ABOUT THE SECOND IMAGE OF FACE DETECTED ON THE TURIN SHROUD

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Abstract

A second faint image of the face of the Turin Shroud has been discovered in 2004 and many scientists in the world confirmed the discovery, but a recent paper has questioned in a debatable way its presence. With a perhaps too high degree of certainty it explained those patterns with pareidolia and Gestalt effects of the human perception, supporting its conclusion on the basis of illusory images perhaps built on purposes and on numerical results also derived from spatial cross-correlation used in a not proper way. This paper both discusses these results showing why the image processing used in that paper seems not proper to sustain its thesis and presents additional image processing for pattern recognition.

Keywords: Pattern recognition, human perception, digital image processing, Turin Shroud.

1. INTRODUCTION

The presence of a second faint image of face on the back surface of TS (Turin Shroud), that corresponds in shape, scale and position to the more visible one on the front side was discovered in 2004 [1, 2]. In fact in 2002 the reinforcement Holland Cloth to which the TS was stitched from the XVI Century was removed and therefore it was possible to make some photographs of the back of the TS.

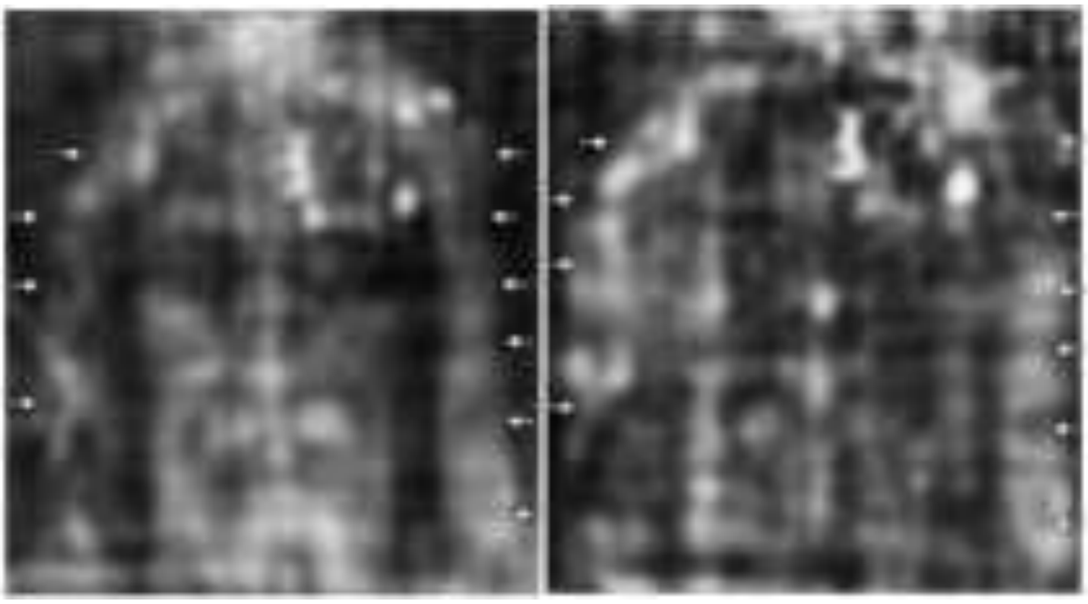
No evident body image appeared at a first glance even if someone [3] soon recognized something like the hair. Some rough image processing with negative have been done soon after [4], but more detailed analyses [1, 2] detected the presence of a second faint image.

These two images are similar but not equal. The contrast of the second image is so low that it is not easy to be detected for a naked eye and therefore some digital processing to reduce the background noise and to increase the contrast was necessary to evidence it, see Fig. 1.

The most evident patterns of the frontal face such hair, moustaches, beard and nose are also present in the second face. Instead patterns such as those of cheeks, eyes and forehead are much less evident probably because the mechanism that produced the frontal image was too weak to produce these signs on the second image.

The fuzzy TS body image is printed on a linen fabric where there are several problems such as wrinkles and spots; the image is characterized by much lower spatial frequencies while those relating to disturbances and weft are higher.

It is possible to eliminate or at least reduce the image noise by filtering the corresponding spatial frequencies using the FFT (Fast Fourier Transform). Once you have identified the frequency peaks relative to the details to be deleted in the FFT spectrum it is sufficient to cancel these peaks and back-transform the resulting spectrum to obtain the filtered image.



a b

Fig. 1. a) image of face on the front side of the TS; b) second image of face on the back side of the TS corresponding to the first one in position, shape, and scale. In addition the arrows show the correspondence of the two images of the hair undulations (corresponding to different gray levels) [1].

The image of the face is made up of different elements (nose, moustaches, eyes, cheekbones) all of which can be described by sinusoidal frequencies and amplitudes different from each other. For example, the first spatial frequency relative to the image of the mustache is about 4 times that corresponding to the nose.

Therefore, in reference to the filtering of the image of the face, it is necessary to perform the analysis along different sub-areas in which the details are described with similar frequencies and amplitudes of the corresponding sine waves under the examination. To make the same process directly on the whole would result in an inevitable average of frequencies and amplitudes thus resulting in considerable reduction of the filtering; therefore this procedure, that was performed in Ref [4] must be avoided. Fig. 2 shows the resulting quality difference after FFT filtering sub-areas of the image or the whole image.

After filtering of the various defects of the image and the weft, the template matching performed by comparing the front and back images of the TS is thus improved both because the resulting imprint on the TS can be enhanced by image processing, and because the weft of the front image is different from that of the back.

Notwithstanding many attempts to explain the mysterious image of a man visible on the TS [5, 6, 7], this image is still not scientifically explainable. The presence of a second image of face is an additional information important for the comprehension of the formation mechanism. In fact, among the many peculiar features of the body image, to the well known superficiality of the image, it must be added the double superficiality of the face on the very thin linen fabric.

Among the various hypotheses of image formation [7], there is one based on Corona Discharge produced by intense electric fields [8] that is able to explain the double superficiality of the TS image of a human body. Nevertheless this hypothesis is still not able to explain the source of such an intense electric field and therefore many studies are in progress to find an acceptable explanation [9].

The presence of a second faint image on the back side of the TS is therefore an important evidence useful to the understanding of the mechanism of the body image formation. As a recent paper [10] questioned its real presence arriving to apparently sure results, it is important to understand how much reliable is that conclusion. The present discusses those questionable results that need clarification. In fact Ref. [10], after showing some fault of the human perception, bases its rebuttal both on digital processing and on misleading images built in for purpose using patterns unduly declared as noise (like the construction of an apparent image of belly-face using the imprints of scourge wounds, see Fig. 8). But it is not simple to explain the results of human perception only on the basis of computer vision and the following Section will try to explain why.

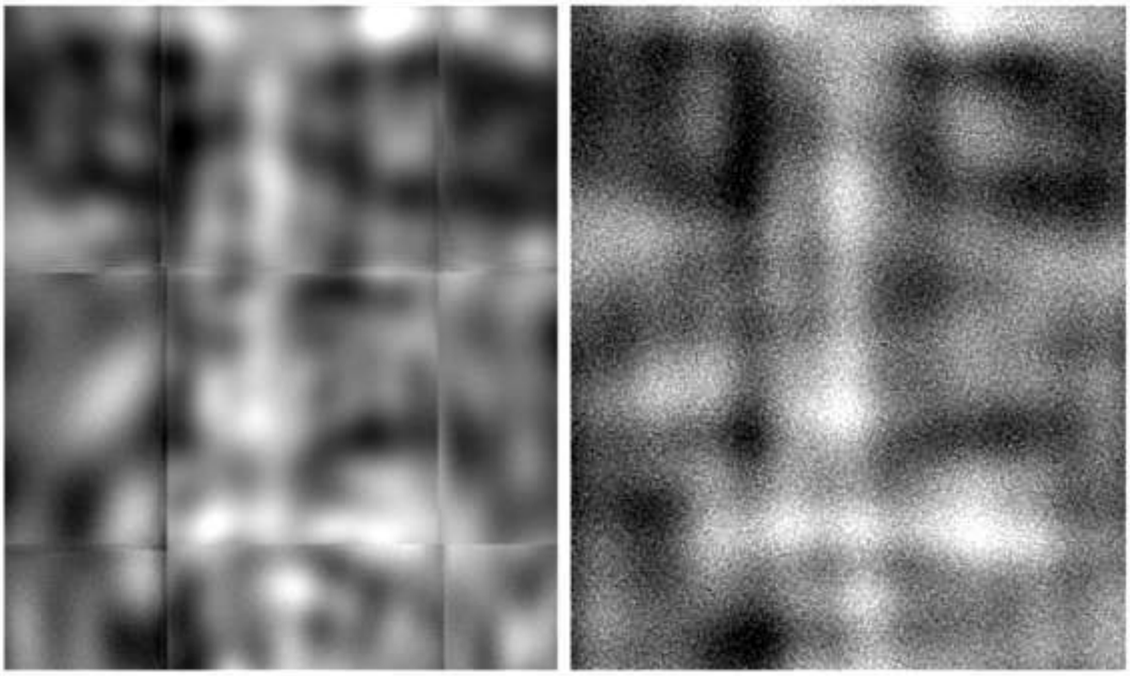


Fig. 2. Difference of details after FFT filtering sub-areas of the TS image of face (on the left) or the whole image (on the right).

2. HUMAN VISION AND DIGITAL PROCESSING

The human visual perception is a complex phenomenon involving many disciplines as radiometric photometry, physical anatomy, physiology, neurology, neurophysiology, psychology of knowledge that produce subjective results [11 - 13] not easy to obtain in an objective way using digital image processing. It seems in fact not easy to judge problems relative to analog signal like those relative to the visual perception in digital terms such are those derived by computer vision, as it is done in [10]. This because while the eyes-brain system works on the basis of analog information (except for the case of spatial variations), artificial systems are based on the very different digital processing.

Both analog processing of human vision and digital processing of computer vision have strengths and weaknesses but at this moment the human vision seems more efficient especially in the recognition of image of faces. For this reason there are many studies that try to improve the efficiency of digital methods [14 - 18].

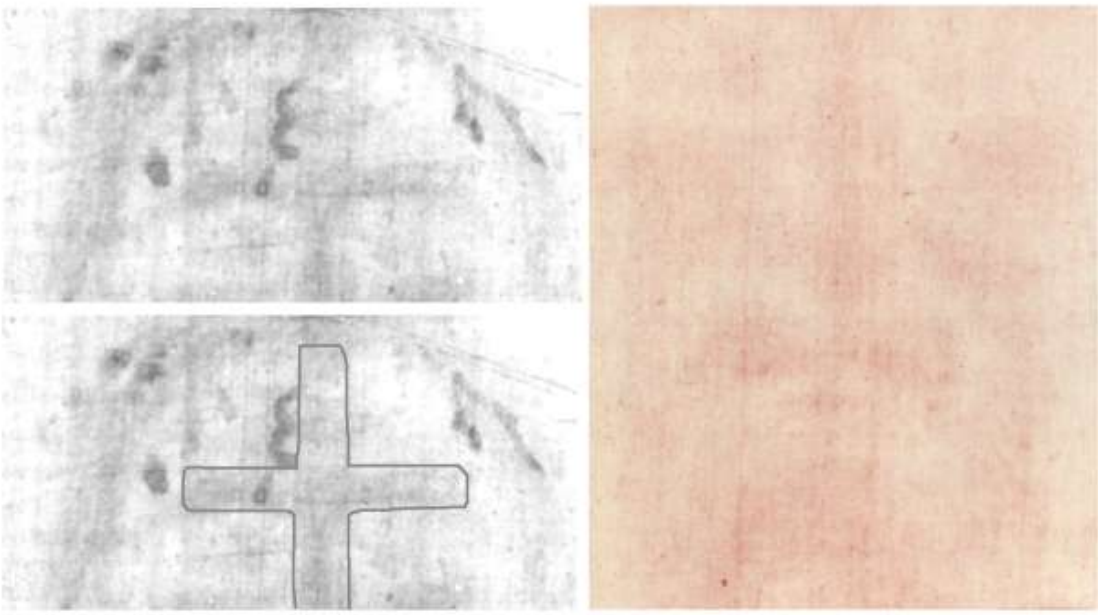
On the other hand human vision is not always reliable and some particular images can lead to misinterpretation of some pattern thus leading to the recognition of false shapes like those described by pareidolia [19] and Gestalt [20] effects. Ref. [10] bases its critics just on this, perhaps discrediting too much the human perception. In fact from that discussion it appears credible only the pattern that can be objectively detected via computer vision, while from the following examples we'll see that it is not so simple to reach an objective conclusion.

Consider the following question. Are we sure that there is really codified a human face on the front side of the TS (see Fig.1 a)? The question seems to have an obvious answer because everyone can recognize the pattern of a human body on the TS, but the literature [11 - 18] seems not to suggest a completely objective method sure to demonstrate that the image in question is really a human face with a zero percent risk of error.

On the other hand the examples of Fig. 3 show possible ambiguous interpretation of the human perception in reference to the patterns just contained in the TS face. Fig.3a is the upper part of the photo of face made by G. Enrie [21] in 1931 using a orthochromatic plate to enhance the low-contrast image. Looking at Fig 3a our eyes-brain system can alternatively recognize a bloody image of a forehead with eyes and hair, or the image of the cross highlighted in Fig. 3b.

Also Fig. 3c that is a the first color photo of face made by G. B. Judica Cordiglia in 1967 [22] is not easy to interpret because of its low-contrast. The set eyes-nose-moustaches can alternatively be interpreted as the pattern of a butterfly (corresponding to nose-cheeks) over a flower (corresponding to the moustaches).

Again no objective and sure methods, able to exclude one of these possibilities are know by the authors both using digital or analog methods. Therefore we must conclude that the boundary between sure detection of patterns and false interpretation is not yet well defined. At the light of this conclusion it appears quite odd the sure conclusion reported in [10].



a (up), b c

Fig. 3. a) and b) G. Enrie's photos of the TS upper face of the TS alternatively showing eyes and forehead of face or a cross. c) G. B. Judica Cordiglia's color photo of face [22] alternatively showing the set eyes-nose-moustaches or a butterfly over a flower (corresponding to moustaches).

3. SPATIAL CROSS-CORRELATION FOR DIGITAL PROCESSING

An example of software widely used for pattern recognition, is the template matching based on spatial cross-correlation (eVision's EasyMatch®). It furnishes a score corresponding to the matching degree of gray levels relative to two groups of pixel belonging to the image under analysis and to the template image. In addition it furnishes the scale and the position of the template image in the image under analysis and these two data are very important for a reliable recognition.

The human vision instead bases its judgment on front of the recognition of analog shapes previously stored its data-base (brain). If and when it recognizes patterns corresponding to nose, eyes, lips, cheeks and hair it recognizes the image as that of a face.

The template matching based on the spatial cross-correlation of two images is a technique widely used in industry to verify the presence of components and its efficiency has been employed in many cases, also for face recognition [16 - 18], but is criticized in [10]. We are aware of the fact that the template matching does not always give sure and unquestionable results, but this is a valid mean to detect the presence of patterns especially if to the simple numerical value of the score S are coupled the right detection of template's scale and position.

The template matching furnishes values of the score S relative to the spatial cross-correlation that varies from S=0 to S=1. S=0 means no correlation while S=1 means perfect correlation. In general S>0.6 suggests a probable correlation, while the value of S=1 is very hard to reach because of the presence of noise.

The template matching technique is more reliable if the pattern in question is quite simple like electronic components in computer cards or the lower part of left hair in the images of TS face while its reliability decreases with the complexity of the patterns like the case of a human face.

Focalizing the attention on the two faces of Fig. 1, while it is relatively simple for the software to recognize the presence of some areas like those of nose-moustaches or left hair [1], it is more difficult to make a comparison between the undulations of hair (indicated by the arrows) that instead the human vision more easily recognizes as similar (the arrows help this comparison).

Using the template matching based on spatial cross-correlation, the paper in question [10], is not able to recognize images that our eyes-brain is (see Figures 1) obtaining S=0.4 and concludes in a debatable way that the image of face of Fig 1b does not exist because it is a trick due to both pareidolia and Gestalt effects.

Instead the authors have obtained a relatively high [1] correlation between some details of the two faces shown in Fig. 1. For example it has been recognized the detail of nose-moustaches with S=0.86; Fig. 4 again shows the recognition of the lower part of left hair in the images of TS faces shown in Fig. 1 obtaining S=0.83 with corresponding shape and position.

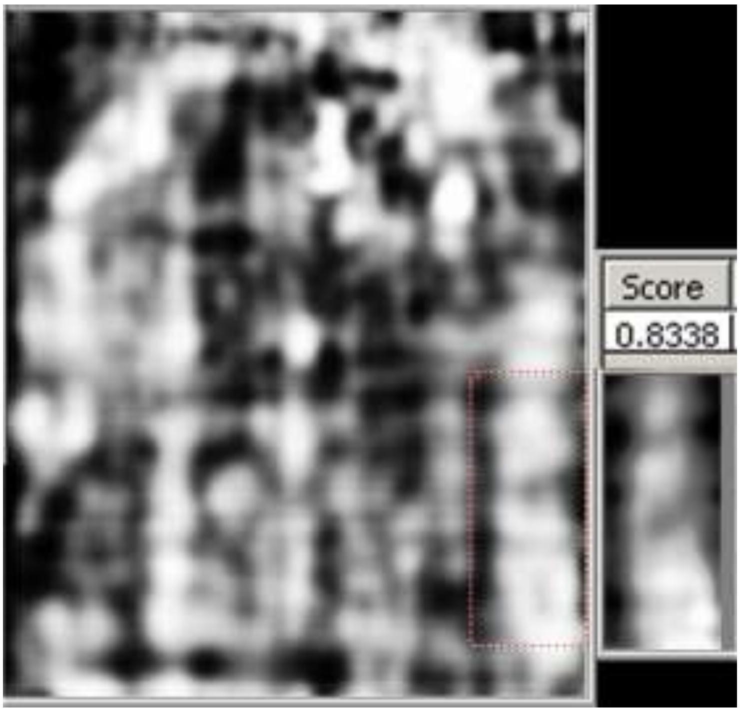


Fig. 4. Detail of the left hair detected on the fainter image of the back side of the TS compared (on the right) with the same detail taken from the front side of the TS image of Fig. 1a: a score of S=0.83 results from the template matching algorithm demonstrating the very probable presence of the same pattern in the two images because also scale and position correspond.

It is known that the results obtainable by commercial software based on the template matching (for example EasyAccess®) are quite dependent on set-up parameters like image deformation, normalization, scale and rotation of the image and a proper set-up of these parameters gives a score of S=0.87 showing the right recognition of the second faint image in question, in scale and position as it is reported in Fig. 5. Also from a digital point of view, the results obtained in [1] are therefore confirmed.

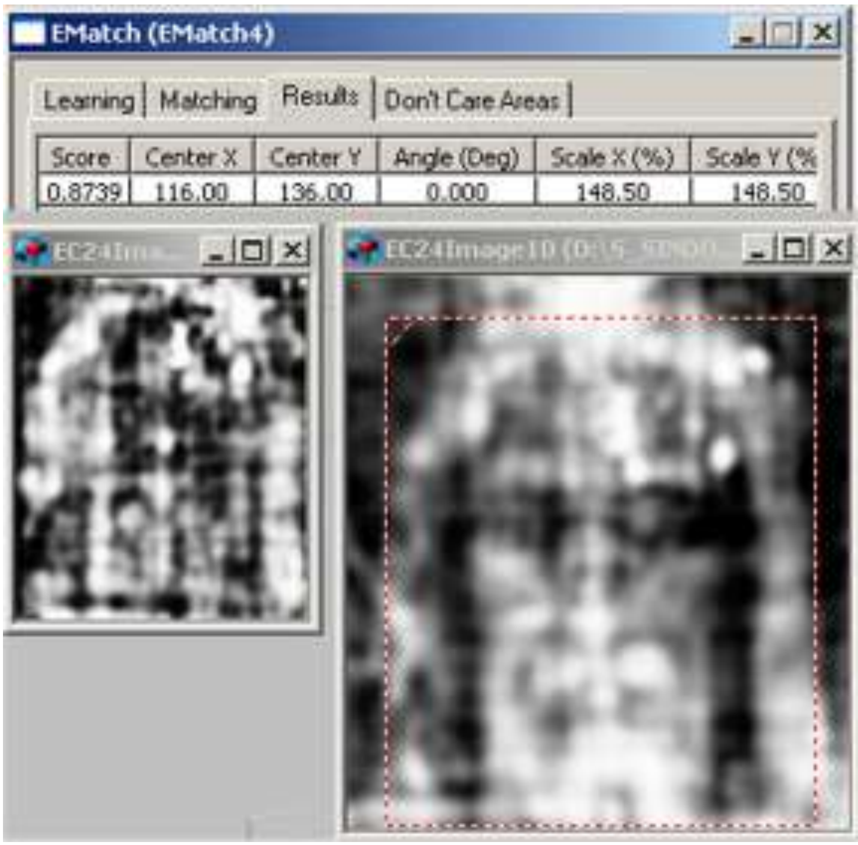


Fig 5. Template matching between the two images of Fig. 1 with a score S= 0.87 with corresponding scale and position thus confirming the presence of a second faint image on the back of the TS.

4. OTHER COMMENTS ON THE PRESENCE OF A SECOND IMAGE OF FACE

Worth to note seem the following additional comments on questioned presence in Ref. [10] of the second faint image on the back surface of the TS reported in Fig. 1b and described in the Ref. [1].

4.1) The mentioned "*first concern on the reliability of the results*" is based on the following statement: "*The acquisition and digital processing of a photograph printed in a book and convoluted by a complex photomechanical reproduction process may easily lead to uncertain and debatable results.*".

This criticism is widely explained in Ref. [1]. We resume it here stating that the spatial frequencies of interest for the detection of face's features are relatively low, when on the contrary the digital processing in general can alter the higher frequencies or the hue scale. This last is of minor importance in pattern detection if the variation is uniform along the whole image as it is supposed. We also add that at that time (2004) no other images of the back of the TS were available to the scientific community, but these results have been successively confirmed when the Turin Archdiocese made these photos free.

4.2) It is reported in Ref. [10]: "*A confirmation of this doubt came from the results of the Fourier transform of a high-resolution image directly obtained by in-depth scanning of the reverse side of the Shroud, which did not show any face or any other image [22].*".

This statement has already been disproved in Ref. [2] because the cited Ref. [4] processed images not acquired by means of a camera as it was done in 2002 (to which the present discussion refers) but images of worse quality acquired with a scanner that added noise (also due to the inclination of it lighting system that enhanced the fabric folding). In addition these results lack of pre-filtering procedures, that are necessary to reduce optical noise that masks information related to somatic features of low-contrast images [4].

4.3) In order to reach its goal, Ref. [10] proposes a very simple method based on the differences of two images that is theoretically applicable if the images in question are noiseless. It affirms that "*the absolute value of the difference of gray levels between* [Figs. 1a and 1b] *should give an almost black figure when the two figures are perfectly correlated, or a noisy figure when they have a partial degree of correlation, or a still recognizable face when the correlation is very poor*. *The result …* [shows] *a Shroud-like face …* [and not a black figure], *thus confirming the poor degree of spatial correlation…"* between the frontal and the back image of TS face.

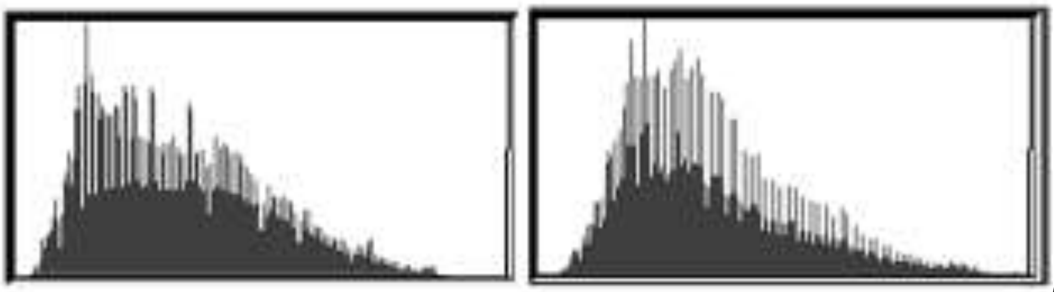
The following notes help to better understand why the reported results seem debatable:

-a. The difference has been made between two photos acquired in different environmental conditions.

-b. In agreement with [1], the image of face on the back surface of the TS is not equal to that on the front side.

-c. The image difference performed by Ref. [10] is not correct because the images have different spatial scales. It is then obvious that the result evidences the differences due to the relative image enlargement.

-d. It is not explained in which sense the two images in question "*have the same histogram of "number of pixels" vs. "gray levels*".", because the corresponding histograms reported in Fig. 6 show similar distribution of gray levels in general, but different maximum values and different shape of the curve interpolating the peak values. For example the more uniform distribution of peaks in the region of the dark-gray levels of Fig. 1b may be correlated to the higher presence of noise in correspondence of the eyes-cheek-lip area, because these details seems almost lacking in this image.

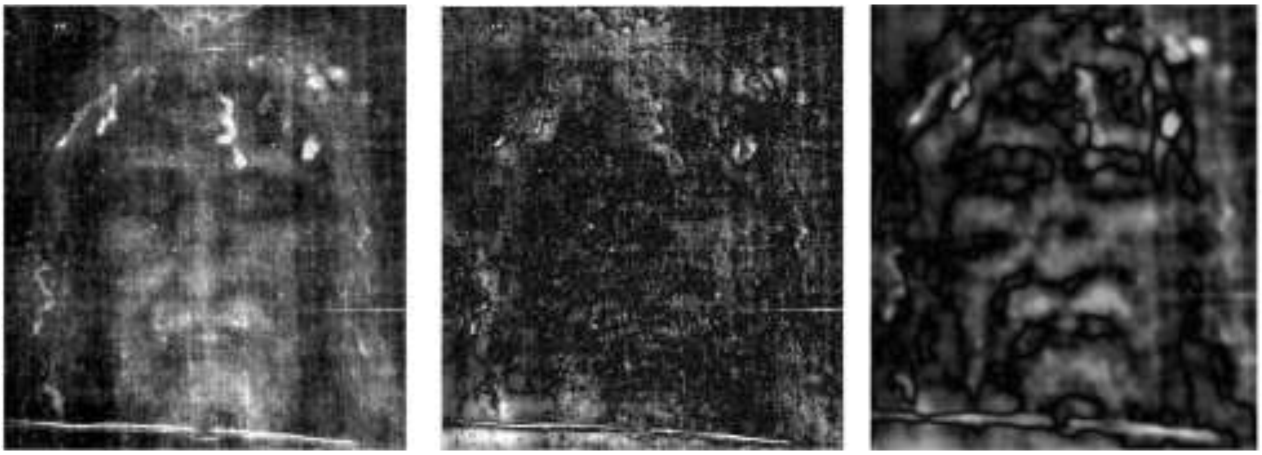


a *b*

Fig 6a, b. Histograms of the respective images of Fig. 1a and b showing similarities and differences.

For example, Fig. 7a shows a photograph of the TS face made by G. B. Judica Cordiglia [22] and Fig. 7b the absolute value of the difference of gray levels between Fig 1a and Fig. 7a properly conformed in scale. Contrarily to what stated in [10], instead of a black image, the hair and some other features can still be detected thus demonstrating that different photos of the same image do not produce a black figure as it was implicitly supposed in Ref. [10]. In fact, differently from what is reported in the same Ref., we can still recognize some pattern, especially of the hair in Fig. 7b, when the correlation is good because two photographs of the same detail of the TS face (see Figs. 1a and 7a) have been used.

Fig. 7c in addition shows the image resulting from the difference of the same two photos (see Figs. 1a and 7a) without a scale conformation as it was not correctly done in Ref. [10]. It is here obvious the presence a great number of patterns, different from the black background, corresponding to a face, thus questioning the deductions of that paper.



a b c

Fig 7. a) Photograph of TS face made by G. B. Judica Cordiglia [22]. b) Result of the absolute value of the difference of gray levels between Figs. 1a and 7a after scale conformation of the two images. The non black resulting image shows the difference between two photographs of the same face. c) Same processing of (b) but with a slight scale difference between the two images: some features typical of a face appear as it was done in Ref. [10].

4.4) Alternative to the difference discussed in Sub-Section 4.3, other methods can be used to compare the features present in two images. For example the arithmetic mean of the luminance levels, made pixel by pixel, furnishes brighter areas corresponding to features common to the two images. The square geometric mean (multiplication of the two images in question) enhances the bright areas in common to the two images. Even more is obtained by the squaring the previous result.

Fig. 8 shows some results in reference to the following three images under analysis: Fig. 1a, Fig. 1b and Fig. 5a of [10] (a violin).

The following operations have been performed:

$$\text{(Fig. 8a)} = \text{(Fig. 1a)} * \text{(Fig. 1b)} / 250 \quad (1)$$

$$\text{(Fig. 8b)} = \text{(Fig. 1a)}^2 * \text{(Fig. 1b)}^2 / 250^2 \quad (2)$$

$$\text{(Fig. 8c)} = \text{(Fig. 1a)} * \text{(Fig. 5a of Ref. [10])} / 250 \quad (3)$$

where the symbol “*” indicates the image product pixel by pixel. The value 250 has been selected to limit the maximum resulting luminance values, that is lower to the whiter color of the image (equal to 255).

Figs. 8a and b present similar features (the brighter features refers to parts in common to the two images of face) thus confirming the presence of a second faint image on the back side of the TS. Instead Fig. 8c shows the completely different features of the two images that still appear superimposed each other. It is worth to note the undulation of the lower left hair, also detected by the template matching of Fig. 4 that clearly appear also in Figs 8a and b.

a b c

Fig 8. a, b) Respectively results of the product of Fig. 1a by Fig. 1b and of their squares showing features typical of TS face; c) Result of the product of Fig. 1a by Fig. 5 of ref.[10] showing the clear differences between the two images.

4.5) Ref. [10] additionally pretends to recognize another smaller image of face in the same photo of the TS face. This was probably suggested by the template matching software that, if not properly set-up, can give this misleading result. It is obvious that if a pattern is recognized, this must have the same dimensions of the template in order to be considered as a possible solution. Therefore while Figs 1a and b have comparable scale and position, all other "faces" of different sizes cannot to be considered in the discussion.

5. TRICKING?

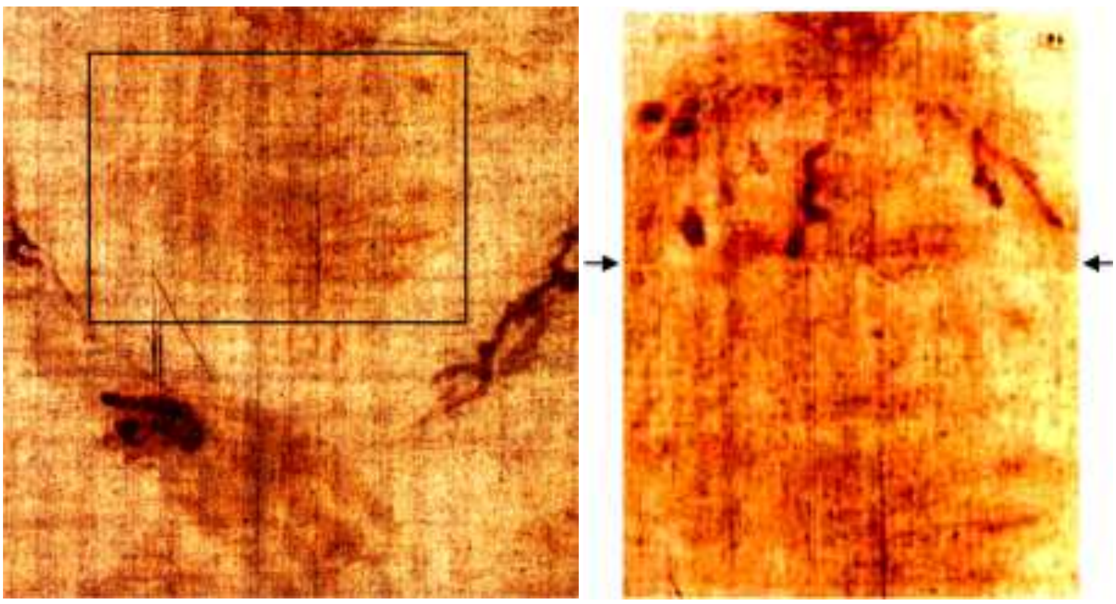


Fig 9. a. Contrast enhanced area of belly-hand in the TS frontal image. The part framed into the rectangle corresponds to Fig. 7b of Ref. [10] and clearly shows the horizontal patterns of blood produced by scourge marks. b. Contrast enhanced Figure 8 of Ref. [10] showing that some bloodstains are just positioned in correspondence of mouth and moustaches while vertical bands are in continuity with the right limit of face.

Section 5 of Ref. [10] states in reference to a detail of the TS image: "*When zooming into a detail of the belly as shown in* [Fig. 9]*, we cannot see any pattern that makes sense.*" There are instead horizontal patterns in this area that correspond to the bloodstains produced by scourge marks; there are also vertical patterns due to the fabric weaving that help to define the vertical limit of a human face. Exploiting pareidolia effects, these horizontal and vertical patterns help the eyes-brain system to perceive patterns of mouth-moustaches, and the right side of the face, see Figs. 9.

In fact the low-contrast image of Ref. [10], here contrast-enhanced in Fig. 9b, clearly shows that some bloodstains have been used to simulate mouth and moustaches and the vertical bands of the belly, that are typical of the TS linen, have been put in continuity with those of face image.

Therefore the sentence of Ref. [10]: "*Then, the previously discussed pareidolia and ability to supply the missing information "create" the illusion of nose, mouth chin and long hairs*" can be only partially true. The eyes-brain system of the observer is clearly helped here by patterns really present in the image. It seems that they have been, perhaps involuntarily, just selected in a crucial position to take advantage of them with the aim to trick the human vision. The attempt of explanation in Ref. [10] relative to this human perception of face based on "*random stains*" is therefore obviously questionable.

CONCLUSION

The human visual perception is a complex phenomenon involving many disciplines. As we have seen it is quite illusory to pretend to judge analog problems like visual perception only in digital terms such are those derived by computer vision. Worse seems to pretend to dismiss a result as stated in Ref. [10] by comparisons with built-in images that tend to trick the human perception.

Pareidolia and Gestalt effect can in some case trick the human vision and there is not a well defined separation line between real patterns and those built in by the human perception. The human perception is a very complex analog method, able to assign a preconceived model stored in our memory to a pattern contained in an image. Various digital methods have been proposed in Refs. [11 - 18] for the recognition of these patterns that up to now not always completely reach their goal.

Among them there is the template matching using spatial cross-correlation that, if properly used gives acceptable information. Additional checks for face recognition can derive from the mutual comparison among the results obtained by other methods like those proposed in Refs. [15 - 18]. But a not questionable answer will be probably obtained in the future when we will dispose of a software able to recognize, measure and compare with no doubts important details of face like mouth, nose, moustaches, beard, hair, eyes.

After admitting that "*Our perception may be subjective*" and therefore that "*we cannot be sure that our perception is correct*" without proposing a sure and objective method to recognize a pattern, Ref. [10] oddly states: "*we have shown that image processing of recent, high-resolution photographs of the Shroud may lead some to perceive … patterns that do not actually exist*". It also adds. "*we have shown for the first time that the "discovery" of a hidden image of a face on the reverse side of the Shroud … has a very poor spatial correlation with the corresponding face image on the frontal side of the Shroud*".

Before to reach a conclusion in agreement to Ref. [10] it will necessary a sure and objective demonstration that the second fainter face detected in Ref. [1] is really a trick of the human perception. Meanwhile, in agreement with various TS experts, see Refs. [23 - 26], we consider credible the presence of a second image of face on the back side of the TS. The analysis of the UV photo of face made by Turin Archdiocese in 2002 and not yet made available to the scientific community will help to confirm this fact.

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