TRIPOD: Computer Vision for Classroom Instruction and Robot Construction

Paul Y. Oh

Drexel University – Mechanical Engineering

Program for Robotics, Intelligent Sensing and Mechatronics

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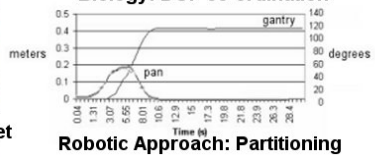
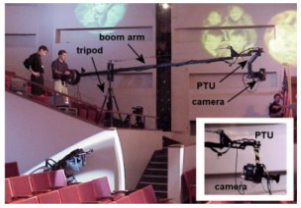
Motivation: Research in Seeing Robots and Mechanisms

Challenging: Tracking moving target

Biology: DOF co-ordination



Robotic Approach: Partitioning



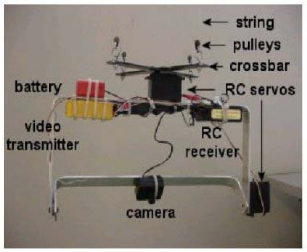
Human augmentation

Mobile Platforms: aircraft, rovers, UAVs

Visually Servoed Tracking IROS 2002

Design Space:

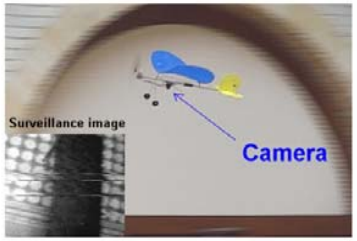
- ✓ Affordable ($500/unit range)
- ✓ Easy to Fly (2 hours or less)
- ✓ Transportable (backpack)
- ✓ Various weather (10 MPH)
- ✓ Stealth



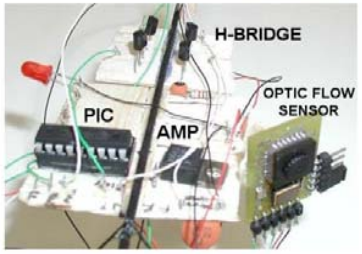
Design Problem:

- Controllable camera pose
- Lighting
- Wireless and Network Communications

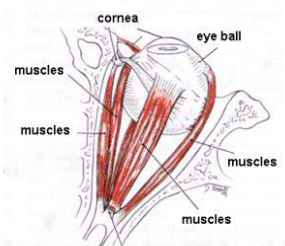
LEAP: Low Elevation Aerial Photography ICRA 2003



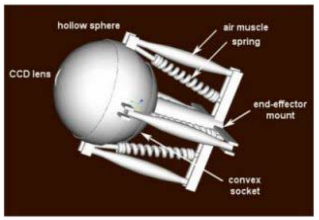
- Support Personnel
- Flying vs. crawling
- Swarms



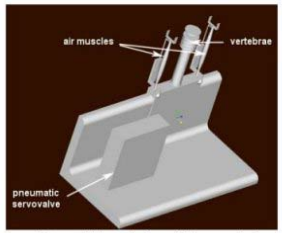
CQAR: Closed Quarter Aerial Robots IROS 2003



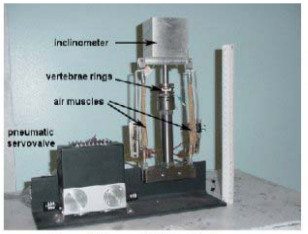
Balance Disorders / Motion Sickness



ProE Ocular Model



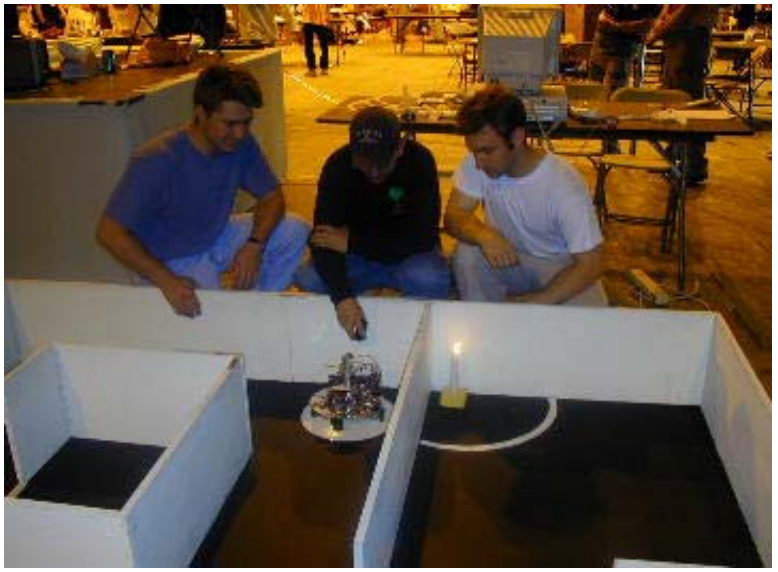
ProE Head (neck) model

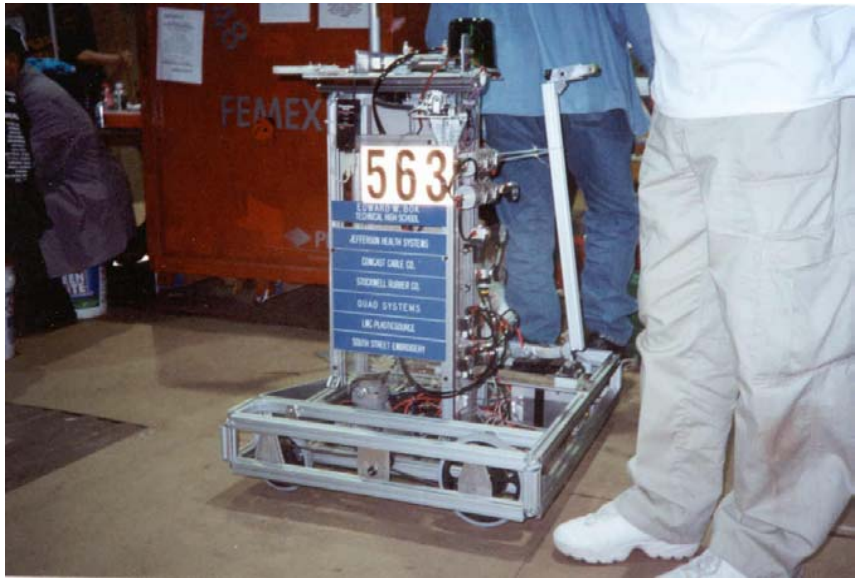


Head (neck) Prototype

Visually Servoed Bipeds

Motivation: Undergraduate Robotics and Outreach





US FIRST – High Schools and ASME

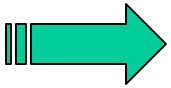
Future Drexel Teams?

Computer Vision for the Classroom?

Vision Package	Platform	Hardware	Pros	Cons
X-Vision, X-Vision 2	**Unix**	Various	Open, Libraries	Setup difficult
Intel Open CV	**Windows**	VFW	Open, e-Community	Setup difficult
Matrox MIL	**Windows**	Proprietary	Documentation	Expensive
Coreco Sherlock	**Windows**	Proprietary	Turnkey	Proprietary
Matlab I/P Toolbox	**Unix, Windows**	VFW	Robust	No video
Matlab I/A Toolbox	**Windows**	VFW	Robust	Must learn Matlab

Common Denominators:

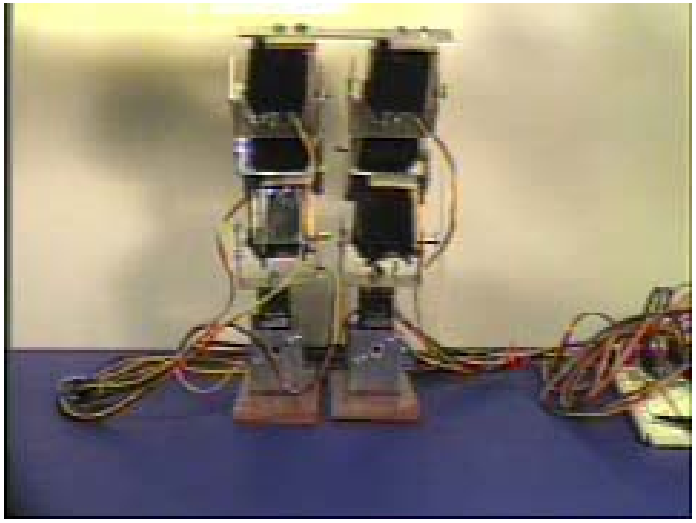
- ANSI C/C++
- Access to Windows PC
- No DirectX, ActiveX, MFC
- Cost constraints
- Microsoft always changing!

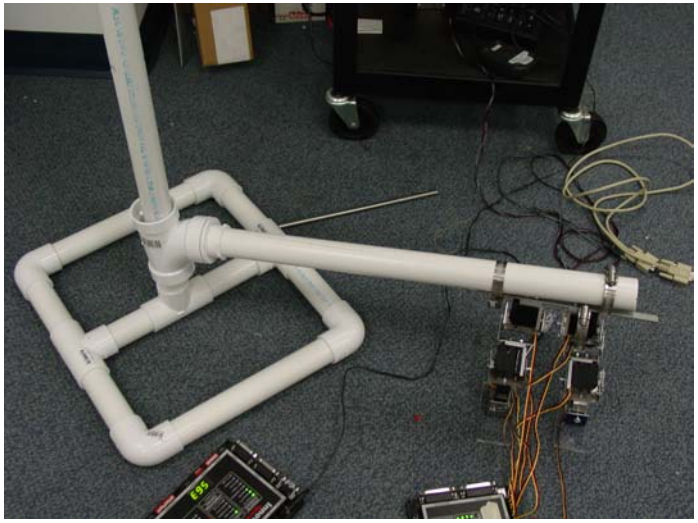


Design Parameters

- Teach Computer Vision!
- Affordable
- Robust
- Customizable

Computer Vision for Robot Construction?



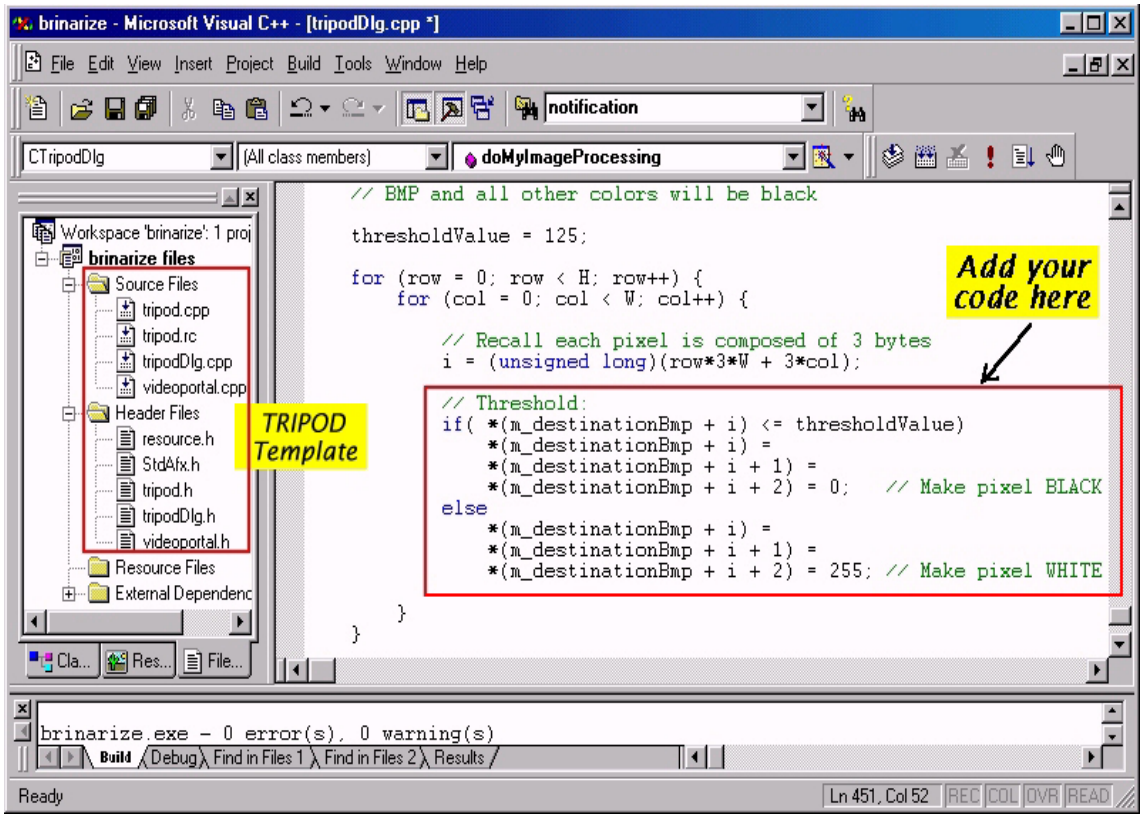


Video vs. Images

- Mechanism Dynamics
- Bandwidth
- Control Laws
- Robustness
- System Integration

Need: Classroom training with realistic tools to build realistic systems

TRIPOD: Template for Real-time Image PrOcessing Development



- Teach Computer Vision! ✓
  - ANSI C/C++
  - Avoids compiler specifics
  - Pointer to pixel data
  - Frame rate and Video
- Customizable ✓
  - Open-source
  - No royalties

Input – Output Window

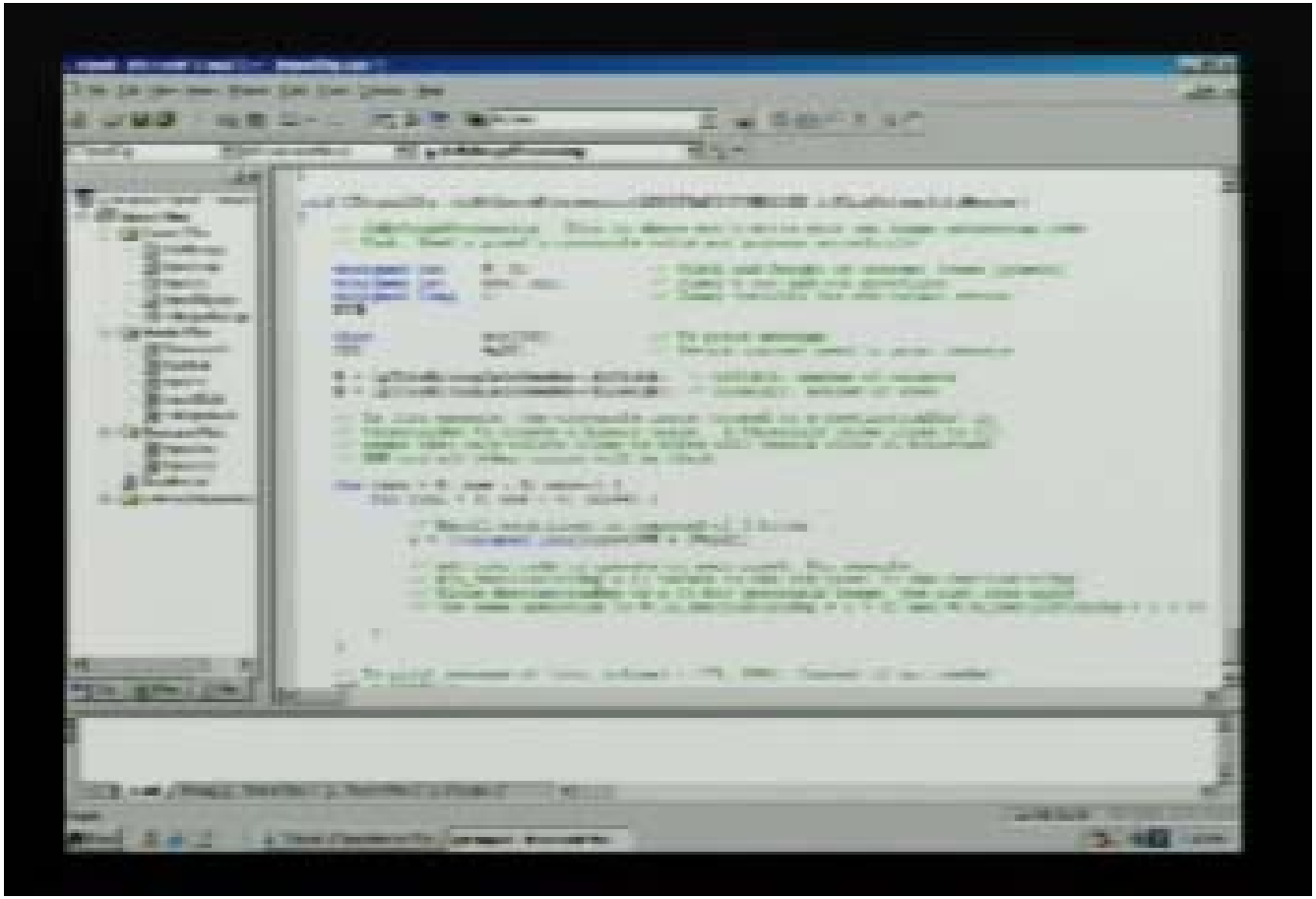
Affordable ✓

- TRIPOD and QCSDK are free
- $50 USB camera

- Robust ✓
  - Logitech SDK
  - Windows Compatibility

On-line Tutorial: http://www.boondog.com/

Philosophy: Learn Computer Vision - Not Compiler



Steps

1. Open Visual C++
2. Copy TRIPOD template
3. ANSI C/C++ on pixel data
4. Compile
5. Execute and see results

Hardware Specs Used:

Pentium 3 – 500 MHz – 256 MB RAM – LEGO Camera

Classroom Implementation: Envisioned Syllabus

Description: Computer vision fundamentals namely segmentation, pattern recognition, edge detection and tracking for robotic systems

Pre-requisites: Intro to C Programming, Linear Algebra

Objectives: Provide students the fundamentals of computer vision. Emphasis is on understanding the physical principles governing image processing and applying them to solve engineering problems

Text: Myler, H,. *The Pocket Handbook of Image Processing Algorithms in C* (ISBN: 0-13-642240-3)

Schedule:
(3 Hrs/Week)

Lecture	Topic
1	BMP Files, raster data, row-column vectors, pointers
2	Memory handling: negatives, thresholds, binary, brightness
3	Centroids, areas, clustering
4	TRIPOD exercises: threshold, binary, centroids
5	Color recognition and tracking
6	Kernels and edge detection
7	Pattern recognition: SSD Tracking
8	Image-based Visual-Servoing
9	Visual-Servoing Project
10	Project Presentation

Test Case: Independent Study

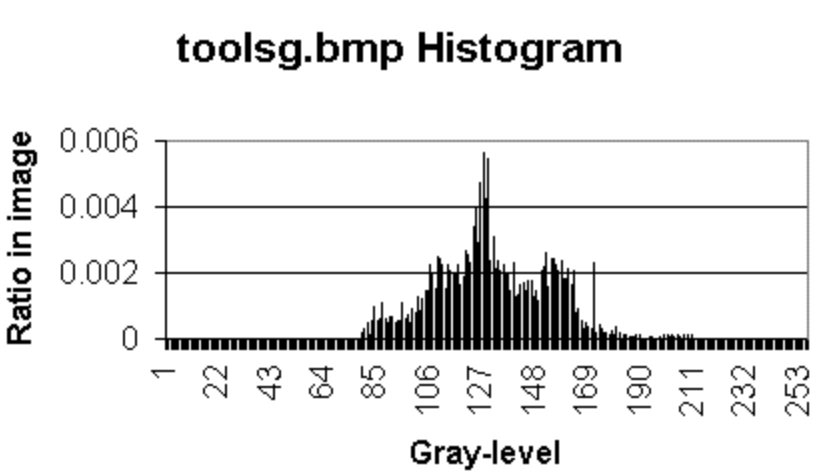
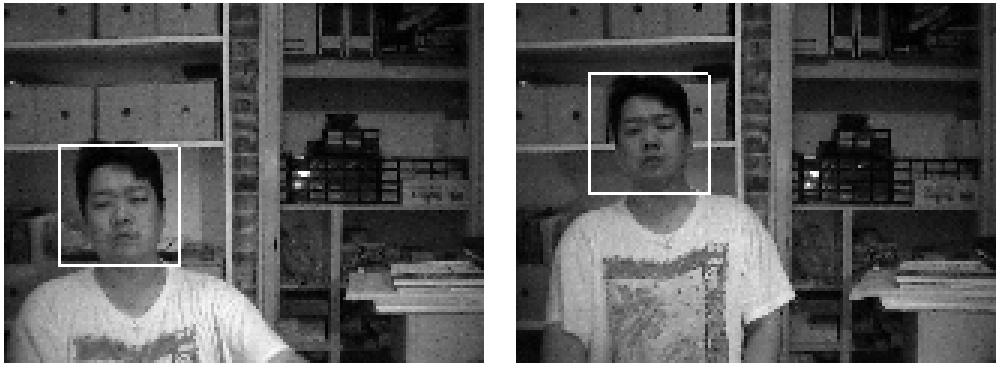


Image analysis, edge detection

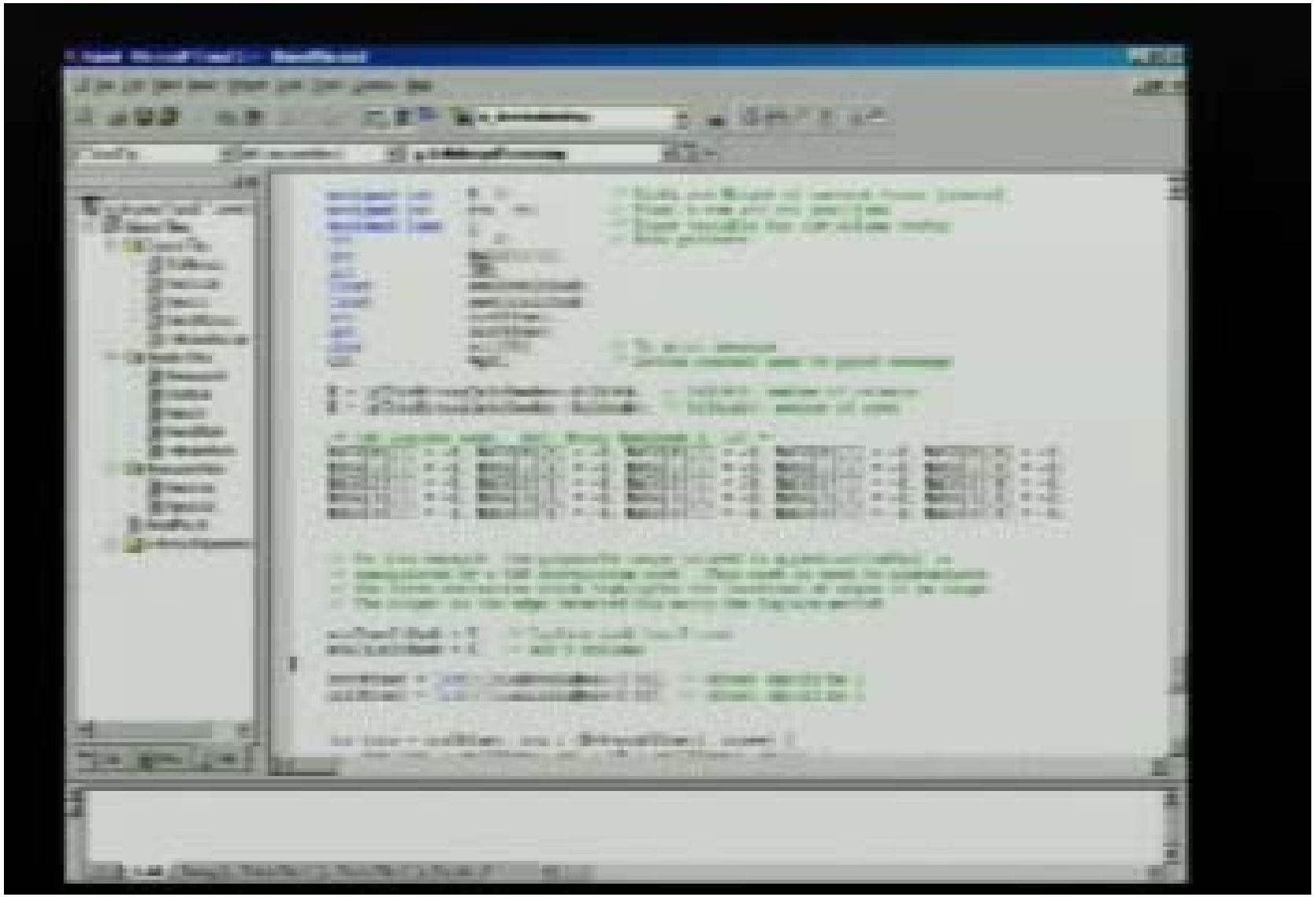
Pattern recognition, SSD tracking

Visual-Servoing Project



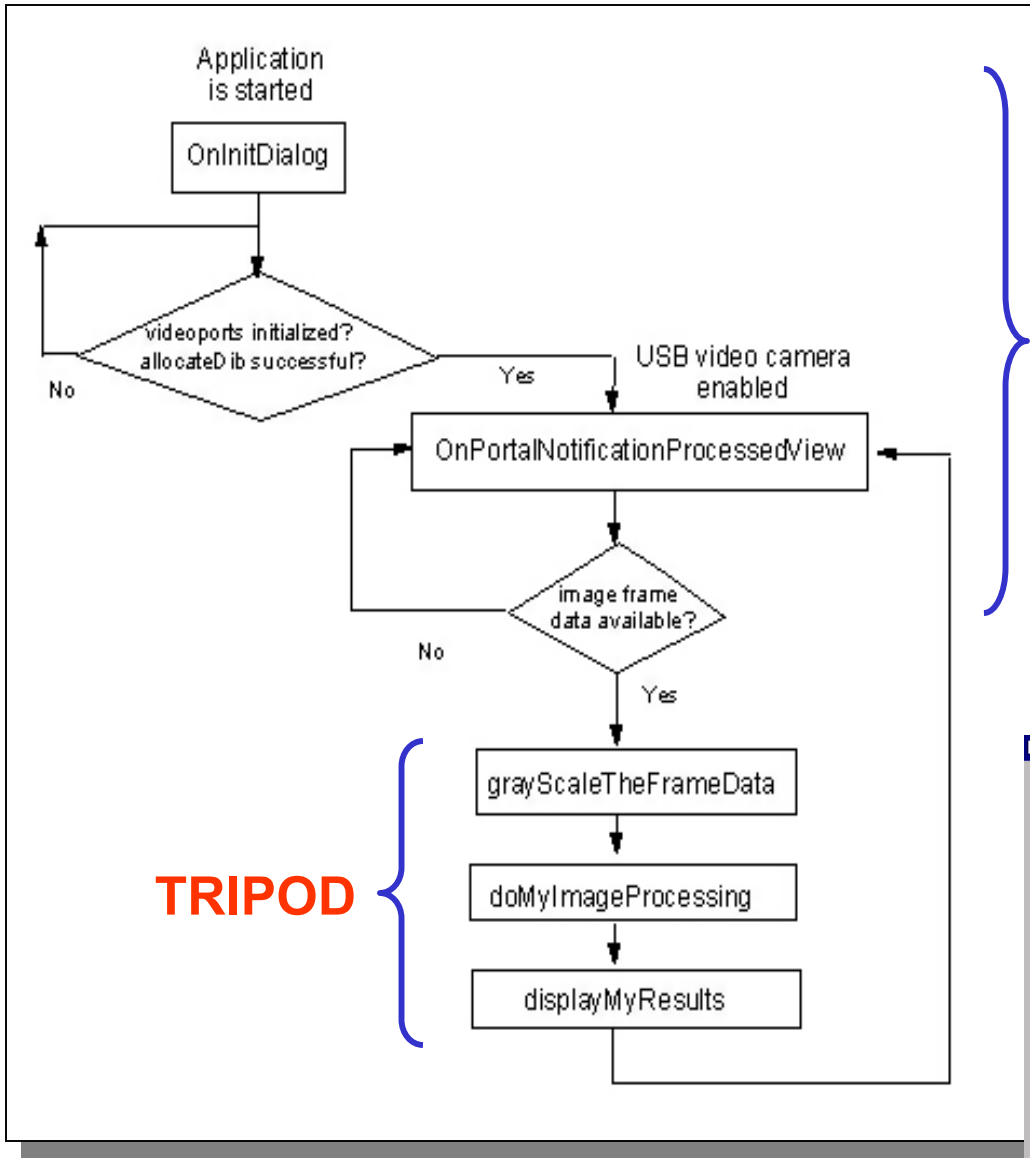
http://www.pages.drexel.edu/~weg22/tutorials.html

Test Case: Independent Study



TRIPOD: edge detection

TRIPOD: How it Works

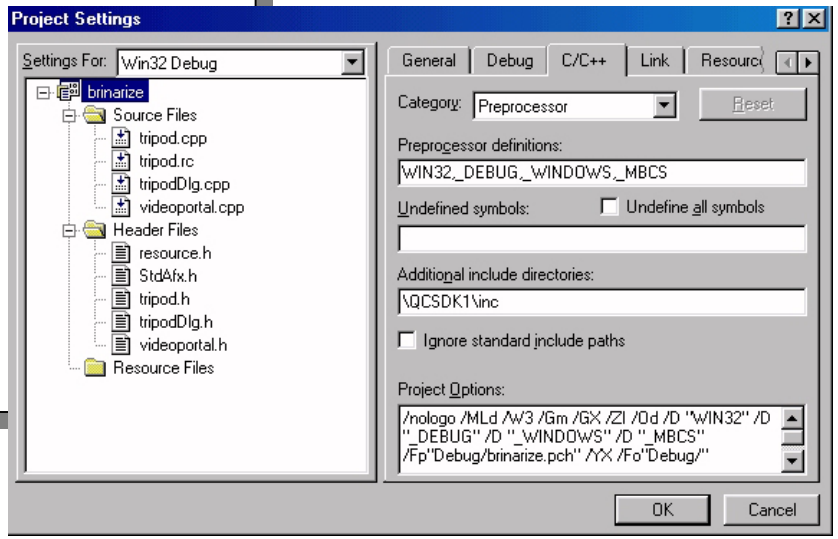


QCSDK (Low-level)

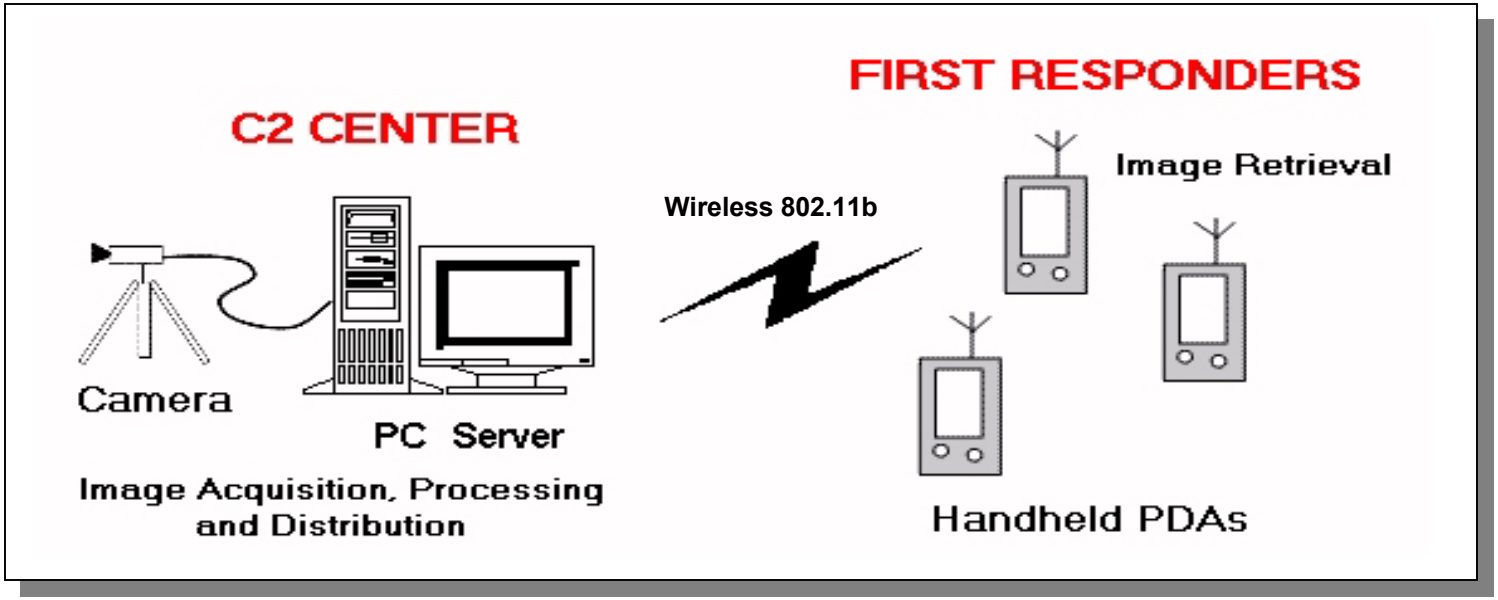
- USB Interface
- DirectX
- Logitech API

TRIPOD (Hi-level)

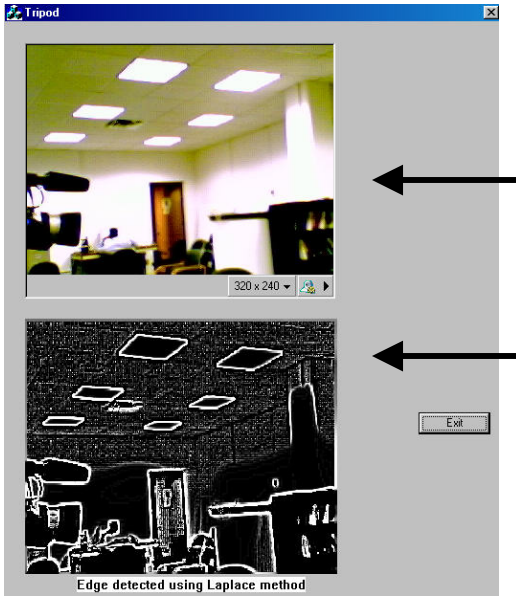
- Pointer to data
- ANSI C/C++
- Minimal MFC
- Hooks to API



Project: Wireless Imagery for C2 Augmentation



C2 CENTER



Live view

Processed Image
(edge enhancement)

PDA SCREEN VIEW

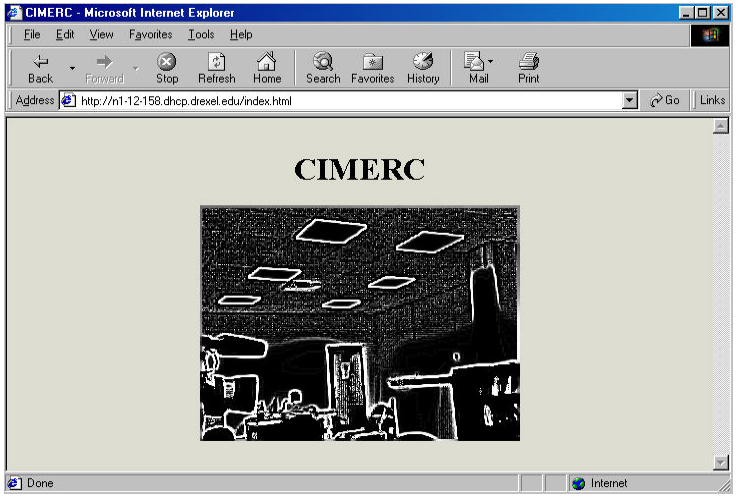
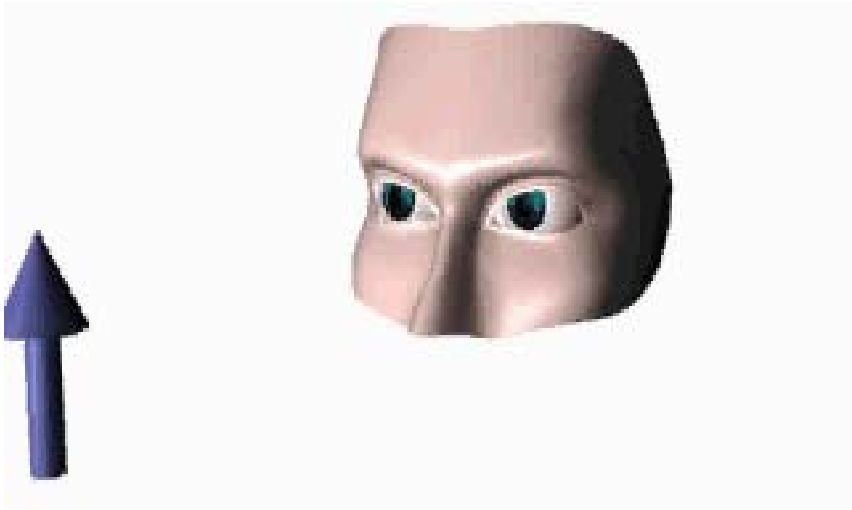


Image retrieved from C2

Wireless Imagery for C2 Augmentation

Video Demo

Project: Biomimic Human Head-Eye Motion for Servoing



Two Rotational DOF

Camera Point-of-View

Contributions

- Free and open source package
- Uses widely available and affordable cameras
- ANSI C/C++ with minimum MFC
- On-line tutorials and code
- Integrate LEGO Vision Command with Mindstorms

Conclusions

- Suitable for Independent and Honors Study
- Can affordably and effectively implement in classroom
- Rapidly ascend CV learning curve
- Apply concepts to prototype robot-camera systems