Prototype of a Microsurgical Tool Tracker

Team 5

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600.466 Advanced Computer-Integrated Surgery

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Outline

Project Summary

Paper Selection

Key Results

Technical Approach

Threshold	Connect	Merge

Analysis

Project Summary

- Problem: A need for tool tracker in eye surgery
  - Monitor surgical protocol
  - Assess surgical performance
  - Improve surgical safety

- Project Goal: Micro-Surgical Tool Tracker
  - Build a prototype of a goggle
  - Provide positional feedback

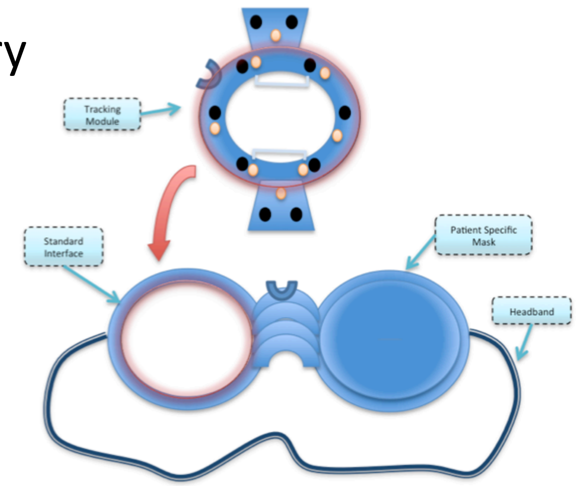
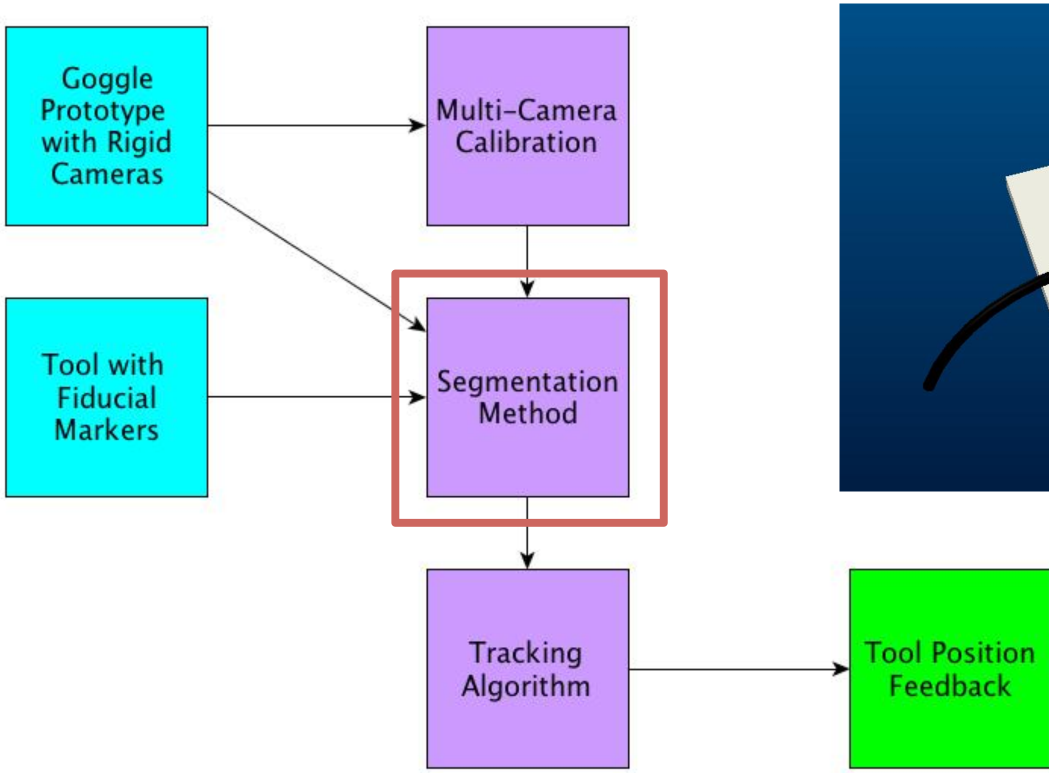
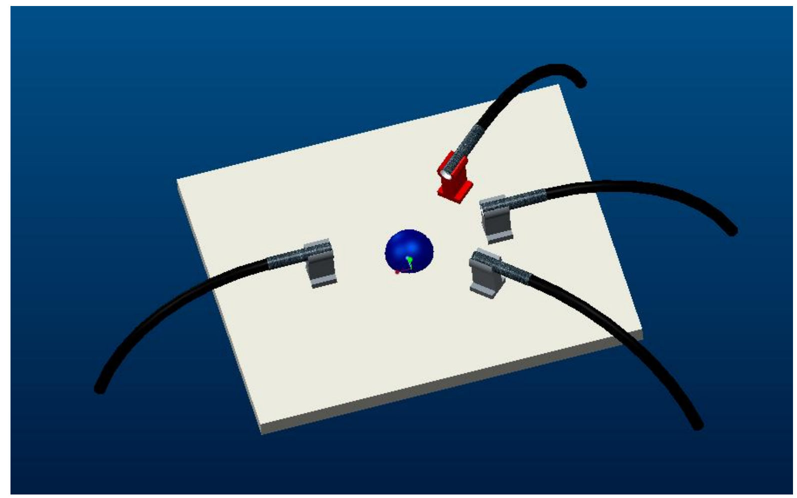


Figure 1. Idea proposed by Marcin Balicki

Project Summary





Project Summary | Paper Selection | Key Results | Technical Approach | Analysis

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Paper Selection

Title: Fast Inexpensive Color Segmentation for Interactive Robots
Authors: James Bruce, Tucker Balch, Manuela Veloso
Published: IEEE International Conference Intelligent Robots and Systems, 2000

Relevance to Project	
Color segmentation	✔
Fast (real-time)	✔
Computationally inexpensive	✔
No special equipment	✔
Easy to implement	Δ
Robust	Δ

Key Results

Problem:

- Real-time segmentation relies on specialized equipment

Solution:

- Utilize algorithmic efficiency
- Track 32 colors at 30 Hz

Importance:

- Make real-time segmentation affordable and accessible
- Doesn’t sacrifice accuracy for efficiency
- Various computer vision applications

Technical Approach

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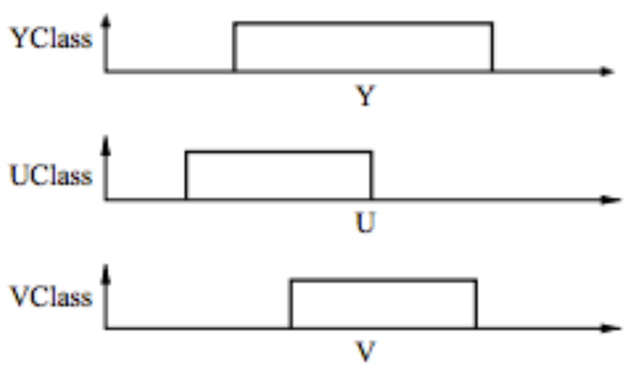
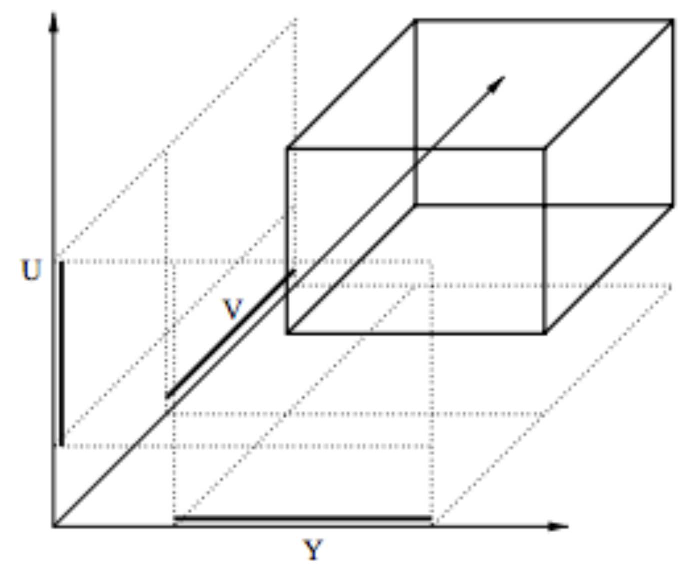
Step 1: Color Threshold

- Extract YUV matrices
- **Why?** Robust against luminance



Binary Signal Decomposition of Threshold



Visualization as Threshold in Full Color Space

Figure from Bruce et al.

Technical Approach

Step 1: Color Threshold

- Classify pixel color with logical AND gates
- **Why?** 2 operations rather than 192

Pixel_in_class = YClass[Y] AND
UClass[U] AND VClass[V]

YClass[Y] = {0,1,1,1,1,1,1,1,1,1}
UClass[U] = {1,1,1,0,0,0,0,0,0,0}
VClass[V] = {0,0,0,1,1,1,0,0,0,0}

YClass[Y] = {00,11,11,11,11,11,11,11,11,11}
UClass[U] = {01,01,01,00,00,00,00,10,10,10}
VClass[V] = {00,00,00,01,01,01,00,10,10,10}

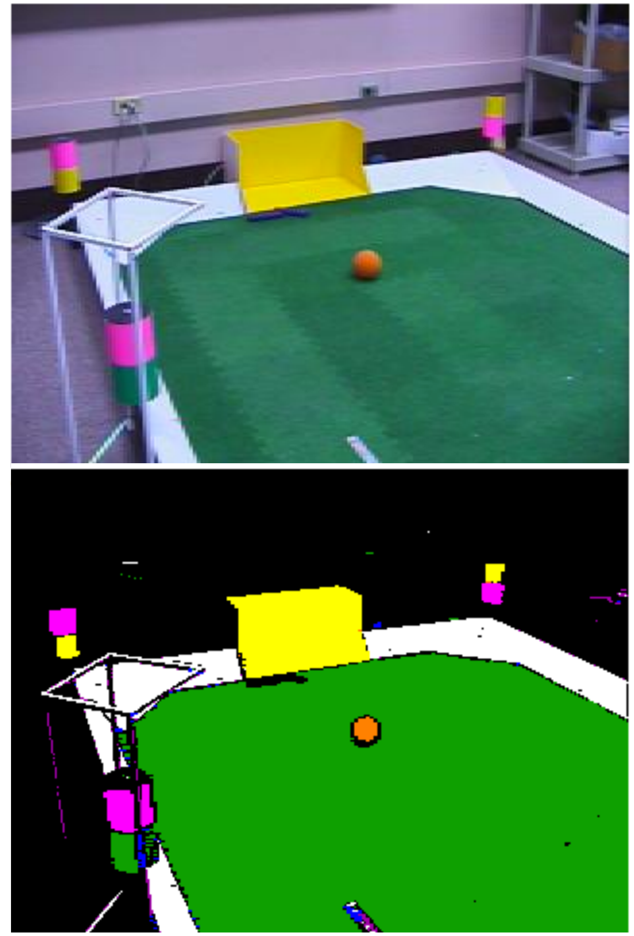


Figure from Bruce et al.

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Technical Approach

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Step 2: Connect Components

- 2 runs of a tree-based union
- **Why?** Linear time bound

(1) Scan row for adjacent pixels of the same color

(2) Create disjoint forest of 'runs' with identifier for parent node

(3) Scan runs for four-connectedness

(4) Point each run's parent node to global parent

(5) Run second pass to compress path

Technical Approach

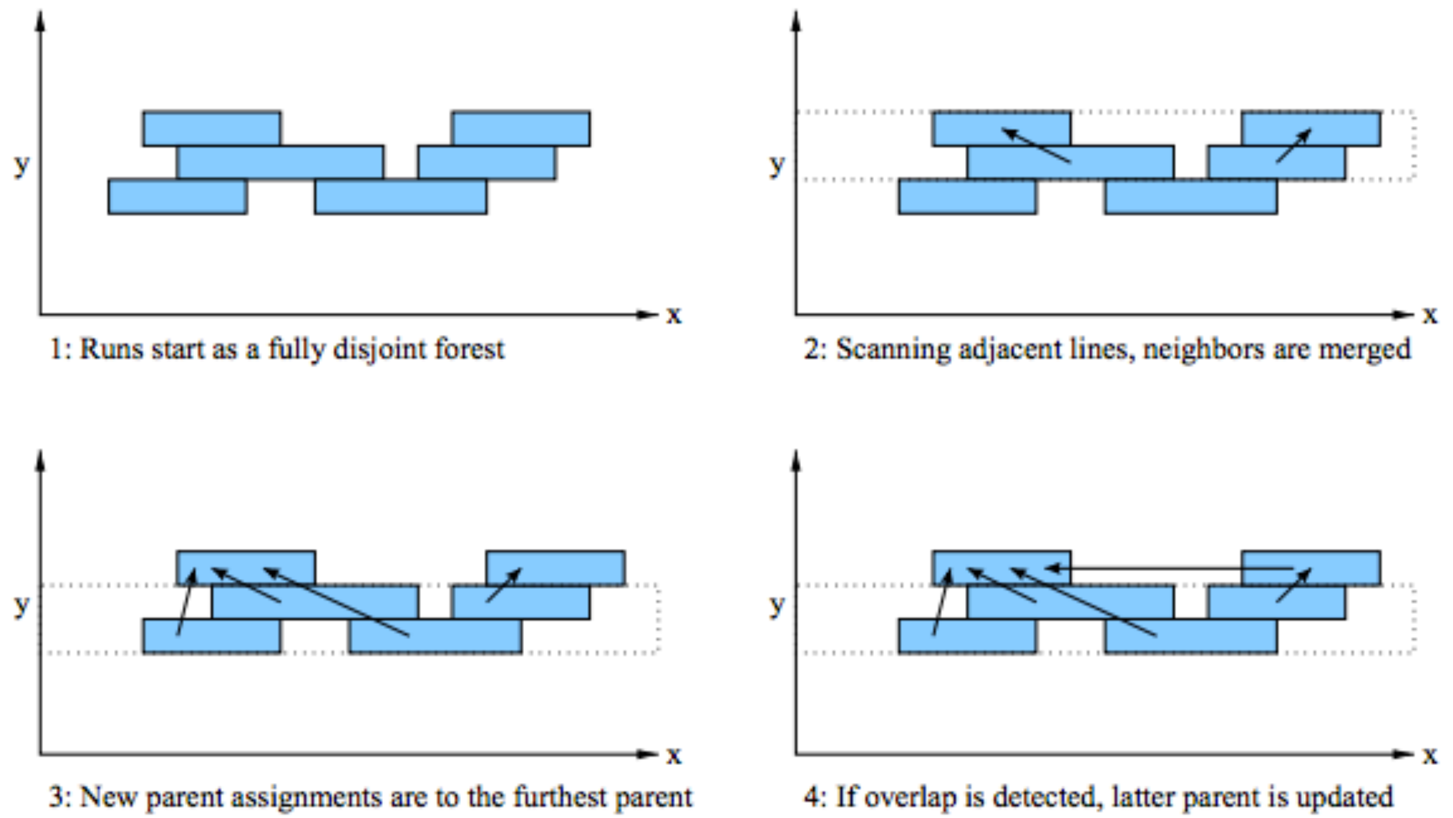
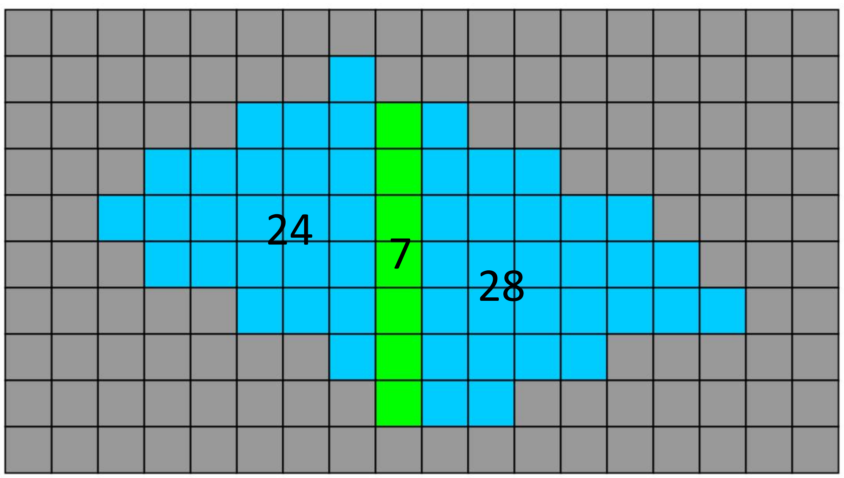


Figure from Bruce et al.

Technical Approach

Step 3: Density-based Merging

- Merge similar objects based on a grouping force threshold
- **Why?** Account for bottom up region generation error and occlusion



Steps:

- Find pairs of components
- Merge
- Calculate density
- Check against threshold

(blue)/(blue + green) = .88

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Analysis

Significance
Color segmentation
Fast (real-time)
Computationally inexpensive
Cheap
No special equipment
Robust to luminance

Changes for our Project
Capture in RGB
Transform to YUV
No density-merging

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Analysis

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Tested Applications:
- Probotics Cye Platform
- RoboCup-99 Robot

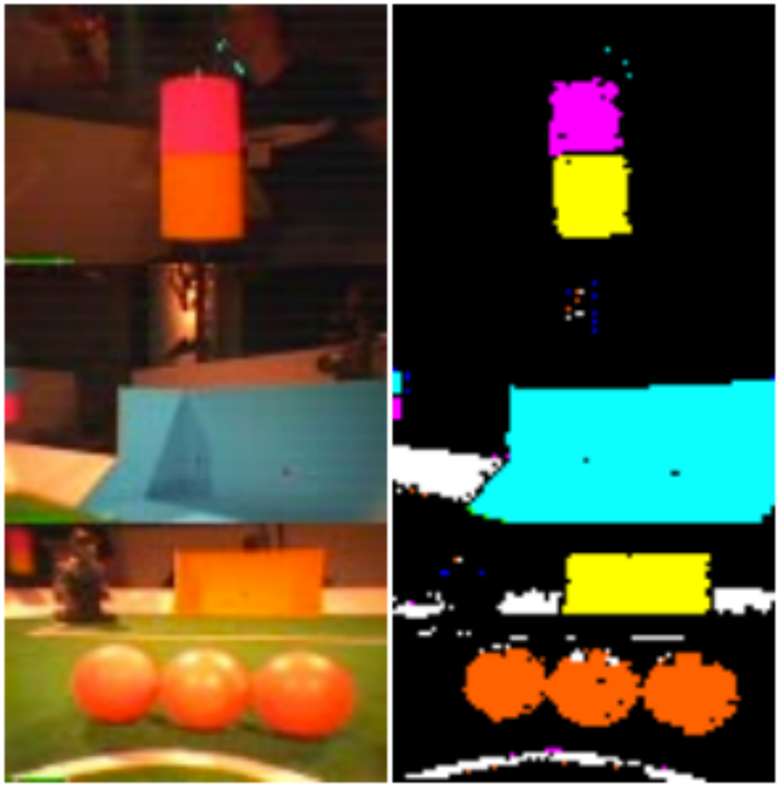

Figure from Bruce et al.

Improvements/Future Directions
Applications beyond robot-soccer
Analysis of accuracy of blob detection
Description of hardware set-up

Bibliography

Paper Reviewed:

J. Bruce, T. Balch, and M. Veloso, “Fast and inexpensive color image segmentation for interactive robots,” in Proc. IEEE Intl. Conf. Intell. Robot. Syst., 2000, pp. 2061–2066.

Clinical Background:

J. D. Pitcher, J. T. Wilson, S. D. Schwartz, and J. Hubschman, “Robotic Eye Surgery: Past, Present, and Future,” J Comput Sci Syst Biol, pp. 1–4, 2012.

Neily, Mills, et al. "Incorrect Surgical Procedures Within and Outside of the Operating Room." Archives of Surgery 16 Nov. 2009: Vol. 144, No.11:1028-1034. Web. 12 Feb. 2013

Questions?