No.6

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

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農学研究科　地域環境科学専攻

近藤　直・清水　浩

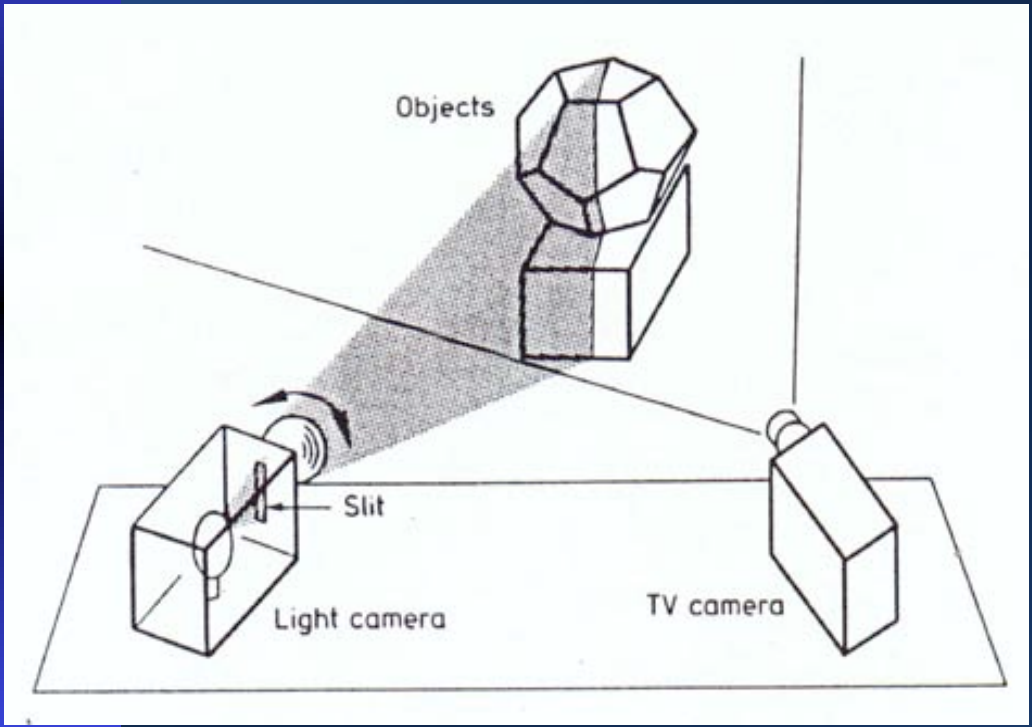
Applications as robotic eyes

Software of machine vision as robotic eyes

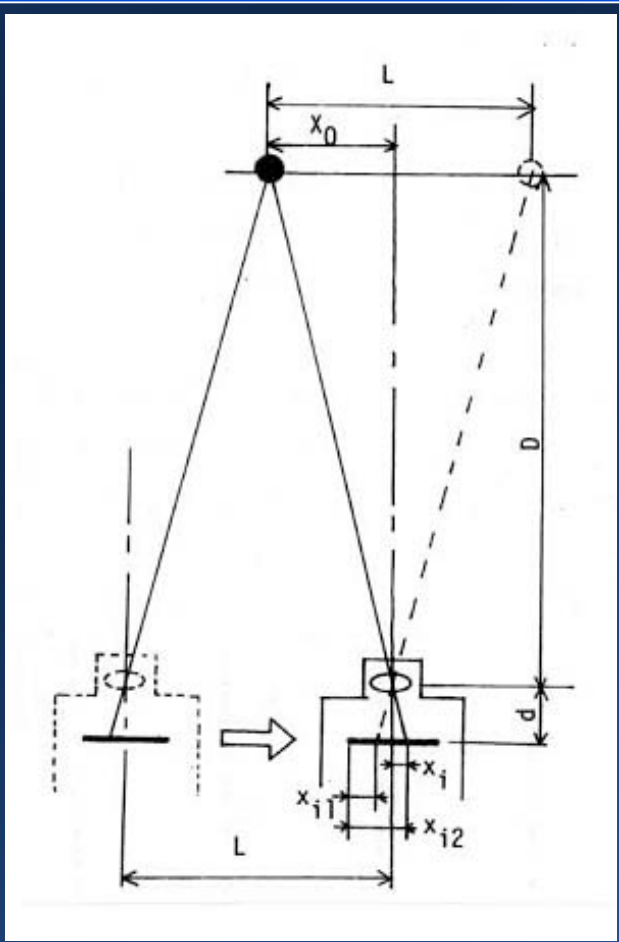
- Color conversion
- Preprocessing
- Binarization
- Processing of binary, gray level images
- Feature extraction
- Recognition
- 3 D understanding

Strawberry harvesting robot

Stereo imaging for Depth measurement for 3 D reconstruction

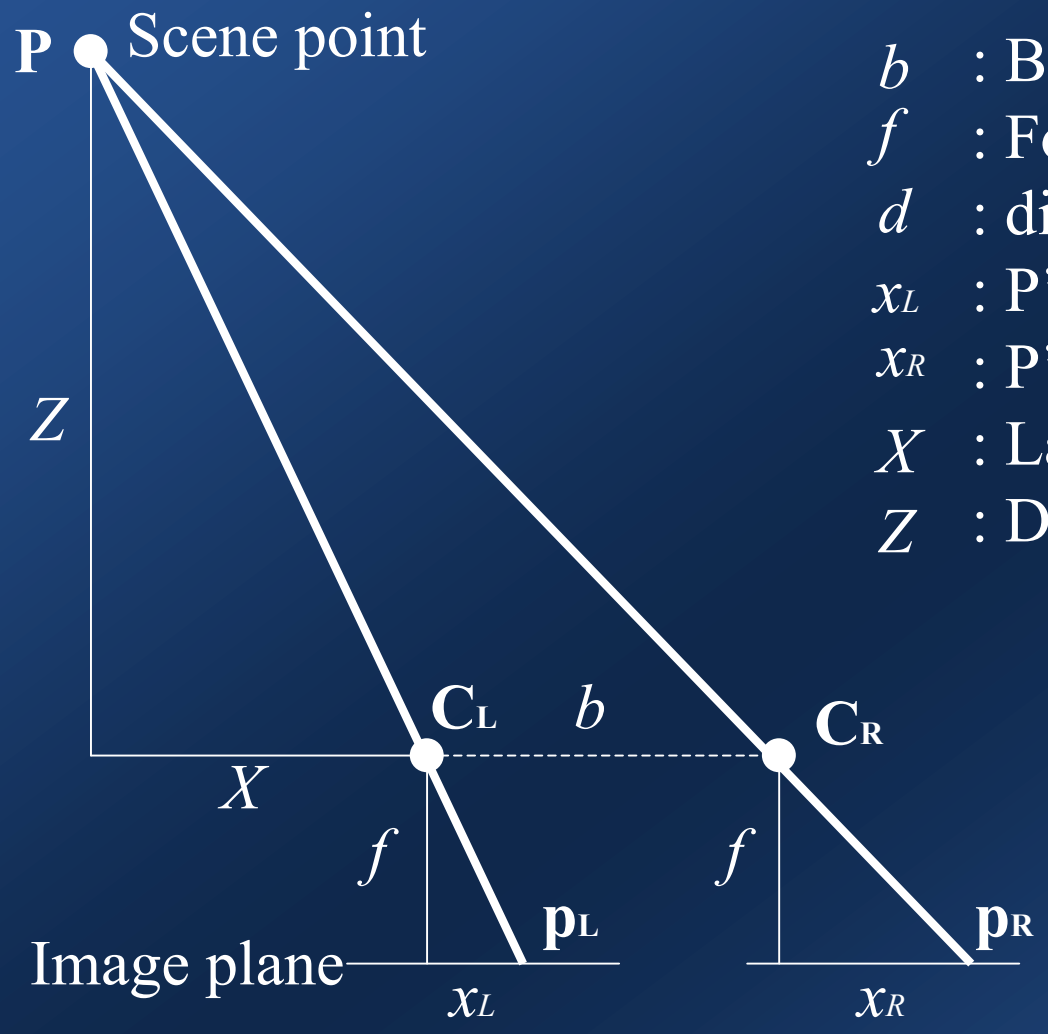


Active stereo vision



Passive stereo vision

Stereo geometry



Identical parallel cameras

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

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

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

d is proportional to f and b
inversely proportional to Z

Correspondence problem

Occlusion problem, Ambiguous matching

<u>Area-based stereo matching</u>

(use of larger image regions (or areas) that contain enough information to yield unambiguous matches)

<u>Feature-based stereo matching</u>

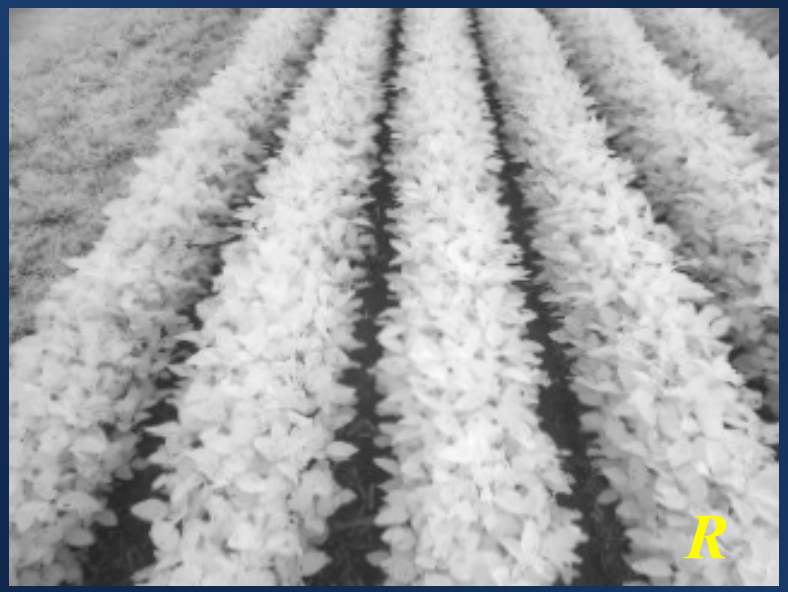
(Feature extraction by color or edge detection and deal with only points that can be matched unambiguoisly)

Area-based stereo vision

Stereo camera mounted tractor [1)]

Stereo camera

1) Kise M., et al. : A Stereovision-based Crop Row Detection Method for Tractor-automated Guidance, Biosystems Engineering, 90(5) 357-367 (2005).



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

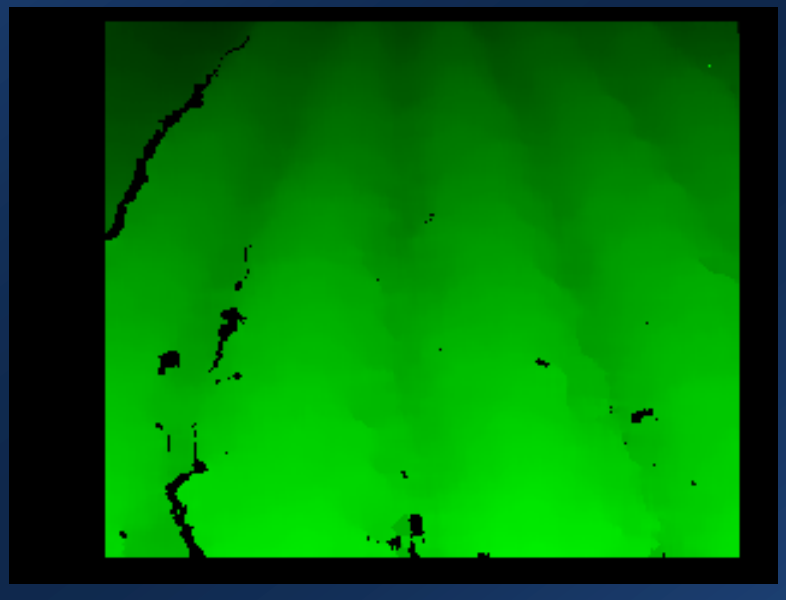
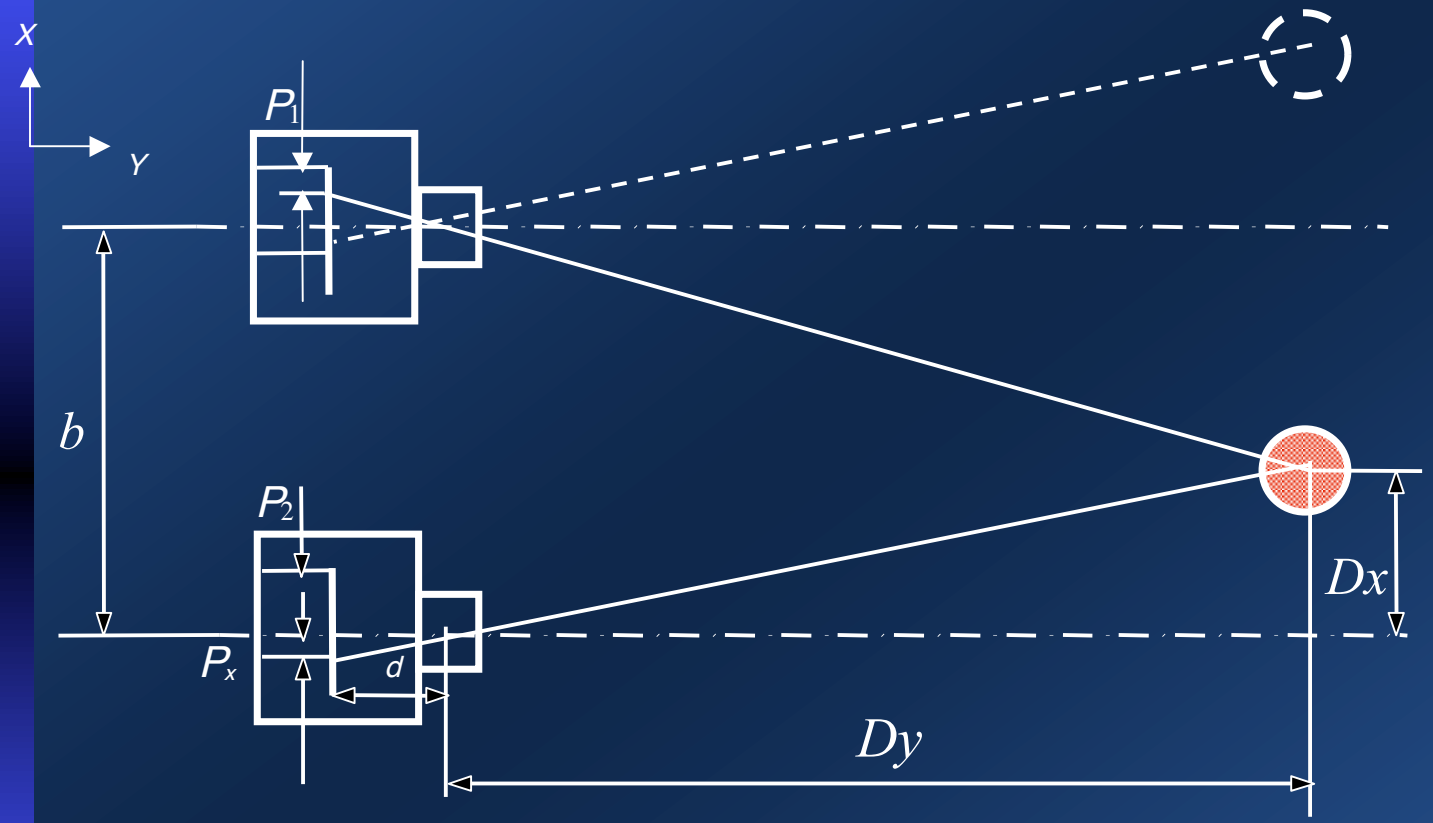


Image size: 320 X 240
Mask size m: 25 X 25
d'= 0～32 (setting value)

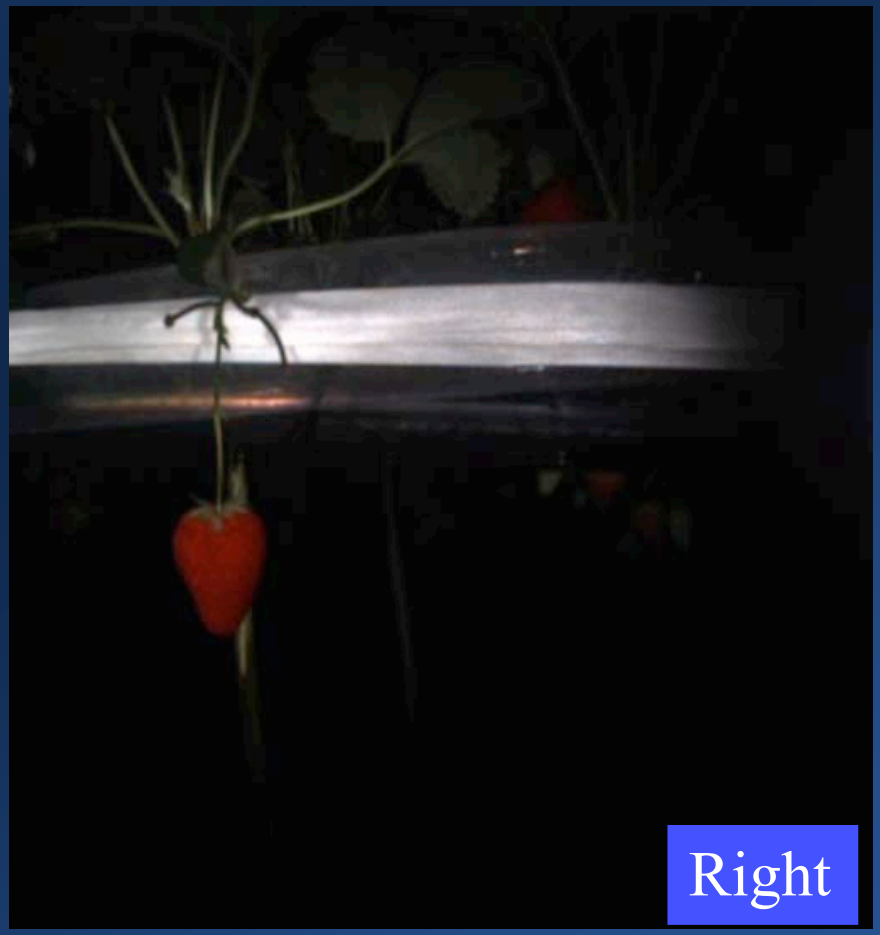
Disparity image
(darker pixel is farther)

Q1: Describe how we can get $Dy = d\,b/(P_2 - P_1)$

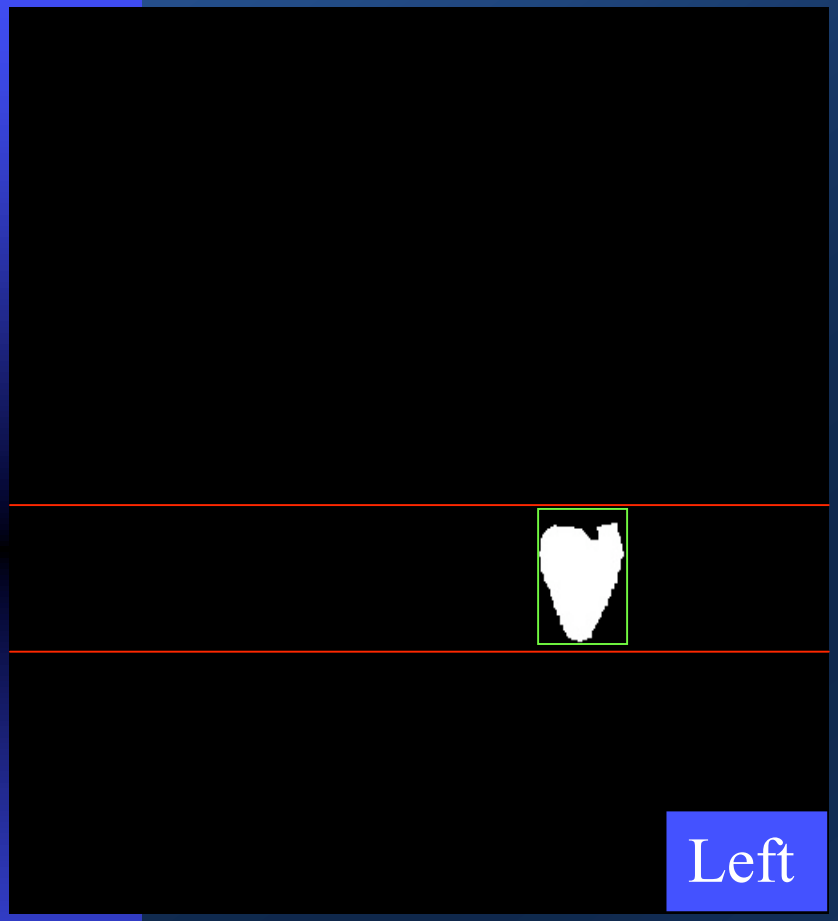


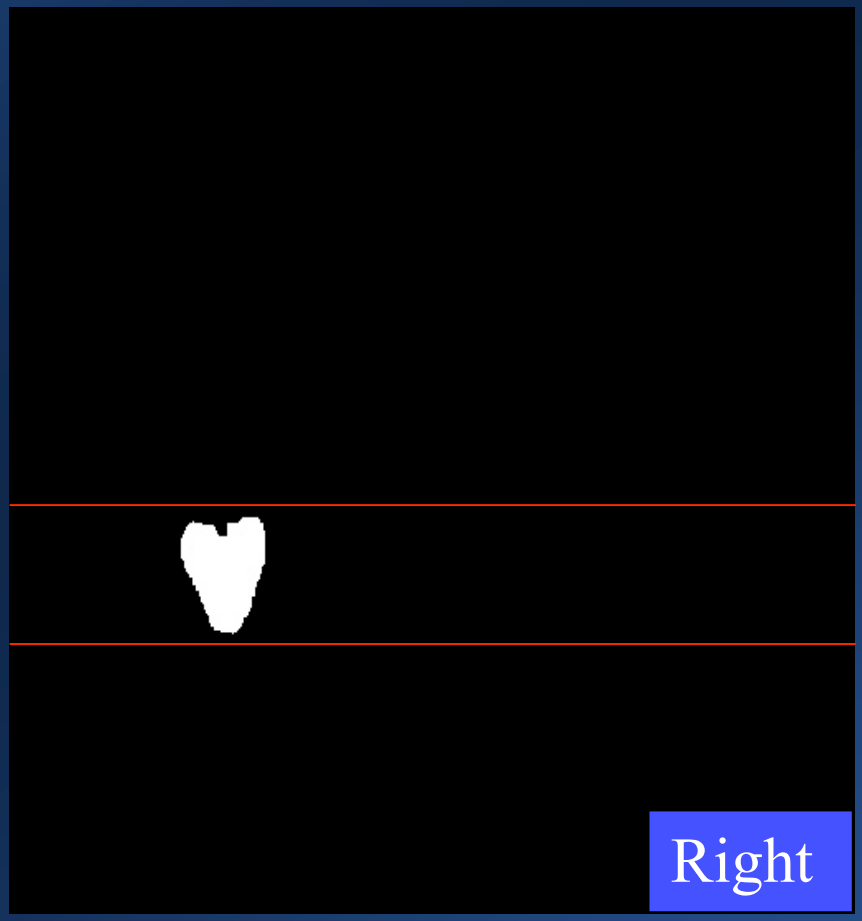
$$Dy = d\,b/(P_2 - P_1)$$
$$Dx = Px\,Dy/d$$
$$Dz = Py\,Dy/d$$

Strawberry fruit images from stereo vision



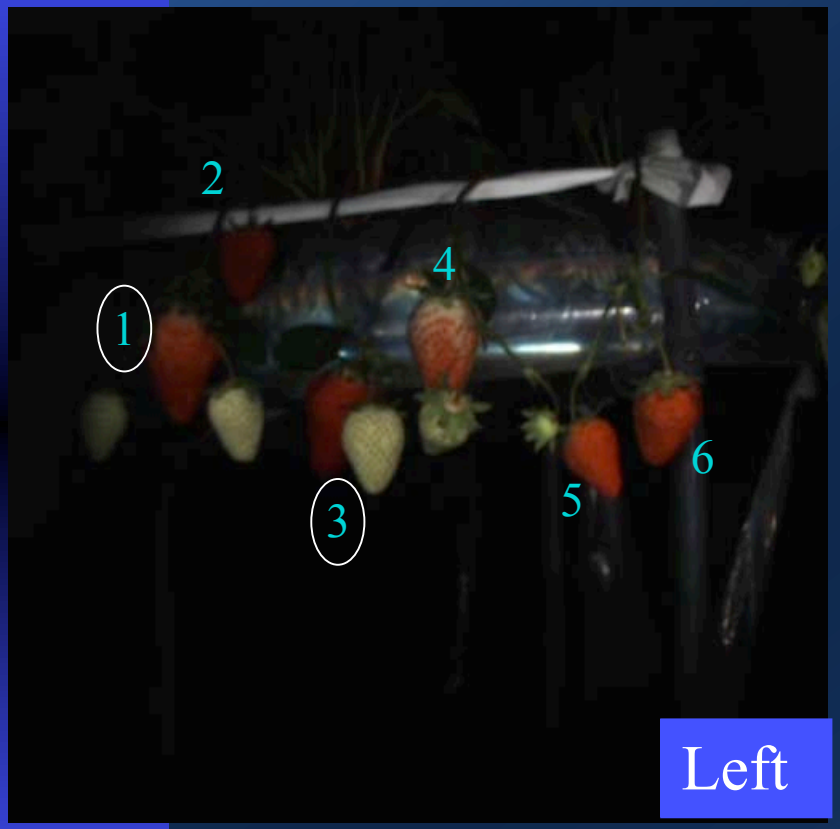
Matching on binary images

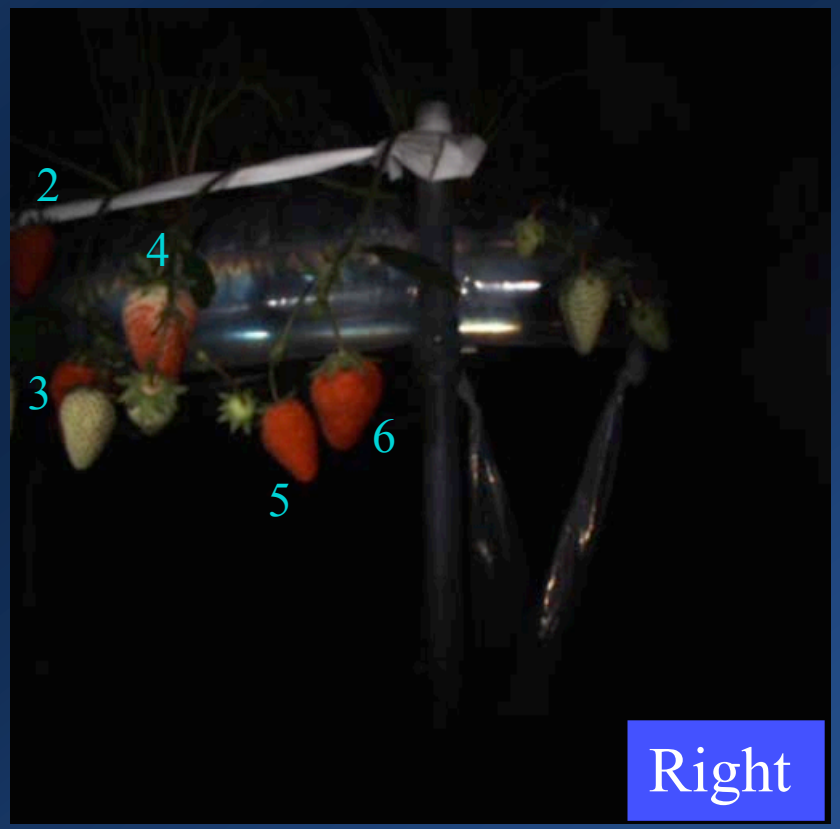




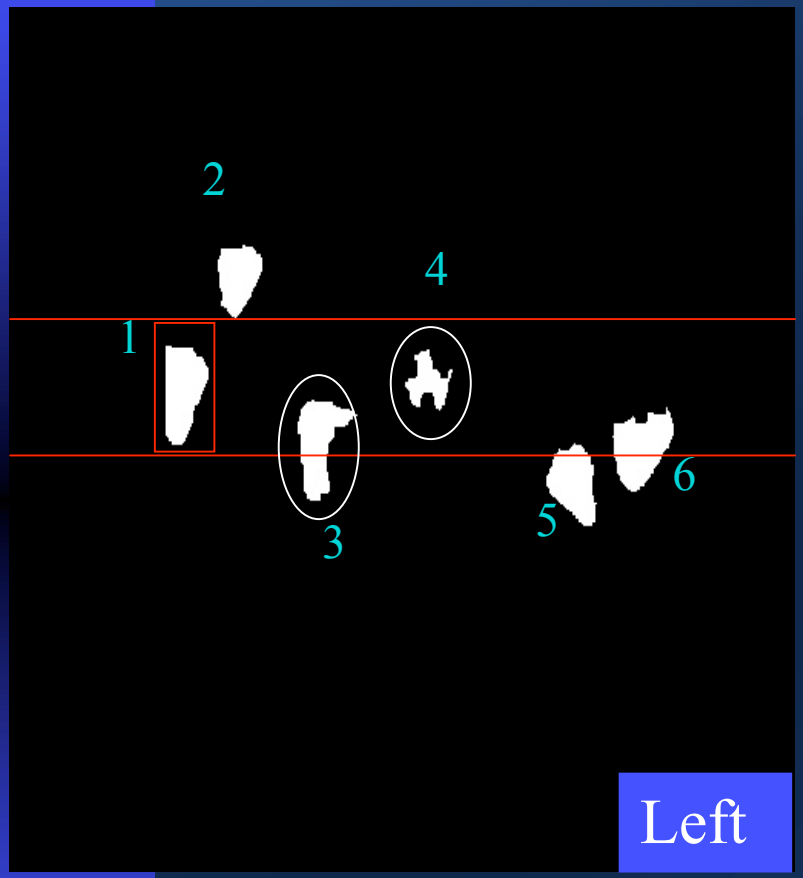
Matching criteria: Horizontal level and strawberry size should be almost equal

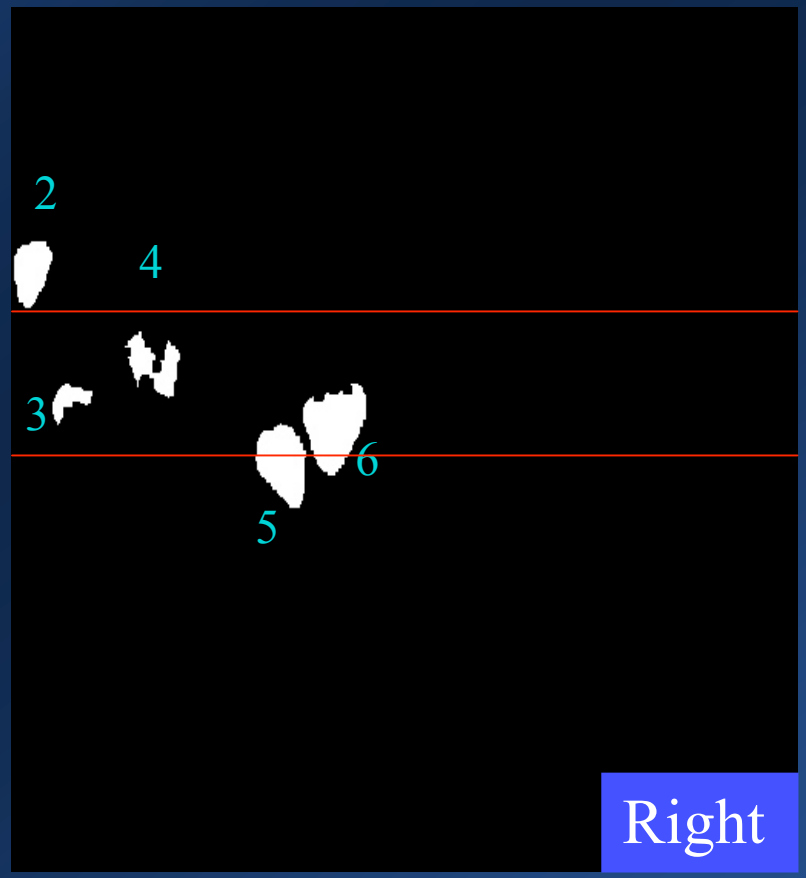
Cluster of Strawberry fruits





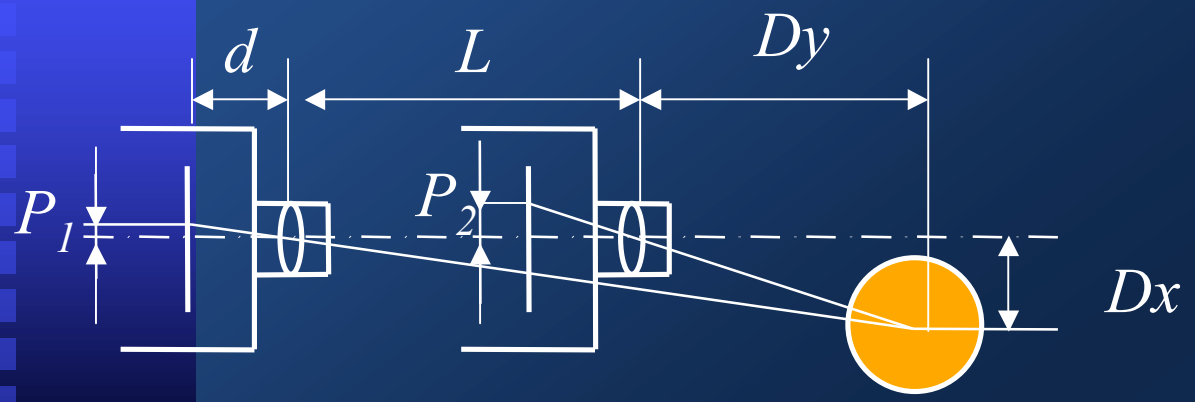
Un-Matched fruits (No.1, 3, 4)



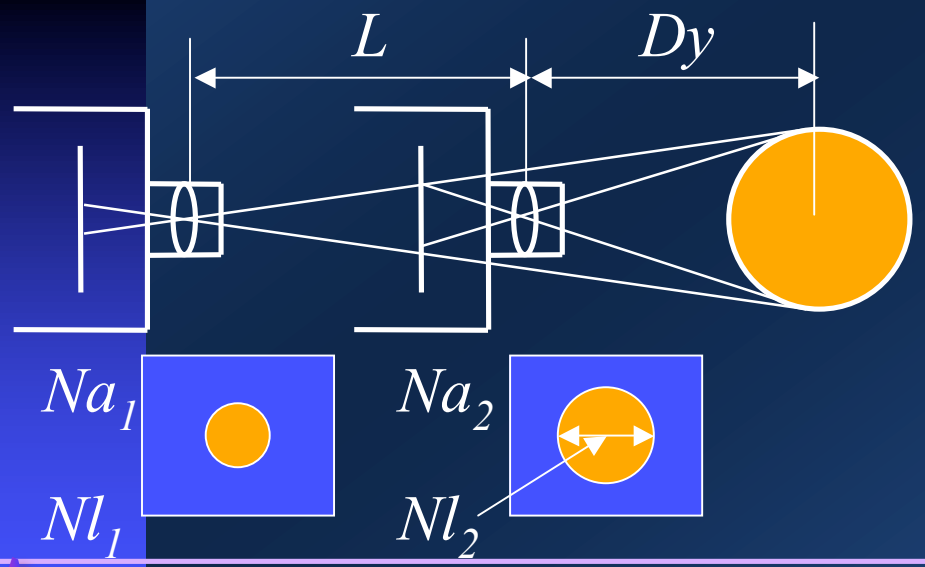


No 1: out of view in right image
No.3: occluded on right image
No.4: different immature parts from different angle

Q2:Describe how we can get $Dy = Nl_1 L / (Nl_2 - Nl_1)$



$$Dy = P_1 L / (P_2 - P_1)$$
$$Dx = P_2 Dy / d$$

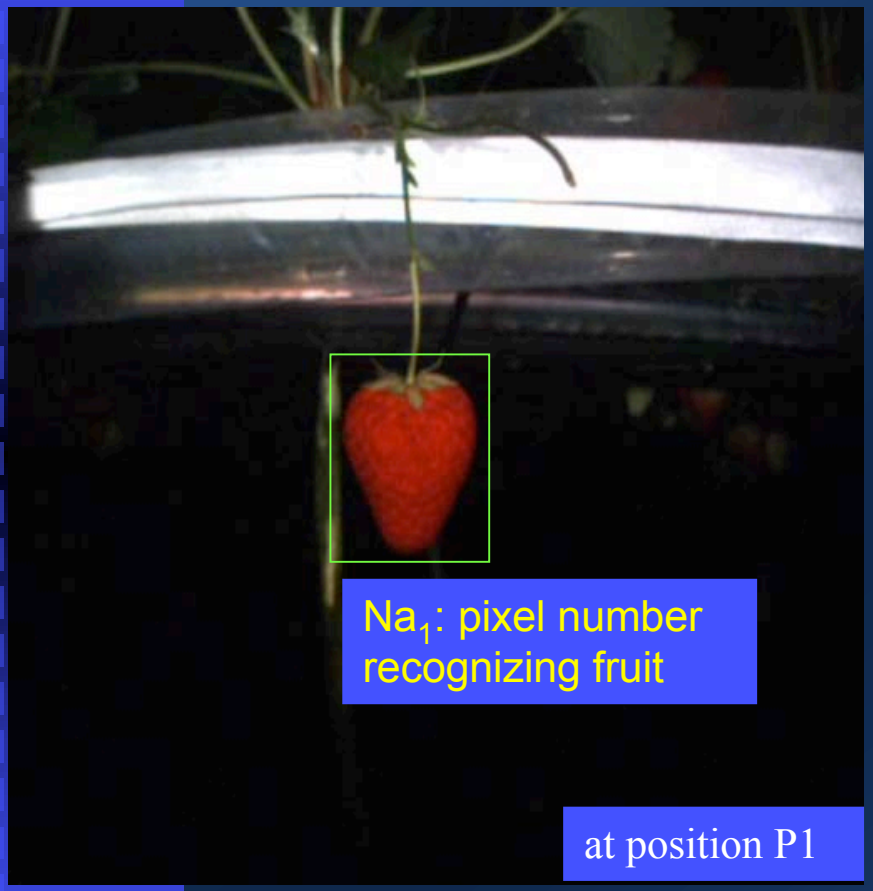


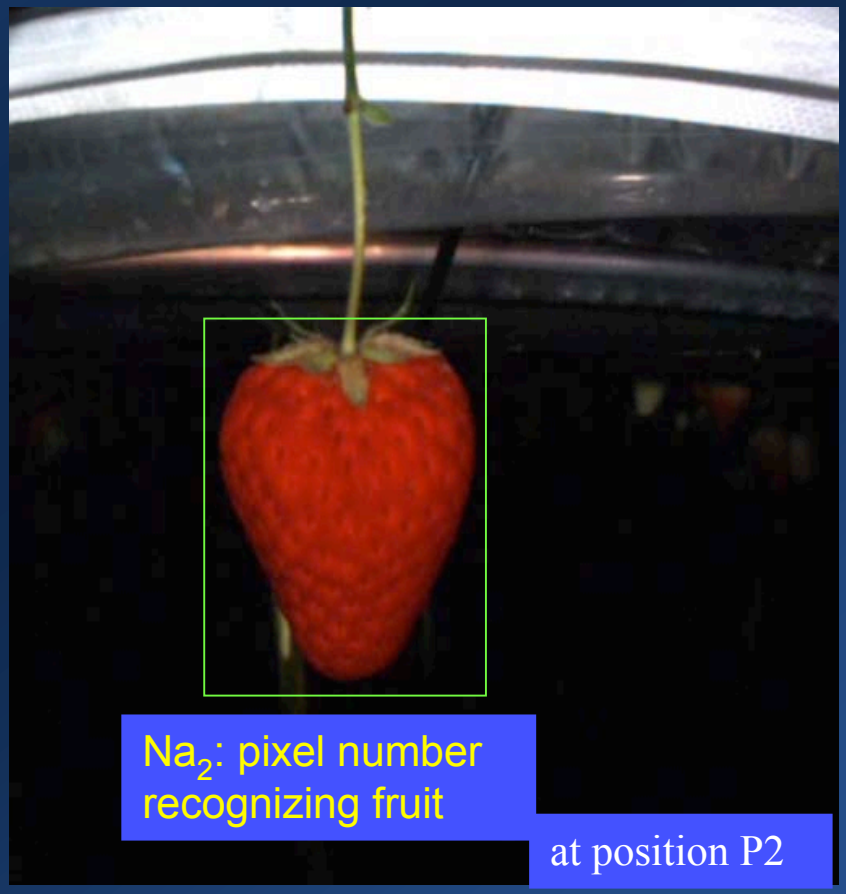
$$Dy = L\sqrt{Na_1} / (\sqrt{Na_2} - \sqrt{Na_1})$$

$$Dy = Nl_1 L / (Nl_2 - Nl_1)$$

Na_i: area of object on image
Nl_i : length of object on image

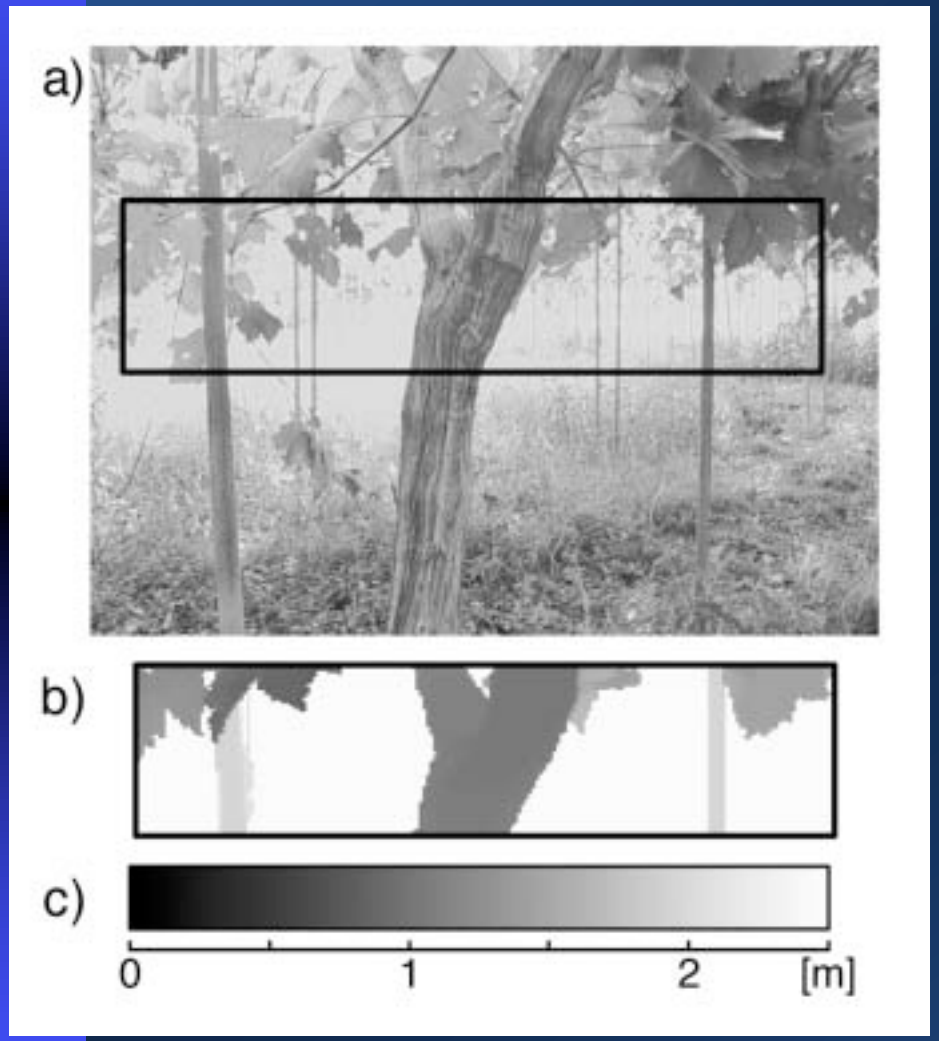
Actual images from camera attached to manipulator end

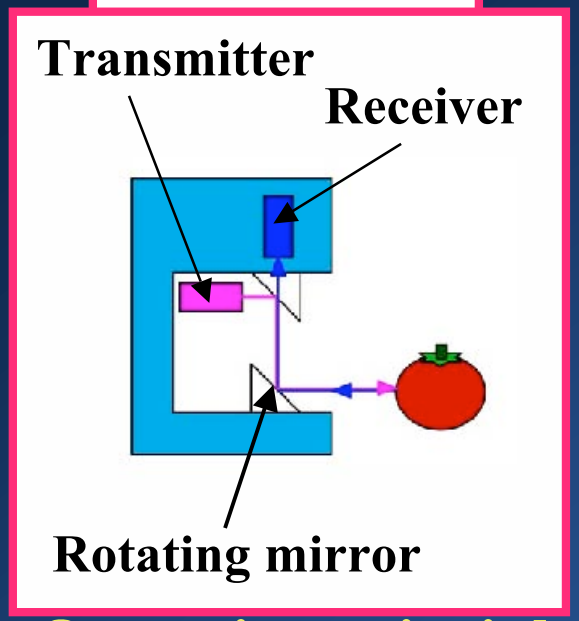




$$Dy = L\sqrt{Na_1} / (\sqrt{Na_2} - \sqrt{Na_1})$$

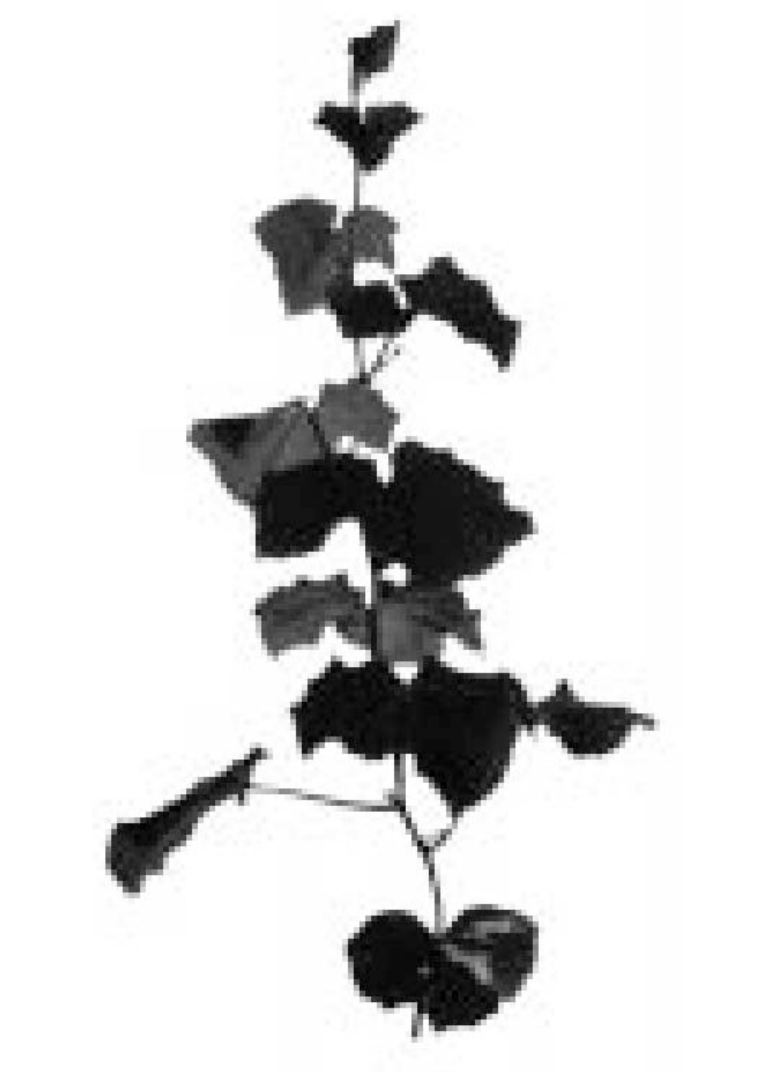
3 D image from active range finder

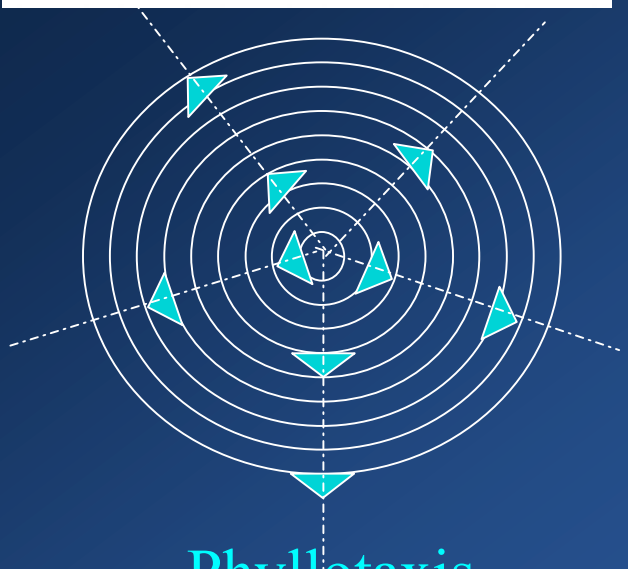




Operating principle (Time of flight)

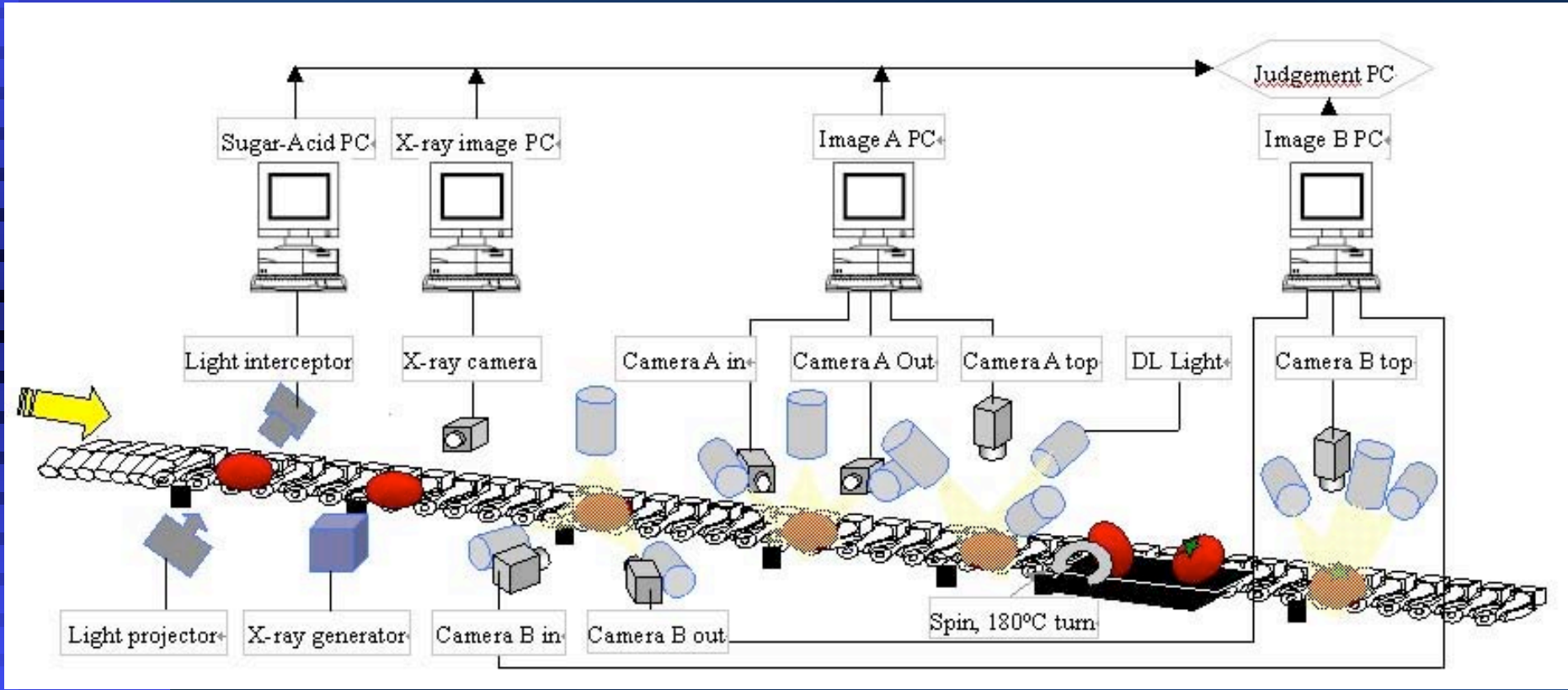
3 dimensional shape recognition



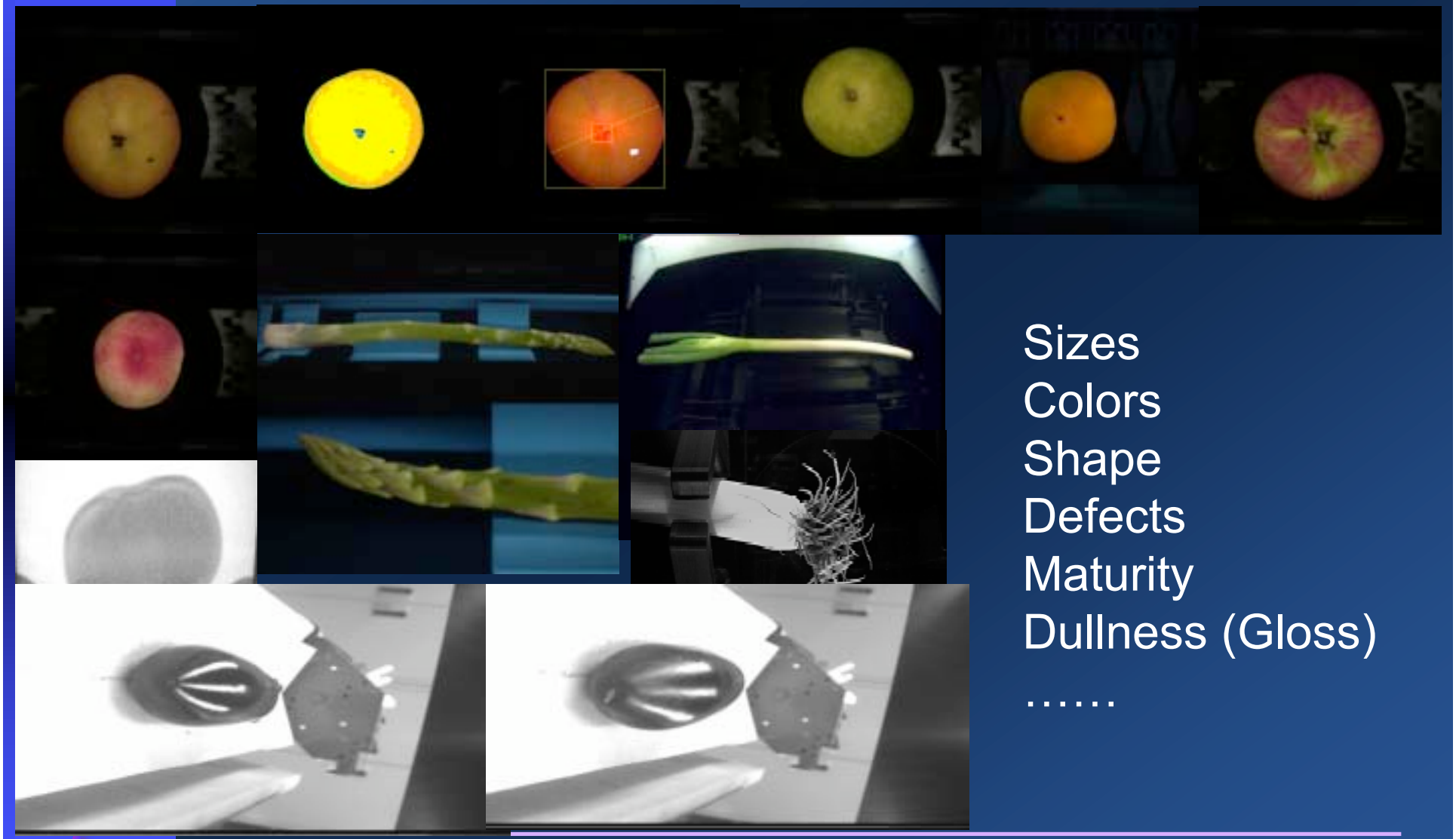


Phyllotaxis

Machine vision for fruit grading system

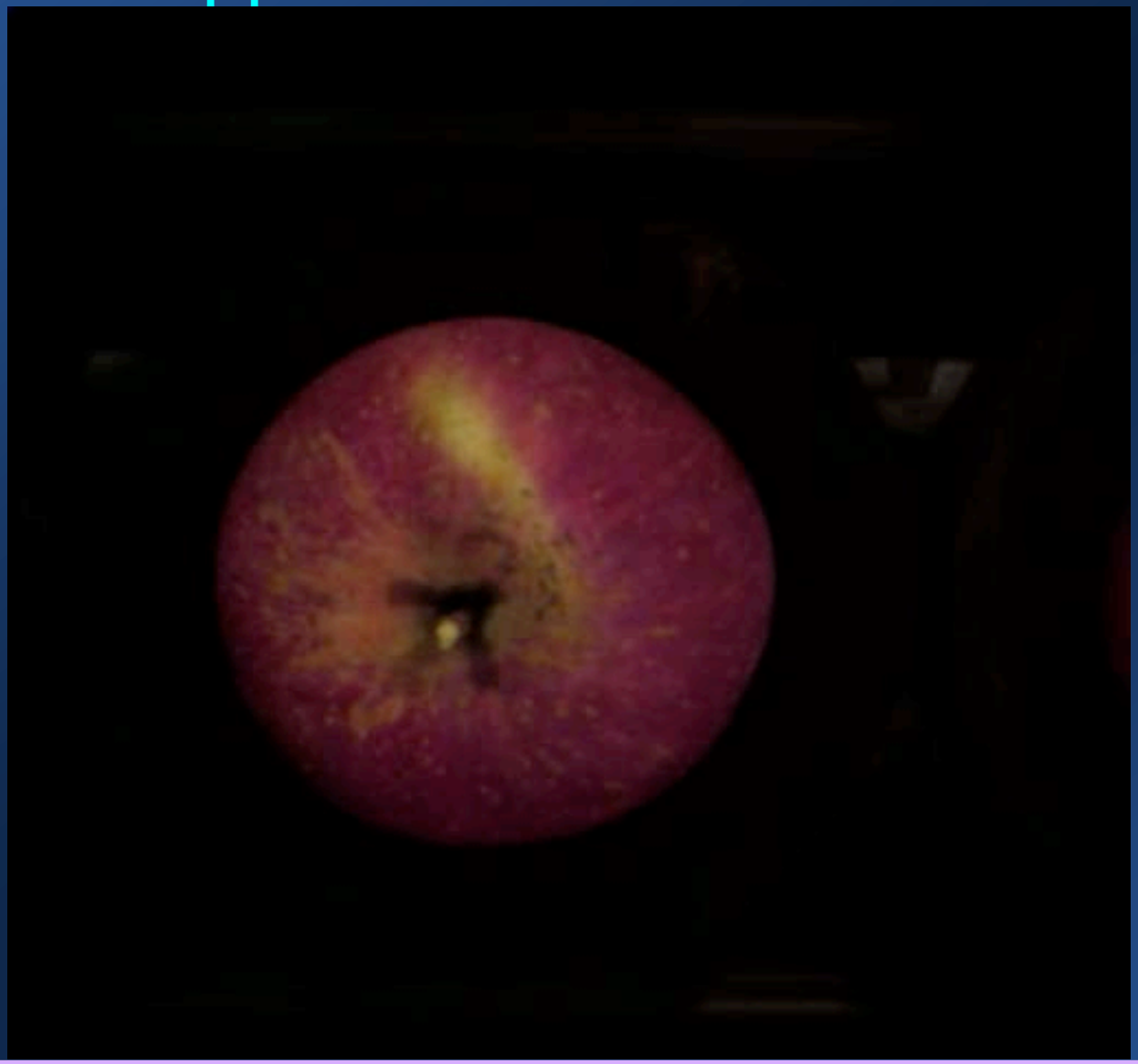


Extracted features from images

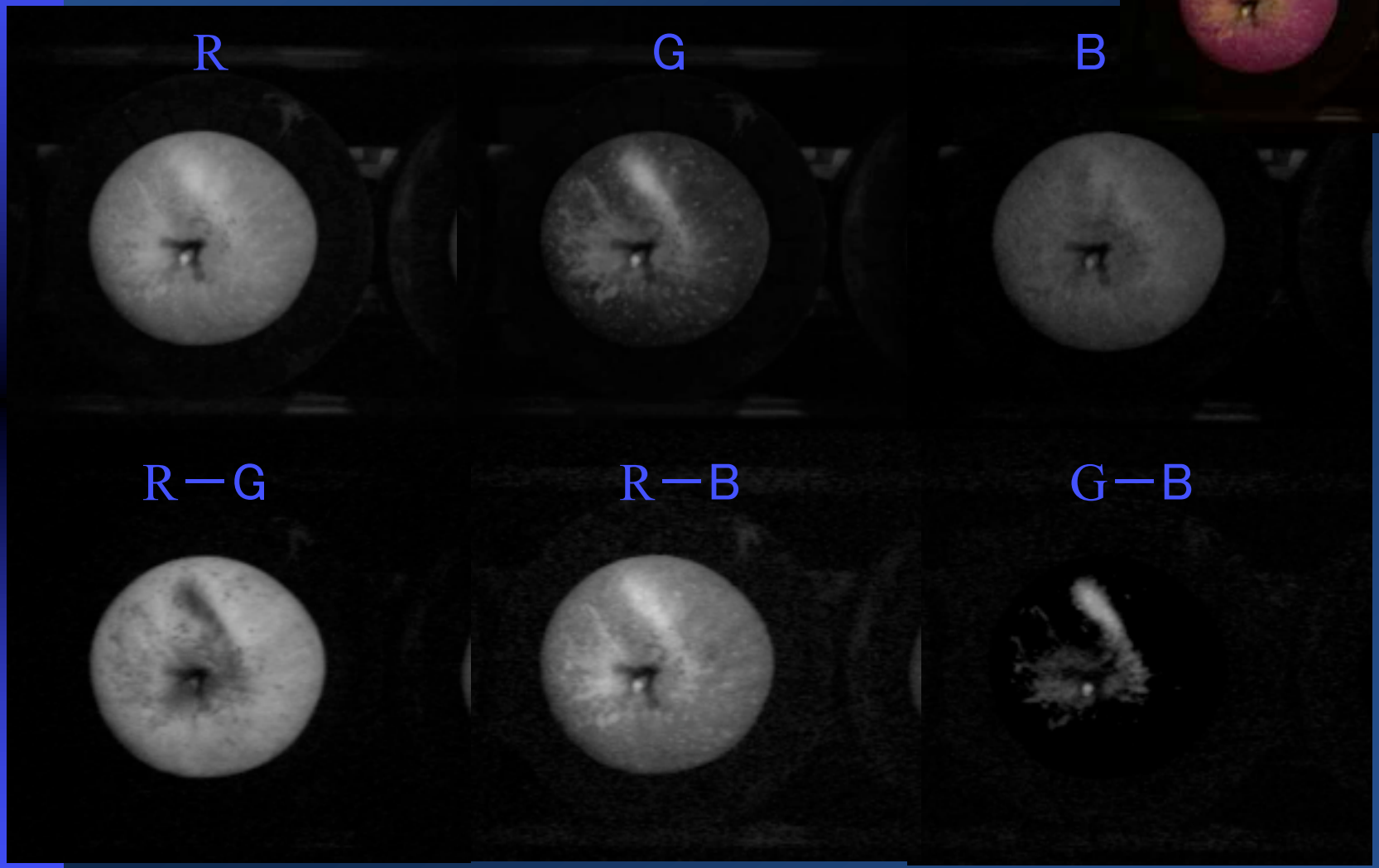


Sizes
Colors
Shape
Defects
Maturity
Dullness (Gloss)
……

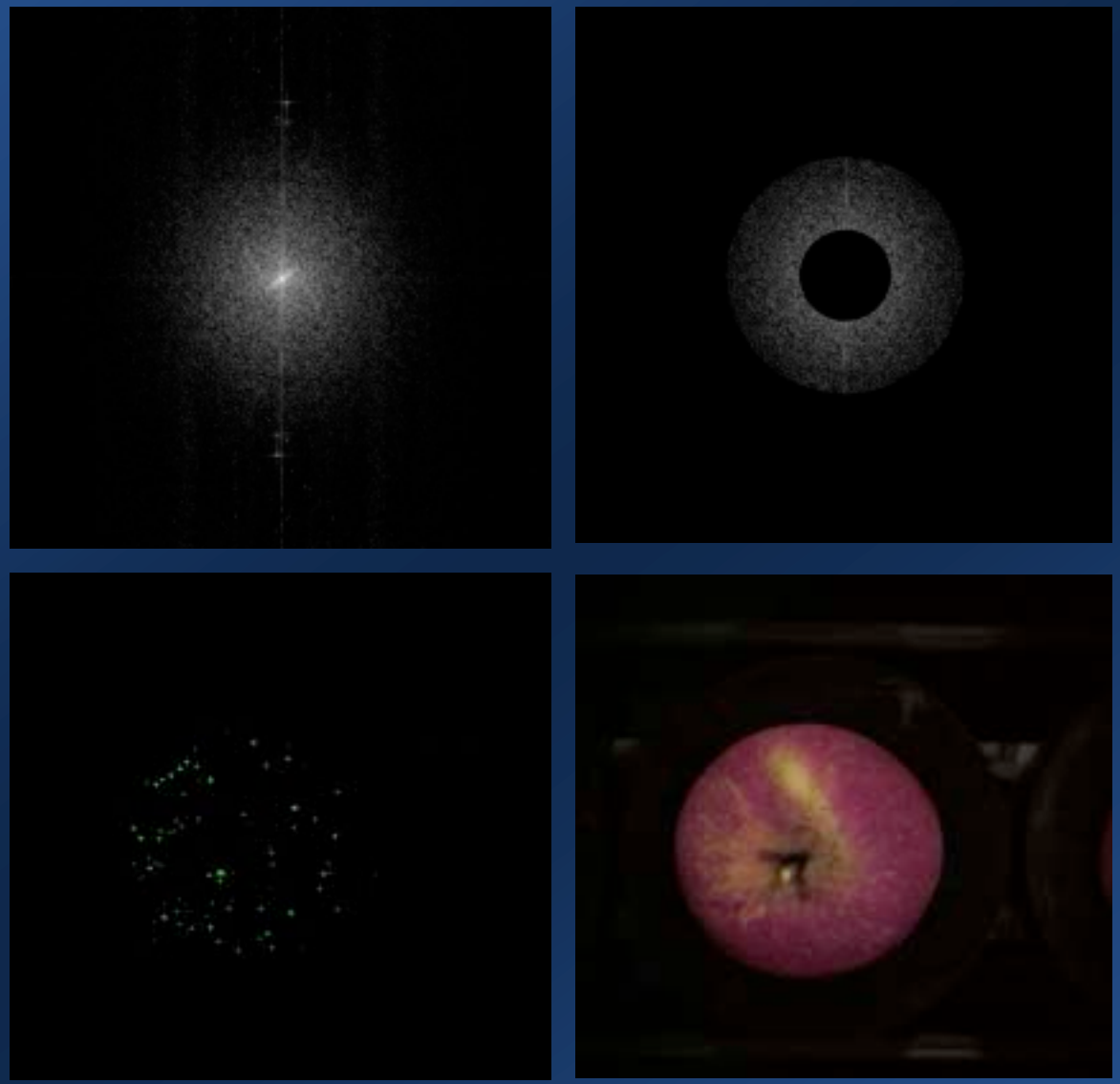
An apple fruit with discoloration



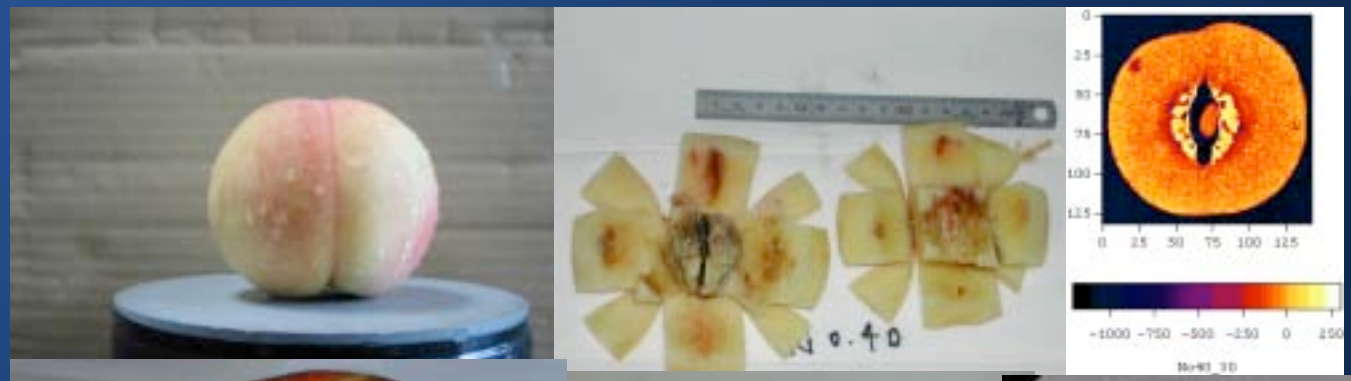
Color component images



FFT

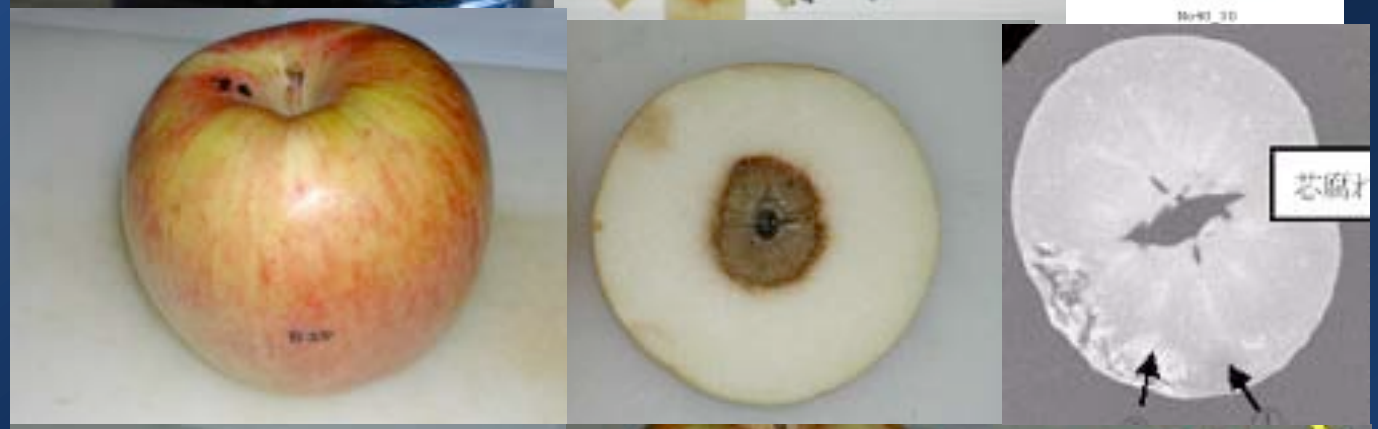


Internal defects detection by X-ray CT



Peach with

Split-pits

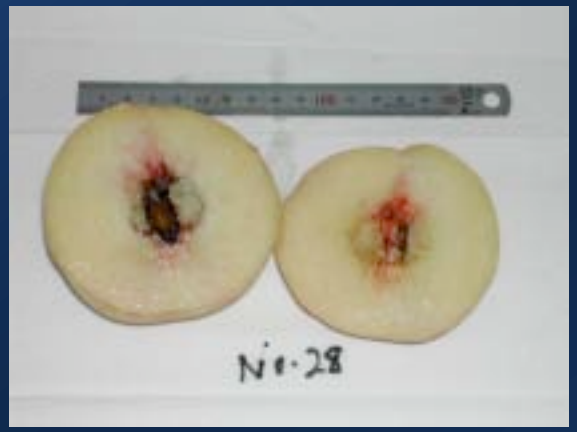


Rotten core

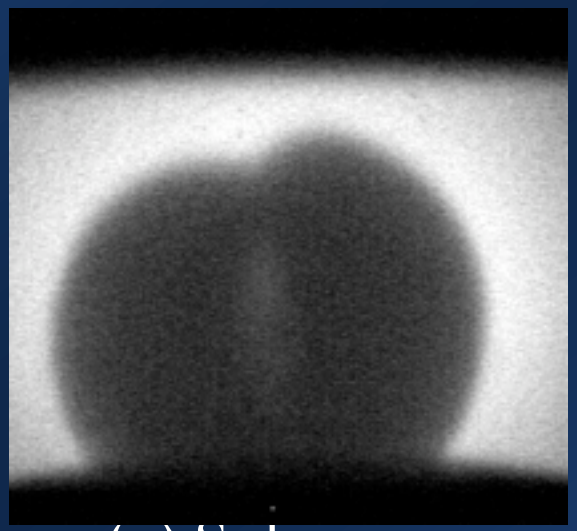
Moth sucked defect

Experimental result（sprit-pit of peach）

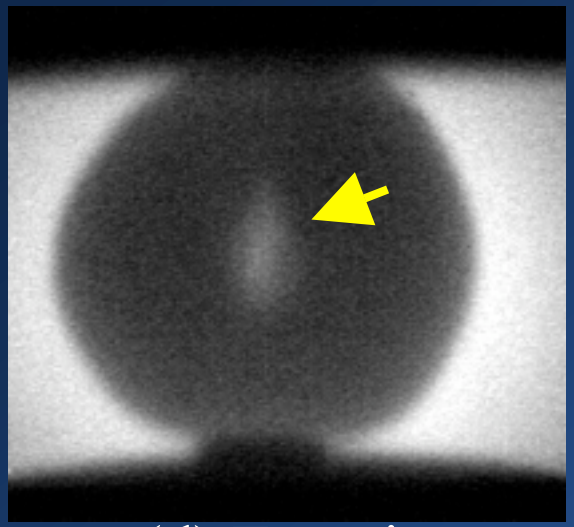
(a) Appearance



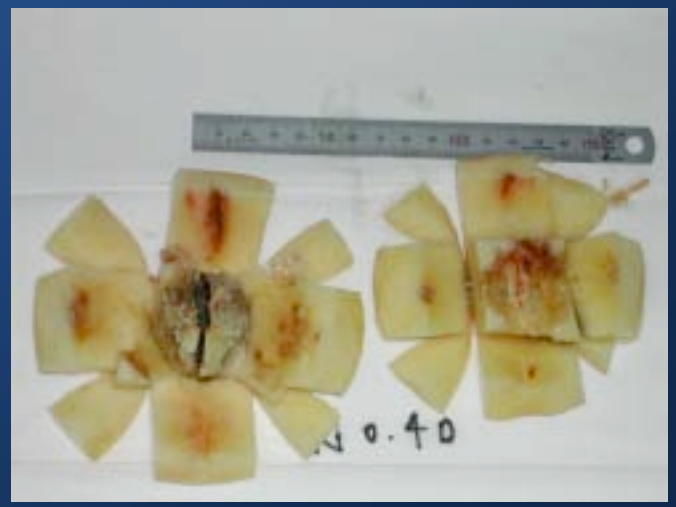
(b) Cut sample (Sprit-pit)



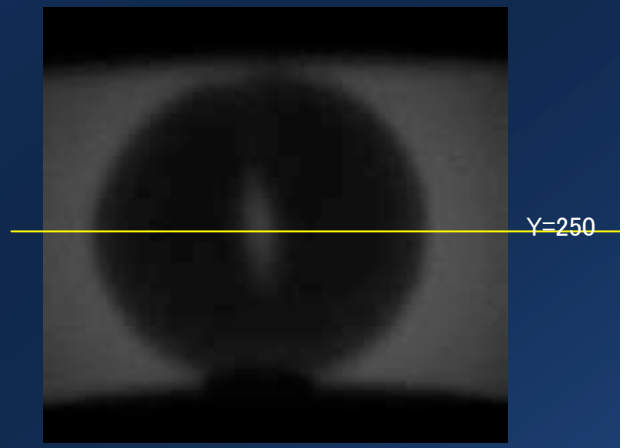
(c) Side view

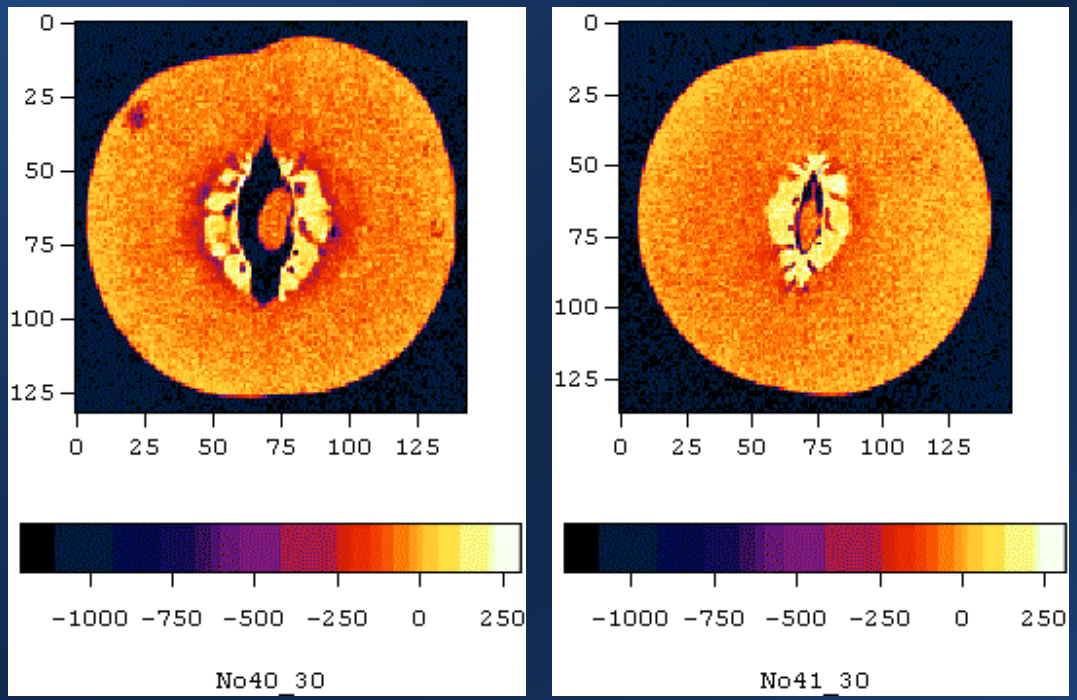


(d) Top view

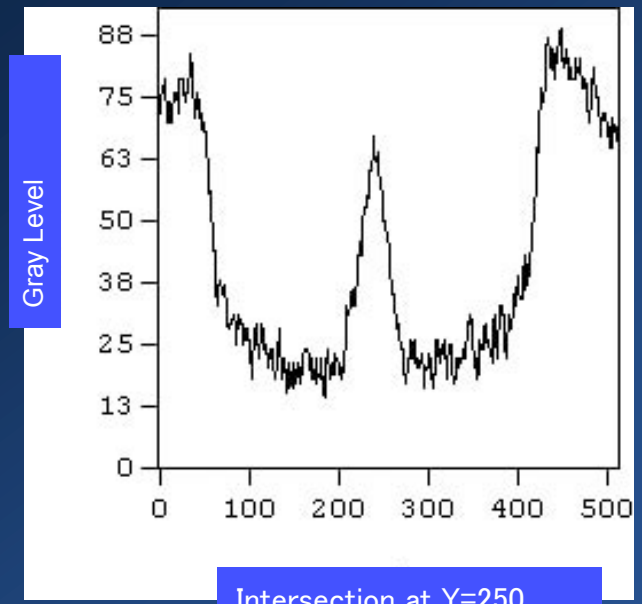


Transparent Image
Output Voltage: 50keV





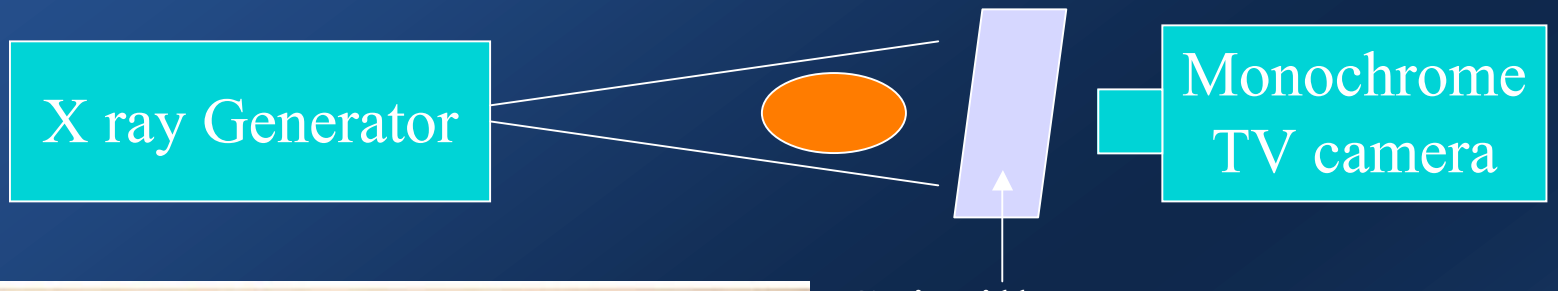
CT Image



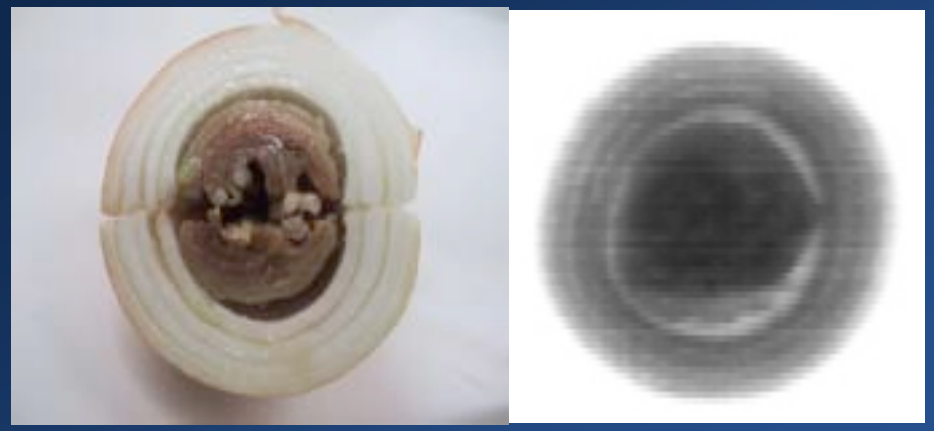
Intersection at Y=250

Peach with Split-pits

X ray image



Hollow potatoes

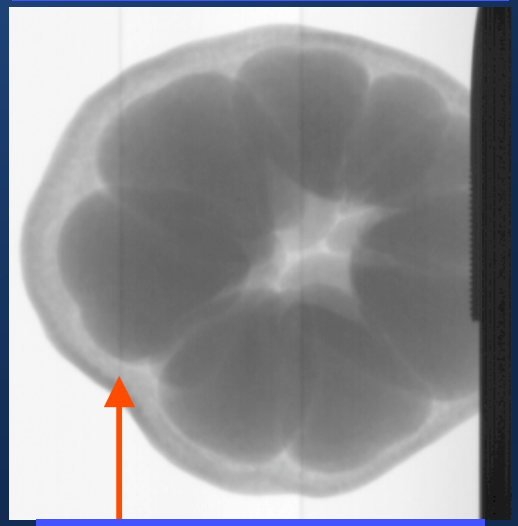


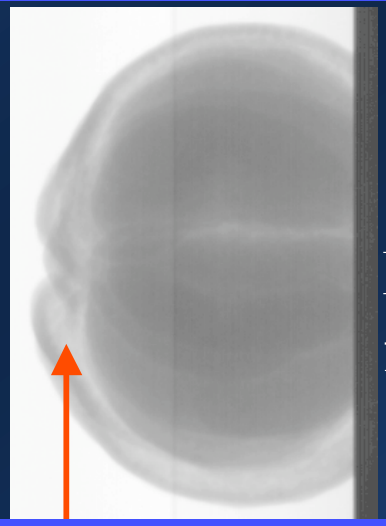
Rotten core onion

X-ray images of orange fruits

Top view

Side view

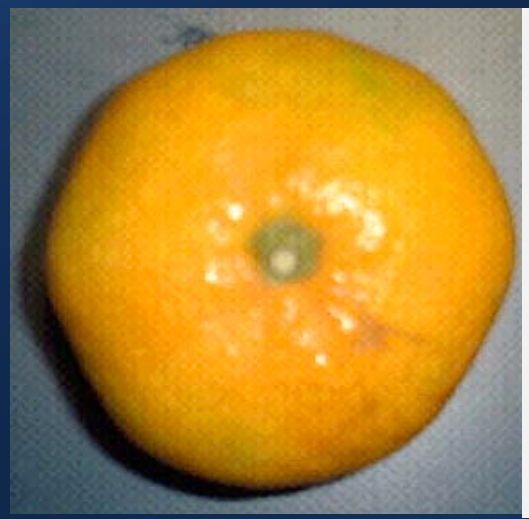


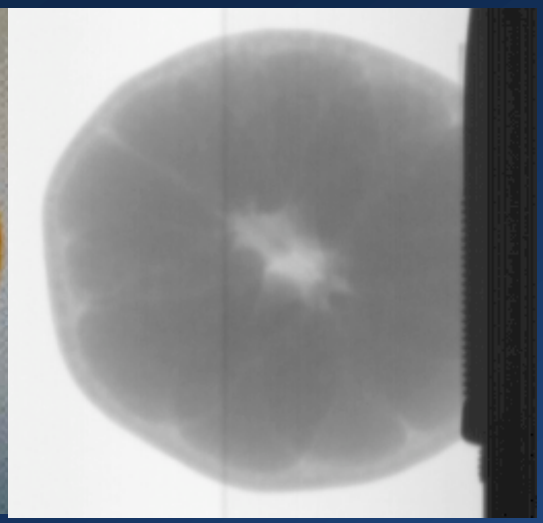


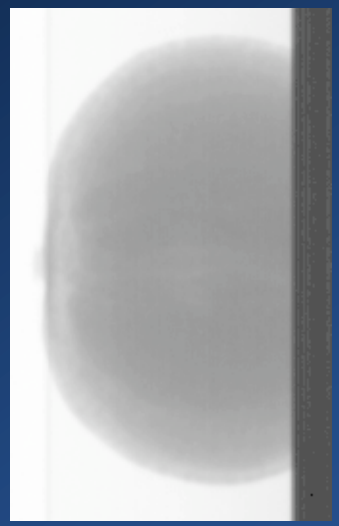
Rind-puffing fruit

Empty portion

Empty portion





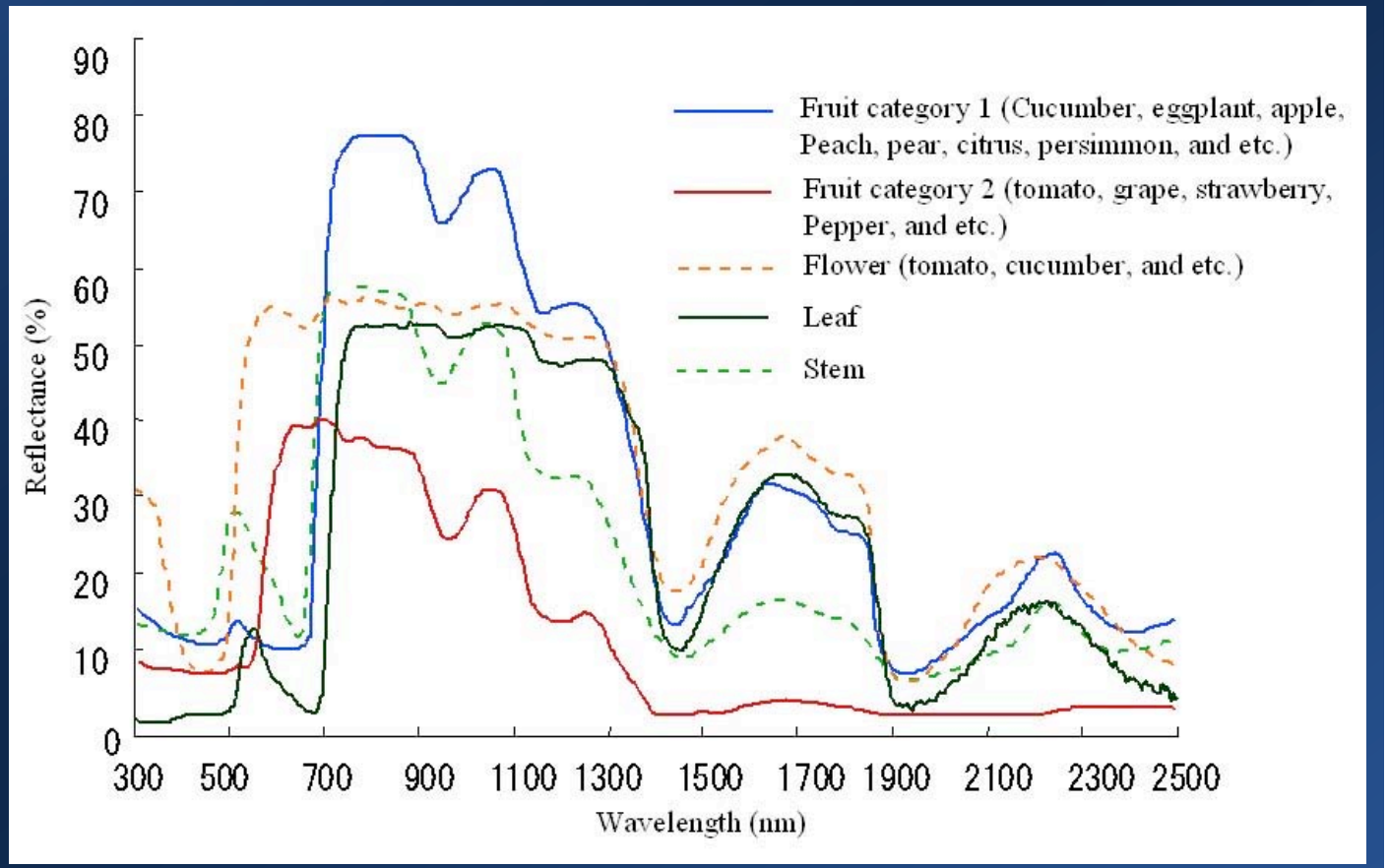


Normal fruit

Ultra violet image

Visible camera

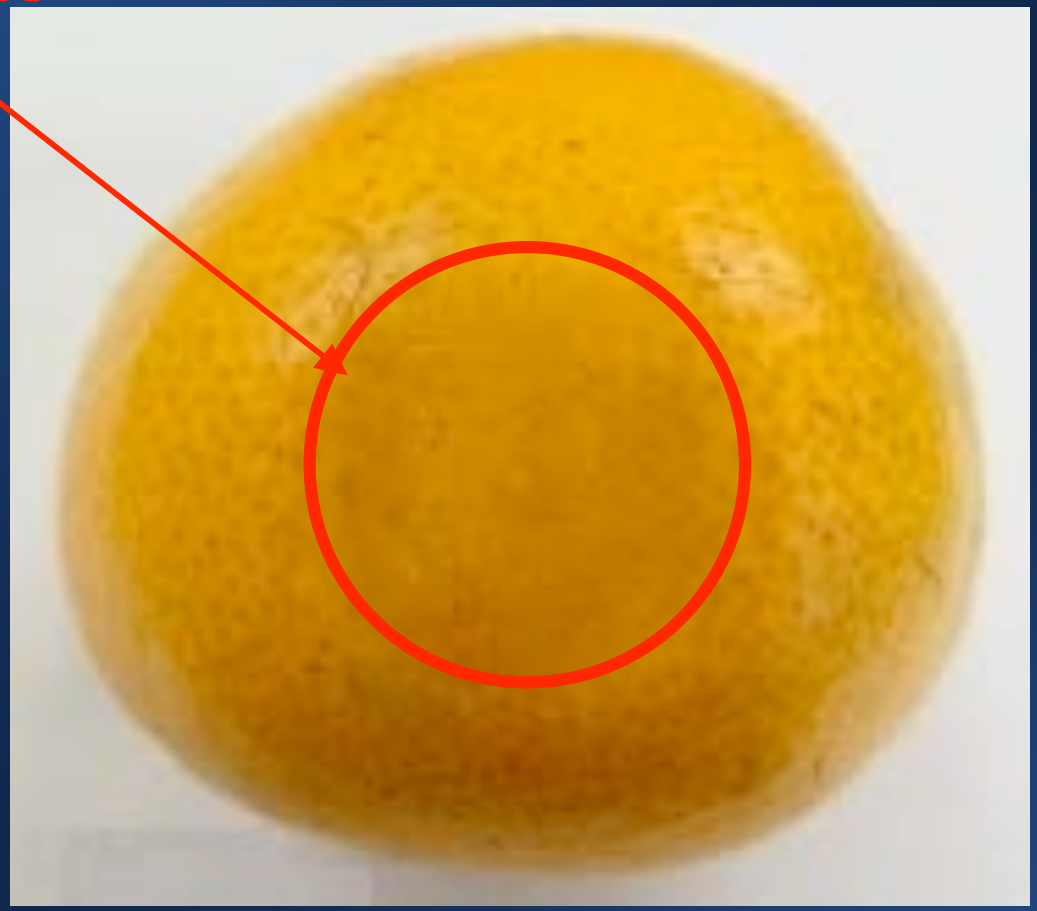
UV camera



Review

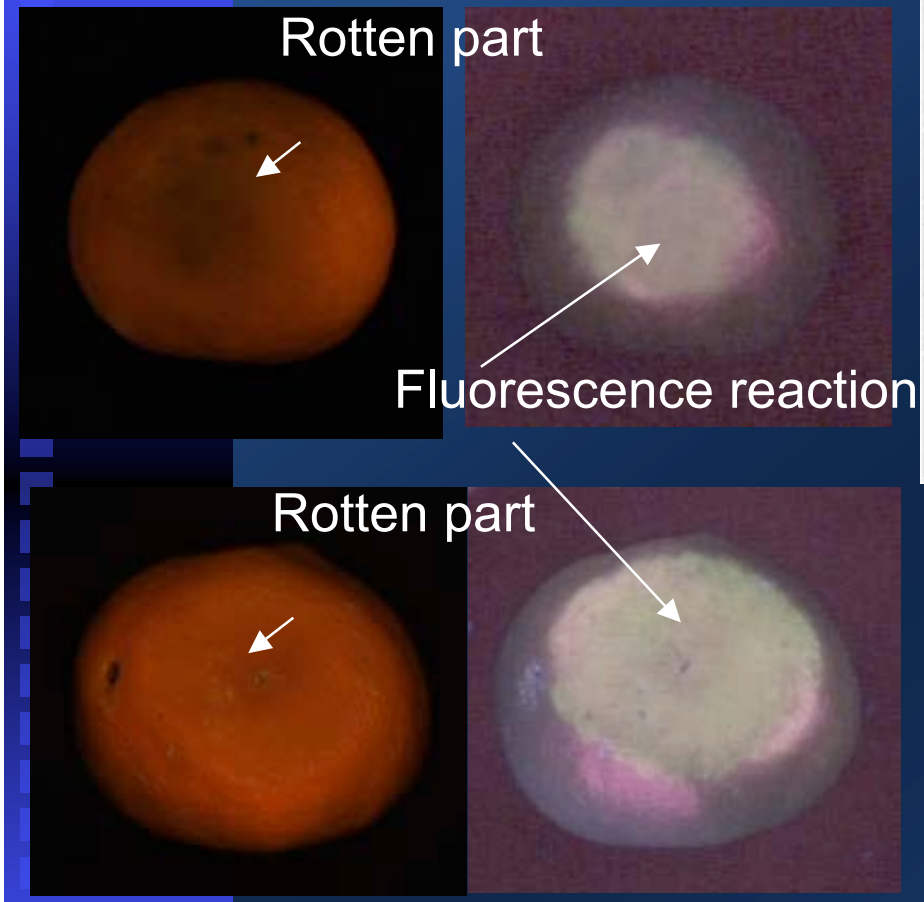
Describe what was the phenomenon “ fluorescence”.

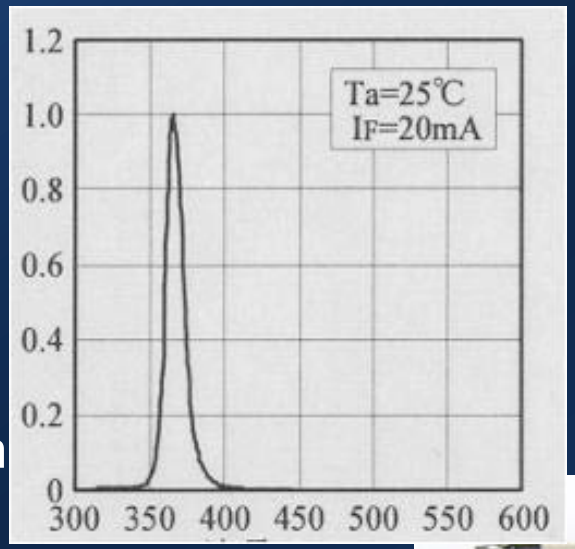
Rotten part

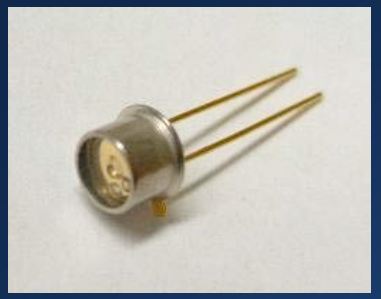


Fluorescence image

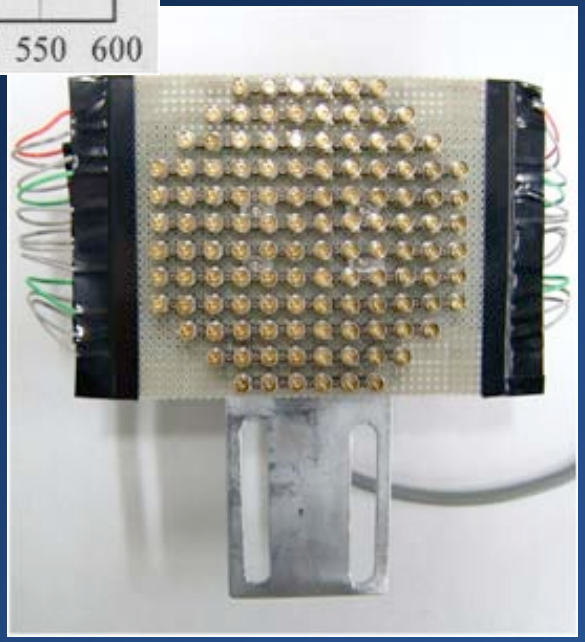
(365nm exciting light)







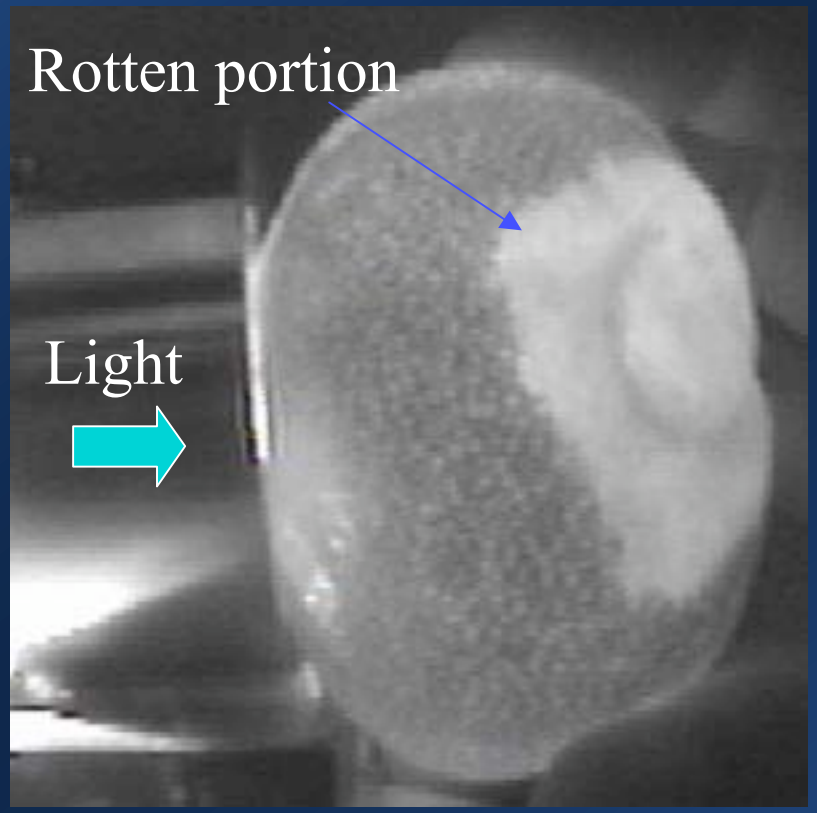
UV LEDs



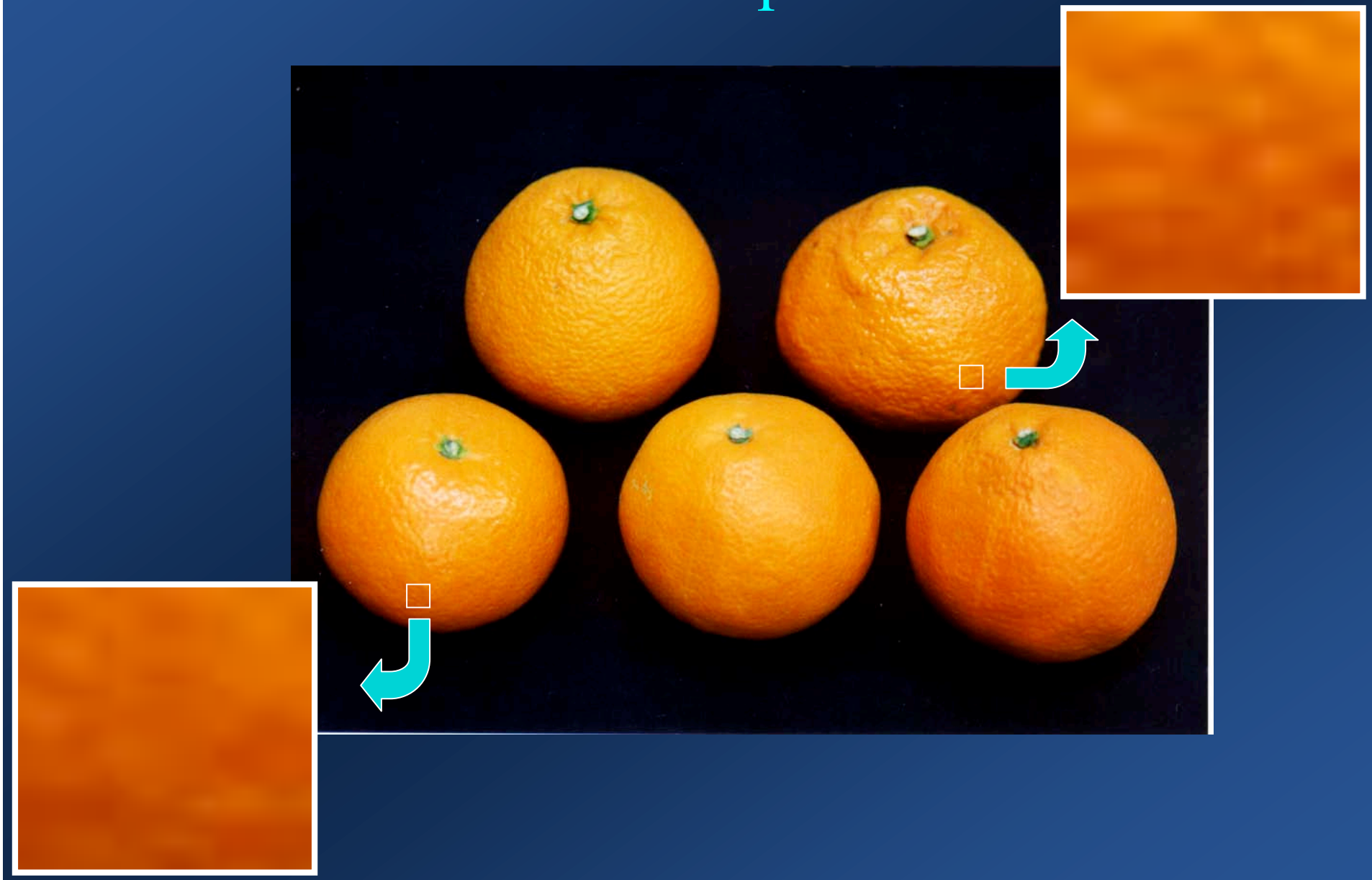
Color images fluorescence images

Infrared

Transmitted image



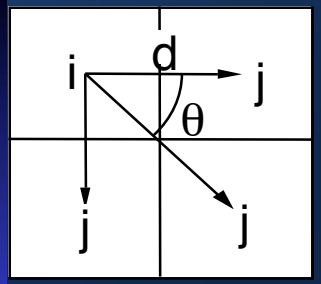
Texture on bioproducts



Cooccurrence matrix and textural features

0	0	1	1
0	0	1	1
0	2	2	2
2	2	3	3

Gray level image



Distance and direction

	0	1	2	3
0	4	2	1	0
1	2	4	0	0
2	1	0	6	1
3	0	0	1	2

$d=1, \theta=0$

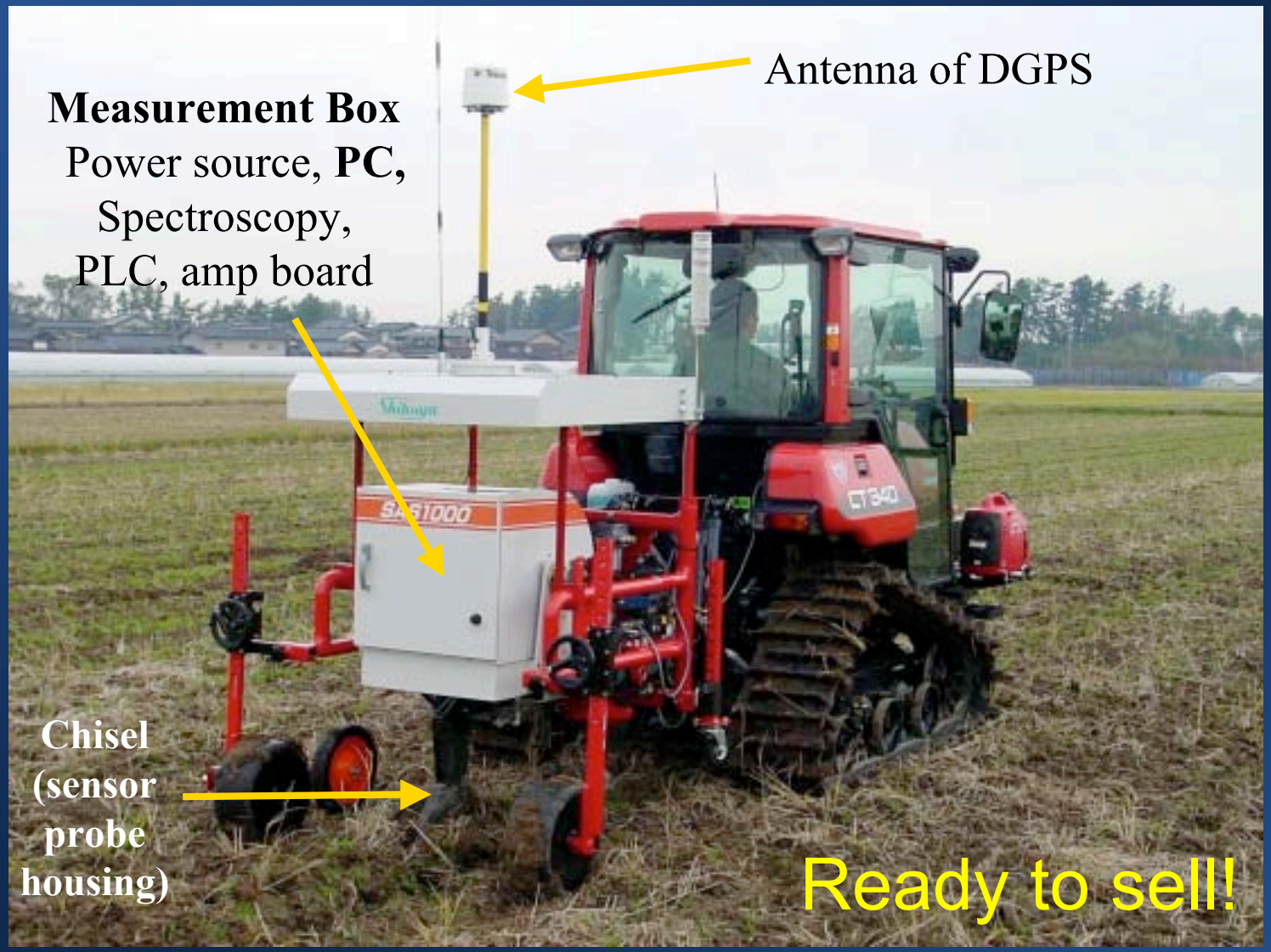
ASM: $\sum_{i=0}^{n}\sum_{j=0}^{n}\{p(i,j)\}^2$

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

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

Haralick, R.M., K. Shanmugam and Its'hak Dinstein. Textural features for image classification, IEEE Transactions on systems, man, and cybernetics, Vol.SMC-3, No.6, 610-621.1973.

SAS1000 – Outline (Real time soil sensor)

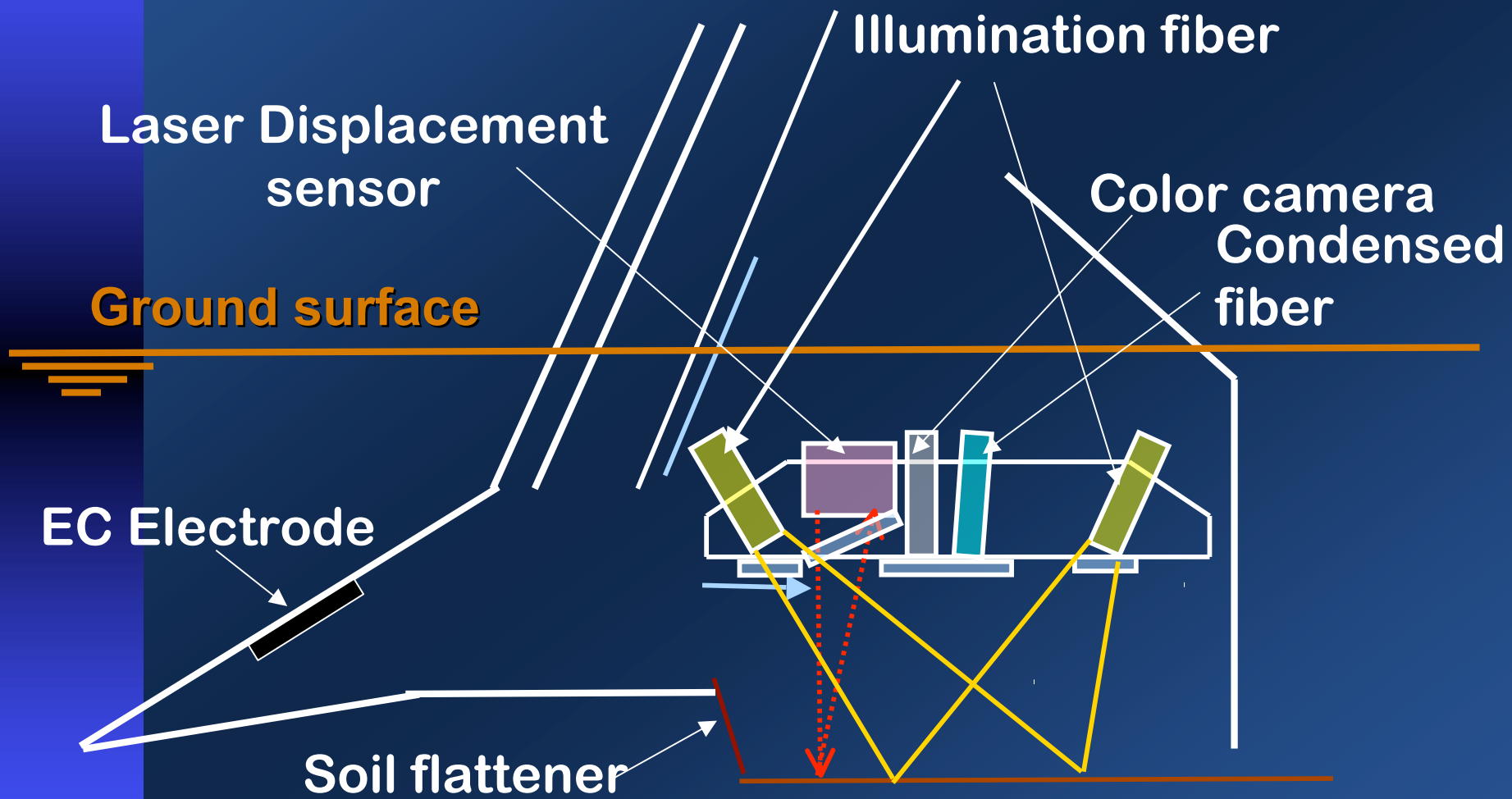


Measurement

Nitrogen
MC
SOM
EC
pH
Compaction
+
Image data

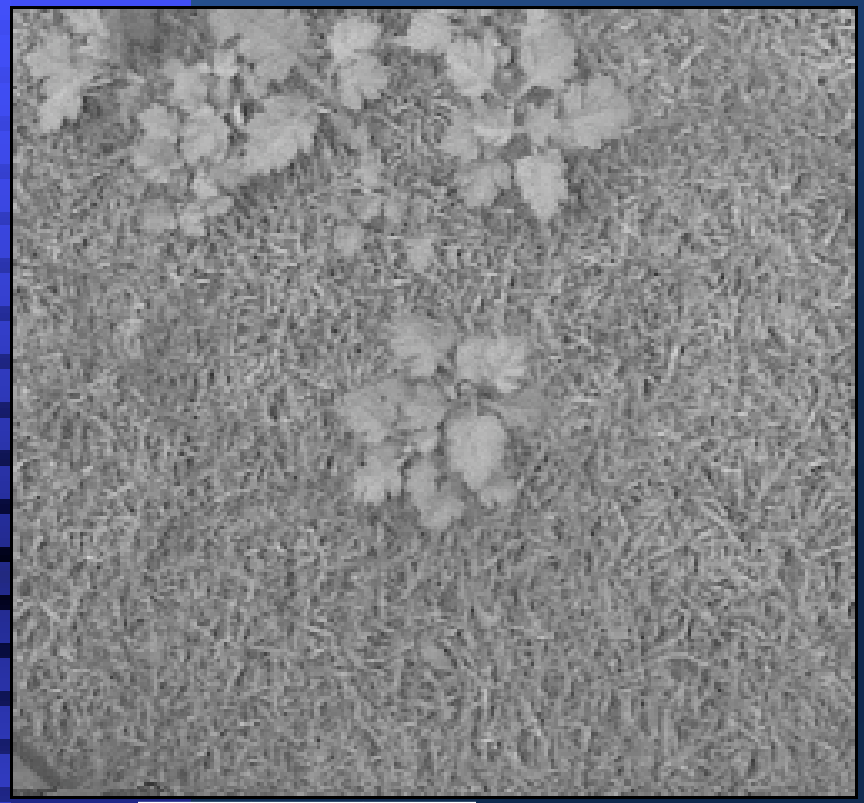
※ Date: 2004. 11. 21 Depth: 150mm, Speed: About 30cm/ sec
Cooperation with SHIBUYA MACHINERY CO.,LTD., TUAT

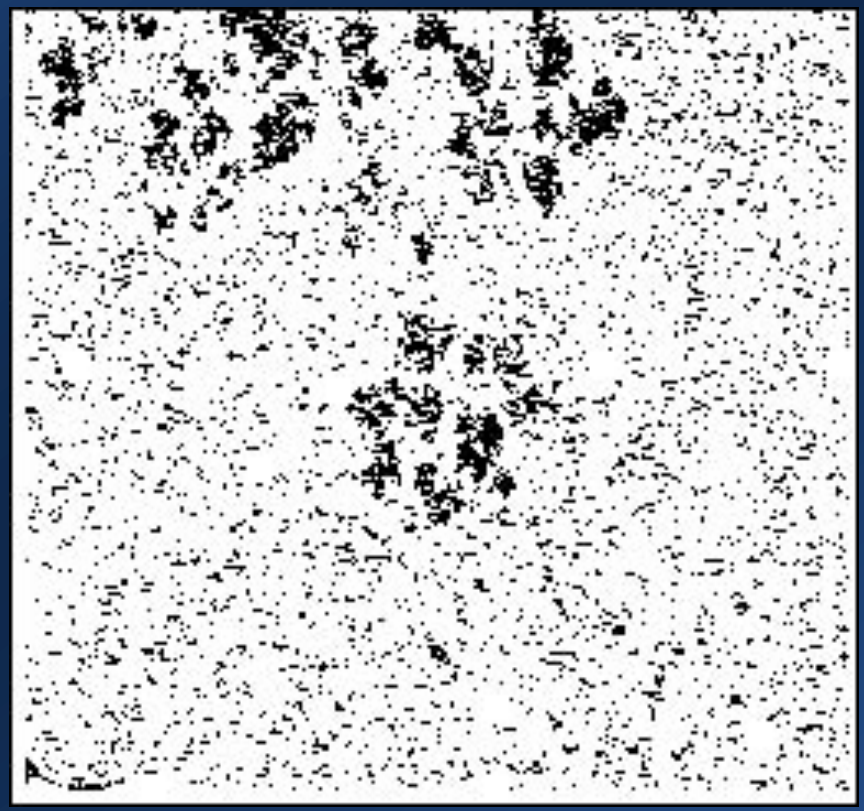
Arrangement of equipments in chisel



Under-ground-Images by the soil sensor

Textural analysis

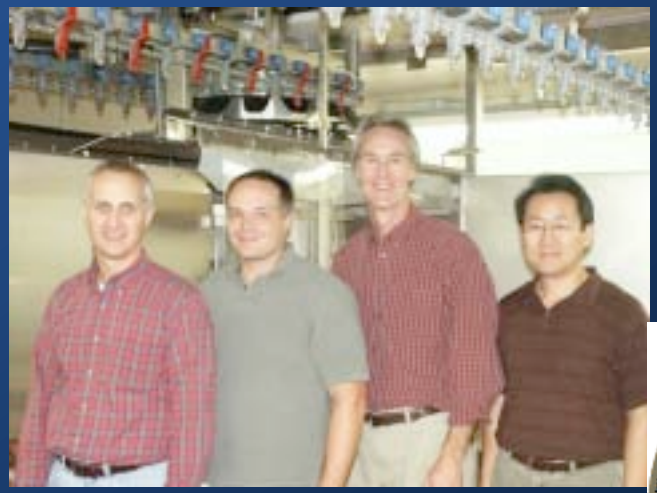




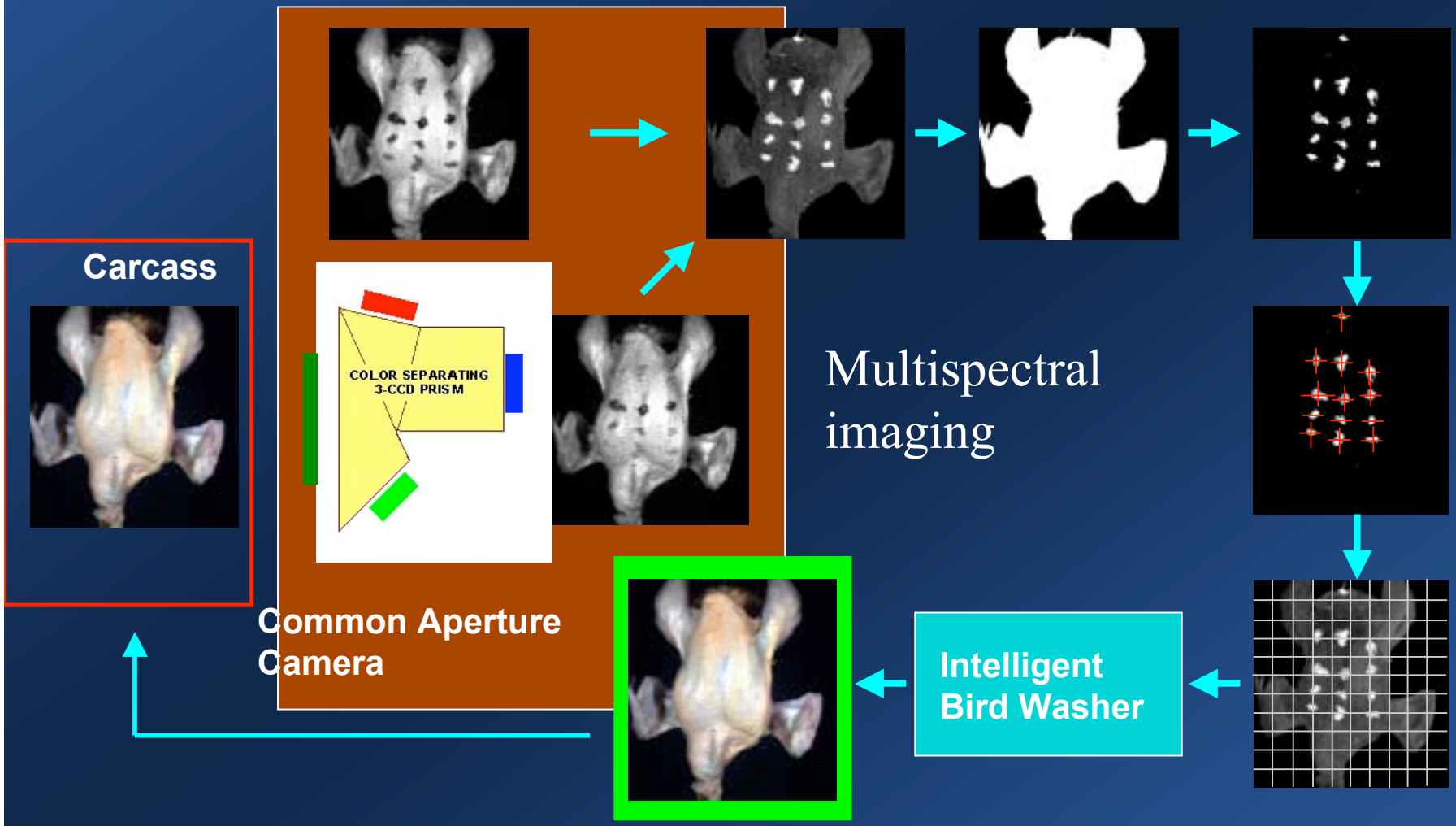
a	b	c
d	e	f
g	h	i

$$\frac{(\max\{a,b,c,d,e,f,g,h,i\}-\min\{a,b,c,d,e,f,g,h,i\})\times k}{(a+b+c+d+e+f+g+h+I)/9}$$

USAD-ARS Imaging Research Team



Method & System for Intelligent Washing of Fecal & Ingesta Contaminants

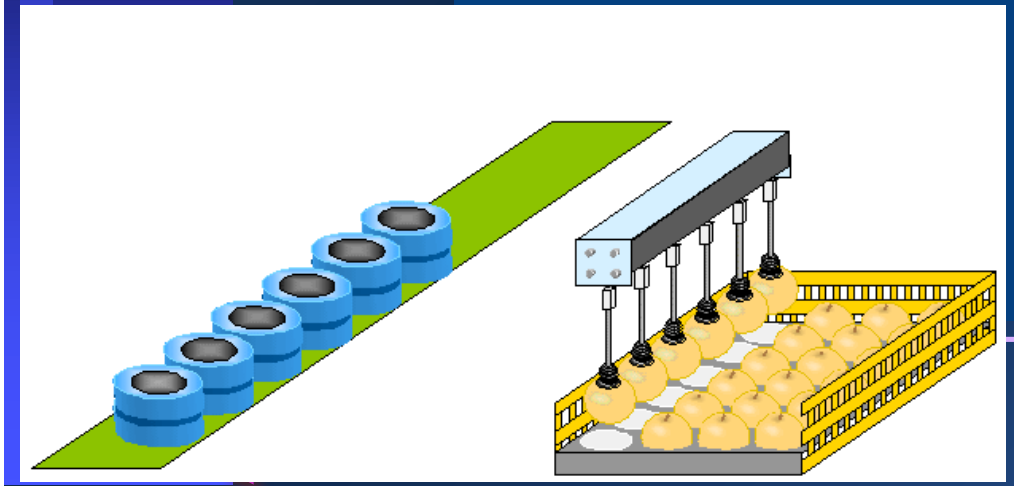


Machine vision for seedling production

Cutting sticking robot

Transplanting robot

A fruit grading robot with machine vision



KYOTO 京都大学 UNIVERSITY

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…..)