A Features Model of the Shroud of Turin

Considering it as a system

José L. Fernández-Sánchez
Industrial Engineering School
Madrid Technical University (UPM)
Madrid, Spain
joselfernandez@ieee.org

Abstract—The Shroud of Turin is among the most studied, controversial and enigmatic of all archaeological objects. The Turin Shroud is an old linen fabric imprinted with the image of a man who lies prone with his hands crossed before him.

The big effort spent in studying the Turin Shroud has produced a huge amount of observations and features describing it. Unfortunately this knowledge is not well classified and structured, and it is frequently presented as ordered lists or tables of properties of the archaeological object.

This paper proposes a modeling approach borrowed from systems engineering and computer science, to be applied to the structuring of the Turin Shroud knowledge representation. The scope of the research modeling presented in the paper includes those features related to the image, but includes, although incompletely, other features as well.

The model shows the features allocated to the different parts of the object, giving a quick view of the Turin Shroud breadth of properties. Further organizing the features in this model makes it easier to identify inconsistent features, missing features and redundant features. The features model presented here may be a framework for adding the new features to be discovered in future observations and experiments of the Turin Shroud.

Keywords—Features modeling, systems thinking, systems engineering, Shroud of Turin.

I. INTRODUCTION

The Turin Shroud (TS), Figure 1 upper side, is among the most studied, controversial and enigmatic of all archaeological objects. The TS is an old linen fabric imprinted with the image of a man who lies prone with his hands crossed before him. Various marks resembling wounds are visible on the body. Many people believe it to be the cloth that covered Jesus when he was placed in his tomb, and that his image was somehow recorded within its fibrils.

How the image was formed on the TS is still unknown. Different theories have been proposed by the scientific community to explain the image formation process. Some are based on testable experiments, others are merely speculative. The image formation mechanisms proposed are unable to explain all the features identified on the TS. It is still not possible to duplicate the image and its features by any known means.

In an earlier paper the author proposed an ontology describing the knowledge concepts and their relations for understanding the image formation process to map out the TS image formation more systematically, and to identify the research challenges more precisely [1].

This paper continues the previous research proposing a modeling approach combining systems engineering and computer science disciplines, to be applied to the structuring of the TS features.

The effort spent in studying the TS has produced a huge amount of observations and features describing it. Unfortunately this knowledge is not well classified and structured, and is frequently presented as ordered lists or tables of properties of the object [2] [3].

Here, a feature is a collection of related observations or measurable properties grouped by affinity that characterizes the TS as different from paintings, burial cloths, photos or other representations. In the current TS literature features are represented as lists or tables of textual elements, sometimes unstructured and not well organized. Here the author proposes a features model or features diagram with an established notation that may be enhanced in the future with all the currently identified features not included here or observed in future tests of the TS.

A features diagram is a visual representation of these features, and their relationships. It articulates the differential aspects in a system, here the TS. A feature diagram consists of features, which also comprise sub-features. The diagram can have as many levels as are necessary to describe the knowledge domain modeled.

The paper is organized into three sections beyond this introduction. Section II of the paper proposes an approach for dealing with the TS as a system with its constituent elements and the interfaces among them. The approach of identifying explicitly the system elements interfaces is new in the TS literature. Section III describes the features model elaborated with special identification of image features. The paper finishes with a conclusions and future work recommended section.
II. THE TURIN SHROUD AS A SYSTEM

The TS is an archaeological object that can be considered as a physical object and so as a system. The NASA Systems Engineering Handbook, describes a system as the combination of elements that function together to produce the capability to meet a need [4].

The TS is considered as a system that contains diverse constitutive elements: cloth, image, blood and body fluids; representing together the frontal and dorsal image of a tortured man (Figure 1). The need to be met by the Shroud of Turin may be considered as a religious issue out of the scope of the scientific research.

Large burn holes and water stains are also shown on the TS. They are associated with damage from a fire in a chapel of Chambéry, capital of the Savoy region, where the Shroud was stored in 1532.

The systems approach followed on Figure 2 represents the main constitutive elements of the TS and the interfaces between them as well. Interfaces are an important issue considered in this paper. An interface defines the properties and constraints that exist at a common boundary between two TS elements. Interfaces include as necessary, observations, measurements, and all other significant properties of the interaction between the TS constitutive elements.

These interfaces have features or properties that are not only attributable to the system elements alone but to their interaction.
III. FEATURES MODEL OF THE TURIN SHROUD

A feature is a collection of related observations or measurable properties grouped by affinity that characterizes the TS as different from paintings, burial cloths, photos or other objects.

The process followed by the author of identifying features began by exploring the literature and thinking about TS features that are at the same level or that are sub-features to those. After the initial pass of feature identification was completed, features were organized by allocating each of them to one of the TS system elements represented in Figure 2, and grouping similar sub-features together into a parent feature.

The notation used to represent the features model was proposed by the Product Line Software Engineering Paradigm (PLSE) [5], and illustrated in Figure 3. The structural view of a feature model is organized using two types of relationships: aggregation and generalization. Aggregation is used when a feature can be decomposed into a set of constituent sub-features. In cases where a feature can be specialized into more specific ones, they are organized using generalization.

A feature may have one or more sets of alternative sub-features. A grey filled arc between the sub-features lines denotes alternatives. Alternative sub-features may indicate a set of sub-features, from which only one must be present. A feature may have one or more features from a set of or-features. A black filled arc between the features lines denotes or-features. The required dependency between two features means that when one of them exists for either a system or system element, the other must also be present in the same system.

It is important to note that the order of the features in the tree is not relevant.

Features related to image and represented in Figure 3 are:

- Resolution. Using the smallest anatomical feature discernible in the image, particularly the lips, confirms its resolution is as least as good as 0.5 cm [6]. Other authors propose that the scourge marks are part of the image and primarily not caused by blood coming out of the wounds [7]. Both are represented in the Image Features Model (Figure 3) and a “requires” relation is used for the assumption of the scourge marks as part of the image. Forensic studies, not included in the features model, determine that the impact of heavy lead objects concerns structures under the skin such as a bruise in connective and muscle tissue.

- Narrow color/luminance image. The color space is significantly compressed. Color and luminance spaces overlap to some degree and to that extent using just that information will lead to multiple classifications for some image pixels [8].

- Elements absent. There is no image of the top of the head, the sides of the body and thumbs (Figure 1).

- Not visible in transmitted light. In transmitted light, the intensity of the body image relative to burns thermal discolorations appears to be considerably less than for those same areas in the usual reflected light image for which the relative intensities are nearly equivalent [6] [9].

- No major image distortions. Some elements of the image as face or hips appear wider than a real human body. These are small image distortions coherent with the Shroud loosely lying on a body when the images were formed [10] [11].

- Elements represented. Major parts of a human body such as face, frontal and dorsal body and hair, are represented in the TS including some teeth and bone structures. In fact, the image appears to reveal bones associated with the palm of the hand [12].

- Fuzziness-No Contours. The TS image is very faint. The image on the TS is more readily perceived at a distance of meters, than it is a close range. The reflected optical densities are typically less than 0.1 in the visible range [9]. The image does not have sharp boundaries nor well defined contours (Figure 1).

- 3 Dimensionality. The VP-8 isometric results obtained from the TS image are, somehow, three dimensional in nature. The displayed result is only possible by the information contained in the TS image. No other known images produce the same results [12]. Other experiments show that the shading of the TS image has a correlation with expected cloth-body distances as the shading produced by an unknown image formation mechanism actuating on a cloth draping over a body shape [6].

- Negative. The TS image exhibits some properties of photographic negatives (Figure 1). This does not mean that the TS is a photographic negative. However, the negative of the TS image is unique relative to the images of other known archaeological objects including old artistic copies of it [12].

- Directionless. There is no preference for applying the TS image impression for any direction. One of the results of applying the Fourier Transform to the TS face image is its uniform nature that may be considered as an indication that whatever the mechanism which caused the image upon the cloth, it was not directionally oriented [13].

Features related to the cloth and represented in Figure 3 are:

- Antique. Cloth samples taken from a single site of the TS were dated by three independent laboratories using the accelerator mass spectrometry (AMS), radiocarbon technique and stating the TS back to 1260-1390 A.D. [14]. This date does not agree with observations on the linen-production technology nor the chemistry of fibers. The loss of vanillin from
lignin indicates a much older date than the radiocarbon dating [15].

- Hand-spun, Hand-loomed linen. The cloth linen thread was hand-spun and hand-loomed; after ca. 1200, most European thread was spun on the wheel [16].
- Folded sometime. Grazing light photographs of the TS show old fold marks on the cloth [17].
- Thickness. The thickness of the cloth is variable from 318 to 391 µm [3].
- Dimensions. TS traditional dimensions of 436x110 cm are changed slightly after 2002 restoration [2].
- 3 to 1 Herringbone pattern. The weave of the cloth is seen to be a 3 to 1 herringbone twill supposedly typical of near-Eastern cloths of antiquity [18].

Features related to the image-cloth interface and represented in Figure 3 are:

- Density image. The TS can be considered a real density image where the image shading is not accomplished by varying the color but varying the number of fibers per unit area at the micro level [19]. Other authors refer this feature as a half-tone image.
- Superficiality. At the fiber level the image is superficial considering that color alteration of the fiber is restricted in the approximately 200nm thick external cell layer. At the thread level the coloration is also superficial since it extends only to depths of 2 or 3 fibers into the thread. At the fabric level these superficial colorations at the thread and fiber levels cumulative produce the image [20].
- Banding. The first type of banding is one that reflects the herringbone weave of the cloth giving a striped appearance to the cloth at the points where the chevrons change direction [8]. A requires relation is used in the features diagram of Figure 3 to represent this interaction. A second kind of banding shows changes in the relative acceptance on the cloth of the image mechanism and is evidenced by a difference in image density. This effect is most easily seen along the sides of the face [8]. A third kind of banding is produced by yarn density, and is particularly apparent in transmitted light photographs of the TS. Medieval linen manufactured differently, typically do not show banding like the TS [3].

Features related to the image-stains interface and represented in Figure 3 are:

- Density image. The color of the darker portions of the blood areas is quite red [18].
- Elements represented. Three major types of blood areas are identified: well defined wounds, blood flows, for example along the small of the back, and scourge marks. All of these types bear certain similarities and differences [18].

Features related to the blood-cloth interface and represented in Figure 3 are:

- Cementation. Fibrils in the blood areas are clearly cemented together [18].
- Capillarity. Blood flows have gone onto the cloth as viscous liquids penetrating the cloth through to the back, and diffusively seeping along the threads near the edges of the stains demonstrating some limited capillarity flow [18].

A Feature related to the image-stains interface and represented in Figure 3 is:

- Body-only image did not impede the migration of water through the cloth. In contrast to blood, see features tree in Figure 3, the body-only image did not pose a barrier to the migration of water [18].

Features related to the image-blood interface and represented in Figure 3 are:

- Some blood stains outside of the body image. Most blood stains are consistent with body contact. Some as right elbow and below the back are represented outside the body image (Figure 1).
- Absence of body image on the wound image margins. This absence suggests than the blood images where present on the cloth before the body image formation mechanism actuated on the TS cloth [18]
- No image under bloodstains. As the feature described previously this absence, that needs to be confirmed [21], suggests than the blood images where present on the cloth before the body image formation mechanism actuated on the TS cloth.

Features related to the stains and represented in Figure 3 are:

- Water stains. The water stains or water marks are the only ones that show distinctly in x-radiographs. The density of heavy elements in the water stains boundaries is sufficiently great to be apparent on the x-radiographs [18].
- Burn marks. In white light, the scorches and burns vary from a light brown shading into a darker brown and finally into black [18]. The light scorch marks resemble the body-only image in the visible spectrum but not under fluorescence [18].
Figure 3. Features Model of the Turin Shroud
A Feature related to the blood-stains interface and represented in Figure 3 is:

- Blood stains impede progress of diffusion of the water. In those areas where the water stains have interactions with the blood areas; there is a clear indication that blood has impeded the progress of the diffusion of water through the cloth [18].

IV. TO CONCLUDE

The combination of the systems engineering approach and the features model for the representation of the properties of the Turin Shroud is a novelty compared to other approaches used for representing its properties, such as lists or tables.

The author proposes the creation of an experts group to manage the knowledge generated in TS research regarding image formation mechanisms. This committee will use a complete TS features model as the baseline for validation of proposed image formation theories.

New image formation mechanisms and the images produced will be validated and discussed strictly from the features observed and no support will be derived from extraneous speculations.

Unfortunately the features model presented here is still incomplete. Features related to microscopic, chemical, forensic and other observations should be added to the features model. The benefit of the features model is that it can be used as a framework to include these absent features and the new features obtained from future tests proposed for the Turin Shroud [21].

REFERENCES


