Seminar I on Agricultural Process Engineering
農産加工学演習 I

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Applications as robotic eyes
Software of machine vision as robotic eyes

Color conversion
Preprocessing
Binarization
Processing of binary, gray level images
Feature extraction
Recognition
3D understanding

Strawberry harvesting robot
Stereo imaging for Depth measurement for 3D reconstruction

Active stereo vision

Passive stereo vision
Stereo geometry

Scene point $P$:
- $b$ : Baseline
- $f$ : Focal length
- $d$ : disparity
- $x_L$ : $P$’s $x$ coordinate on left camera
- $x_R$ : $P$’s $x$ coordinate on right camera
- $X$ : Lateral offset
- $Z$ : Distance from camera

Identical parallel cameras

$d$ is proportional to $f$ and $b$ inversely proportional to $Z$

$\frac{x_L}{f} = \frac{X}{Z}$, $\frac{x_R}{f} = \frac{X + b}{Z}$

$d = x_R - x_L = \frac{f}{Z} \frac{b}{Z}$
Correspondence problem

Area-based stereo matching
(Use of larger image regions (or areas) that contain enough information to yield unambiguous matches)

Feature-based stereo matching
(Feature extraction by color or edge detection and deal with only points that can be matched unambiguously)
Area-based stereo vision

Stereo camera mounted tractor

\[ E(d') = \sum_{i=-m/2}^{m/2} \sum_{j=-m/2}^{m/2} |I_L(x+i, y+j) - I_R(x+i+d', y+j)| \]

Image size: 320 X 240
Mask size \( m \): 25 X 25
\( d' = 0 \sim 32 \) (setting value)

Disparity image
(darker pixel is farther)
Q1: Describe how we can get \( Dy = \frac{d b}{(P_2 - P_1)} \)

\[ Dy = \frac{d b}{(P_2 - P_1)} \]
\[ Dx = P_x \frac{Dy}{d} \]
\[ Dz = P_y \frac{Dy}{d} \]
Strawberry fruit images from stereo vision
Matching criteria: Horizontal level and strawberry size should be almost equal
Cluster of Strawberry fruits
Un-Matched fruits (No.1, 3, 4)

No.1: out of view in right image
No.3: occluded on right image
No.4: different immature parts from different angle
Q2: Describe how we can get \( D_y = \frac{Nl_1 L}{(Nl_2 - Nl_1)} \)

\( D_y = \frac{P_1 L}{(P_2 - P_1)} \)
\( D_x = P_2 \frac{D_y}{d} \)

\( D_y = L \sqrt{Na_1}/(\sqrt{Na_2} - \sqrt{Na_1}) \)

\( D_y = \frac{Nl_1 L}{(Nl_2 - Nl_1)} \)

\( Na_i \): area of object on image
\( Nl_i \): length of object on image
Actual images from camera attached to manipulator end

\[ D_y = L \sqrt{N_{a_1}} / (\sqrt{N_{a_2}} - \sqrt{N_{a_1}}) \]
3 D image from active range finder

Operating principle
(Time of flight)

Transmitter
Receiver
Rotating mirror
3 dimensional shape recognition

Phyllotaxis
Machine vision for fruit grading system
Extracted features from images

Sizes
Colors
Shape
Defects
Maturity
Dullness (Gloss)
......
An apple fruit with discoloration
Color component images

R, G, B

R - G, R - B, G - B
Internal defects detection by X-ray CT

- Peach with Split-pits
- Rotten core
- Moth sucked defect
Experimental result (sprit-pit of peach)

(a) Appearance
(b) Cut sample (Sprit-pit)
(c) Side view
(d) Top view
Transparent Image
Output Voltage: 50keV

CT Image
Peach with Split-pits

Intersection at Y=250
X ray image

- X ray Generator
- Monochrome TV camera
- Scintillator
- Hollow potatoes
- Rotten core onion
X-ray images of orange fruits

- Top view
  - Rind-puffing fruit
  - Empty portion
- Side view
  - Normal fruit
  - Empty portion
Ultra violet image

Visible camera

UV camera

Agricultural Process Engineering Laboratory

KYOTO UNIVERSITY
Review

Describe what was the phenomenon “fluorescence”.
Rotten part
Infrared Transmitted image

Rotten portion

Light
Texture on bioproducts
Cooccurrence matrix and textural features

\[
\begin{array}{cccc}
0 & 1 & 2 & 3 \\
0 & 4 & 2 & 1 & 0 \\
1 & 2 & 4 & 0 & 0 \\
2 & 1 & 0 & 6 & 1 \\
3 & 0 & 0 & 1 & 2 \\
\end{array}
\]

Gray level image

Distance and direction

ASM: \[\sum_{i=0}^{n} \sum_{j=0}^{n} \{p(i, j)\}^2\]

IDM: \[\sum_{i=0}^{n} \sum_{j=0}^{n} \frac{p(i, j)}{1+(i-j)^2}\]

CON: \[\sum_{i=0}^{n} \sum_{j=0}^{n} (i-j)^2 p(i, j)\]

SAS1000 – Outline (Real time soil sensor)

Measurement Box
Power source, PC, Spectroscopy, PLC, amp board

Antenna of DGPS

Chisel (sensor probe housing)

Nitrogen MC SOM EC pH Compaction + Image data

Ready to sell!

※ Date: 2004. 11. 21  Depth: 150mm, Speed: About 30cm/ sec
Cooperation with SHIBUYA MACHINERY CO., LTD., TUAT
Arrangement of equipments in chisel

- Laser Displacement sensor
- EC Electrode
- Color camera
- Condensed fiber
- Illumination fiber
- Ground surface
- Soil flattener
Under-ground-Images by the soil sensor
Textural analysis

\[ \frac{(\text{max}\{a,b,c,d,e,f,g,h,i\}-\text{min}\{a,b,c,d,e,f,g,h,i\}) \times k}{(a+b+c+d+e+f+g+h+i)/9} \]
USAD-ARS Imaging Research Team

RDA 2004 Symposium

October 13, 2004
Method & System for Intelligent Washing of Fecal & Ingesta Contaminants

Common Aperture Camera

Carcass

Multispectral imaging

Intelligent Bird Washer

RDA 2004 Symposium

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Machine vision for seedling production

Cutting sticking robot

Transplanting robot
A fruit grading robot with machine vision
Assignment

Describe how you may apply the imaging technologies to your own research project.
For improving my lecture

Tell me anything (teaching techniques) I can improve for your understanding in my lecture. (For example, small voice, too fast PPT page changing, hard to see letters on blackboard, more explanation, use more blackboard…..)