3D properties of the Shroud revised

Version 1.0

By O.K.

Part 1

- This analysis is made predominantly with ImageJ software
- The short history of 3D analysis of the Shroud is presented at http://shroud3d.com/home-page/introduction-3d-studies-of-the-shroud-of-turin-history
- The fundamental papers on the issue are Jackson, J.P., E.J. Jumper and W.R. Ercoline, "Three Dimensional Characteristic of the Shroud Image," IEEE 1982 Proceedings of the International Conference on Cybernetics and Society, October 1982, pp. 559-575 and Jackson, J.P., E.J. Jumper, and W.R. Ercoline, "Correlation of Image Intensity on the Turin Shroud with the 3-D Structure of a Human Body Shape," Applied Optics, Vol. 23, No. 14, 1984, pp. 2244-2270
- Some other important papers: G. Fanti, „A review of 3D characteristics of the Turin Shroud body image", Worksohop Italy-Canada on 3D Digital Imaging and Modeling Applications of: heritage, industry, medicine & land, Padova, April 3-4 2001 and Giulio Fanti, Emanuela Marinelli, Alessandro Cagnazzo, „Computerized anthropometric analysis of the Man of the Turin Shroud"

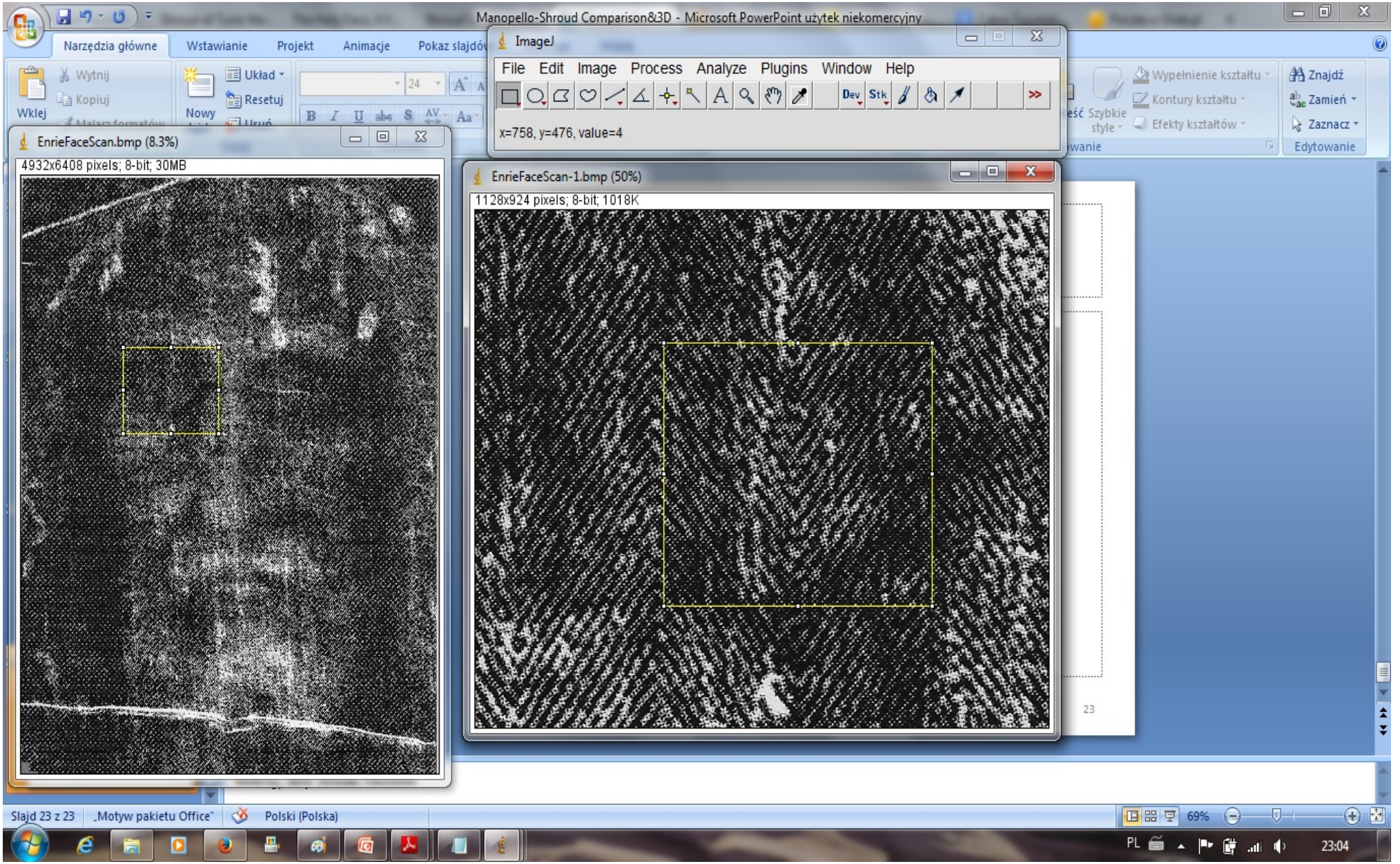
  Giovanni Tamburelli,

  „Reading the Shroud, called the fifth Gospel, with the aid of the computer" , SSI No . March 1982, pg. 3-11 „An image resurrection of the man of the Shroud", SSI No 15, June 1985, pg. 3-6.
- And absolute must-watch: „The real face of Jesus?" documentary (available https://www.youtube.com/watch?v=WNJPJ4JwHeE, unless YouTube removed it for copyright issues).

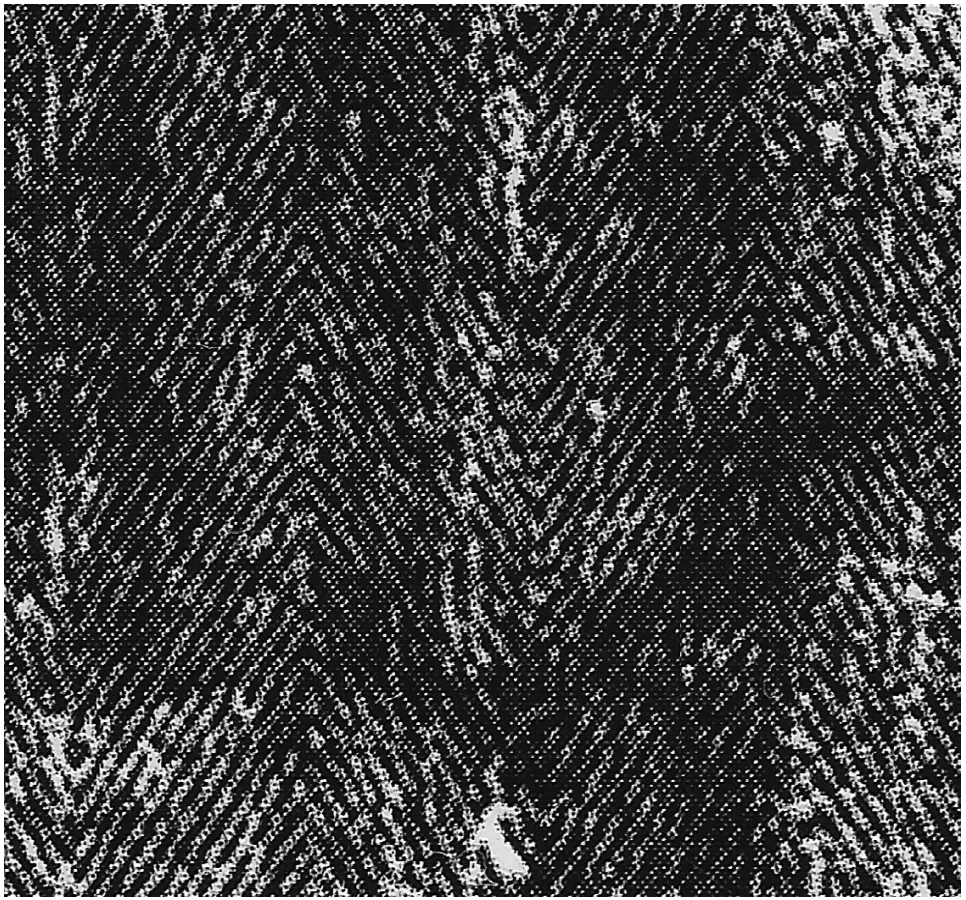
So let's begin our play with the Shroud image

← Here is Enrie's photograph of the face. Actually it is JPEG converted and compressed image scanned at 1200 DPI from the cover of Paul Badde's book.

To show all of you how really good is this photo, a magnification of the alleged coin area over the right eye:



And further. Now practical demonstration of the halftone effect on the Shroud of Turin:

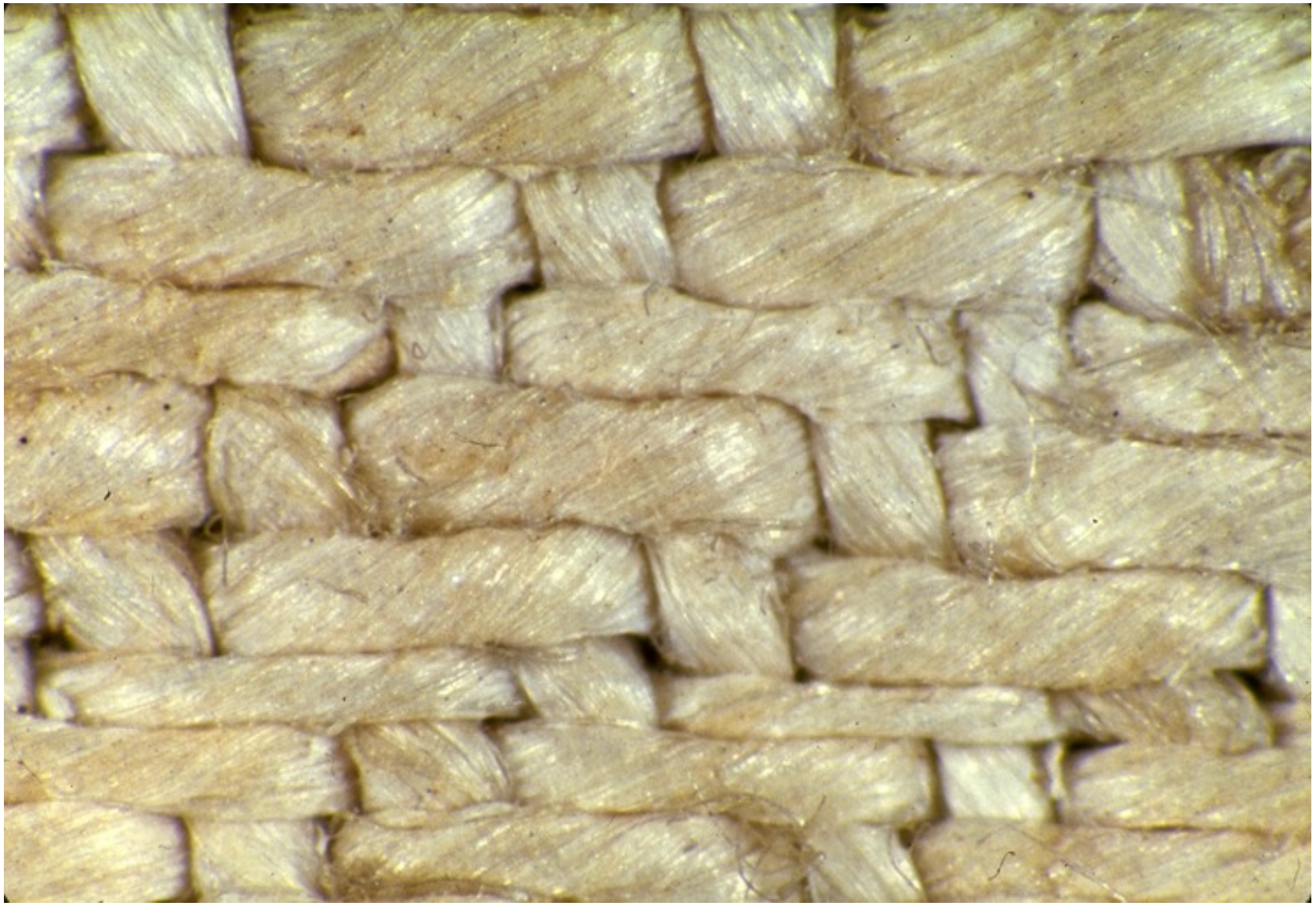


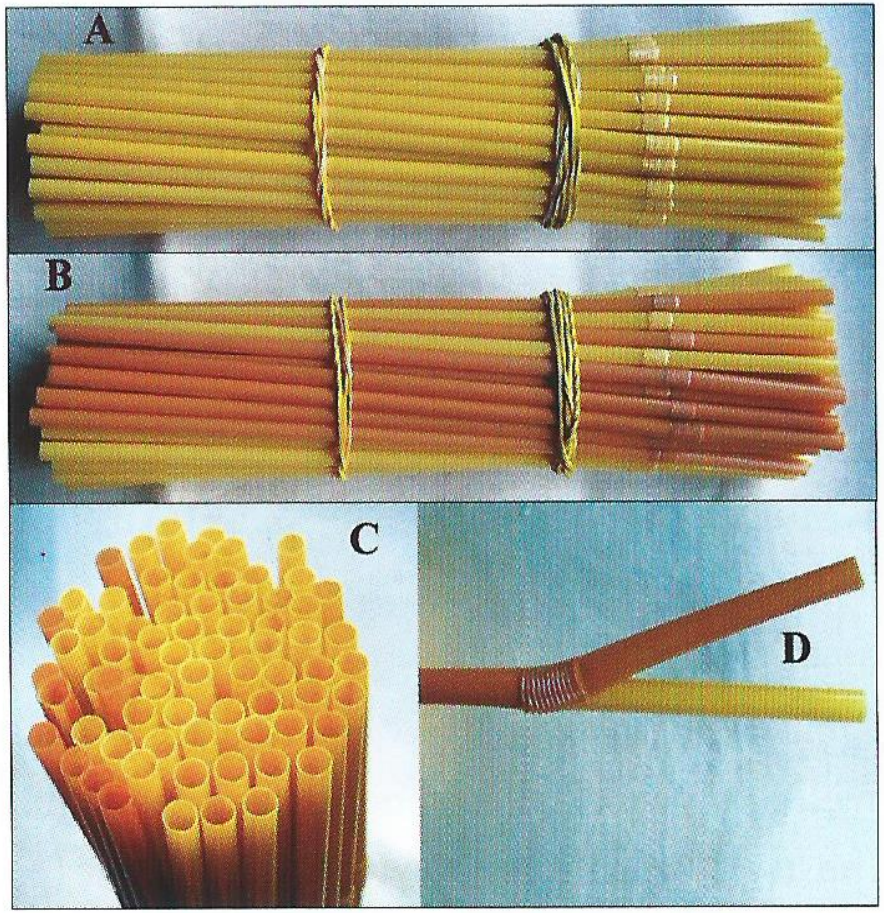
Count: 248160
Mean: 54.761
StdDev: 70.749
Min: 0
Max: 255
Mode: 0 (12949)

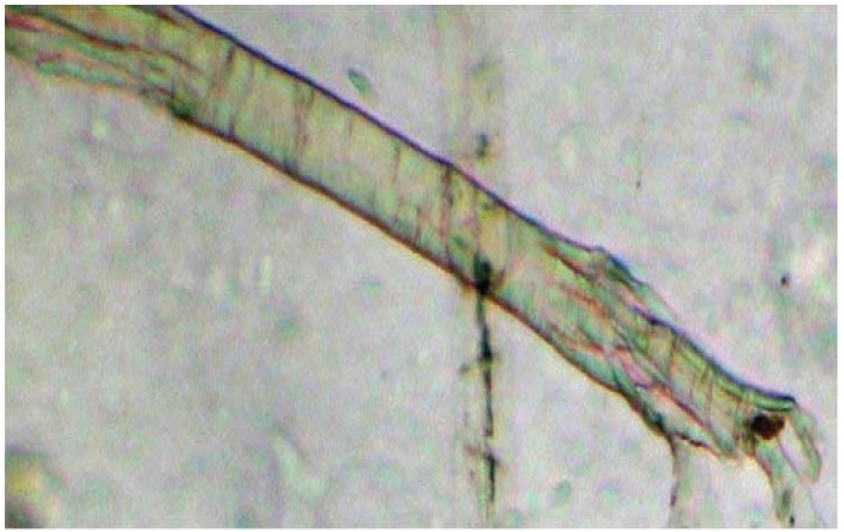
Caveat: As the image from the cover is already set at max contrast, this is not a proof of the halftone effect of the body image -it is merely a demonstration of this usually accepted property.

Right above you have histogram of the pixel intensity values.
(Analyze > Histogram in Image J menu)

Here you have the microphotograph of the same eye area (ME-02, 32x magnitude):







← Here is the model of Shroud thread made from sippers (from Fanti & Gaeta book „Il mistero delle Sindone").

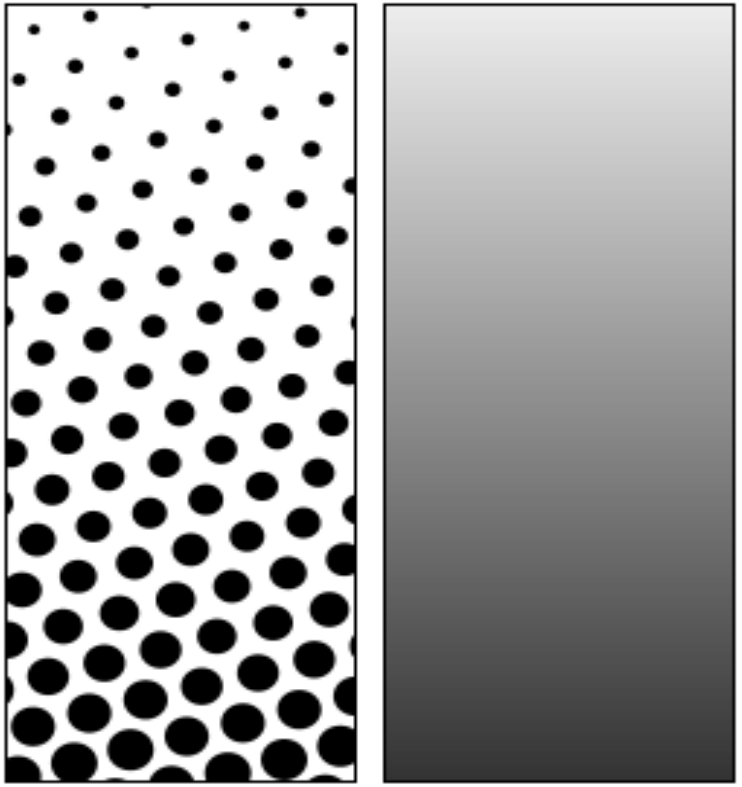
A: Non image thread
B & C: Image thread, several of its fibers (on surface of the thread only) have been colored (or we can say „activated"). The fibers show uniform, very thin layer of color distributed all around themselves (see picture D)

← Microscopic photo of Shroud colored fiber (STURP sample 1-EB)

What is halftone? From Wikipedia:

Halftone is the reprographic technique that simulates continuous tone imagery through the use of dots, varying either in size or in spacing, thus generating a gradient like effect.[1] "Halftone" can also be used to refer specifically to the image that is produced by this process.[1]

Where continuous tone imagery contains an infinite range of colors or greys, the halftone process reduces visual reproductions to an image that is printed with only one color of ink, in dots of differing size (amplitude modulation) or spacing (frequency modulation). This reproduction relies on a basic optical illusion: the tiny halftone dots are blended into smooth tones by the human eye. At a microscopic level, developed black-and-white photographic film also consists of only two colors, and not an infinite range of continuous tones.



Left: Halftone dots. Right: How the human eye would see this sort of arrangement from a sufficient distance.
←

History:

The first printed photo using a halftone in an American periodical, December 2, 1873

William Fox Talbot is credited with the idea of halftone printing. In the early 1830s, he suggested using "photographic screens or veils" in connection with a photographic intaglio process.[3]

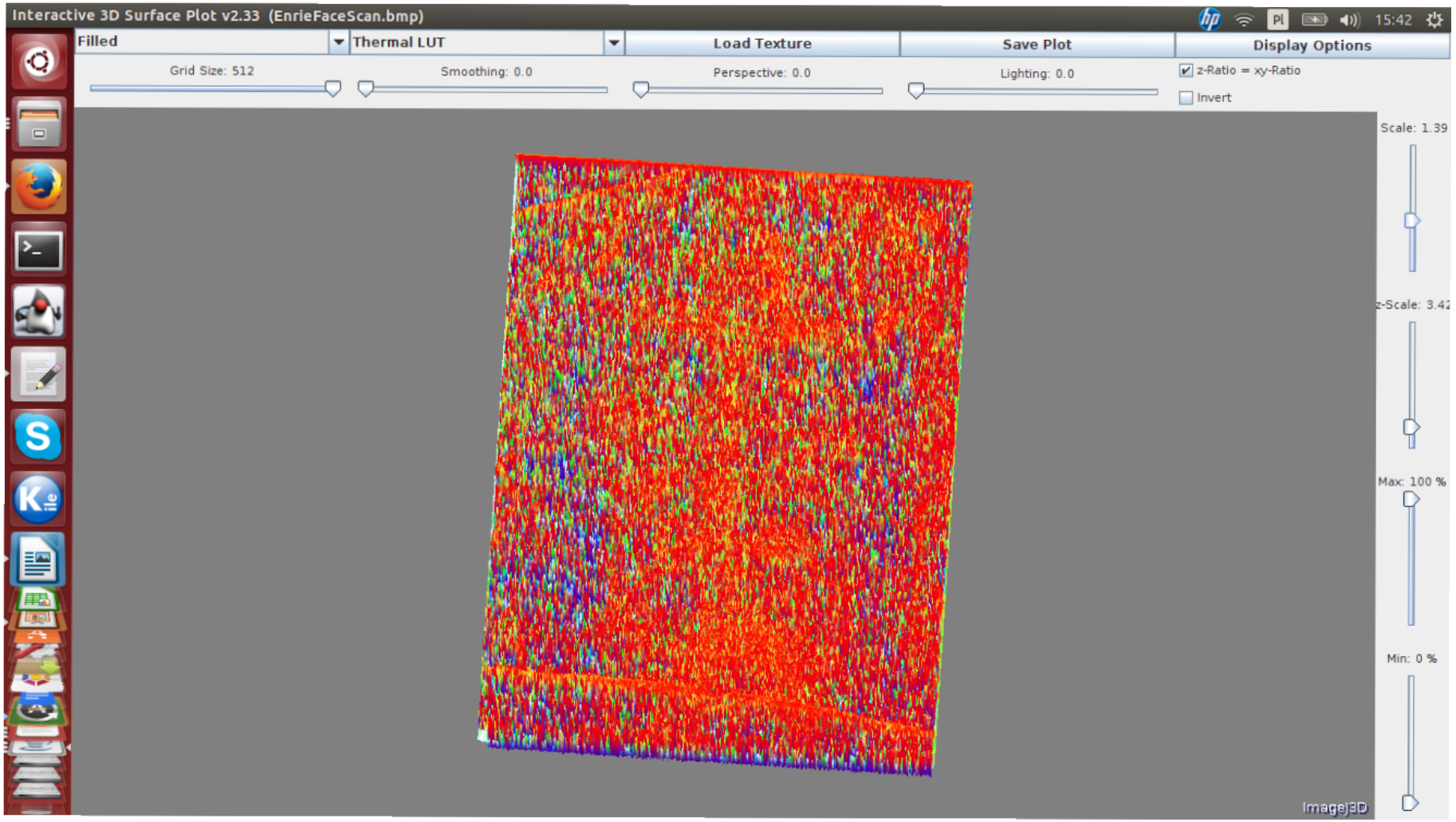
Several different kinds of screens were proposed during the following decades. One of the well known attempts was by Stephen H. Horgan while working for the New York Daily Graphic. The first printed photograph was an image of Steinway Hall in Manhattan published on December 2, 1873.[4] The Graphic then published "the first reproduction of a photograph with a full tonal range in a newspaper" on March 4, 1880 (entitled "A Scene in Shantytown") with a crude halftone screen.[5]

The first truly successful commercial method was patented by Frederic Ives of Philadelphia in 1881.[3][5] Although he found a way of breaking up the image into dots of varying sizes, he did not make use of a screen. In 1882, the German Georg Meisenbach patented a halftone process in England. His invention was based on the previous ideas of Berchtold and Swan. He used single lined screens which were turned during exposure to produce cross-lined effects. He was the first to achieve any commercial success with relief halftones.[3]

Shortly afterwards, Ives, this time in collaboration with Louis and Max Levy, improved the process further with the invention and commercial production of quality cross-lined screens.[3]

The relief halftone process proved almost immediately to be a success. The use of halftone blocks in popular journals became regular during the early 1890s.[3]

And the halftone effect + magnificient resolution results in... complete obscurity of the 3D image! **No 3D at all (at least at 0 smoothing)!!!**

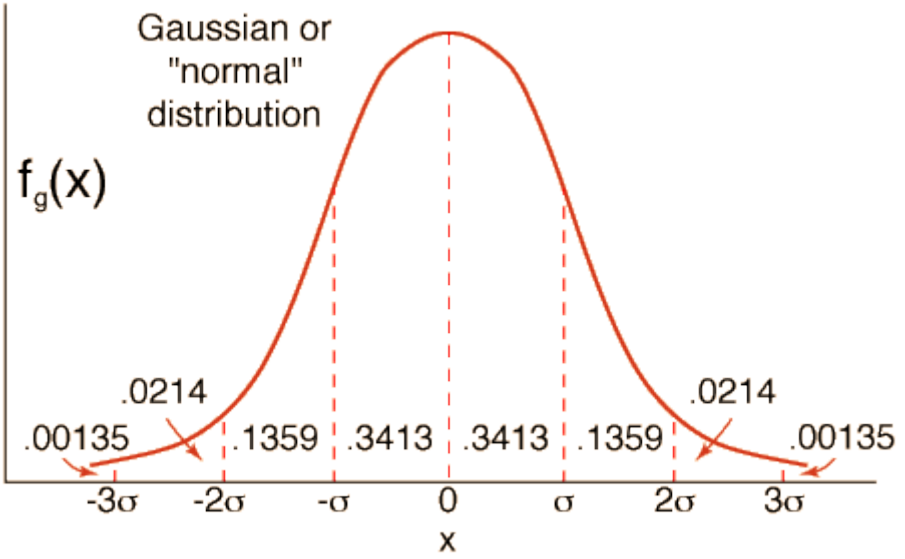


All we see is technically called (by me) **a needle forest**. In 3D see a large sharp peaks practically the same height in the place of bright spots. This is the result of halftone and actually **too great** resolution. So we need to cheat...

The trick is known as gaussian blur. And here is what aunt Wiki says on that:

In image processing, a Gaussian blur (also known as Gaussian smoothing) is the result of blurring an image by a Gaussian function. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail. The visual effect of this blurring technique is a smooth blur resembling that of viewing the image through a translucent screen, distinctly different from the bokeh effect produced by an out-of-focus lens or the shadow of an object under usual illumination. Gaussian smoothing is also used as a pre-processing stage in computer vision algorithms in order to enhance image structures at different scales—see scale space representation and scale space implementation.

Mathematically, applying a Gaussian blur to an image is the same as convolving the image with a Gaussian function. This is also known as a two-dimensional Weierstrass transform. By contrast, convolving by a circle (i.e., a circular box blur) would more accurately reproduce the bokeh effect. Since the Fourier transform of a Gaussian is another Gaussian, applying a Gaussian blur has the effect of reducing the image's high-frequency components; a Gaussian blur is thus a low pass filter.

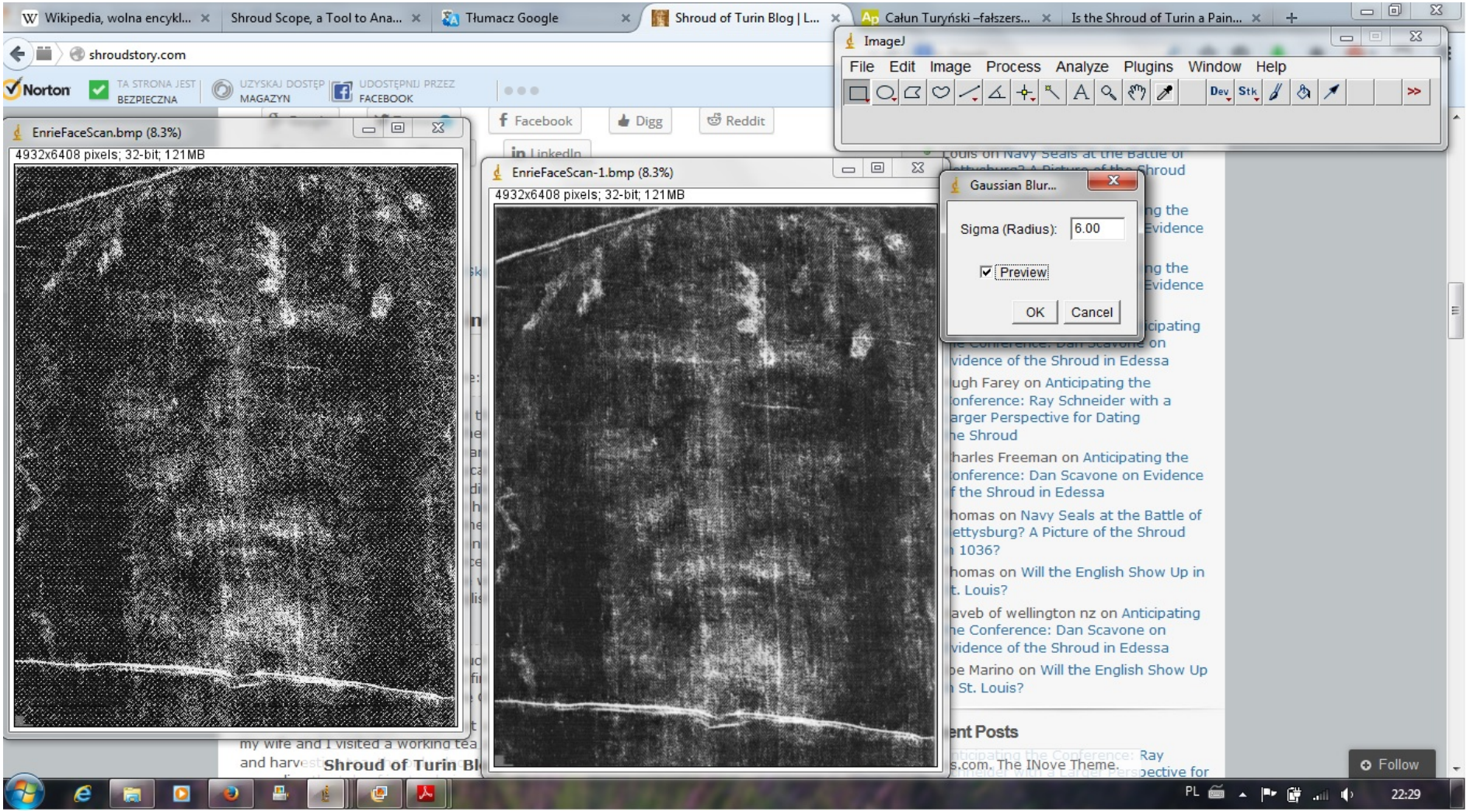


The effects of a small and a large Gaussian blur

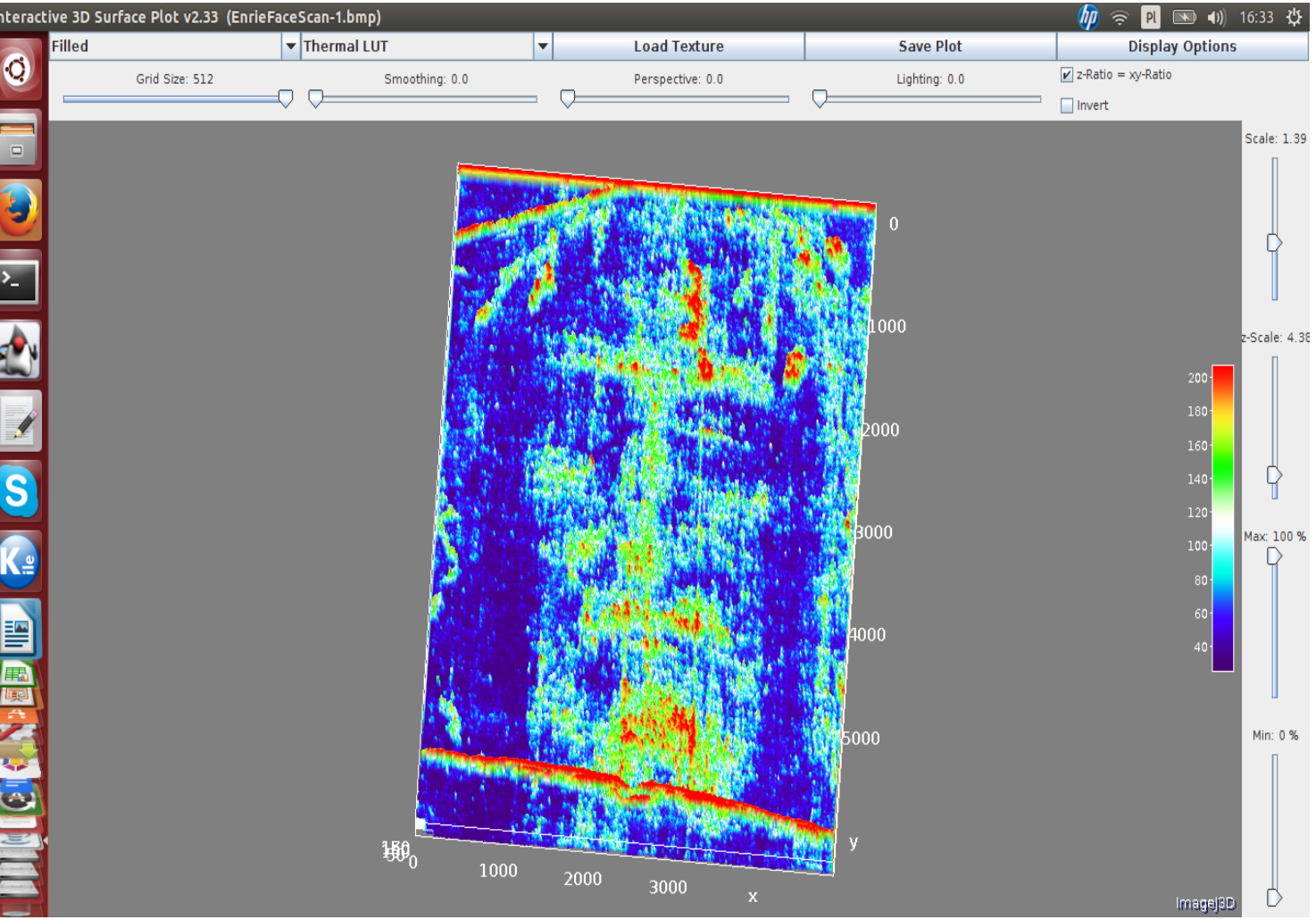
←

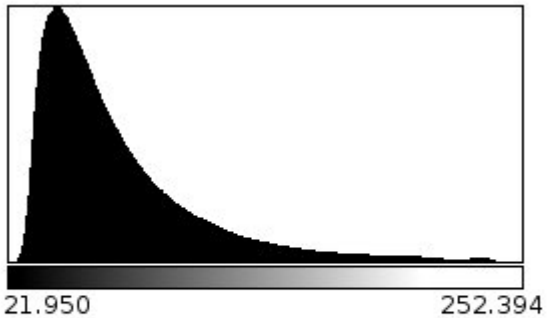
Gaussian blur can be used in order to obtain a smooth grayscale digital image of a halftone print

So if we don’t want to have a needle forest in our 3D reconstruction, we need to convolve it with a gaussian.



And here is what we got after applying 6-pixel gaussian blur (and a small adjustment of brightness & contrast, see histogram on the right) It's **much** better, though still not perfect.





Analogy

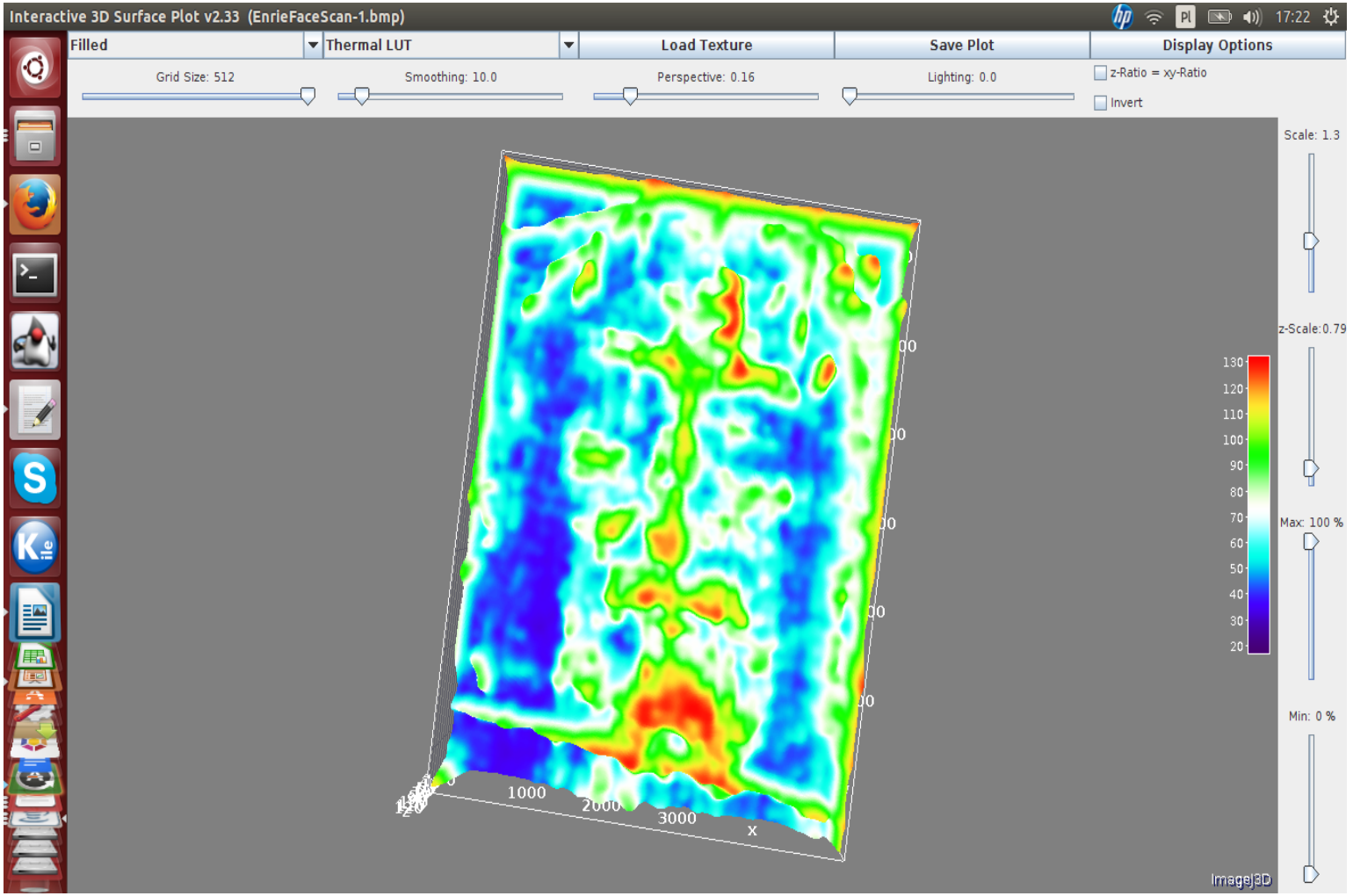
The Milky Way -on low magnification (naked eye) we see it as a large cloud on the sky, with brighter and dimmer parts. But using binoculars or telescope, it fragmentates into individual stars, just like the Shroud image fragmentates into individual dots.

This is also one of the reasons one need to stay at least 2 meters away to see the body image. Close-in you see nothing.

Overview

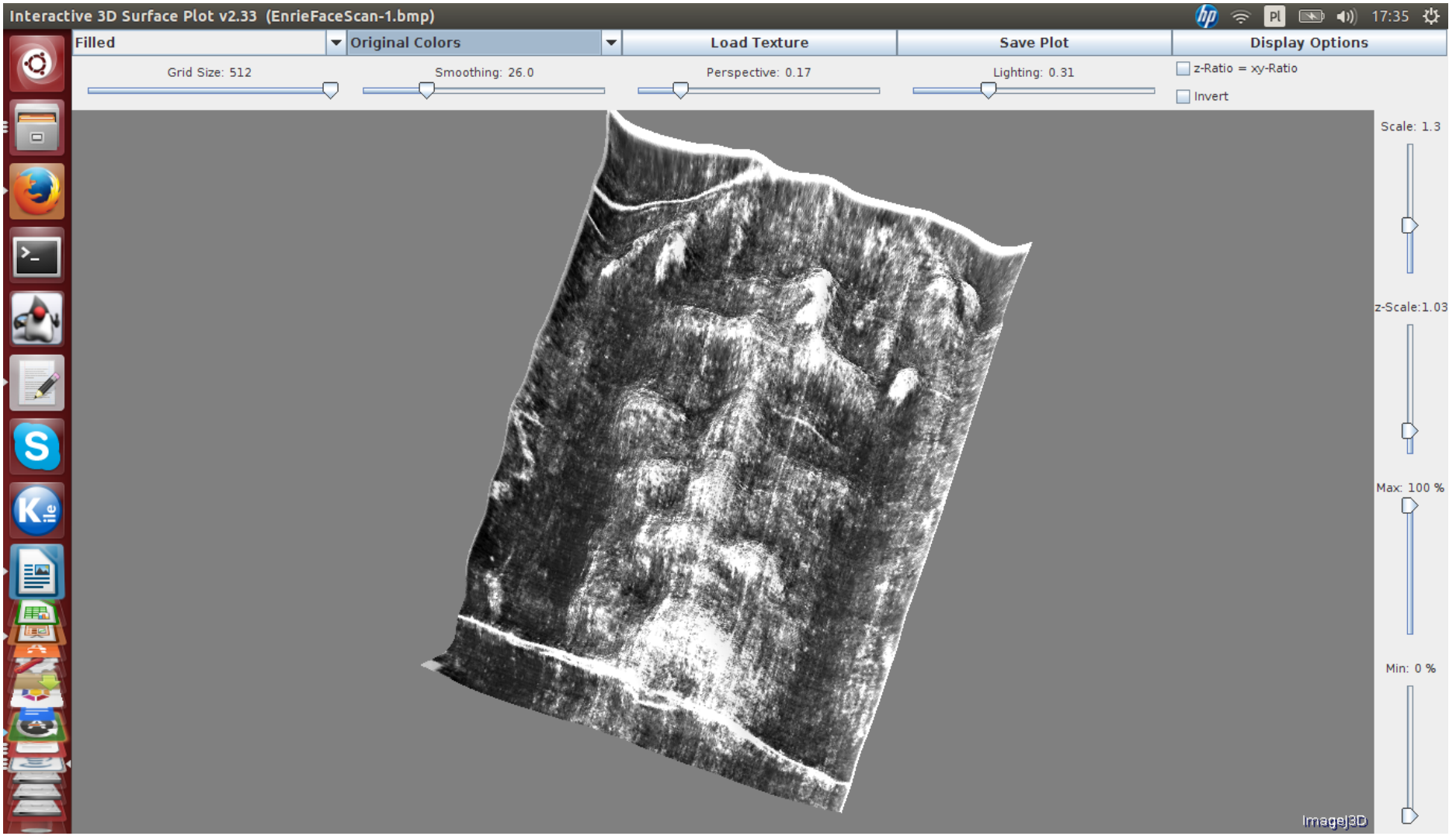
- The image on the Shroud is a halftone image. It is made of several monocolor dots (pixels) on the outermost fibers on the surface of the threads. The number of colored fibers define size of those dots, and thus the color distribution -the intensity of the image -on macroscopic level.
- However on the microscopic level -or at least high magnification -the intensity of dots is the same -the differences are only in the size of dots, composed of bundles of adjacent colored fibers.
- Thus on high resolution, the image is monotonous -with the same intensity. And as 3D effect on the Shroud is described as correlation of image intensity vs body-cloth distance, **there is no 3D on the microscopic level.**
- What we need to do to obtain 3D is to cheat -**get our eyes fooled** -by lowering the resolution of the image, either naturally -obtaining low resolution image -or artificially by blurring the image with gaussian (or any other) filter.
- The 3D effect is actually an **optical illusion.** Or better saying -it was **intended to be an optical illusion.**

Here we have the same image after more brightness and contrast adjustment -and 10-pixel smoothing.

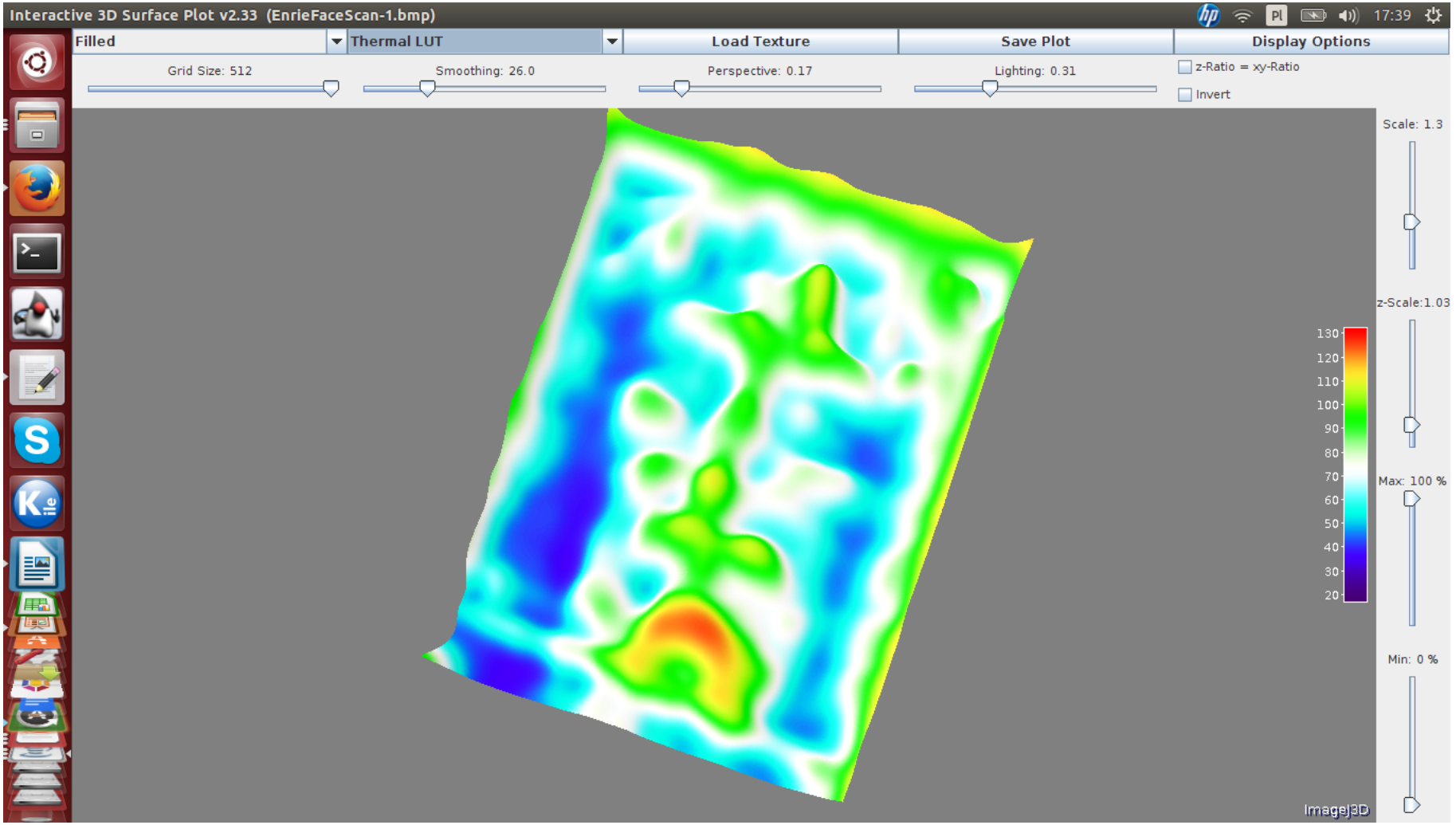


Smoothing in ImageJ is actually nothing else but the **gaussian blur** -smearing the intensity further and further away from each pixel where it is present (like smearing the butter on bread).

Here you have beautiful 3D image of the Shroud face:

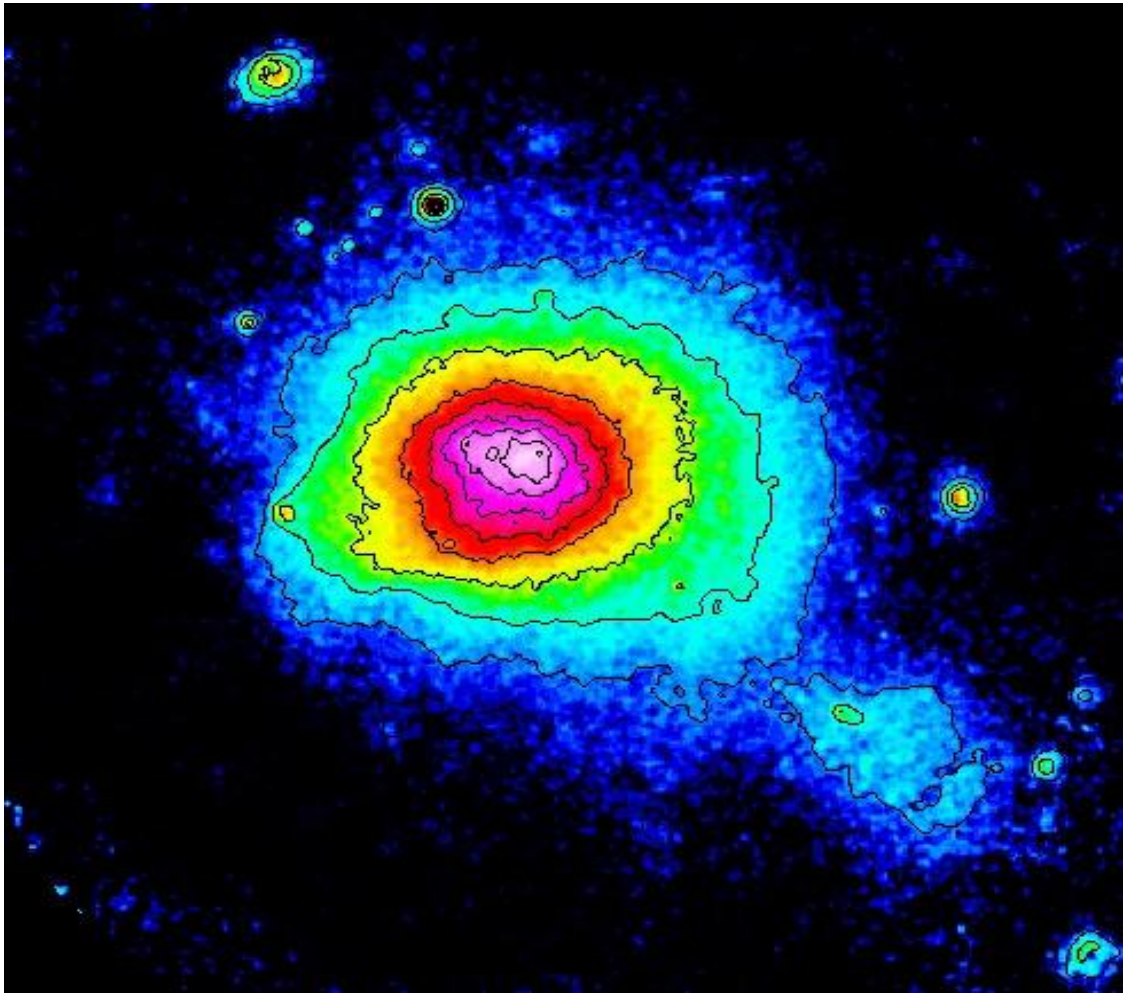


All right, I cheated. Here is the same image, but this time using 'Thermal LUT' instead of 'Original colors'



As you can see, the image is blurred too much -too high smoothing applied, and a lot information is gone. We have a handy image in original colors, but actually disastrous 2D resolution.

That's why you should always use 'Thermal LUT' (or similar) instead of 'Original Colors' mode. Because its more 'objective' and you don't get so easily fooled by perspective when rotating 3D model. And it's actually the same data!

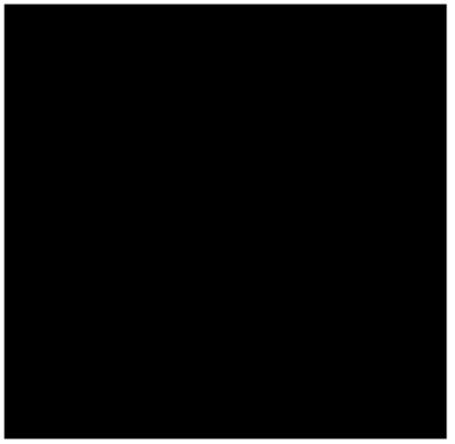


<-Here you have map of X-ray emission from the Coma galaxy cluster. It's actually the same 3D plot as in the case of the Shroud -two spatial coordinates (X,Y) vs intensity. But presented in a very rational way.

Why in the Shroud world no one besides me uses this setting in 3D plots, is a complete mystery to me.

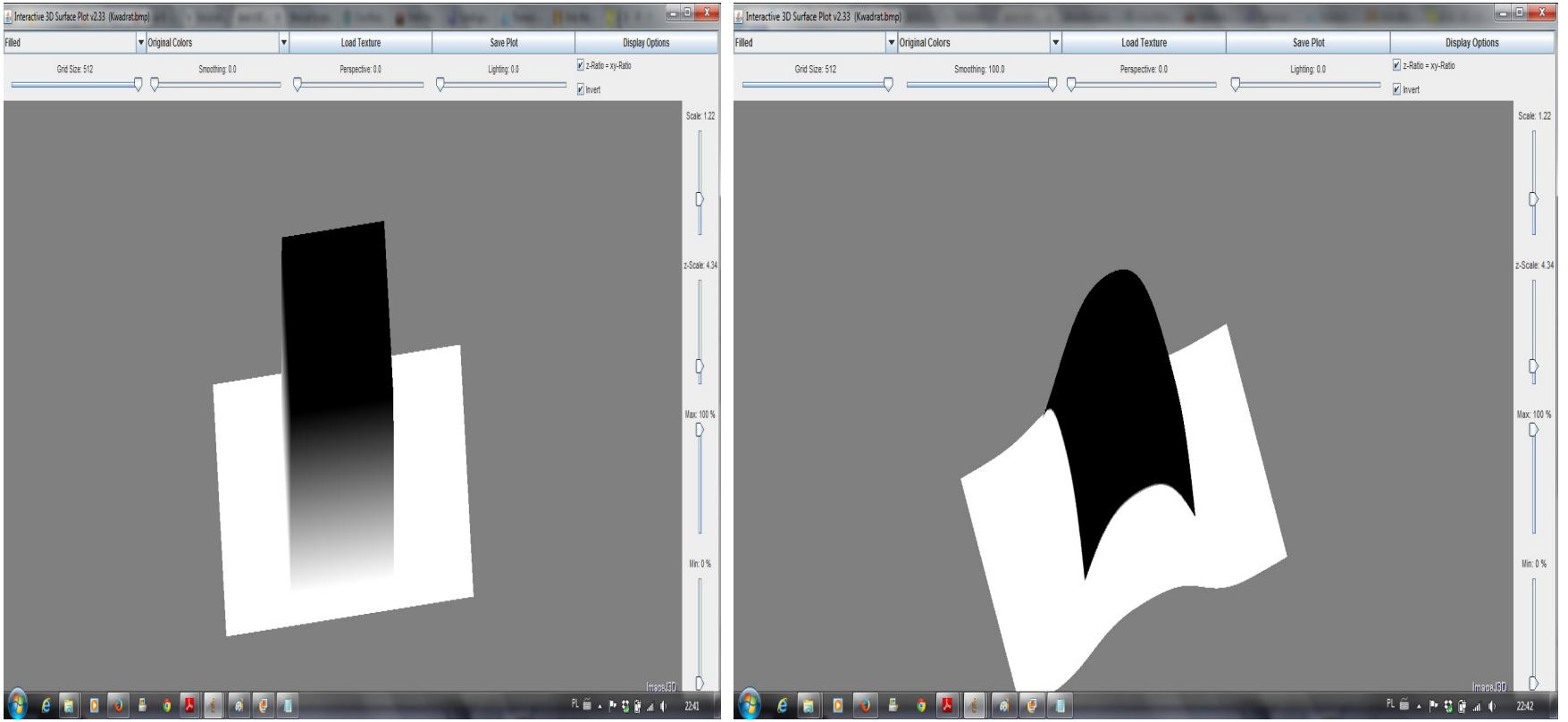
And if I may be honest -I won't be calling names -but there are several highly praised specialists from 3D, big names in the Shroud world, who don't understand those basic principles.

A small experiment



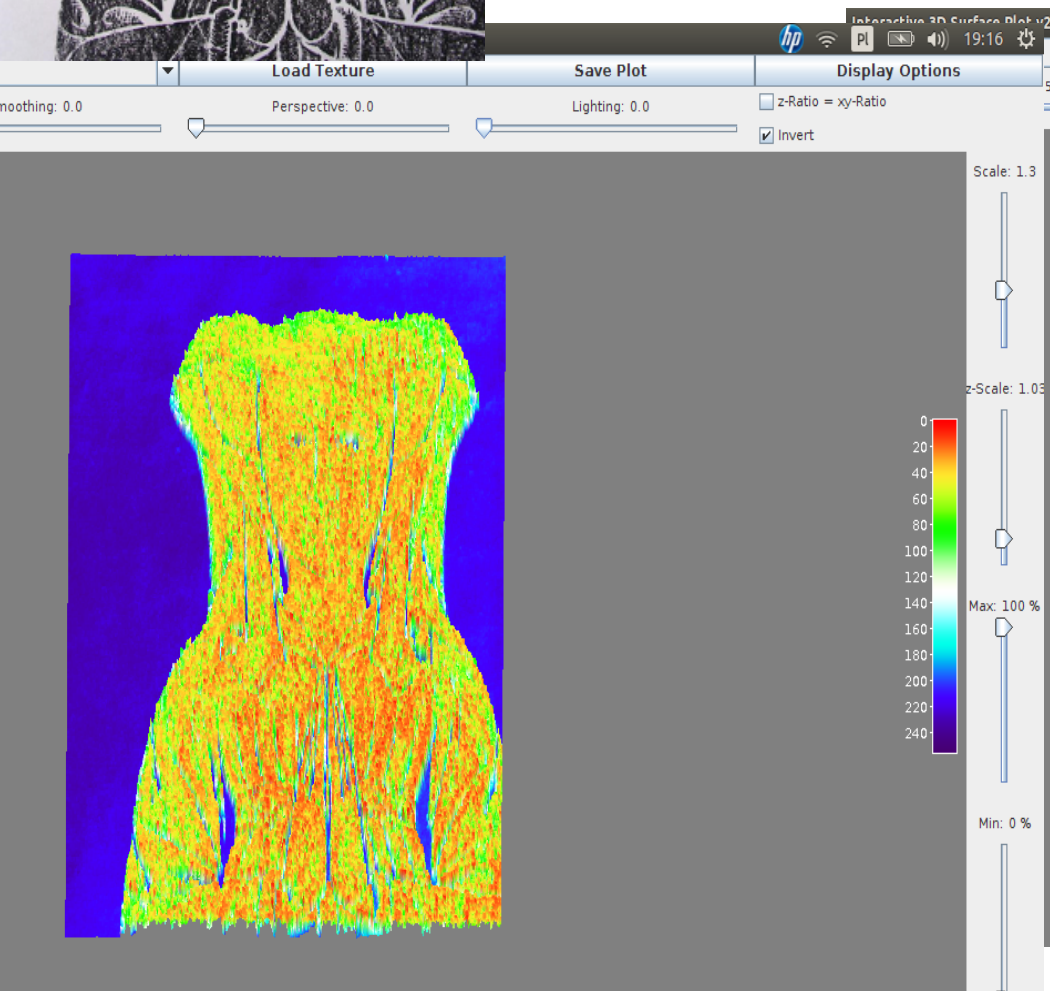
Here you have a simple, monocolor, mono-intensity black & white square

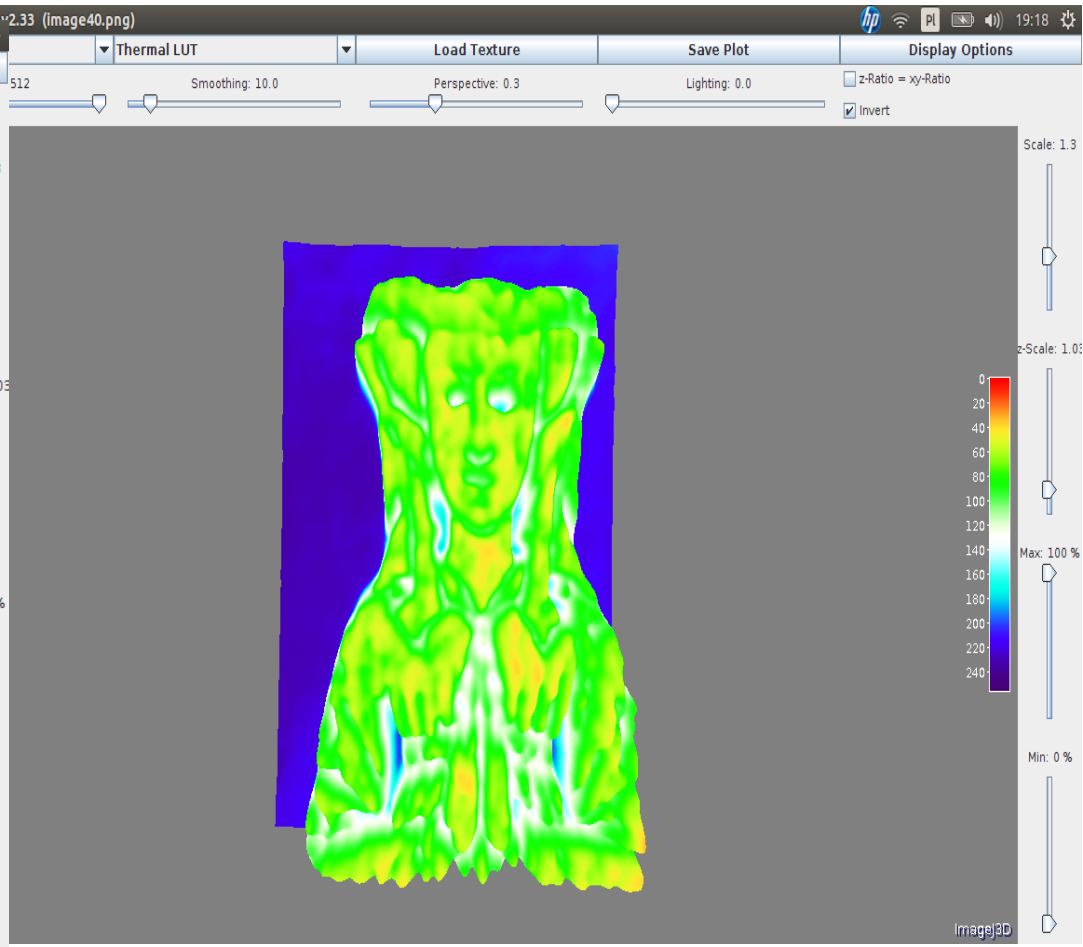
And here you have its 3D representations in ImageJ (inverted tones) with no smoothing (left) and maximum smoothing (right).



Rings a gaussian bell? When you are playing with 3D, use some smoothing -but not **too much**, or you get fooled, and see 3D information where it is actually not present.

Similar example with engravings, no smooth on the left, high smooth on the right





Overview

- You can obtain pseudo-3D images from monointesity images, just using filters like gaussian blur.
- When you are evaluating 3D images of the Shroud or any attempts of its reproduction, always use 'Thermal LUT' or similar mode. **Never** rely solely on visual perception. There are several positions and angles that may mislead you.
- ImageJ settings, use moderate smoothing to get useful image -but not too high, as it is cheating. The 3D effect is then more the result of convolving with gaussian distribution then the inherent property of images.
- This leds us to the question: is the Shroud a true 3D image, or not.
- The answer is **YES.** But we must clarify where 3D information is actually hidden.

The two perhaps most important correlations in the Universe

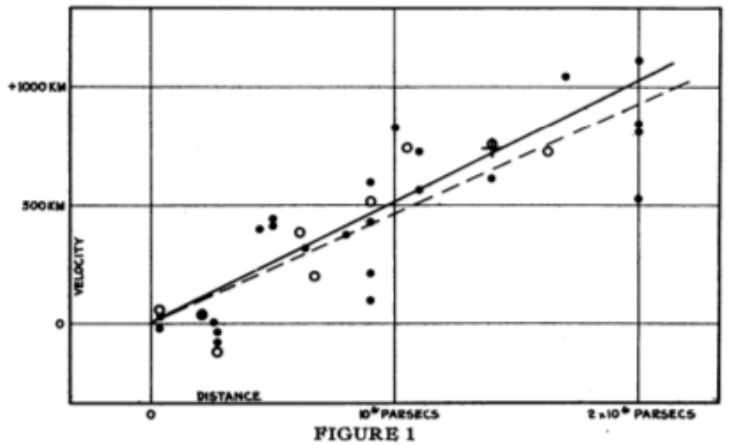


FIGURE 1

Velocity-Distance Relation among Extra-Galactic Nebulae.

Radial velocities, corrected for solar motion, are plotted against distances estimated from involved stars and mean luminosities of nebulae in a cluster. The black discs and full line represent the solution for solar motion using the nebulae individually; the circles and broken line represent the solution combining the nebulae into groups; the cross represents the mean velocity corresponding to the mean distance of 22 nebulae whose distances could not be estimated individually.

present.

We then plotted these data of transmittance and cloth-body distance and determined a linear regression line shown in (Figure 2). As a measure of the degree of correlation we calculated the coefficient of determination, r^2, (correlation coefficient squared) given by (Ref. 10)

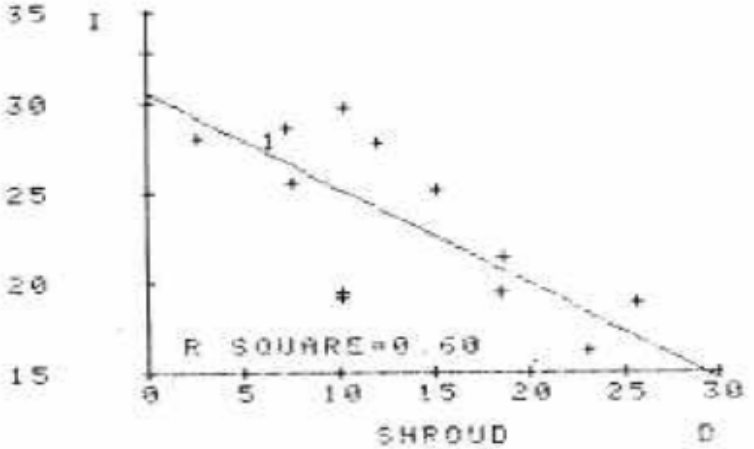


Figure 2. Shroud Correlation

On the left is the figure from Edwin Hubble's 1927 paper about escape of galaxies, proving expansion of the Universe. On the right, the plot from 1982 Jackson & Jumper paper showing correlation between intensity and distance between the Shroud and the body of perhaps, as Christians believe, the Creator of the Universe.

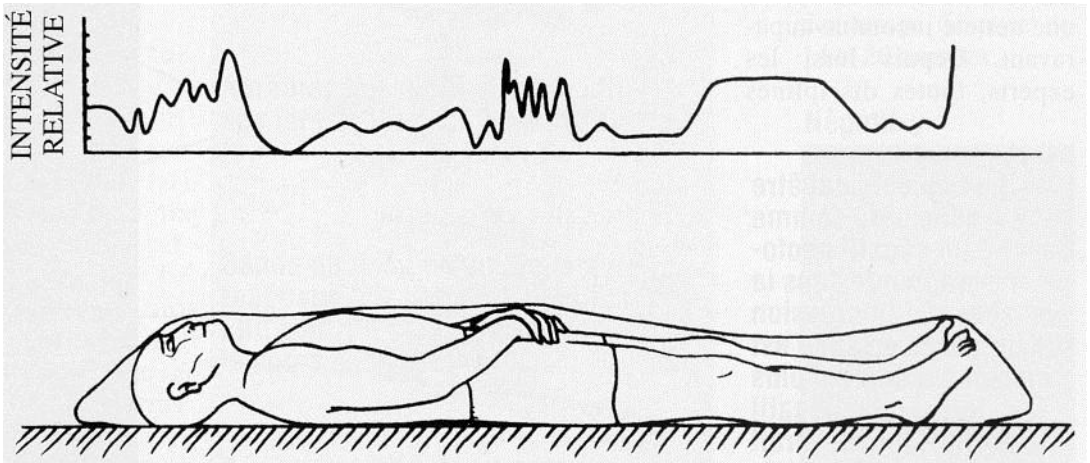
Which data seems less reliable?

In 1982 paper Jackson & jumper wrote (pg. 560-561, my boldings):

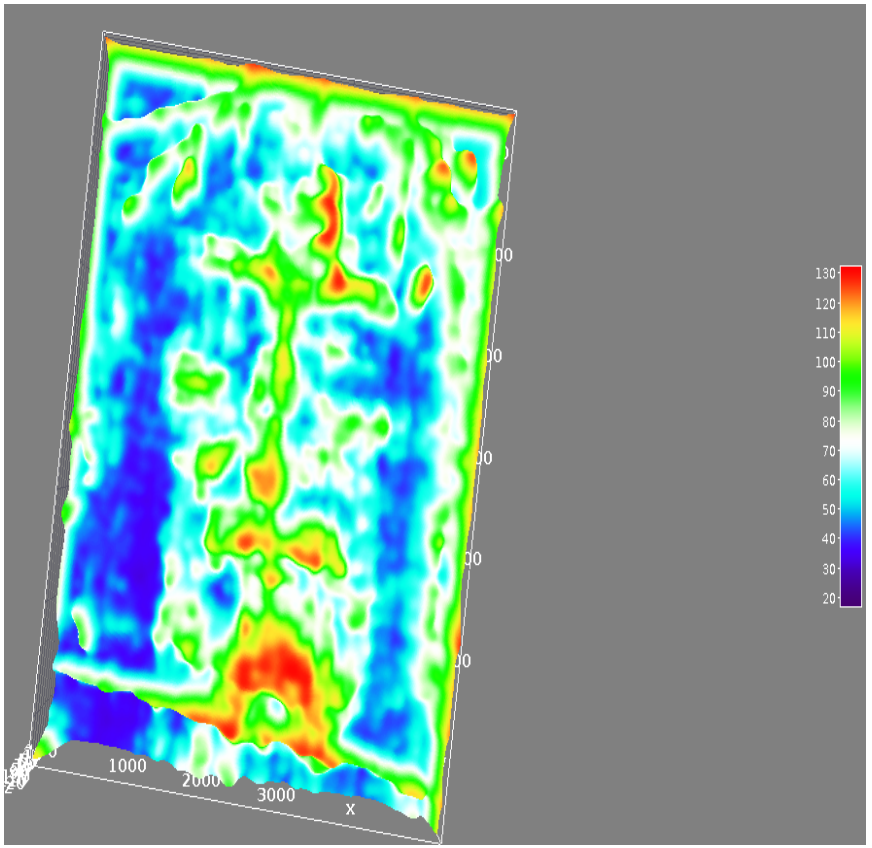
Small Sample Correlation Technique. Our procedure for measuring the degree of correlation between image shading and cloth-body distance involved first measuring the transmittance of a black and white transparency of the face taken of the Shroud in 1978 (Ref. 8) by a microdensiter. ***We chose to sample 13 image locations: tip of nose, edges of nose, cheek, eyes, eye sockets, bridge of nose, lips, mustache, and forehead.*** *The limited number of sample measurements was determined by the small number of image features which we felt could be accurately identified.*

Next we measured cloth-body distance by draping a linen model of the Shroud [...], over a beared volunteer subject. Side photographs were made with the cloth in place and then after immediately being removed. By superimposing these photographs and using contour gadges (taking care not to deform the cloth) we determined cloth body distances. We note that these measurements do not provide us exactly with the cloth-body distances appropriate for the Shroud image since the subject and cloth drape are at best approximation. Thus some intrinsic error can be expected to be present.

We then plotted these data of transmittance and cloth-body distance and determined a linear regression line shown in (Figure 2). As a measure of the degree of correlation we calculated the coefficient of determination r^2 (correlation coeefficent squared) given by (Ref. 10).
[…]
The measured coefficient of determination, r^2, was 0.60 for the 13 data points; *at the 95 % confidence level, this result implies that the actual coefficient of determination, q^2, lies between 0.20 and 0.83 (Ref. 11). Though the range is quite large owing to the small number of data points available, some observations can nevertheless be made.* ***First, the null hypothesis that q^2=0 is excluded by these data with 95 % confidence, indicating that some correlation with the image shading and cloth-body distance is present in the Shroud image as Vignon suggested.*** *Second, if we assume that the image was produced by the cloth draping over a body shape, which is consistent with the data, then we can estimate the effective range of discoloration effects on the Shroud. We define this range as that distance at which the regression line intersects the average cloth background intensity.* ***According to this definition, we calculate the range to be 3.7 cm.***



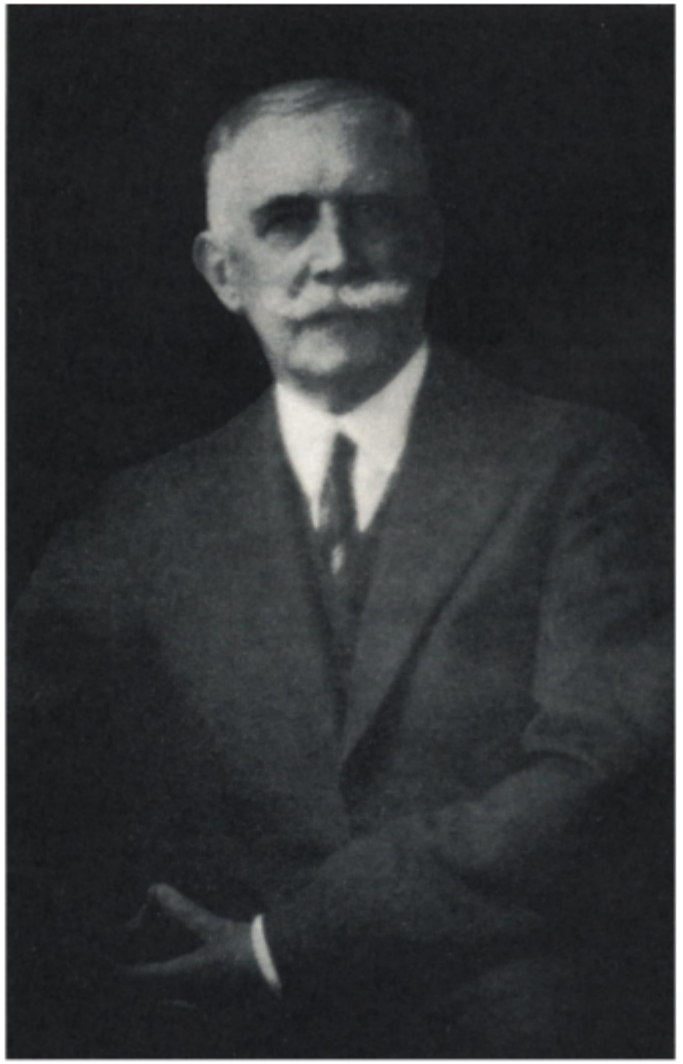
Graphique montrant que l'intensité de l'image est d'autant plus forte que la distance qui sépare le corps du linge est faible : l'image contient donc une information tridimensionnelle



But they also did one important thing: they adressed Paul Vignon.

In essence, Jackson & Jumper took the crude photo of the Shroud, determined location of 13 characteristic points on the face, determined their vertical coordinates on the model, determined the relative intensity of those points with VP-8 (much more primitive than ImageJ we use today), plotted linear regression, obtaining as a parameter max range of 3.7 cm, calculated correlation coefficient, determining that almost certainly there is at least some correlation, and then compared it with the profile for the whole front image of the Shroud. Simple technique, but remarkable achievement.

Paul Vignon -the first discoverer of 3D properties of the Shroud.



PAUL VIGNON

Vignon, in his 1902 book wrote (pg. 136-139, my boldings):

But if nevertheless in these very places there is also shaded modelling as in a drawing, it must indicate that on this stretched linen a projection has taken place. Some emanation from the body has acted on the linen, and since the hollows on the Shroud are less vigorously reproduced than the raised portions it must be admitted ***that this something worked with less intensity in proportion as the distance from the body increased*****.**

[…]

In the present case it is indeed hard to determine with what rapidity the unknown action took place between the body and the Shroud; ***the main point is that we can assert that the action diminished in proportion as the distance of the body from the Shroud increased.***

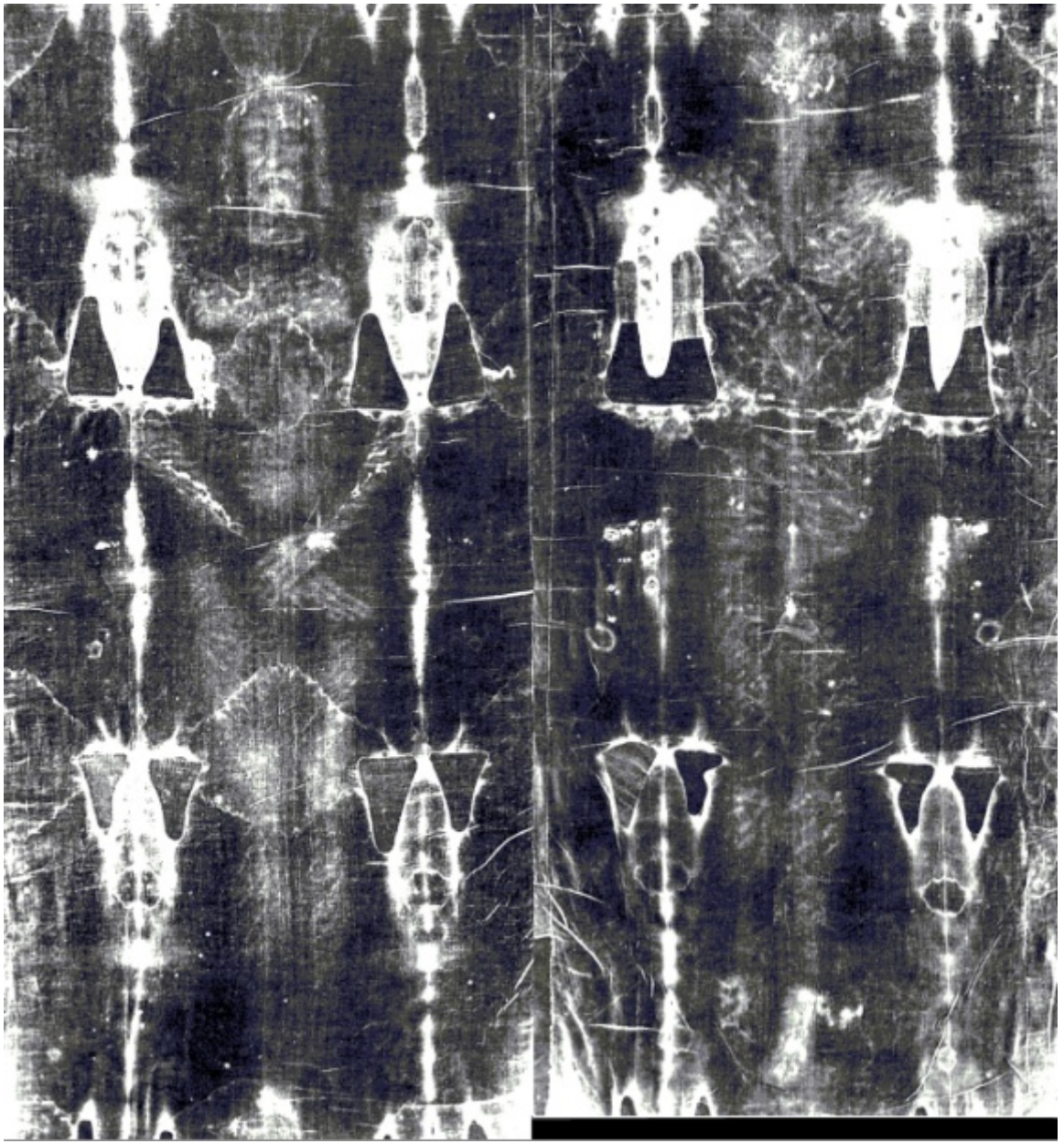
[…]

To sum up: an impression has been formed on the Shroud. ***The figure produced is not to be called a photograph, because light has had no part in forming it. In the language of science it is the result of action at a distance (that is to say without contact)****; geometrically speaking it is a projection.* ***In short we have before us the equivalent of a rough sketch which has been shaded negatively.***

[…]

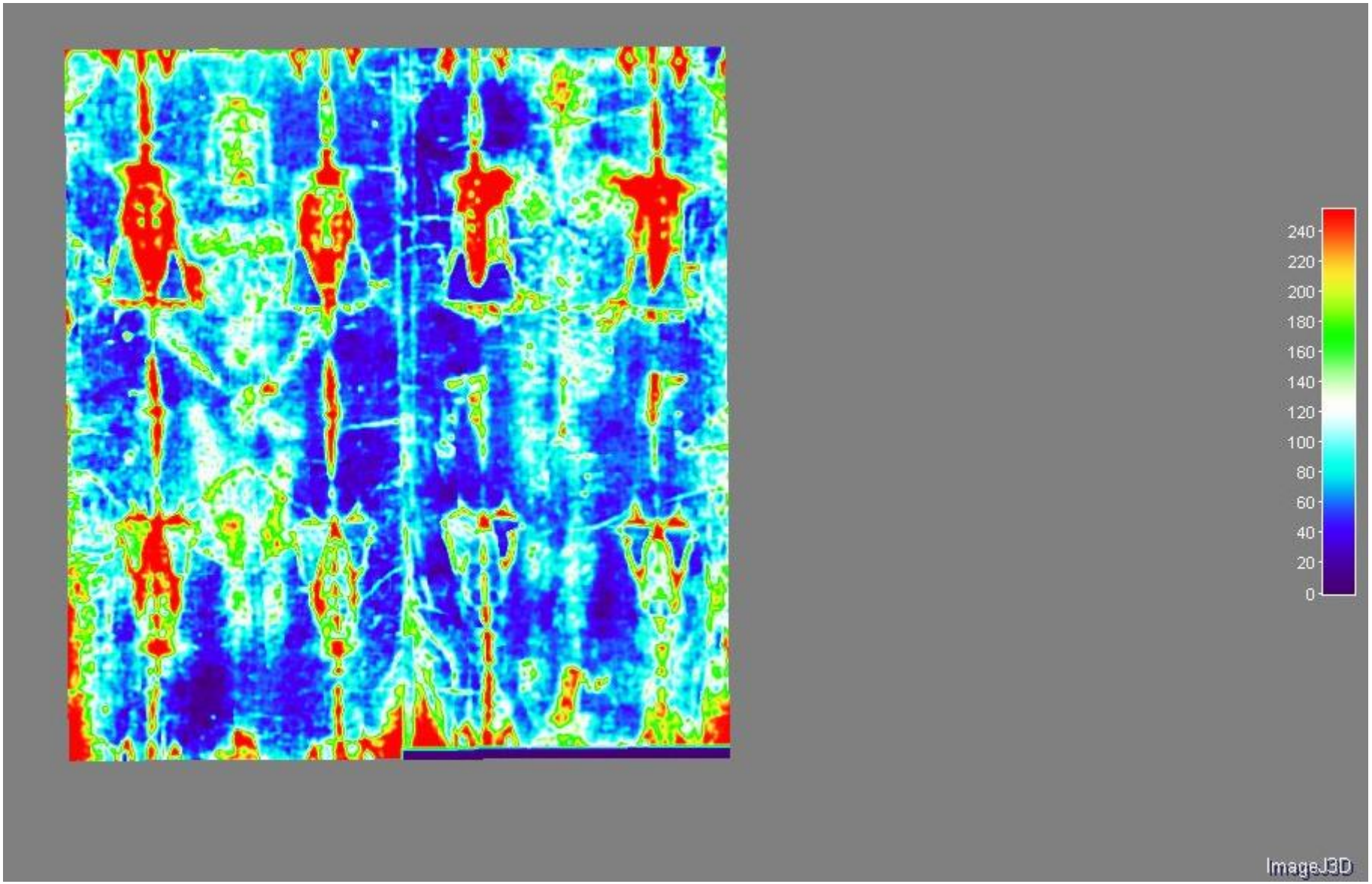
Immediately below the brows the distance between the linen and the face increases, and the circular hollows round the eyeball were sufficiently deep to give but a very slight impression. This proves that chemical action decreased rapidly in proportion as the distance increased, ***and that it ceased when the distance was more than about one centimetre.***

Before we go further, we should examine the 3D properties of the whole body image:



<-Those Enrie images are scanned from Gino Moretto's „Guide to the Shroud”, and slightly processed (gaussian blurred, brightness and contrast adjusted, compressed to JPEGs etc.)

Here is ImageJ 3D plot of the full body images



In general, it confirms the main conclusions of Vignon, Jackson & Jumper -the parts of the body that are further from the cloth are dimmer. Details will be described in next sections.

Overview

- In 1902 Vignon noticed that the parts of the body that should be further from the cloth are dimmer on negative images of the Shroud. Based on his observations, he estimated that the maximum distance before image blending with background to be **„about one centimetre”.**
- On behalf of 1970s-80s, Jackson, Jumper and cooperates established that there is a correlation between supposed body cloth distance and intensity of the image. Based on the measurements for the face (and face only), they plotted linear regression, and obtained the result **3.7 cm** for maximum distance, based on 13 points of the face and assuming linear intensity-distance formula.
- **Remember the difference: 1 cm for Vignon based on his gut feeling and 3.7 cm for Jackson and Jumper based on „precise” regression formula.**

To be continued...