Vision for Automation

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Outline

1. Introduction
2. Applications
3. Vision in Automation
4. Software Tools
5. Examples of State-of-the-Art
6. Summary
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What Is Computer Vision?

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It is challenging.

Steps:

1. Image acquisition
2. Image manipulation
3. Image understanding
4. Decision making
Main Driving Technologies

- Signal processing.
- Multiple view geometry [2].
- Optimization.
- Hardware and algorithms.
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Applications

Automotive:
- Lane departure warning systems.
- Head tracking systems for drowsiness detection.
- Driver assistance systems.
- Reading automobile license plates, and traffic management.

Photography:
- In camera face detection [6], red eye removal, and other functions.
- Automatic panorama stitching [1].

1(From http://www.cs.ubc.ca/spider/lowe/vision.html)
Applications

- Movie and video (a very big industry):
  - Augmented reality.
  - Tracking objects in video or film and solving for 3-D motion to allow for precise augmentation with 3-D computer graphics.
  - Multiple cameras to precisely track tennis and cricket balls.
  - Human expression recognition.
  - Software for 3-D visualization for sports broadcasting and analysis.
  - Tracking consistent regions in video and insert virtual advertising.
  - Tracking for character animation.
  - Motion capture, camera tracking, panorama stitching, and building 3D models for movies.
Camera Tracking

Source: http://www.2d3.com/capability

Show 2d3 video.
Applications

- **Games:**
  - Tracking human gestures for playing games or interacting with computers.
  - Tracking the hand and body motions of players (to control the Sony Playstation).
  - Image-based rendering, vision for graphics.

- **General purpose:**
  - Inspection and localization tasks, people counting, biomedical, and security. etc.
  - Object recognition and navigation for mobile robotics, grocery retail, and recognition from cell phone cameras.
  - Laser-based 3D vision systems for use on the space shuttles and other applications.
  - Image retrieval based on content.
Applications

- **Industrial automation (a very big industry):**
  - Vision-guided robotics in the automotive industry.
  - Electronics inspection systems for component assembly.

- **Medical and biomedical (maturing):**
  - Vision to detect and track the pose of markers for surgical applications, needle insertion, and seed planting.
  - Teleoperations.
  - Quantitative analysis of medical imaging, including diagnosis such as cancer.

- **Security and biometrics (thriving):**
  - Intelligent video surveillance.
  - Biometric face, fingerprint, and iris recognition.
  - Behavior detection.
Minimal Invasive Surgery

Areas of Advancement

- Hardware.
- Image segmentation.
- 3-D reconstruction.
- Object detection.
- Navigation.
Areas of Advancement

- Hardware.
- Image segmentation.
- 3-D reconstruction.
- Object detection.
- Navigation.
- Scene understanding.
What's needed?
cameras
software
actuators
Cameras

- Camera, and a frame grabber.
- IEEE 1394 or USB cameras.
- Ethernet cameras.
Vision in Automation


Source: http://www.matrox.com/imaging/products/vio/home.cfm
Inspection

- Color
- Barcode scanning
- Character recognition
Inspection: Examples

- Defects in parts, measurement of size.
- Robotic bin picking.
- If each slot is filled in a carton of pills.
- Character recognition.
Visual Servoing

- Uses vision in the servo loop [3].
  - Dynamic look and move needs the accuracy of the vision sensor and robot end-effector.
  - Having visual feedback in the control loop increases the overall accuracy of the control loop.
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Visual Servoing
Machine vision can provide closed-loop position control for a robot end-effector—this is referred to as visual servoing.
Visual Servoing—Camera Configuration

- End-effector mounted
- Fixed configuration
Servoing Architectures

- Is the control structure hierarchical, with the vision system providing set-points as input to the robot’s joint level controller, or does the visual controller directly compute the joint-level inputs?
- Is the error signal defined in 3-D (task space) coordinates, or directly in terms of image features?
Servoing Architectures

- Dynamic image-based look-and-move structure.
- Position-based (direct) visual servo structure.
- Image-based (direct) visual servo structure.
Dynamic Position-Based Look-and-Move Structure

Cartesian control law

Joint controllers and power amps

Pose estimation

Image feature extraction

$^c x_d$

$^c \hat{x}$

$f$

video
Dynamic Image-Based Look-and-Move Structure

Feature space control law

Joint controllers and power amps

Image feature extraction

$fd$ → Feature space control law → Joint controllers and power amps

$\Delta f$ → Image feature extraction

Video
Position-Based (Direct) Visual Servo Structure.
Image-Based (Direct) Visual Servo Structure.

- Feature space control law
- Power amps
- Image feature extraction
- Video
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Software Tools

- Octave or Matlab.
- C or C++ with a library such as OpenCV.
Image Processing using Octave or Matlab

- Simple and quick.
- A lot of library functions.
- Interpreted.
Octave Examples

- Image reading and writing.
- Histograms.
- Filtering.
Image Processing using OpenCV

- Power of C++.
- Well coded.
OpenCV Examples

1. Image reading and writing.
2. Edge detection.
3. Template matching.
4. Capturing video.
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Examples of State-of-the-Art

Segmentation Using Graph Cuts [5]
Examples of State-of-the-Art

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Examples of State-of-the-Art Segmentation Using Graph Cuts [5]
Can we obtain a 3-D view of a scene, given only a set of (2-D) images?
3-D Reconstruction

Can we obtain a 3-D view of a scene, given only a set of (2-D) images?
Yes. Using multiple view geometry, we can reconstruct a scene.
Show Leibe et al. video [4].
Examples of State-of-the-Art

Object Detection: Face Detection

[Images of face detection examples]
Navigation: Sanford’s Robot Stanley

Show video.
Conclusion

- Vision-based automation is promising.
Conclusion

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- Solutions are simple in a controlled environment.
Conclusion

- Vision-based automation is promising.
- Solutions are simple in a controlled environment.
- State-of-the-art is very interesting.
Thank you.

OpenCV examples, and Octave examples are here: http://www.ent.mrt.ac.lk/ ranga/publications.html


