

# **A Look Behind the Scenes:**

## **Understanding Digital Imaging Processing**

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## 2008 - The world of Forensics



Latent Print Examiners reactions differ when it comes to latent print enhancements....

In 1997, the IAI passed Resolution 97-9, which recognized digital imaging as a scientifically valid and proven technology

## **State vs. Hayden (Washington, 1998)**

A latent examiner from (King County) treated the prints with amido black and took them to Erik Berg (Tacoma Police) for digital enhancement

Prior to trial, Hayden challenged the admissibility of the digitally enhanced evidence, saying that this was a novel technique and therefore it did not meet the Frye standard

Two forensic experts outlined the steps that were used to enhance the photos and also demonstrated that this was not a novel process



Digital enhancement technology began at NASA JPL in the 1960's as a way to see faint galaxies against the bright sky

## State vs. Hayden (Cont.)

The trial court ruled that the Frye test did not need to be applied to the enhanced digital images

During the trial, the examiners demonstrated for the jury how the enhancements were done

The defense tried to convince the jury that the images were altered and caused the examiners to identify the wrong man.

Three members of the jury worked for Microsoft...

Hayden was found guilty

**This was the first case where digitally enhanced latent prints withstood direct challenge under appeal**

## **State vs. Hartman (Ohio, 2001)**

The defense challenged the admissibility of digitally enhanced prints and also the expert qualifications of the fingerprint expert to testify regarding digitally enhanced evidence

The trial court determined that

- 1.) The witness was an expert (13 years of experience, 1.5 years using digital enhancements)
- 2.) The witness was qualified to testify because defense never challenged the expert's qualifications during trial
- 3.) Digitally enhanced fingerprint evidence was acceptable and was not using novel science (cited the Hayden case)

## OPEN RECORDS

## Metadata Is Public Record, Says Arizona Supreme Court

Arizona's Supreme Court, in a precedent-setting ruling that may influence other states, has ruled that electronic metadata is public record under state law and must be disclosed as part of a public records request.

The ruling came in *Lake v. City of Phoenix*, a case involving a Phoenix police officer who filed a lawsuit accusing his superiors of backdating a document related to his work performance.

According to *Wired.com*, demoted Officer David Lake had filed a federal lawsuit accusing Phoenix of employment discrimination. He also filed a public records request for documents related to his performance, including notes written



them, its justices unanimously agreeing that "if a public entity maintains a public record in an electronic format then the elec-

tronic format must be made available to the public." The court noted that the metadata request could easily be

## TOPICS

How to describe what a digital image is

How the data are changing when contrast enhancements are applied to an image

How the data are affected by noise removal programs

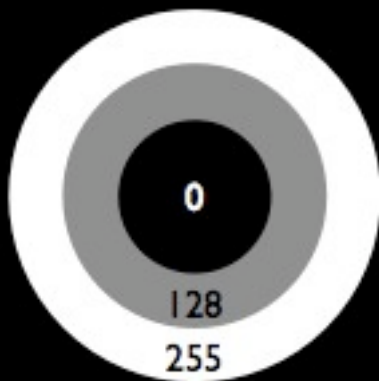
How the data are affected by rotations

Digital enhancement questions that may arise in court

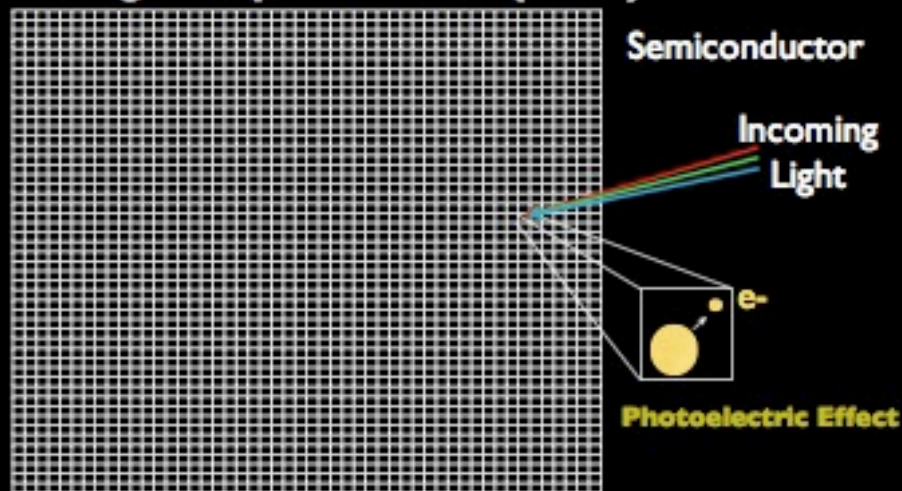


# What is a Digital Image?

A digital image is made of millions of pixels, each of which has a specific position and intensity



# Charge Coupled Devices (CCDs)





**Collectively, individual pixels create the image.**

**We should always be comparing **black** ridges**

*Why?*

The eyes are good at picking out slightly off-white colors on a white background, but not at picking out less black pixels on a black background

**INVERT:** Every pixel gets the “opposite value”  
**Black** becomes **white**  
**white** becomes **black**,  
and the median stays the same.

ACTUAL IMAGE



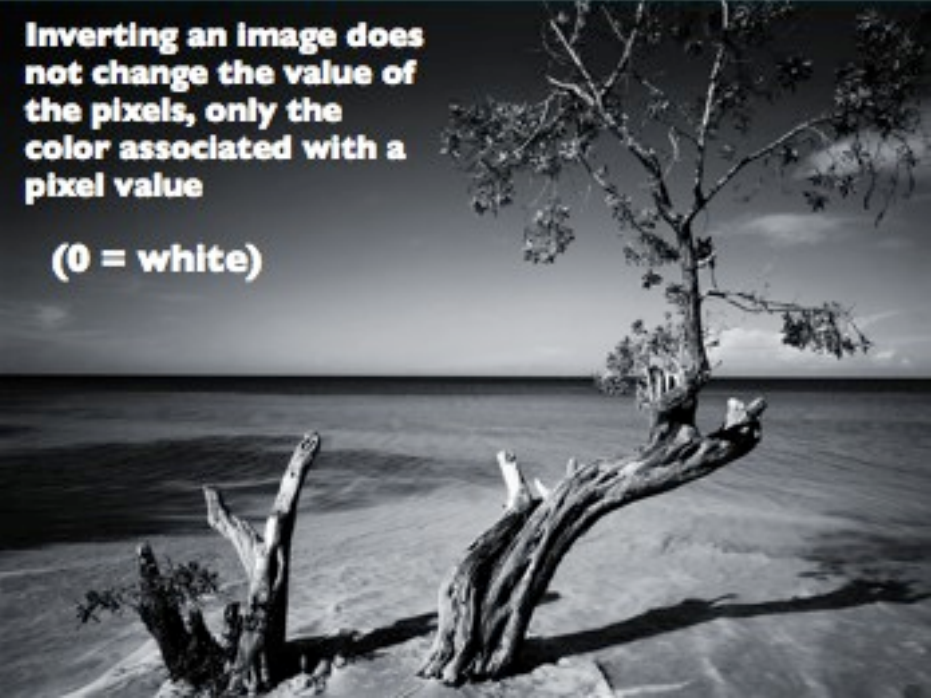
INVERTED IMAGE



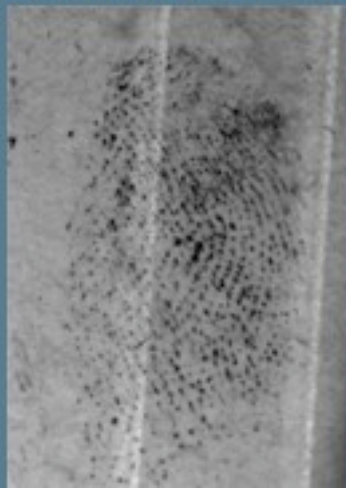
The details are more obvious  
in the inverted image

**Inverting an image does  
not change the value of  
the pixels, only the  
color associated with a  
pixel value**

**(0 = white)**

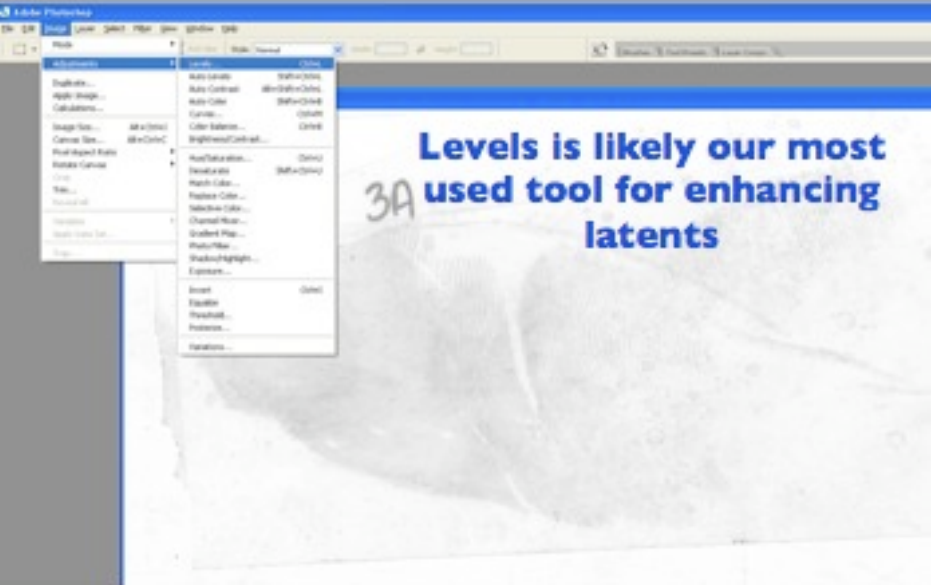


Most digital enhancements are applied to latent images for the purpose of seeing more contrast between ridges and furrows



We need to be able to establish the data (ridges) from the background

**Background:** The level of grey that dominates the image in the areas where there is no data (friction ridge detail)



**Levels is likely our most  
used tool for enhancing  
latents**



# PHOTOSHOP - LEVELS

Levels



Channel: RGB



Input Levels:

0

1.00

255

**Number of  
pixels with  
that value**



**0  
(black)**

**255**

**(white)**

Output Levels:

0

255



OK

Reset

Load...

Save...

Auto

Options...



Preview

# PHOTOSHOP - LEVELS

Levels



Channel: RGB

Input Levels: 0 1.00 255

**SLIDERS**

Output Levels: 0 255

OK

Reset

Load...

Save...

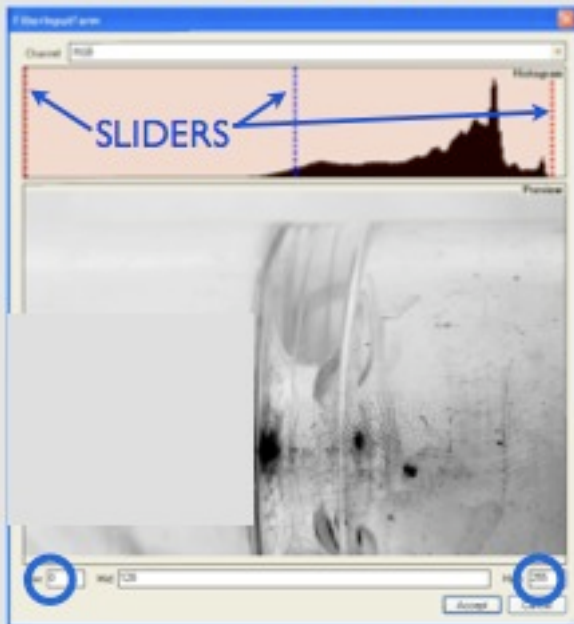
Auto

Options...



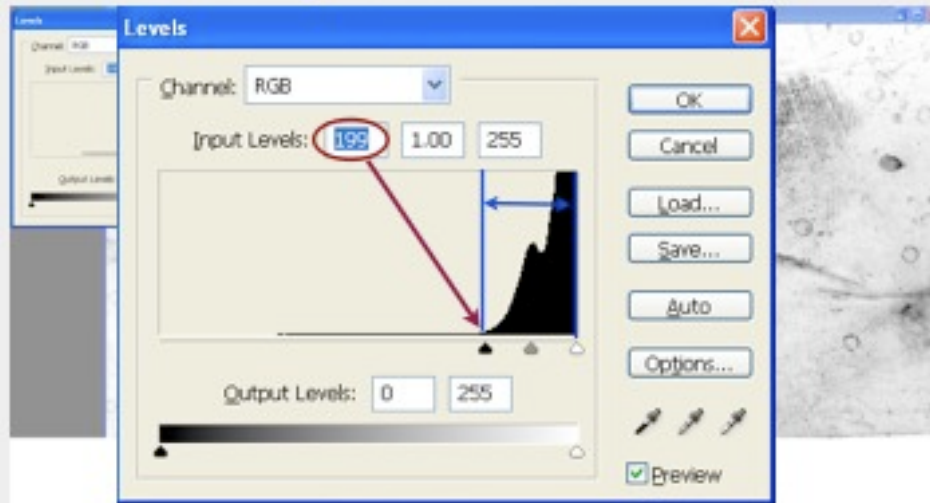
☒ Preview

# MIDEO - ADJUST LEVELS

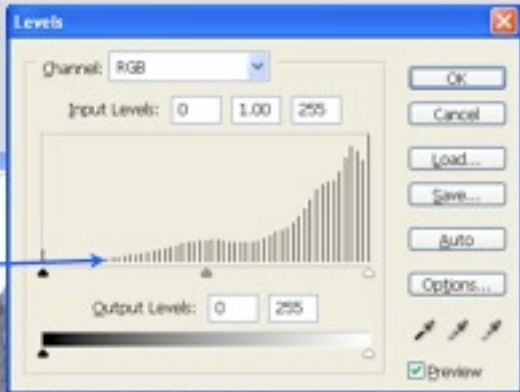


Any pixel that was displayed with a value of less than 200 is rescaled to be black, making the overall image darker

The intensity values (colors) within the slider boundaries are rescaled to range between 0 and 255.

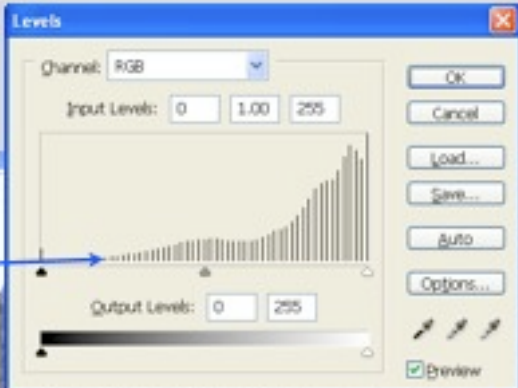


But the data are no longer in a smooth continuum - they are binned.



**This can be useful, because our eyes can not pick out all of the subtle changes in grey - slight differences in intensity become exaggerated**

But the data are no longer in a smooth continuum - they are binned.



**But keep in mind that any details within that intensity range are now invisible because all of those pixels have the same value (zero)**

**SUPPOSE YOU ARE ASKED THE  
FOLLOWING IN COURT:**

**Q:** Does enhancing the image alter the data you are working with in any way?

**A:** No. I am required to keep an original version of every image I work with.

The fact is: **IT DOES change the image that you are working with by changing the information your eyes can see**

## **SUPPOSE YOU ARE ASKED THE FOLLOWING IN COURT:**

**Q:** Does enhancing the image alter the data you are working with in any way?

**A:** The actual data in the image does not change, however increasing the contrast does change the information that my eyes can see. Enhancement is used as an aid to see the ridges and furrows better which, in turn, may lead to a better analysis.



## ANOTHER COURT QUESTION

Q: After performing adjustments on the image, how do we know that you aren't interpreting artifacts from the enhancement as data, and which aren't really data at all?"

A: "I enhanced the image in such a way that my eyes can see the subtle changes in grey better than I could before. It is impossible to add fictitious data to an image by adjusting pixel values in a uniform way."

Q: Is it possible to lose information in the image by adjusting the contrast as you have done in this case?"

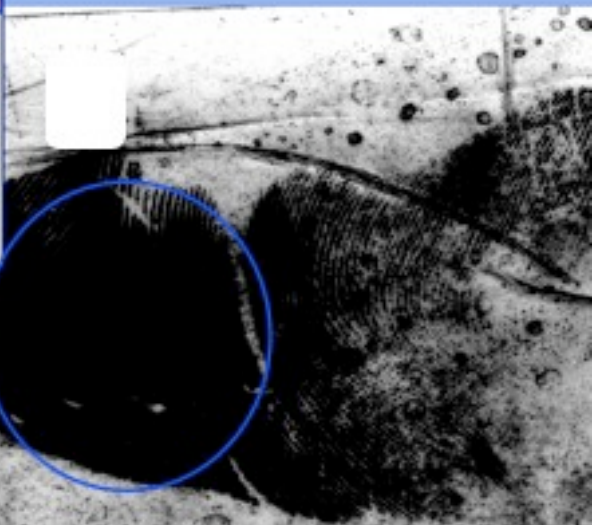
**The moment the contrast is changed in an image, some information becomes invisible**

**What's important is that it wasn't information that would affect your comparison and/or conclusion.**

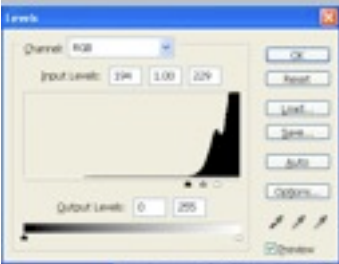
Q: Is it possible to lose information in the image by adjusting the contrast as you have done in this case?"

A: "When I enhance an image, the data are displayed in fewer shades of grey. This allows my eyes to see the ridges and furrows better. Although this does technically reduce the amount of detail present, I am confident that I did not enhance to the point where I have lost information that could affect my analysis."

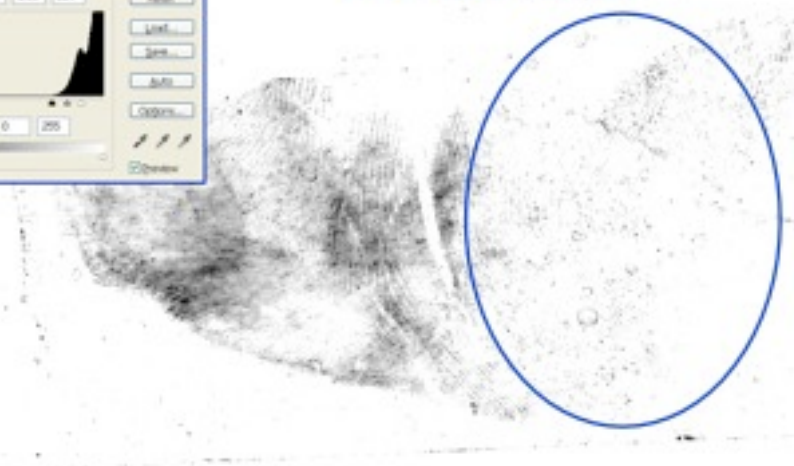
**Never let your pixels start to bleed together with the same shade**



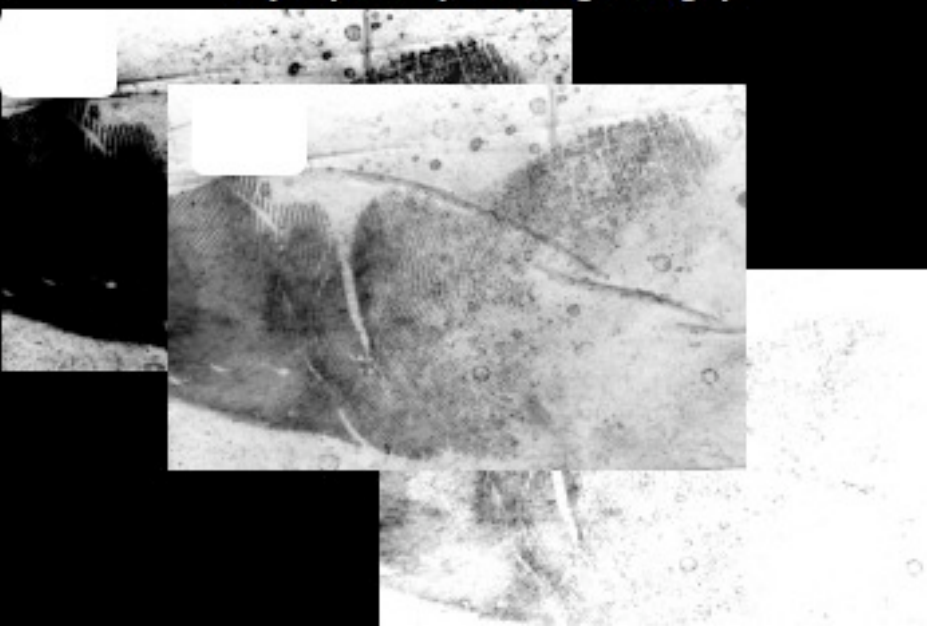
**In this case, the ridges in the latent have been washed out because too high a range of pixel intensities have been reset to 255 (white).**



**Information is lost!**



**Never make the background completely white (or black);  
always try to keep the background grey.**



# MIDTONE

Sliding the slider to the right decreases the gamma value - the overall image gets darker

Gamma Value :  $(\text{intensity})^{1/\gamma}$



**MIDTONE CONTROLS THE  
OVERALL BRIGHTNESS OF  
THE IMAGE**



# Levels



Channel: RGB

Input Levels: 194 0.30 255

All data in this range is  
rebinned to be between  
0 and 127



This value is the "new" 127

Output Levels: 0 255



OK

Cancel

Load...

Save...

Auto

Options...



☒ Preview



# Levels



Channel: RGB



Input Levels:

194

0.30

255

All data in this range is re-binned to be between 128 and 255

Output Levels:

0

255

OK

Cancel

Load...

Save...

Auto

Options...



Preview

# Levels



Channel: RGB



Input Levels:

0

1.00

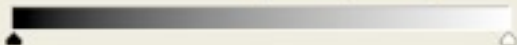
255



Output Levels:

0

255



OK

Reset

Load...

Save...

Auto

Options...



☒ Preview

# How do you know when to stop adjusting?

**Levels** [X]

Channel: RGB [v]

Input Levels: 188 0.60 255

Peak from furrows (background) →

Peak from ridges →

Keep these outside of those peaks

Output Levels: 0 255

OK

Cancel

Load...

Save...

Auto

Options...

[Pencil] [Eraser] [Lasso]

☒ Preview

The screenshot shows the Photoshop Levels dialog box for the RGB channel. The input levels are set to 188, 0.60, and 255. The output levels are set to 0 and 255. A histogram is displayed with two peaks. The first peak is labeled 'Peak from furrows (background)' and the second peak is labeled 'Peak from ridges'. Two arrows point to the first peak with the text 'Keep these outside of those peaks'. The dialog box includes buttons for OK, Cancel, Load..., Save..., Auto, and Options... There are also three icons for selection tools (Pencil, Eraser, Lasso) and a checked checkbox for Preview.

# How do you know when to stop adjusting?

**Levels**

Channel: RGB

Input Levels: 188 0.60 255

Peak from furrows (background) →

Peak from ridges →

And keep the median in the valley between the peaks

Output Levels: 0 255

OK

Cancel

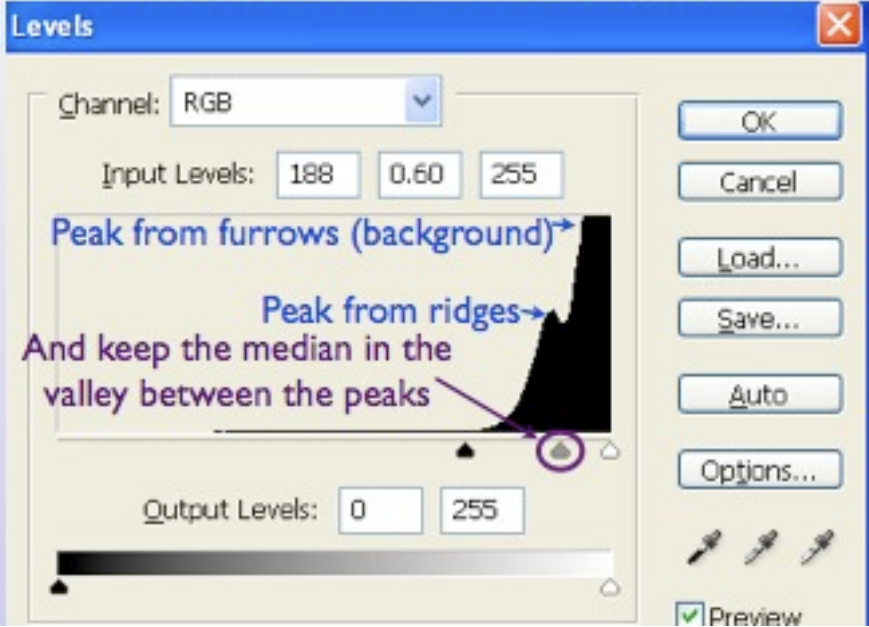
Load...

Save...

Auto

Options...

Preview

The image shows the Photoshop Levels dialog box. At the top, the title bar says "Levels" with a close button. Below it, the "Channel" dropdown is set to "RGB". The "Input Levels" section has three input fields: "188", "0.60", and "255". The "Output Levels" section has two input fields: "0" and "255". A histogram is displayed in the center, showing a distribution of pixel values. Two blue arrows point to the histogram: one to the leftmost part labeled "Peak from furrows (background) →" and another to a small peak labeled "Peak from ridges →". A purple arrow points to the valley between these peaks, with the text "And keep the median in the valley between the peaks". Below the histogram is a grayscale ramp. On the right side, there are buttons for "OK", "Cancel", "Load...", "Save...", "Auto", and "Options...". At the bottom right, there are three eyedropper icons and a "Preview" checkbox which is checked.

# OUTPUT LEVELS

removes solid black  
and white by  
changing where the  
tonal range begins  
and ends.



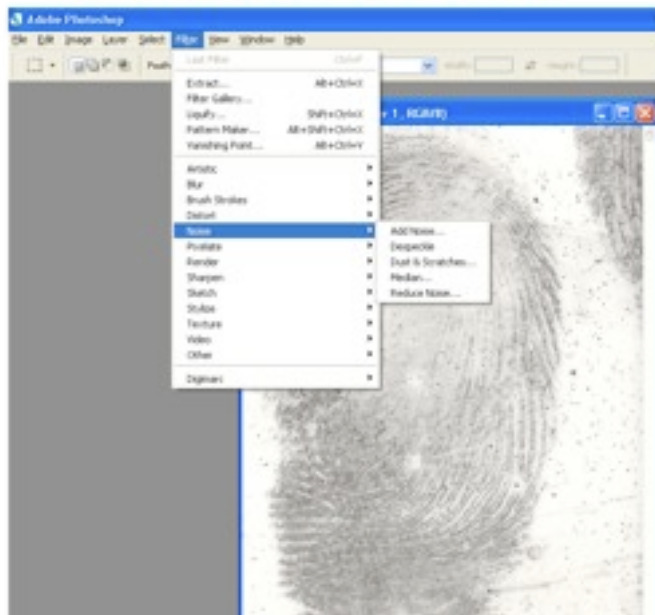


**No shades of white or light grey remain**



**This is probably not a useful tool for us - it is designed to decrease contrast**

# APPLYING FILTERS TO IMAGES



# NOISE

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Any “signal” on the image that does not come from the data you are interested in is “noise”

Noise most often comes from development techniques or the substrate

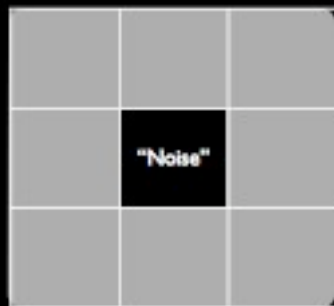
Photoshop Noise Removal Options:

DUST AND SCRATCHES

DESPECKLE

MEDIAN





The "noisy" pixel is  
flagged by the program.  
How?

It is looking for pixels that  
have a value that is much  
higher or much lower than  
it's neighbors

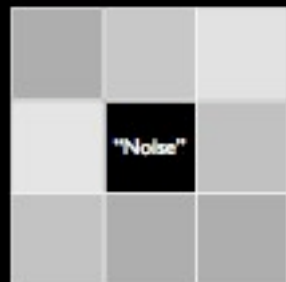
The user (you) *may be able* to determine how  
different a pixel has to be and how many neighbors  
to compare against



The program takes the noisy pixel and makes it the average value of the surrounding pixels.

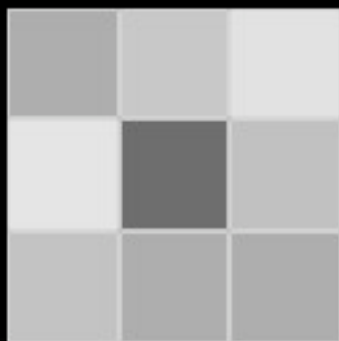
And in a simple case....you get this:

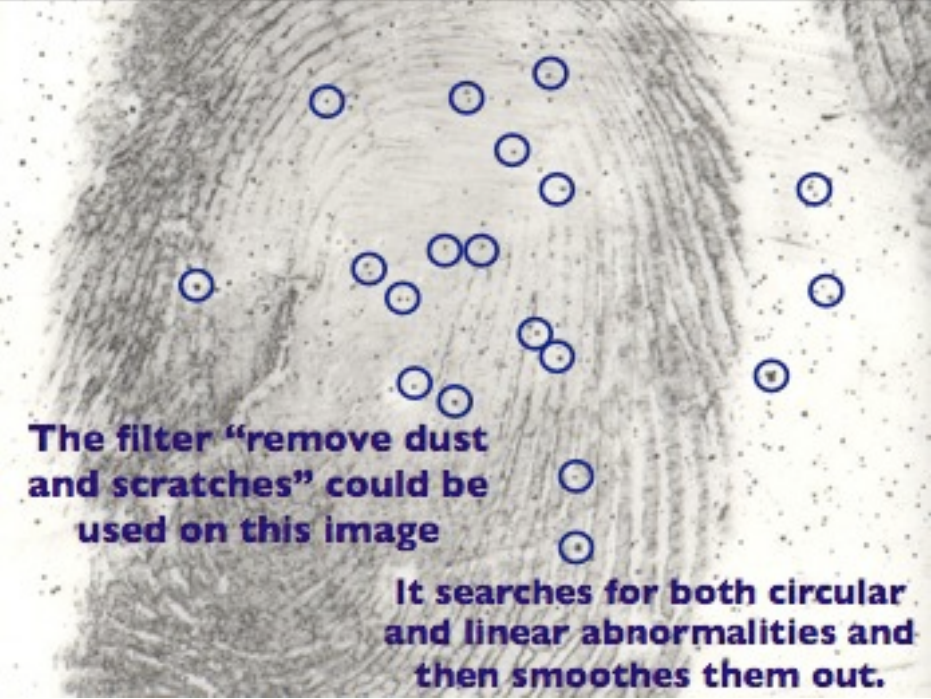




More realistically, the surrounding pixels will be a range of values.

And the noise will just blend in better

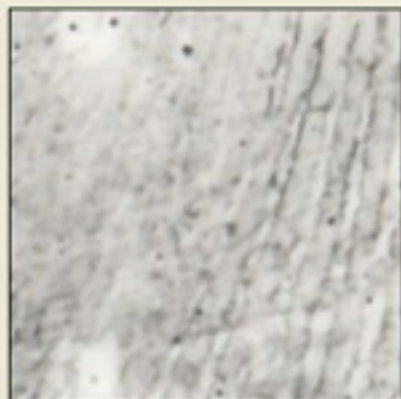




**The filter “remove dust  
and scratches” could be  
used on this image**

**It searches for both circular  
and linear abnormalities and  
then smoothes them out.**

## Dust & Scratches



OK

Cancel

☒ Preview



100%



Radius: 1 pixels



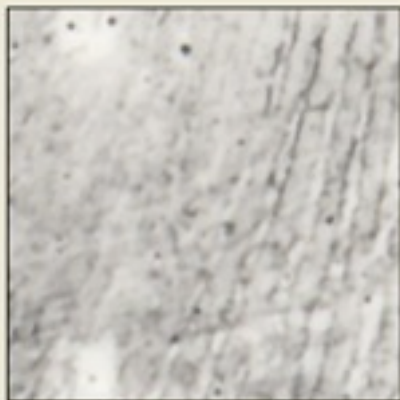
Threshold: 0 levels



The radius defines  
how many pixels  
to average over  
**in every  
direction**



## Dust & Scratches



OK

Cancel

☒ Preview



100%



Radius:  pixels

Threshold:  levels

**The threshold determines the difference in pixel intensity required to replace the value of a given pixel with an average**

100	130	180
180	0	130
130	100	100

Going back to our simple example of an array of pixels....

**In order for a pixel to be smoothed:**

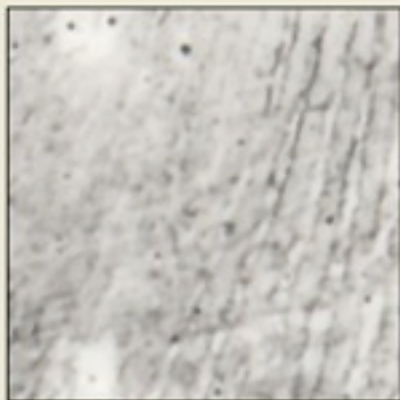
**$\left| \text{Pixel intensity} - \text{neighboring pixel intensity} \right| > \text{Threshold}$**

**Threshold = 200**

**no change to the center pixel**

**Threshold = 50**

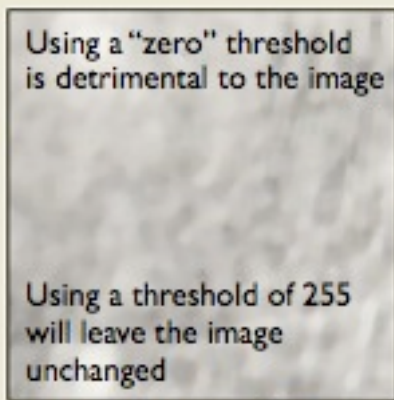
**center pixel smoothed**



- 100% +

Radius: 1 pixels

Threshold: 0 levels



- 100% +

Radius: 4 pixels

Threshold: 0 levels

☒ Preview



**Threshold = 125**

**Noise isn't  
removed**



**Threshold = 95**

**Noise being  
removed**

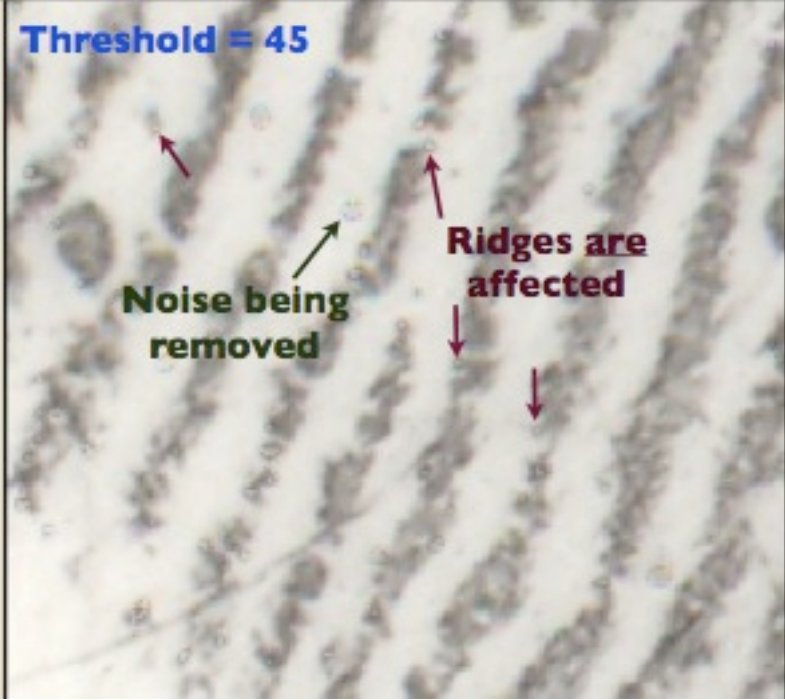
**Ridges are  
unaffected**



**Threshold = 45**

**Noise being  
removed**

**Ridges are  
affected**



**Threshold = 25**

**Be very observant to what is being removed from your image when using the Noise filter "Dust and Scratches" - change the threshold and radius in small increments**

**Very obvious that the ridges are severely affected**



MEDIAN: reduces noise within a box of defined size

Works like "Dust and Scratches" with a zero threshold

## **DESPECKLE OPTION**

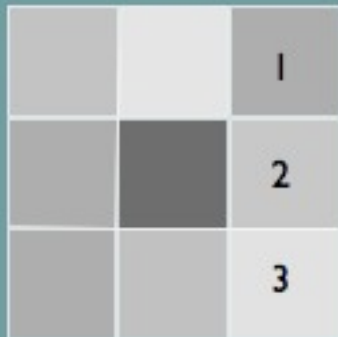
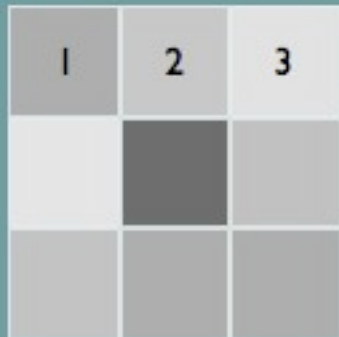
DESPECKLE: blurs the entire image except for edges

The user has no options to play with

Ridges are definitely affected -  
not "seen" as edges by this  
program.

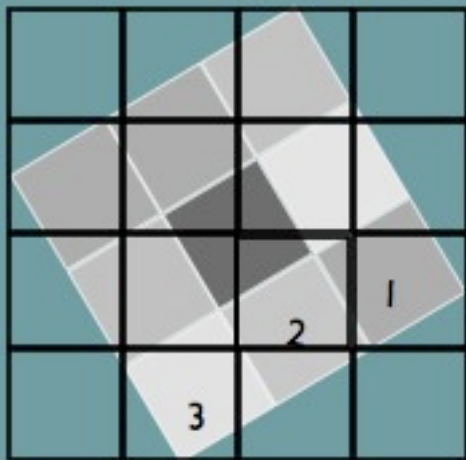
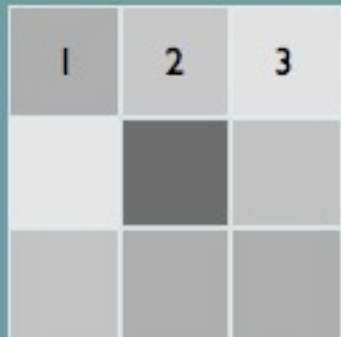
## ROTATION

Because pixels are square, the only way to rotate an image without causing any effect on the individual pixel intensities is to rotate at 90 degree intervals



## ROTATION

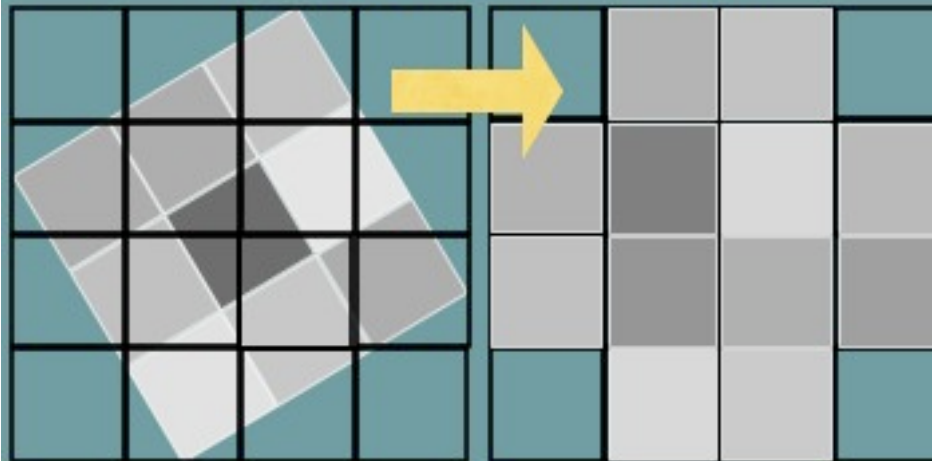
If the rotation is not at a 90 degree interval, the data within any given pixel is then merged into a neighboring pixel






The information gets spread over more than one pixel

**Rotations like this DO change the real information in the image (actual pixel values)**





**⚡ pores and ridge edges  
could be affected!!**

**↗  
ridges are much larger  
than one pixel**

Q: Did rotating your image to conduct your comparison have any effect on the information you are using to reach your conclusion?

A: Information is changed when rotations at angles other than 90 degrees are applied. However, the resolution of the image is at least 1000 ppi, and at this resolution the ridges, [furrows, and pores] will be larger than one pixel. Because these features are larger than the effects of the rotation, rotation does not compromise my analysis.

**If you notice blurriness at the edges, or if edgeoscopy/poroscopy is something that weighs heavily on your conclusion, consider going back to the original image to make sure the rotations are not degrading the image.**

## IN CONCLUSION

This lecture was intended to give you an understanding of what our enhancement processes are doing to digital evidence behind the scenes

- We talked a lot about contrast changes....

- We went over various Do's and Don'ts

- When removing noise, look at the data very closely using small changes in threshold/radius

- Effects of rotation may become important depending on what information you are using to reach your conclusion

Court questions about digital enhancements should not be feared nor keep you from performing enhancements that may make a comparison easier

# THANK YOU!