

A REVIEW OF 3D CHARACTERISTICS OF THE TURIN SHROUD BODY IMAGE

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SUMMARY

The Turin Shroud is a linen sheet 4.36 m long and 1.10 m large that wrapped the corpse of a scourged, crowned with thorns and crucified man; from recent probabilistic studies that man was confirmed to be Jesus.

There are also impressed many marks due to blood, fire, water and folding that partially cancel the double body image (front and back).

The body image is impressed in a scientifically unexplainable way and contains a 3D information related to the body-sheet distance.

The 3D characteristic of the body image help us understanding the wrapping of the Man in the sheet and the possible radiant mechanism that caused the image. Nevertheless the high grade of image damage due to the various marks makes difficult this analysis.

For this reason a computerized reconstruction and cleaning of the body image was done. The front image of the Turin Shroud, 1.95 m long, is not directly compatible with the back image, 2.02 m long. In order to verify the possibility that the same human body generated both images, a numeric-anthropomorphous manikin was constructed by computer and wrapped in the digitized front and back images. The front and back images resulted mutually compatible with a man 175 ± 2 cm tall, which, due to cadaveric rigidity, remained in the same position (except arms) it would have assumed during crucifixion.

1) INTRODUCTION

The Turin Shroud is a linen sheet 4.36 m long and 1.10 m large that wrapped the corpse of a scourged, crowned with thorns and crucified man (Jumper 1984, Adler 1996). There are also impressed many marks due to blood, fire, water and folding that partially cancel the double body image (front and back).

After scientific analysis of the Turin Shroud in 1978, the STURP (Shroud of TURin Research Project) (Jumper 1984, Adler 1996) concluded that the body image on it cannot be explained scientifically, and that the only attempt at explanation consists of stating that the image formed as if it were caused by exposure to a short-lived but intense source of energy coming from the body covered by the Shroud itself.

The body image: is extremely superficial, since only the first 4-6 fibrils, with respect to the 80-120 typical of a linen thread, are involved by the image; was chemically caused by oxidation and dehydration of the cellulose fiber; is yellow in color, and has chromatic uniformity with variations of less than 2%, since the *chiaroscuro* effect is caused by a different number of yellowed fibers per unit of surface, so that this is an image with 'areal' and not 'chromatic' density; has three-dimensional (3D) features which are consistent with the relation linking the distance between Shroud and wrapped body.

The following facts have been verified: the bloodstains, transposed to the linen fabric by fibrinolysis, were impressed on the Shroud before the body image formed, since there is no body image under them; the processes of redissolving and transposition of blood in a damp environment may occur after a period of 10 hours; the body of the Man remained in the Shroud for less than 40 hours, because no signs of putrefaction can be found.

Many experimental tests have been carried out on linen fabrics in order to obtain results empirically similar to those of the body image of the Turin Shroud. Among these are: a) tests involving scorching the sheet lying on top of a heated bas-relief (Ashe 1966, Pesce Delfino 2000) but, according to some researchers (Jackson 1984, Jackson 1990), in order to obtain such a superficial image, exposure to intense sources of heat must last less than one second, even if exposure time may be increased if the sheet is soaked in an aqueous solution of aloes and myrrh; b) tests on a bas-relief model head soaked in a solution of sulfuric acid (Nickell 1997); c) putting linen fabrics in contact with model faces made of plaster of Paris soaked in mixtures of water, blood, aloes and myrrh (Moroni 1987); d) rubbing suitably wrapped model faces covered with ochre with linen fabrics (Nickell 1997); e) proton irradiation for about ten seconds (Rinaudo 1998) which causes acid oxidation of the superficial fibers of a linen sheet; f) a modified carbon dust drawing technique (Craig 1994).

Although good experimental results have been obtained, in the sense that, at first sight, the image of the face is similar to that of the Shroud Man, until now no experimental test has been able to reproduce all the qualities found in the image impressed on the Shroud (Marinelli 1998).

The Man of the Shroud was not completely in a supine position but, according to the rigor mortis which began after his crucifixion, had his head tilted forwards (Basso 2000), his knees slightly bent, and his feet extended as a result of nailing.

The hypothesis now practically accepted by the entire scientific world is that the image is not a painting (Fanti 2000), since the scientists of the STURP, showed the absence of paint pigments in quantities sufficient to explain the presence of an image (Jackson 1990). However, some doubts remain regarding the characteristics of the Man who was wrapped in the Shroud. First, some distortions in the front body image are evident, e.g., points corresponding to the hands and calves, which exclude any kind of photographic procedure used to obtain the image.

Some information about the Man arises from a 3D analysis of luminance level; the present work resumes many studies (Jackson 1984, Jackson 1990, Basso 2000, Balossino 1997, Tamburelli 1984, Fanti b 2000, Fanti c 2000) done to understand how the Man was wrapped and some physical characteristics of him.

2) CHARACTERISTICS OF THE TURIN SHROUD

The characteristics of the Turin Shroud are evidenced in Figure 1 in which the front and back body image in partially cancelled by many other marks such as that due to blood, fire, water and folding.

The linen sheet (4.36 x 1.10 m) wrapped the corpse of a man who was scourged, crowned with thorns, crucified with nails and stabbed by a lance in the side.

The Shroud cloth is hand-made and each thread (diameter of about 0.25 mm) is composed of 70-120 linen fibrils.

The blood stains are human blood and they have formed before the body image formation because under the blood no body image exists.

The body image is impressed as a photographic negative and the luminance levels are correlable to a 3D human body. The image is due to degradation through dehydration and oxidization of the superficial linen fibrils. It is superficial, detailed, thermally and chemically stable. On the Shroud there is an image even where surely there was no contact. Its light and shade images are proportioned to the different distances between the body and the cloth in the various points of draping.

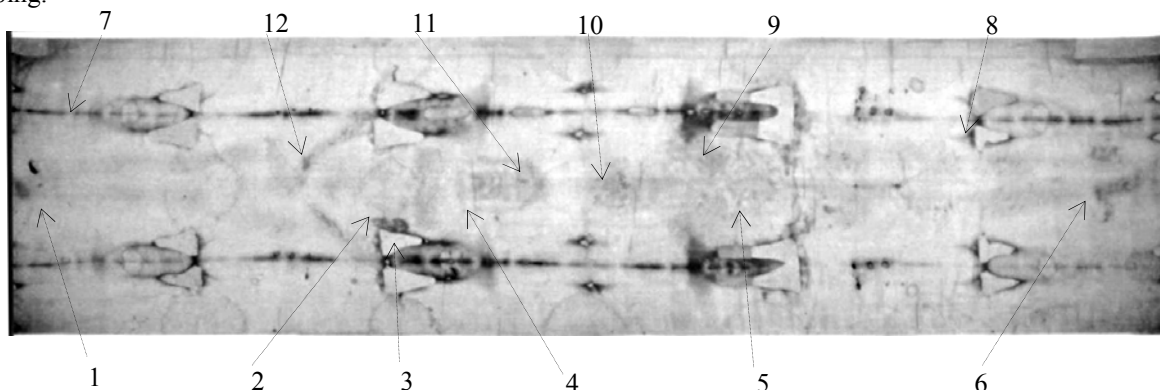


Figure 1: Body image and marks visible on the Turin Shroud: 1. The wound of the right foot 2. Marks of the water used to extinguish the fire of 1532. 3. The wound in the side. 4. Folds of the cloth. 5. Scourging strokes. 6. The heel and sole of the right foot. 7. The carbonated lines in the cloth due to the fire of 1532. 8. Mendings done by the Chambéry Clare nuns. 9. Bruises due to the transport of the patibulum. 10. Wounds on the head due to the crown of thorns. 11. The wound on the forehead. 12. The wound on the left wrist.

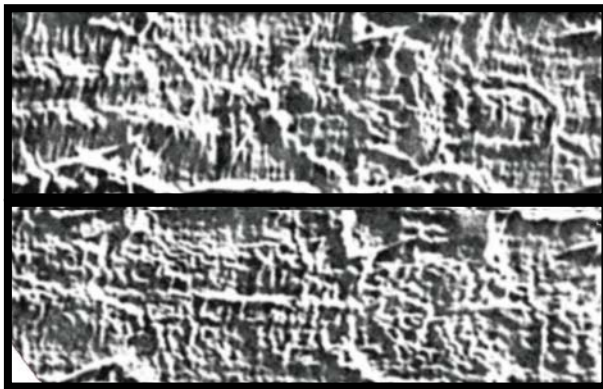
The Shroud was radiocarbon dated; the result, 1260-1390 A.D. was published in Nature (Damon 1989), but a great number of scientists believe that the method used to take the sample and the radiocarbon dating reliability are not satisfying, considering a material like the Shroud that suffered many vicissitudes (fires, restorations, water, exposition to nature, to candle smoke, to believers breath, etc.). For example the 1532 fire modified the quantity of radiocarbon in the Shroud, altering its dating and it was proved the existence of a biological complex made of fungi and bacteria covering the Shroud's threads in a patina. In any case it must be observed that actually science and technology is not able to reproduce all the characteristics of the body image; it is therefore doubtful the application of a measurement method to an object not completely known.

From a probabilistic study (Fanti 2000) analyzing 100 statements formulated in favor or against the Shroud authenticity, resulted that the Turin Shroud is Jesus of Nazareth's burial sheet with a probability of 100% and a negligible uncertainty.

3) CHARACTERISTICS OF THE BODY IMAGE

The body image of the Turin Shroud, the mechanism of formation of which has not yet been explained scientifically, is composed of a front image 1.95 m long and a back image 2.02 m long, separated from the former by a non-image zone of 0.18 m.

The image contains a 3D information related to the body-sheet distance. The first 3D elaboration were done by (Jackson 1978), see Figure 2 and by (Tamburelli 1978), see Figure 3.



Front

Back

Figure 2: 3D front and back image of the Turin Shroud obtained by J. P. Jackson and E. J. Jumper (Jackson, 1978) using the VP-8 Image Analyzer System.

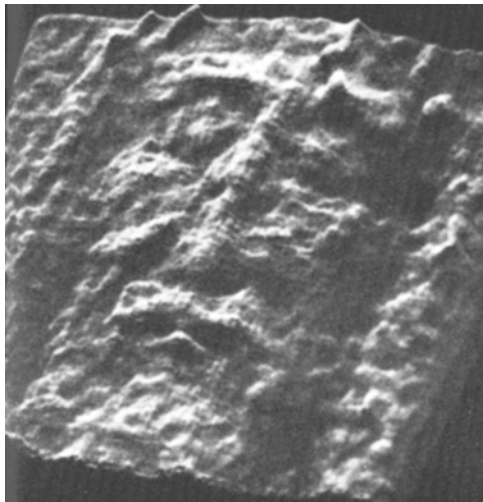


Figure 3: 3D face of the Turin Shroud Man obtained by G. Tamburelli, G. Garibotto (Tamburelli, 1978).

The formation mechanism of the body image, happened after the formation of the blood stains, has particular and non-reproducible characteristics. It is partially explainable if a vertical energy source coming from the body is supposed because the image is almost compatible with a vertical projection.

If the analysis is focussed on the face of the Man, on the contrary the blood stains are compatible with a cylindrical distortion due to the sheet wrapping; therefore they are not in the correct position. For example, in correspondence of the hairs, some bloods dripping are evidenced but, according to experimental test, they correspond to the cheek position on the body image.

In Figure 4 (Fanti 2000) the blood dripping correction is evidenced on a 3D-computer elaboration.

The body image of the Shroud shows physical and chemical characteristics that actually science is not able to explain, some of them are (Jackson 1998):

- 1) The body image is well resolved: the resolution is of the order of 1 cm. For example lips are evident.
- 2) The body image penetrates into the cloth to a depth of no more than a few linen fibrils and there is no cementation.
- 3) The luminance variation of both the front and back body image is correlabile to the distance between the sheet and the corpse and is independent of implied body surface composition (e.g. skin, hair, etc.): a 3D information is then codified.



Figure 4: 3D face of the Turin Shroud Man (Fanti, 2000): some bloods dripping visible on the hairs are corrected to correspond to the cheek position.

- 4) Side images surrounding the front and back body images, including the region between the two heads are absent.
- 5) The body image is due chemically to a molecular change of the cloth cellulose, in particular a conjugated carbonyl structure associated with dehydration.
- 6) The red images stains are composed of human blood (AB group) and were impressed before the body image.
- 7) The body image is almost completely coherent with a vertical projection of the corresponding human body if the Shroud was draped naturally over a body shape lying in the supine position.
- 8) The maximum luminance level of the front and back images are compatible within an uncertainty level of the order of 1%; this means that the back image is not influenced by the body weight.

To explain the formation mechanism of the body image, some researchers proposed the hypothesis of the artist intervention that constructed the image artificially, but this is inconsistent with Items 2, 3, 5, 6 and 7. Other researchers proposed a diffusion mechanism, but this is inconsistent with Items 1, 2, 5 and 7. Other proposed mechanisms connected to the direct contact body-sheet, but this is inconsistent with Items 3, 4, 6 and 8. At the end other proposed the presence of a radiation source coming from the inner of the wrapped body. This hypothesis is the most reliable even if Items 4 and 7 must be demonstrated with experimental test.

4) LUMINANCE ANALYSIS OF THE FACE ON THE SHROUD

Two photographs of the Shroud face were compared with two photographs of faces obtained by means of experimental techniques, the results of research by J. Nickell and V.D. Pesce (Figure 5 a, b, c and d).

A 3D elaboration of the luminance of photographs shown in Figures 5 is reported in Figure 6 in which the luminance values are interpreted as height values from a plane defined by the black color. The elaboration is based on the negative images of all Figures 5. All the photographs show some 3D characteristic, but Figures 5a, 5b, although disturbed by many defects, seem to be more correlable to the sheet-face distance.

Due to the high contrast obtained in photographs of J. Nickell and V. Delfino Pesce experiments, Figures 5 c and 5 d show the best 3D visual result, but its less easy to correlate it to the sheet-face distance.

The technique described by (Fanti 2000b) was used to correlate the black-and-white luminance of various photographic images with the image on the Turin Shroud. Instead, the different photographs of the facial image on the Turin Shroud were used to verify the stability of the results obtained, according to variations in the photographic characteristics of the same subject.

With respect to the photographs of the Turin Shroud, the experimental photographs of Nickell and Pesce have a much higher percentage of saturated pixels correlated to areas of non-contact between face and Shroud; this fact is contrary to the hypothesis that the body image of the Turin Shroud formed according to a technique proposed by the two above researchers.

Numerical processing procedure of photographs 5 c and 5 d (experiments of Nickell and Pesce) show large light areas corresponding to parts where there is no contact between sheet and underlying face; in particular, no body image is impressed in the areas round the eyes and between nose and cheeks.

Instead, processing of photographs 5 a and 5 b shows more continuous variation of luminance near those parts of the face, and indicates that the image formed by means of a mechanism different from that used for photographs 5 c and 5 d. This is confirmed by the 3D elaboration shown in Figure 6 where both Nickell and Pesce results show a flat area near the nose and the eyes.

It is therefore more probable that the way the image formed on the Shroud is also to be related to a non-contacting phenomenon such as radiation.

With respect to the photographs of the Shroud, which have a pixel percentage with extreme L-values of $23\% \pm 5\%$, the photographs of Pesce's and Nickell's experiments have much higher percentages, respectively $41\% \pm 5\%$ and $60\% \pm 5\%$. This is contrary to the hypothesis that the body image of the Shroud formed according to the contact technique proposed by these two researchers.

From these considerations, it may be confirmed Jackson's hypothesis that the Shroud image is due to vertical radiation emitted by a human body if we observe that no cylindrical distortion appear in photos 5 a and 5 c because there are two lateral bands (between eyes and hairs) in which no image is impressed. These results also confirm that the Shroud image cannot be the sole result of a process of image formation by direct contact.

Furthermore a singeing is supposed by D. Pesce, but the comparison of the luminance level of the Turin Shroud with an experiment (Pesce 2000, figure 52 and 53) show the difficulty to sustain the hypothesis. In fact, as shown in Figure 7, if the luminance levels are correlated to the body-sheet distance, the surface of the Shroud Face is almost cylindrical but the surface of the scorched sheet is almost plane. Perhaps the non-horizontal best fitting of Figure 7 b is caused by the fact that the sheet was first put on one side of the bas-relief.

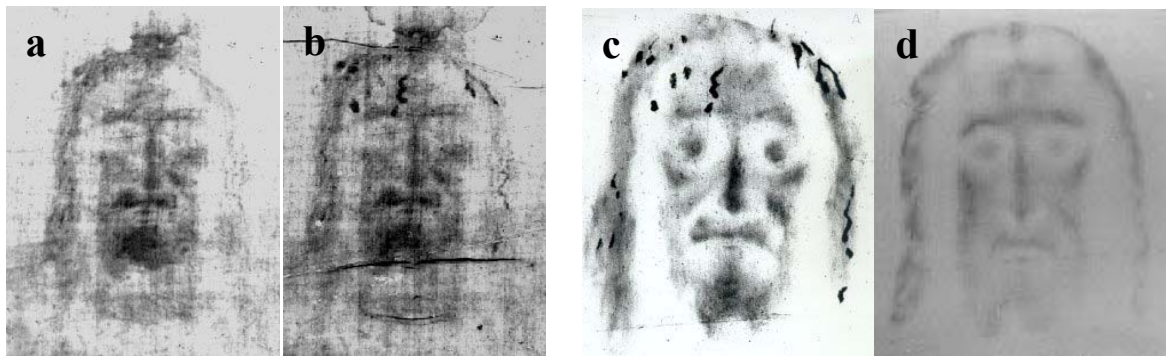


Figure 5. a) Image obtained from a photographic copy made by contact of one of Enrie's plates; the image was cleaned of various imperfections and of bloodstains; b) image obtained from a photographic contact copy with one of Enrie's plates (courtesy of Mario Moroni); the photograph was obtained by direct contact; c) digitized photograph, obtained by (Nickell 1997) from a bas-relief model head sprinkled with iron oxide powder containing traces of sulfuric acid; a sheet was then laid over the face and rubbed with cotton wool ('*frottage*'). Due to its acidity, the iron oxide exerts a chemical action on the linen, turning it a brownish color; d) digitized photographs obtained by (Pesce Delfino 1982) using a metal bas-relief model heated to 220°C, on which a linen sheet was laid for several seconds, thus scorching the fabric.

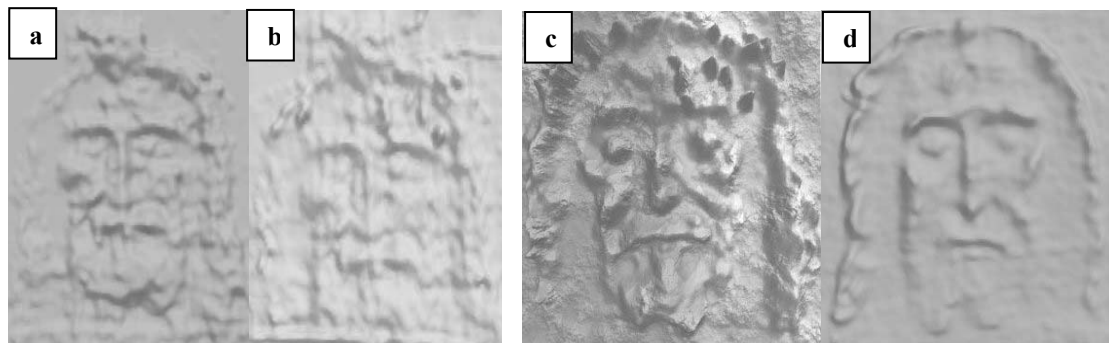


Figure 6. 3D elaboration of the luminance of the corresponding photographs shown in Figure 5.

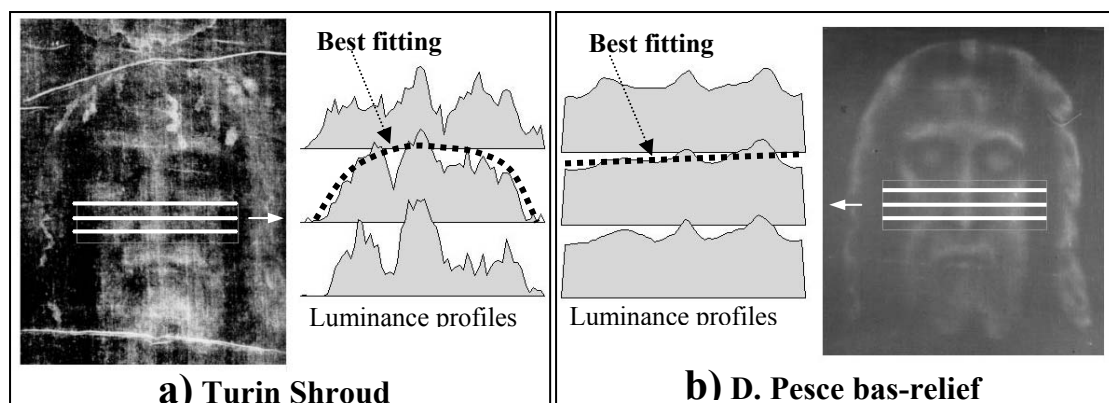


Figure 7. 3D elaboration of the luminance levels of 3 lines (white) of (a) the Turin Shroud and (b) D. Pesce experiment obtained scorching a sheet lying on top of a heated bas-relief. In (a) the 3D correlation with a cylindrical surface corresponding to a first approximation of the face envelope is to be supposed. On the contrary, in (b) the correlation with a slightly inclined plane corresponding to the bas-relief is evident.

5) NUMERICAL MANIKIN

The front image of the Turin Shroud, 1.95 m long, is not directly compatible with the back image, 2.02 m long. In order to verify the possibility that the same human body generated both images, a numeric-anthropomorphic manikin was constructed by computer and wrapped in the digitized front and back images (Basso 2000).

The numeric-anthropomorphous manikin, especially constructed to assume all the possible positions of a human body (Figure 7) was wrapped in two numerical sheets, on which the body points characteristic of the front and back images of the Shroud were indicated. It could be moved by computer according to all the possible kinematics of a human body. Once the manikin had been constructed, kinematic analysis was carried out to determine the most probable position of the shoulders and arms, according to the known position of the hands and forearms. It was so possible to size the numerical manikin and determine the most probable position, in order to verify whether it is compatible with the actual front and back images of the Shroud.

Once the initial configuration of the manikin had been established, the following angular parameters were chosen, to be varied following the congruence, if any, with the a-points on the numerical sheets (see figure 8): α : angle of head; β_1 and β_2 : angles of right and left femurs γ_1 and γ_2 : angles of right and left tibias δ_1 and δ_2 : angles of right and left feet.

Comparisons between front and back numerical sheets, manikin and Shroud reveal their reciprocal compatibility, with an uncertainty of ± 2 cm. The front and back images resulted therefore mutually compatible with a man.

The following information was also obtained:

- the anthropometric indexes of the Man are reliable and the hypothesis that the image on the Shroud was caused by a man being simply wrapped in it is supported;
- the Man was 175 ± 2 cm tall;
- bone lengths are as follows: humerus: 35 ± 0.5 cm; radius: 26 ± 0.5 cm;
- femur: 49 ± 0.5 cm; tibia: 40.5 ± 0.5 cm;
- the Man has the following characteristic angles: $\alpha = 30 \pm 4^\circ$; $\varphi_1 = 10 \pm 1^\circ$; $\varphi_2 = 12 \pm 1^\circ$; $\beta_1 = 8.5 \pm 2^\circ$; $\beta_2 = 10.5 \pm 2^\circ$; $\gamma_1 = 11 \pm 2^\circ$; $\gamma_2 = 13 \pm 2^\circ$; $\delta_1 = 34 \pm 2^\circ$; $\delta_2 = 30 \pm 2^\circ$, indices 1 and 2 referring respectively to right and left arms.

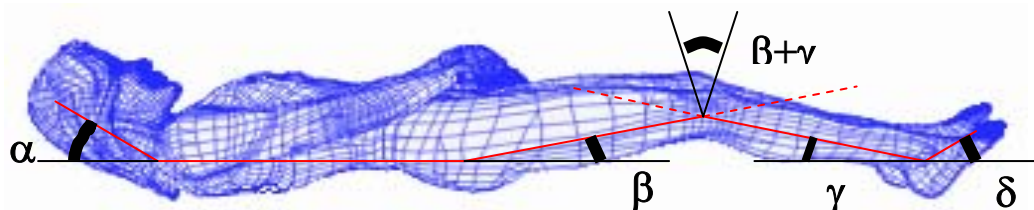


Figure 8: Angular positions varied to verify compatibility between manikin and front and back body images of the Shroud.

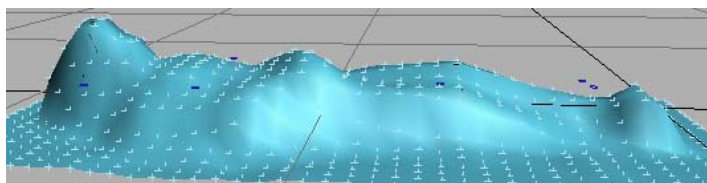


Figure 9: Manikin wrapped in numerical sheet.

Forensic analysis indicates that the Man wrapped in the Shroud was positioned so as a crucified man taken down from the cross (except arms): head tilted forwards, knees slightly bent, feet stretched out, hands afterwards placed on the pubic area and, already in complete rigor mortis. Confirmation of this hypothesis comes from the shape of the gluteal muscles, which show no signs of flattening as a result of body weight, which would be normal if the body had not been rigid.

The manikin constructed by means of a computer and sized on the basis of the congruence with the front and back images, reproduced these characteristics.

The overlap of the numerical sheets on the manikin shows that the front and back images of the Shroud are distorted due to wrapping of the sheet on the body. In particular, even in the case of orthogonal projection, it may be observed that the wrapping of the sheet round the body causes a distortion of about 10% more with respect to the corresponding dimensions projected on a plane.

As the back image of the Shroud also shows distortion due to partial wrapping of the sheet, the Man of the Shroud was probably not laid on a flat surface but on a curved one, like a stretcher or litter. This hypothesis fits the possibility that the Man was laid on a flat surface covered with a layer of flowers, since various types of pollens and remains of flowers which bloom around Easter in Palestine have been found on the Shroud.

6) RECONSTRUCTION OF THE BODY IMAGE AND 3D RESULTS

The results obtained by means of the numerical manikin were compared with experimental ones obtained by overlapping a sculpture strewn with ochre with some linen sheets (Figure 10).

The results obtained allowed the reconstruction of the damaged body image of the Shroud (Fanti 2000c) (Figure 11) and finally the 3D representation of the body image (Figure 12).



Figure 10: experimental results obtained by overlapping The Turin Shroud Man of Luigi Mattei with two linen sheets.



Figure 11: reconstructed and cleaned body image of the Turin Shroud.

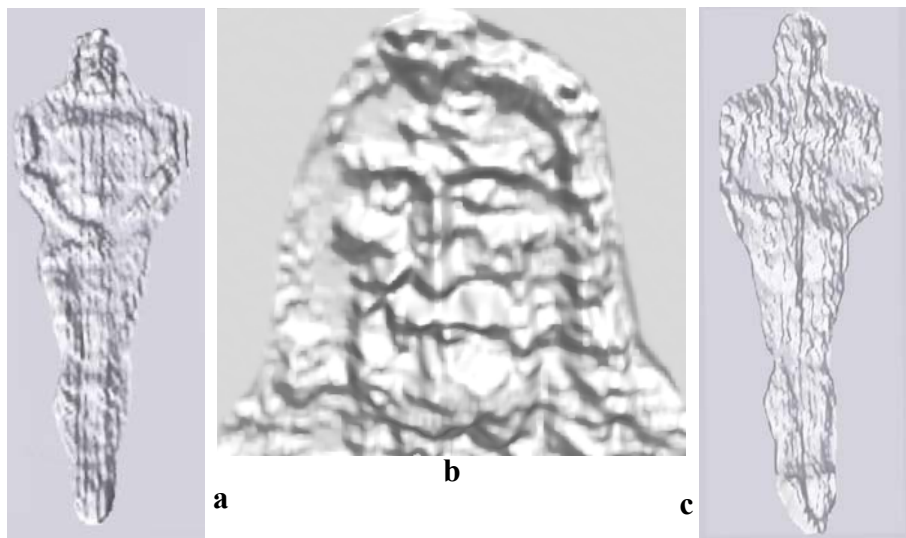


Figure 12: a) 3D elaboration of the cleaned and rebuilt front body image; b) idem of the face image; c) idem of the back image.

CONCLUSIONS

The Turin Shroud is a linen sheet that wrapped the corpse of a scourged, crowned with thorns and crucified man; from recent probabilistic studies that man was confirmed to be Jesus. There are also impressed many marks due to blood, fire, water and folding that partially cancel the double body image (front and back). The body image is impressed in a scientifically unexplainable way and contains a 3D information related to the body-sheet distance. The 3D characteristic of the body image help us understanding the wrapping of the Man in the sheet and the possible radiant mechanism that caused the image. Nevertheless the high grade of image damage due to the various marks makes difficult this analysis.

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possibility that the same human body generated both images, a numeric-anthropomorphic manikin was constructed by computer and wrapped in the digitized front and back images. The front and back images resulted mutually compatible with a man 175 ± 2 cm tall, which, due to cadaveric rigidity, remained in the same position it would have assumed during crucifixion (except arms).

In spite of these results, also supported by the debatable radiocarbon results, some researches affirm that the Turin Shroud was constructed in the Middle Age using a bas-relief and publish some experimental reproductions of the Man face. They show 3D characteristics similar to that of the Turin Shroud, but a luminance levels analysis show some typical differences that are evidenced in this work.

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