Image Analysis for Recovered Fibers

Created by Roy Rosenberger, Verity IA LLC

For Tappi Recycling Workshop 2005

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IA as a Quality Control Tool

- This presentation was created by the founder of Verity IA, Roy Rosenberger, for a TAPPI event in 2005. Some of the information has been updated, but the material in general remains a good introduction to the insides of Image Analysis vs. Dirt Count

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Why use Image Analysis?

- To get quality measurements more consistent than those that can be achieved through visual inspection.
- To save time producing data in a live production environment.

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Topics

- Equipment: PC with ample memory; Desktop scanner
- Theory
  - Desktop Scanner: Resolution (600 ppi), digitized image
  - Threshold: Automatic Offset from Mode or Average
  - Filters: Shape - Size - Luminance
- Measurements: Dirt Count, PPM, Reports
- Stickies

- Measurements - White Stock
  - Traditional Dirt Counting (TAPPI T-213, T-437)
  - Single color Gray
  - Dirt - Specks - Contraries; Fiber - Shives - Other
- Linerboard __ Two Color minimum
  - Dirt, Specks, Contraries, black and brown
  - White Coated Broke
- Stickies - Size — Shape — Luminance T-277 white coated stickies with multiple contaminants

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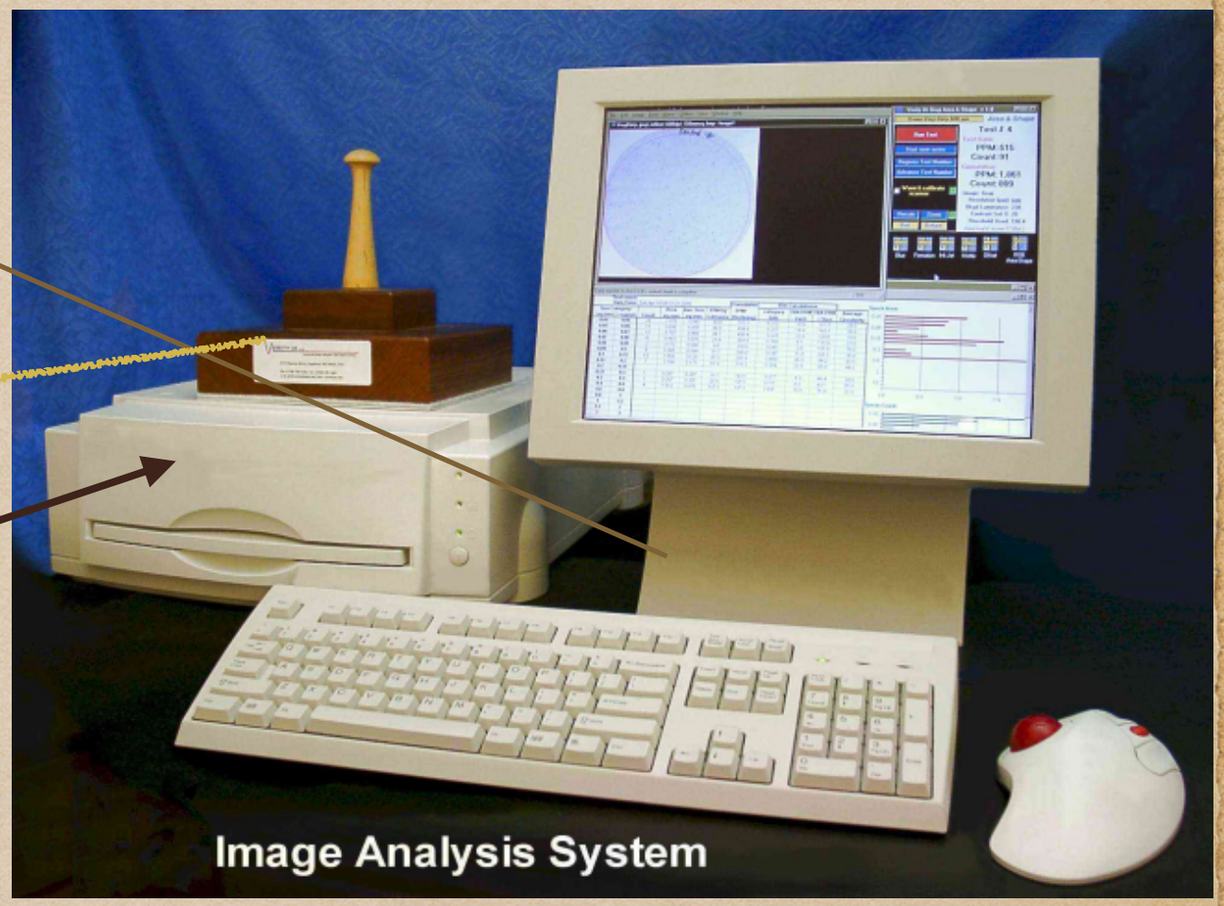
Scanner-Based Measurement Apparatus

Image Analysis software with Excel Reports

- Verity IA Software Application
- White faced specimen weight
- Scanner with axially symmetric illumination
- Multi-core PC with 16 GB RAM, Storage of 1 - 2 TB



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Recommended Scanner

- Graphic Arts quality scanner
- Standard off the shelf with specific characteristics
- Minimum Resolution – 600 ppi
- Color – Red, Green, Blue
- Should have two LED lamps for even illumination, such as:
    - Epson Expression 12000 XL
- White faced smooth flat bottomed 2.2 kg weight to hold specimen flat (OPTION)

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Image Analysis Theory

- Scanner & Camera
- Resolution
- Digitized Image
- Gray Thresholding
- Automatic Offset Thresholding
- Object Size - Area in sq mm
- Object Shape – Circularity
- Object Luminance
- Sorting & Reporting
- Filtering

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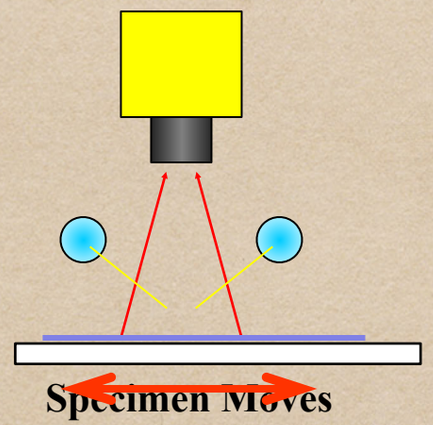
Image Acquisition

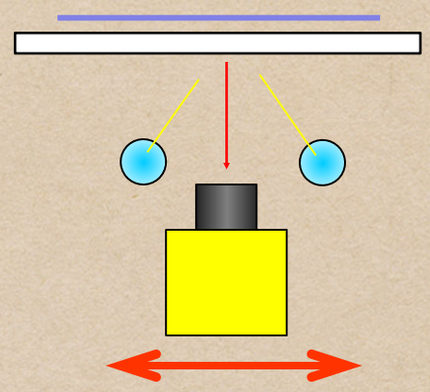
CAMERA
Small Areas

Frame Camera
Forms image one rectangular frame at a time

Axially Symmetric Illumination (T-563)



Specimen placed on glass



Dual Bulb Axially symmetric Illumination minimizes cockle and shadows

Line Scan Camera
Moves & Builds Image one line at a time, similar to on-line devices

SCANNER
Large Areas

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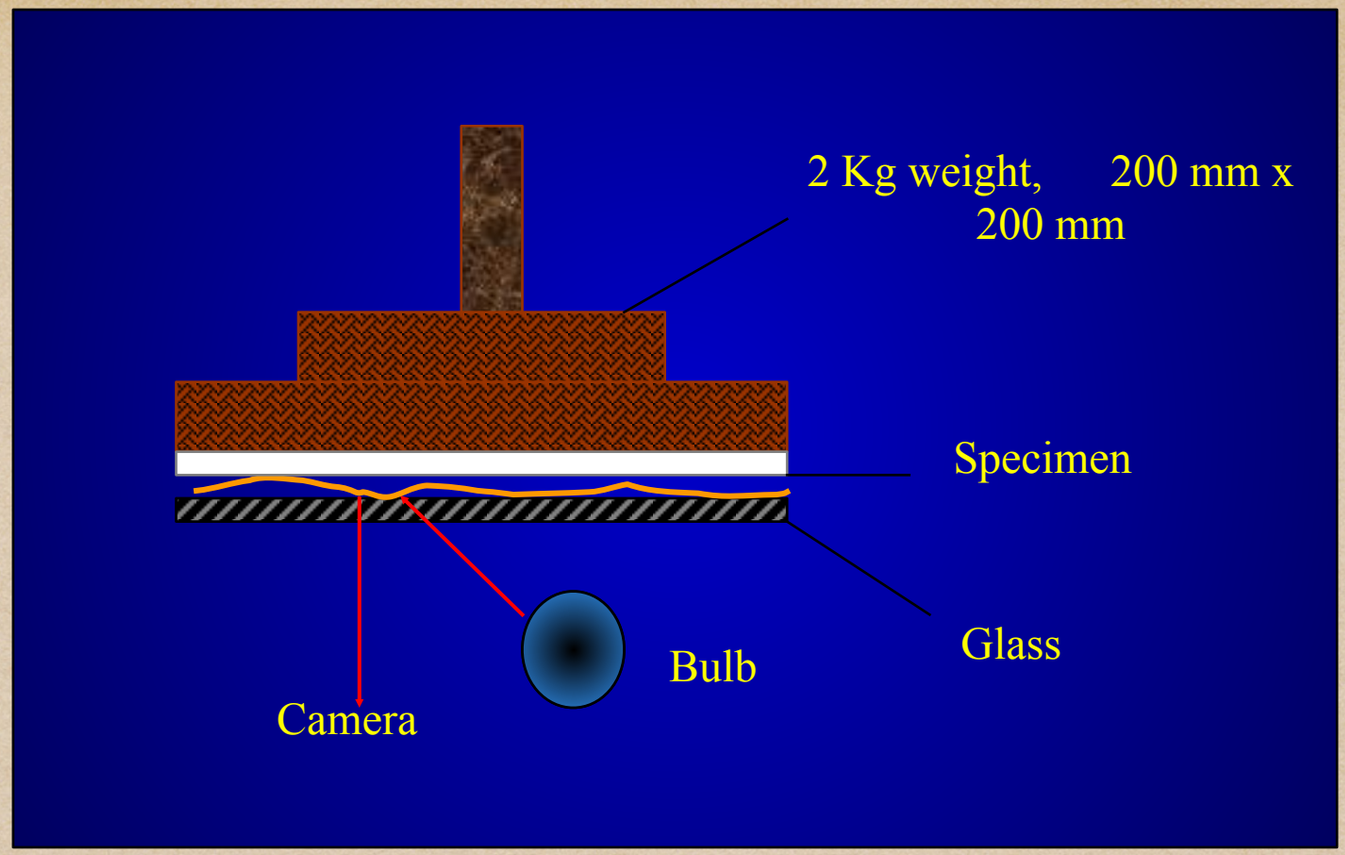

Unidirectional light causes shadows
Uniform Weight of 2 Kg / 200 x 200 mm
Presses specimen fibers and cockle against glass
Helps diminish shadows - does not eliminate in one

This is no longer an issue since scanners now symmetrically aligned LED devices that eliminate shadows and do not require warm-up routines.

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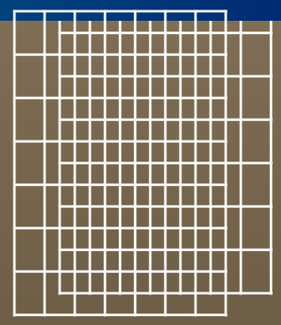
Resolution

Resolution Effect
Doubling resolution
Increases Pixels by 4



Optical resolution

Internal camera optics picture point count per inch

Pixel

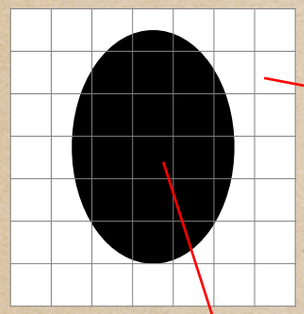
The sensor inside the camera is a Point

Sensor points are in either a 1 or 2 dimensional array

Picture points become squares when viewed and occupy 2 dimensional space and are then pixels

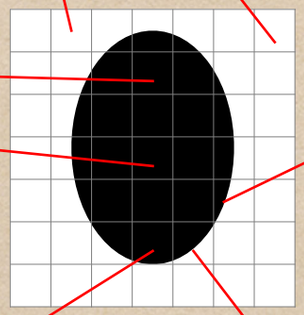
Digitized Image of Dirt

8 bit Gray Scale
0% Reflectivity = 0 Gray
Value (GV) 100%
Reflectivity = 255 GV



235 GV
Background

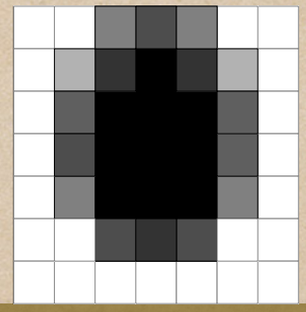
55 GV
Completely
enclosed



231 GV
Peripheral

60 GV
Peripheral

190 GV
Peripheral



Speck - Digitized
Video Display

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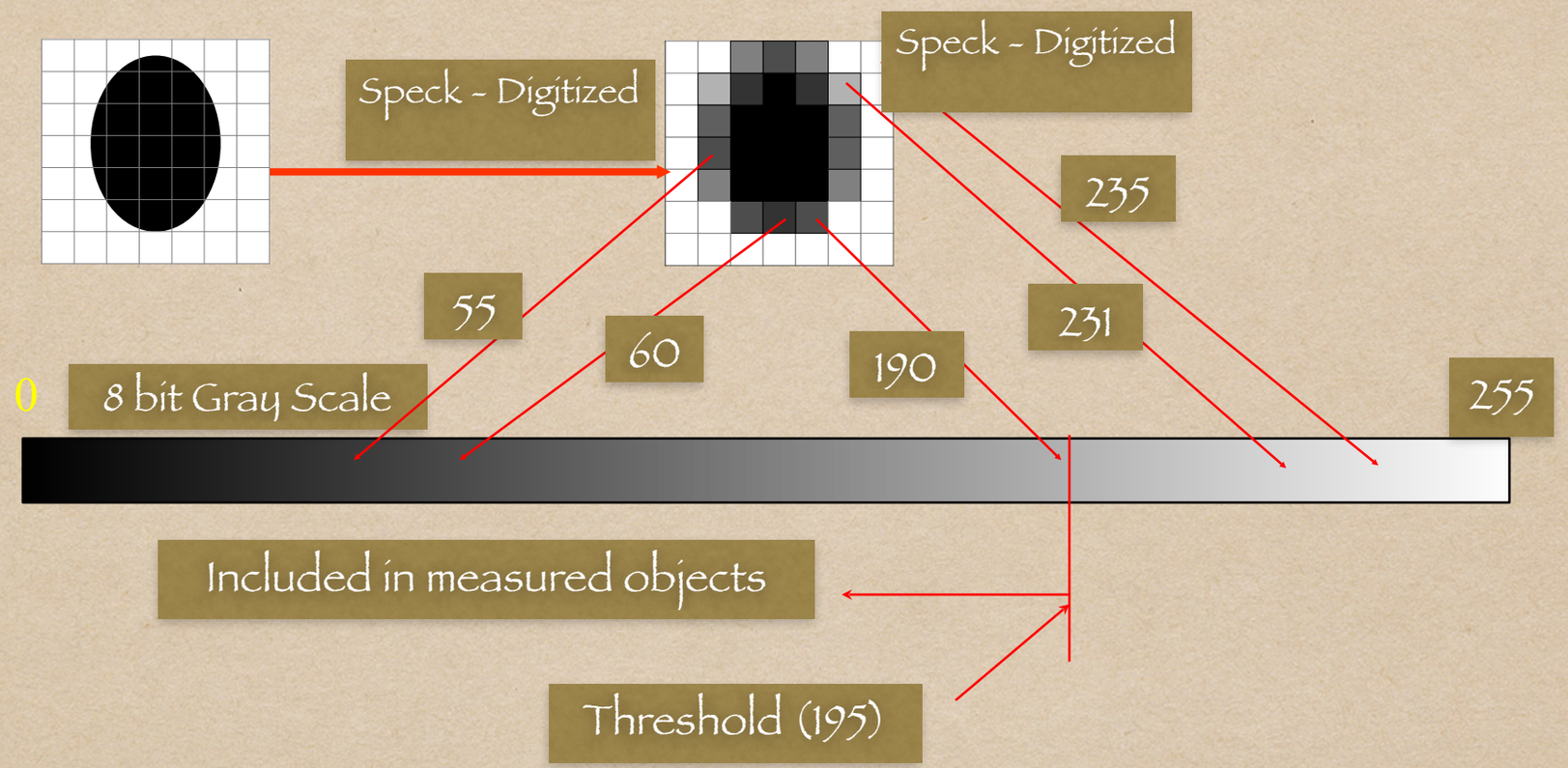
8 bit - 256 Luminance Value Scale



The threshold setting directly effects the reported size and shape of an object.

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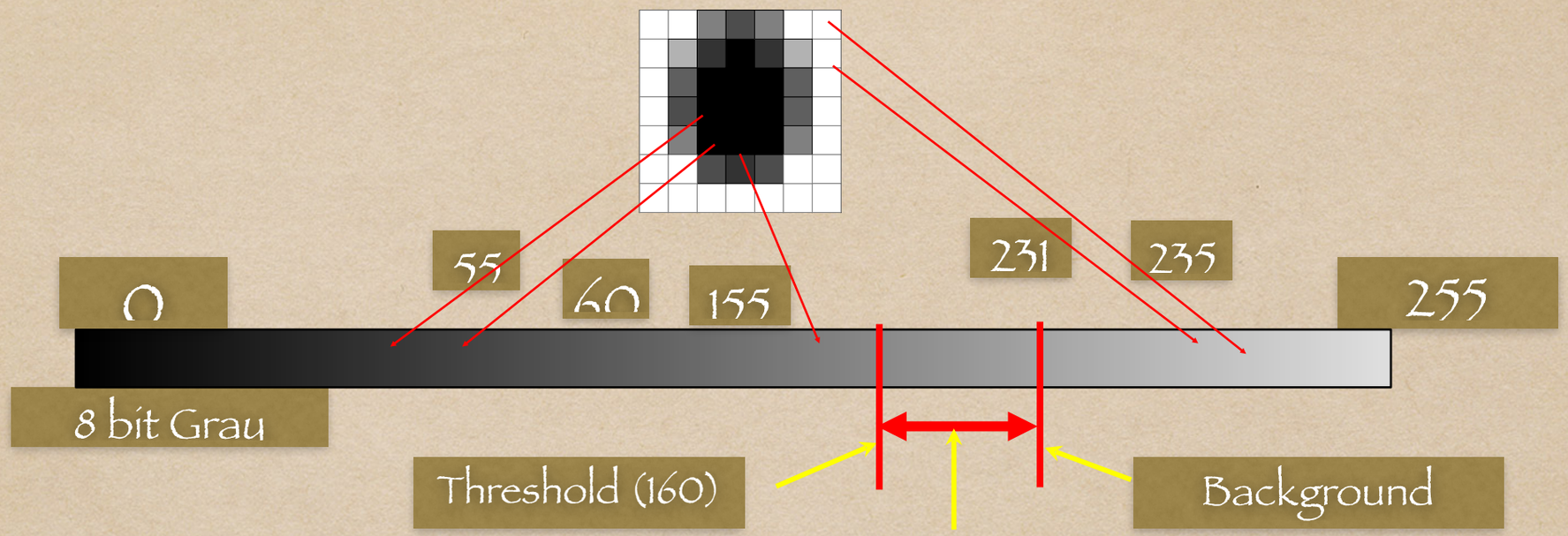
Measure Object Size (Area) - Automatic Threshold



1 – As soon as scan is made- calculate the background

2 – Recover offset from memory

3 – Calculate threshold position

4 – Calculate size of each object based on pixels below (or above) threshold

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Image Analysis

Set threshold

Offset calculated as difference between threshold and background.

Histogram of image pixel luminance values

Background statistics

Histogram and background statistics area calculated immediately when scan is made.

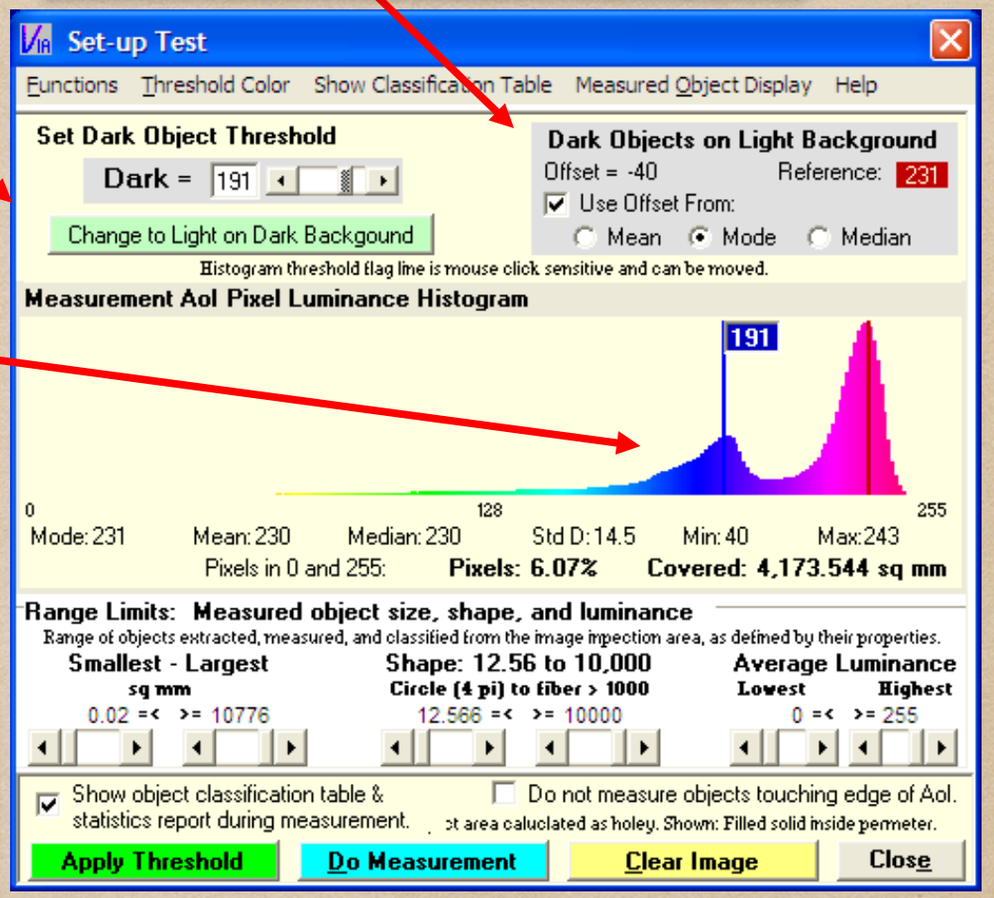

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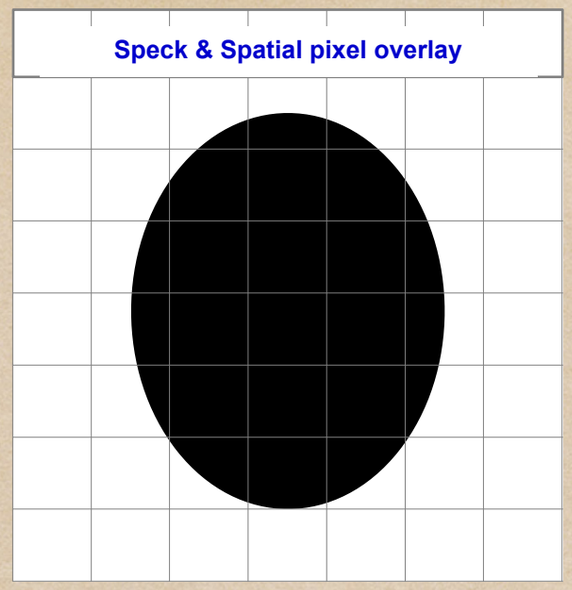
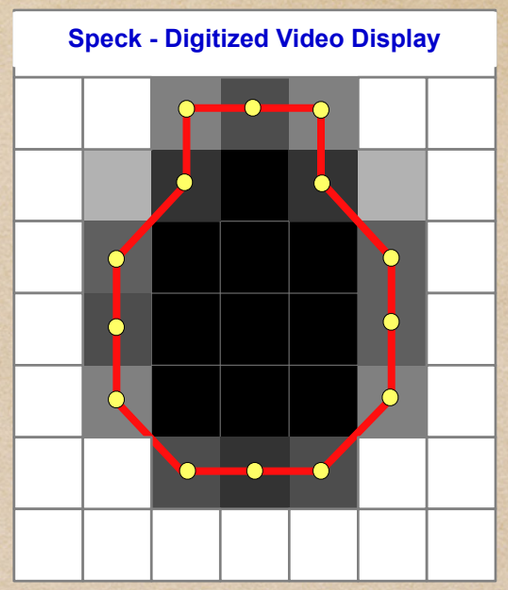
Image Analysis



Picture point spacing = 0.042 mm

Pixel area = 0.001764 sq mm



Peripheral picture points.
A threshold defines area.
Polygon defines perimeter.

Estimates area
Good perimeter & shape

Area = 24 pixels X 0.001764 sq mm / pixel = 0.042 sq mm

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Shape is the same as circularity

Setting shape analysis

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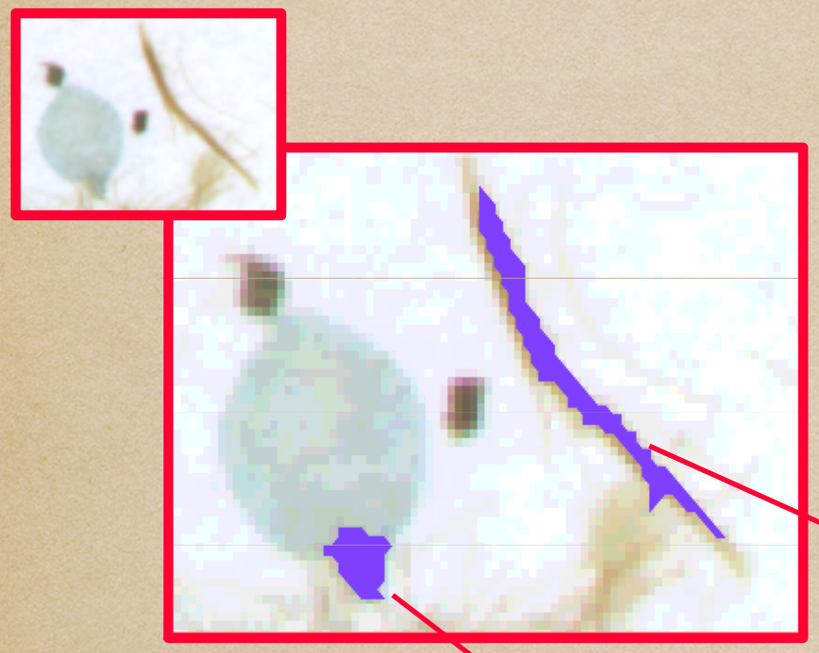
P= Perimeter

A = Area

C = Circularity (Shape)

$C = P^2 / A$



C = 28

C = 452

For a circle, circularity is always:

C = 12.57, which is 4* Pi,

"C" becomes greater as the shape changes from a circle. "C" for a long thin fiber becomes asymptotic to infinity.

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What is Shape?

It is the same as circularity.
Most of the objects we measure in pulp and paper can be typified by this rather simple relationship between the perimeter and the subtended area of an object. Circularity of round objects like ink tend towards the number 12.57 and fibers are greater than 150 with bundles falling in between.
The limits to the measurement of dirt excluding fiber bundles would be between 12.56 and 75. Very brief experiments with these limits will yield the proper settings for a test configuration.
Paper & Print Quality offers the user five (5) different object extractions each with its own range limits.

$$C = P^2 / A$$

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