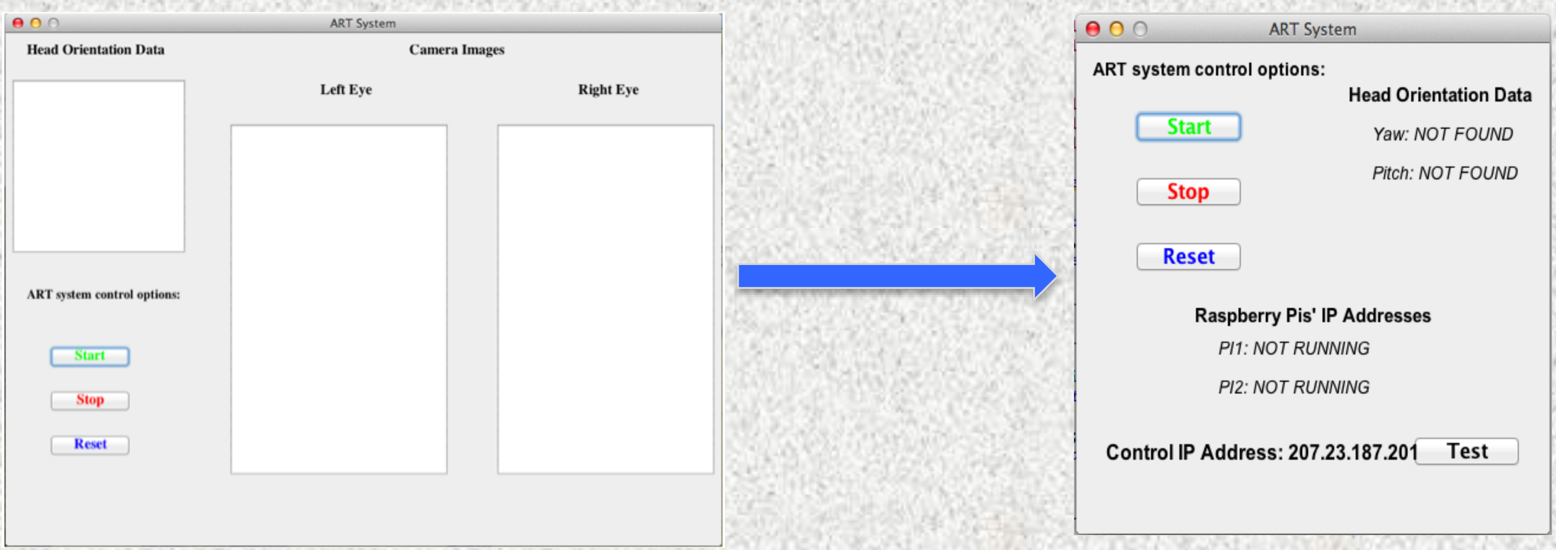




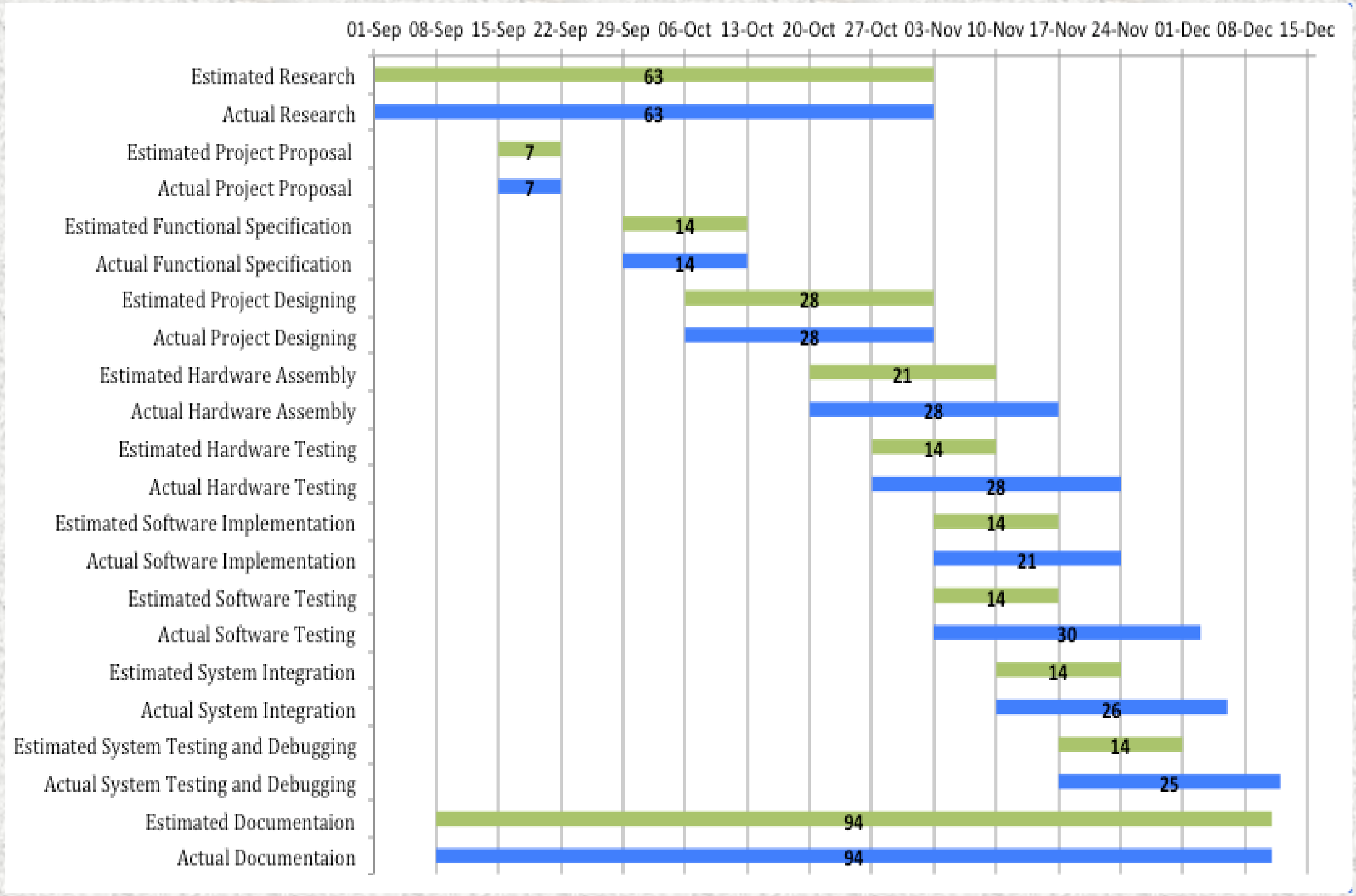
Design Challenges/Modifications

❑GUI

- Stereoscopic video from RPi are transferred directly to Android app to reduce latency
- Video no longer displayed on GUI
- Control PC IP address added for user convenience



Project Timeline



Project Timeline

- Causes of delay in meeting soft deadlines:
  - Android Application:
    - Incompatibility between multimedia frameworks and our application
  - Mechanical design:
    - unexpected malfunctions, jitter in controlling servo motors, lack of experience
  - Video Streaming:
    - Incompatibility between multimedia frameworks Achieving lower latency in video streaming from 7s (unacceptable) to 500ms (desirable)

Finances

Table: Estimated cost breakdown of materials

Category of Equipment	Part	Quantity	Estimated Unit Cost ($)
Microcontroller	Raspberry Pi	1	50.00
Memory	16 GB SD Card	1	10.00
Cable	USB Cable	1	10.00
Camera	Webcam (720p resolution)	2	100.00
Miscellaneous	Pan tilt mount (Lynxmotion)	1	35.00
Devices	Servomotor (HS-422)	4	50.00
Camera	Camera multi-mount	1	70.00
VR Device	Google Card board	1	35.00
Camera	Camera mount tripod	1	30.00
Miscellaneous	Shipping & handling fees	N/A	200.00
	Total cost	**N/A**	**590.00**
	Total cost (incl. 20% contingency)	**N/A**	**708.00**

Finances

❑Budget Analysis

- Funding: **$500** from Engineering Science Student Endowment Fund (ESSEF)

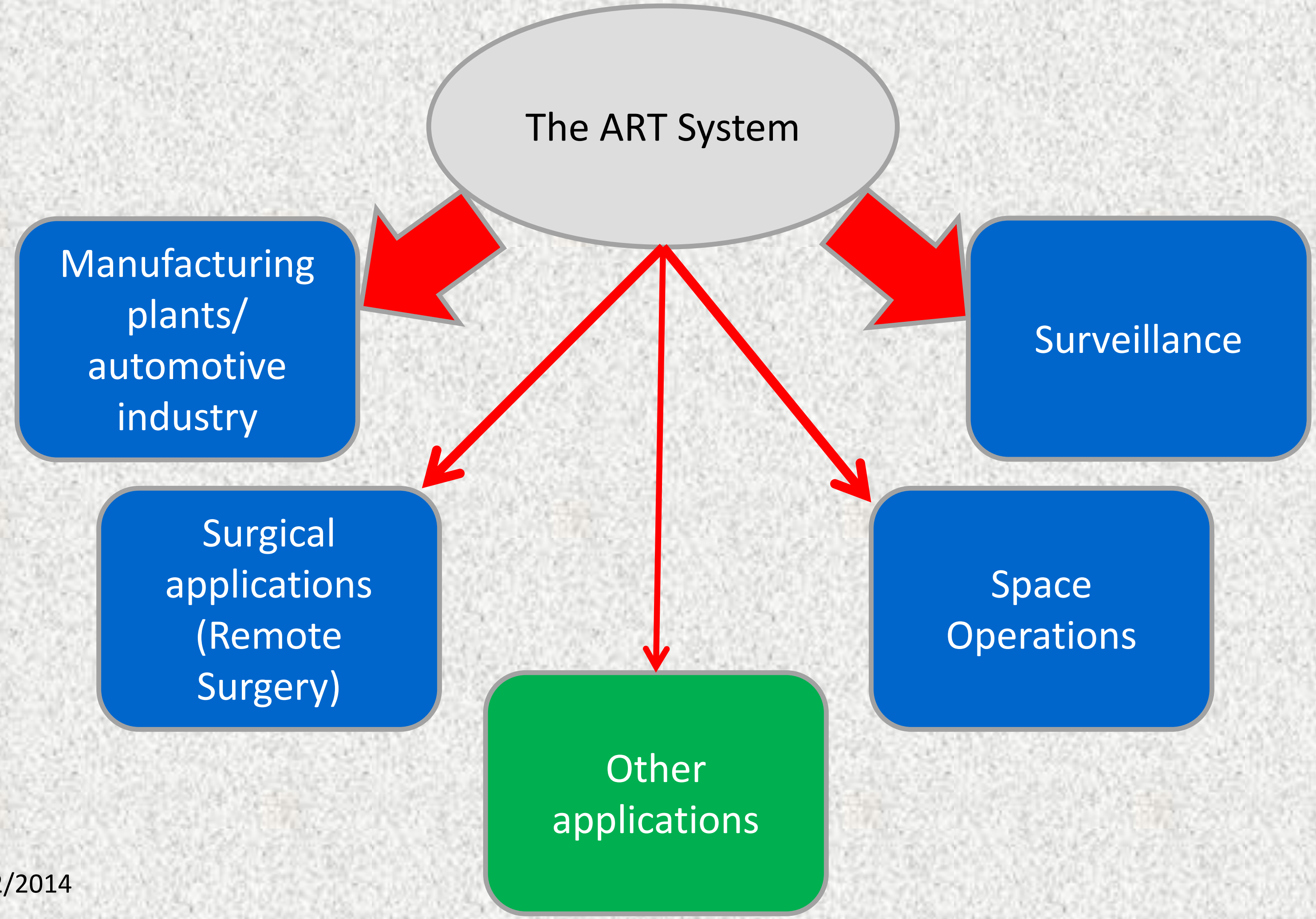
Table: Final cost breakdown of materials upon completion of project

Item Purchased	Date Purchased (DD/MM/2014)	Amount (CAD)	Reason for Purchase
Markers for whiteboard	5/24/2014	$4.00	Meetings
Raspberry Pi B+ Mode Ultimate Camera kit	6/10/2014	$95.95	Project parts
2 Camera Board Modules for Raspberry Pi	6/10/2014	$69.98	Project parts
Lynxmotion Pan and Tilt kit	6/10/2014	$50.39	Project parts
Raspberry Pi B+ Model kit	18/11/2014	$100.74	Project parts
Netgear WNR3500L Router	17/11/2014	$45.24	Project parts
Ethernet cables	17/11/2014	$8.94	Project parts
Casing for circuitry, battery pack, screws, etc	2/12/2014	$99.10	Project parts
Presentation complimentaries	12/12/2014	$25.50	Project parts
	Total=	$499.84	

Future of the ART System

- Future development/improvement
  - Low latency to real-time
  - Increase distance between the remote location and the user
  - Added features and easy to troubleshoot
  - Design a circuit to power the entire HCSC
- Reliability/Durability requirements
  - Long-term functionality of components
  - Stable and continuous functionality over a long period of time(>24 hours)
- Safety Requirements
  - Circuitry, devices, powering systems safe under abnormal conditions (temperature, humidity,)
  - Meet the most applicable standards relevant to the scope of the system
- Marketability and market potential
  - Currently no product in market targeted specifically for manufacturing plants and similar industries

Future of the ART System



Future of the ART System – Business Case

- ❑Total Cost : $621.39
- ❑Market Price : $1000
- ❑Profit : $378.61 per prototype
- ❑30% ROI

Project Part	Cost ($)
2 Raspberry Pis	110.00
2 Cameras	76.00
Lynxmotion Pan and Tilt Kit	50.39
Google Card board	35.00
Accessories	50.00
Employee Royalty	300.00
Total cost	**621.39**

Conclusion

- Prototype model of the ART system complete
  - Enhanced development if given more time and money
- Learning outcomes:
  - Android application development
  - Video streaming using various methods over WIFI
  - Mechanical design, machine tools, assembling parts
  - User Interface design
  - Virtual Reality devices
  - Compatibility between software platforms
  - Setting up development environments
  - Group dynamics, effective communication
  - Technical documentation
  - Meeting soft/hard deadlines
  - Experience of the process and each phase of building a prototype
- Proud of our accomplishment and this eventually “enjoyable” experience

Acknowledgements

- Dr. Andrew Rawicz and Mr. Steve Whitmore
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- ESSEF Endowment
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- Gary Houghton
- Gary Schum

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Questions

Auxiliary Slides:
Sensor Fusion Algorithm

- Background
  - To get the 3 orientation angles of an Android device, use *SensorManager.get()* method
  - Two of the angles: accelerometer (gravity vector) and magnetometer (magnetic field sensor) outputs. Both outputs inaccurate and lots of noise
  - Gyroscope provides angular rotation speeds for all 3 axes. More accurate and shorter response time
    - Speed values integrated over time (multiply angular speeds by time interval between last and current sensor output, yields rotational increment). Sum yields absolute device orientation
  - Problem: Gryo drift
    - Small errors produced during each iteration. Result in constant slow rotation of calculated orientation

Auxiliary Slides: Sensor Fusion Algorithm

- Solution to orientation output noise from accelerometer/magnetometer and gyro drift:
  - Sensor Fusion Algorithm via Complimentary Filter
- Sensor Fusion Algorithm:
  - Gyroscope output applied only for orientation changes in short time intervals
  - Magnetometer/accelerometer output data used as support information for long periods of time

Auxiliary Slides: Sensor Fusion Algorithm

- Result:
  - low-pass filtering of accelerometer/magnetic field sensor output data
  - high-pass filtering of gyroscope signals

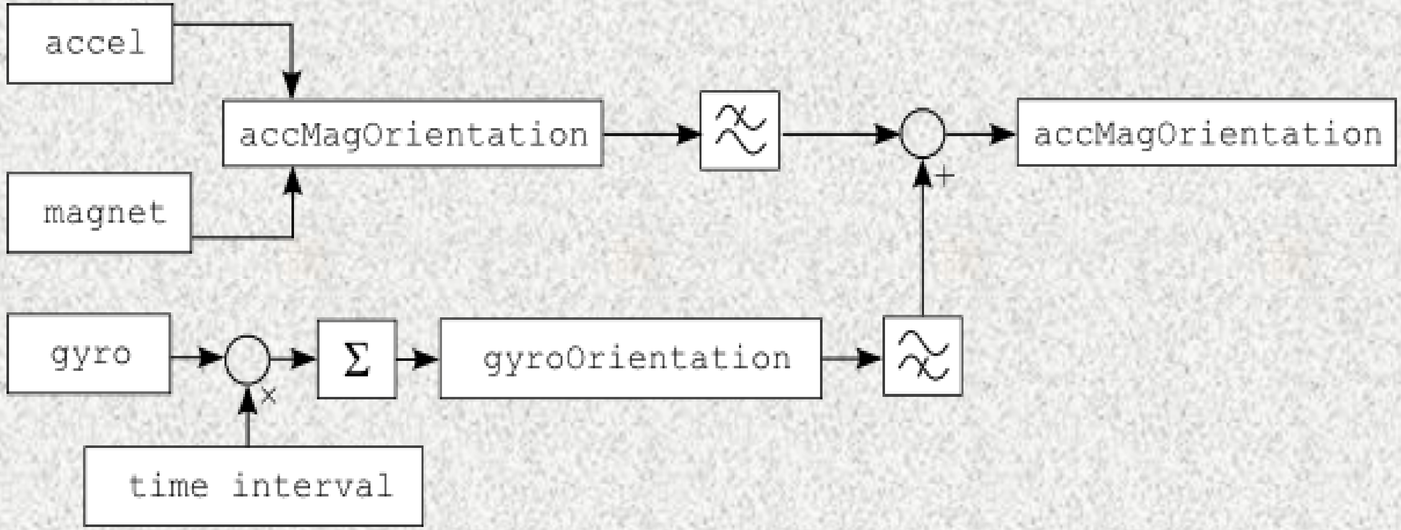

Figure 1: Sensor Fusion algorithm block diagram

Auxiliary Slides: Sensor Fusion Algorithm

- Gyro drift in the integrated gyroscope signal
  - Cause of undesirable slow rotation in gyroscope orientation

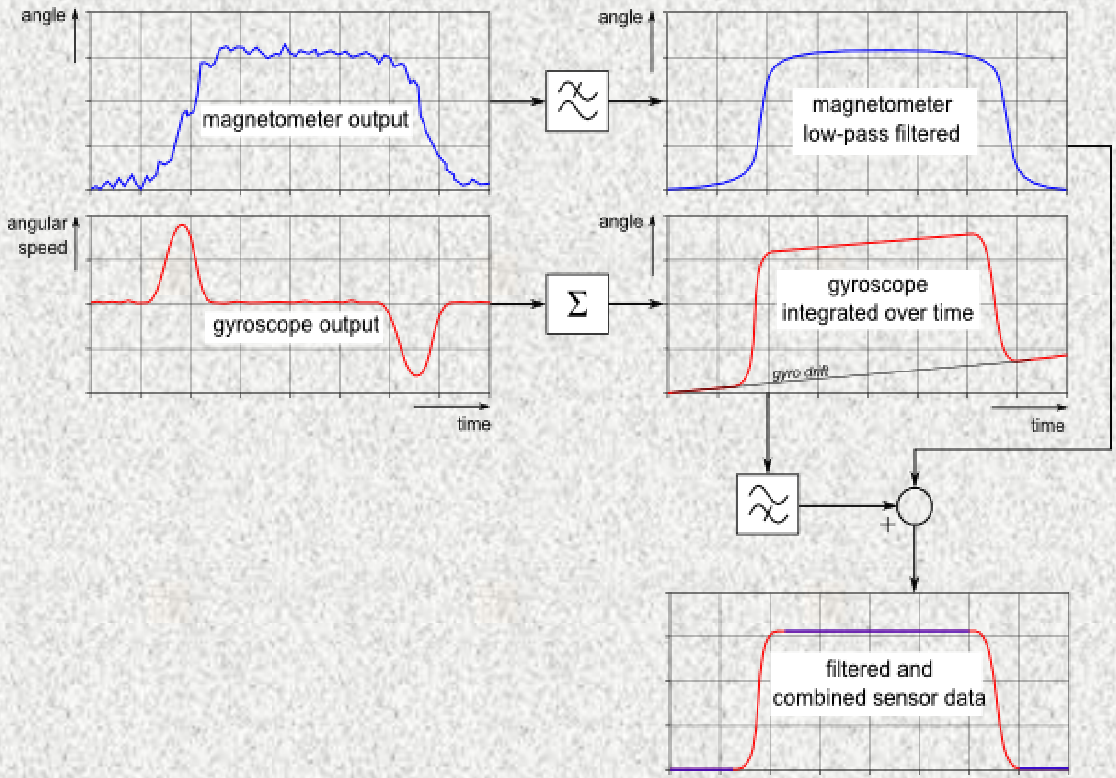

Figure 2: Intermediate signals in the filtering process

Back