A Systematic Approach for Understanding the Image Formation on the Turin Shroud

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Abstract:

To map out the Turin Shroud image formation more systematically, and to identify the research challenges more precisely, we propose an ontology describing the concepts and their relations for understanding the image formation process.

The proposed Shroud image formation process ontology consists of a conceptual model represented in Unified Modeling Language notation, a vocabulary, and a set of attributes and assumptions.

1.Introduction

The Shroud of Turin is among the most known, controversial and enigmatic of all archeological artifacts. The Shroud is a centuries 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 Shroud is still an open issue. Different theories have been proposed by the scientific community to explain the image formation process. Some are based on testable experiments, others are speculative. Unfortunately, the image formation mechanisms proposed are unable to explain all the aspects identified on the Shroud image. It is still not possible to duplicate the image by any known means.

To map out the Turin Shroud image formation more systematically, and to identify the research challenges more precisely, we propose an ontology describing the concepts and their relations for understanding the image formation process.

The Shroud image formation process ontology consists of a conceptual model represented in Unified Modeling Language notation, a vocabulary, and a set of attributes and assumptions (section 3). The conceptual model represents the metadata encompassing the critical set of concepts related to Shroud image formation process and their relationships.

Examples of instances of the elements of the ontology are described in section 4. The examples of the ontology application are intentionally incomplete. In the conclusion the author proposes further research and use of the ontology as a validation technique of the diverse mechanisms explaining image formation.

2. Ontologies. What are they for?

Ontologies are content theories about the sorts of concepts, properties of the concepts and relationships between them that are possible in a specified domain of knowledge. Ontologies provide potential terms for describing our knowledge about the domain [3].

In philosophy, ontology is the study of the kinds of thing that exist. Today ontology has grown beyond philosophy and now has many connections to information technology.

Although differences exist within ontologies, general agreement exists between ontologies in many issues:

- There are concepts and physical things in the world
- Concepts may represent physical things but are more general
- Concepts have properties or attributes that can take values
- Concepts can exist in various relations with each other
- Properties and relations can change over time
- Concepts may be specialized. Thus the specialized concept represents a variation on a parent concept
- Concepts may have parts. Thus a whole-part relationship may exist between two concepts.

Ontological analysis clarifies the structure of knowledge. Given a domain, such as Shroud image formation, its ontology forms the heart of any system of knowledge representation for that domain. Without ontologies, or the conceptualizations that underlie knowledge, there cannot be a vocabulary for representing knowledge.

Ontologies are used in artificial intelligence, semiconductor manufacturing, Internet search engines and software development. Any software that does anything useful cannot be written without a commitment to a model of the relevant world-to concepts, properties and relations in that world. More recently, ontologies are being developed for systems biology. The systems biology ontology represents its key concerns, allowing the University College London researchers to identify the computational challenges of the physiological model of the human liver [5].

3. A Conceptual Model for Shroud Image Formation

A conceptual model illustrates meaningful concepts in a problem domain. The conceptual model shows concepts, relations between concepts and the attributes of the concepts.

In addition to decomposing the knowledge space into comprehensible units (concepts), creating the conceptual model aids in clarifying the terminology or vocabulary of the researchers and specialists on the domain.

The concepts are formed from the control vocabulary. Within our research, we built the control vocabulary from published Shroud scientific papers related to Shroud image formation [8], Shroud physics and chemistry [7][12] [13], and digital image analysis and processing [2] [4] [14].

The main concepts identified are: mechanism of image formation, assumption, Shroud image aspect, property, protocol, observation and interpretation.

Mechanism of image formation is a simple or complex process to explain how information is transported from a body shape to the Shroud cloth in order to produce the Shroud image.

Shroud aspects are those qualities that characterize the Shroud image as different from paintings, burial cloths, photos or other representations. A description of the Shroud aspects is given below.

A simple aspect may be described by several properties or attributes.

Assumptions condition or determine the relationship between mechanisms of image formation and the aspects found in the Shroud. Typical assumptions are the need of a corpse, the contribution of gravitational force to image formation, presence of sweet or other body fluids and others. Assumptions may be simple or complex. Complex assumptions are formed by simple assumptions joined by the logical and operator.

Interpretation of observations is part of the scientific method. The important issue is that interpretation is a consequence of observation. Observation as it is described below is not always associated to measurement.

Shroud properties may be observed and in some cases measured. Observations yield interpretations through expert analysis.

A protocol is the method by which observations were made.

Besides the identification and description of the main concepts, it is necessary identify the relations between them in order to build the conceptual model representation of the ontology. The notation used for the model is based on the Unified Modeling Language (UML) [15]

For our purposes, here we have three main relations: associations between concepts, specialization and whole-part relation.

An association represents a conceptual connection among instances of the concepts represented in the conceptual model. The UML notation for an association is a line between the concepts (see figure 3). Semantically what we mean when two concepts are associated is that they have to know each other and the relationship needs to be preserved for some duration. For example an instance of the interpretation concept has to be associated with an instance of the observation concept (see figure 3).

Just as we can describe the instances of a concept with attributes, so we can describe the links of an association with attributes. The UML notation represents such information with an association class or concept. In Figure 3, Assumption is identified as an association concept describing the association between a Mechanism of image formation and a Shroud image aspect. Each of the assumptions identified may have diverse attributes.

A generalization-specialization structure defines a specialization relationship between concepts. A concept is a generalization of a second concept when the attributes of the first concept all belong also to the second concept. The second concept is considered a specialization of the first concept, and may contain additional attributes not belonging to the first concept. The specialization concept is said to inherit its attributes from the generalization concept.

A generalization-specialization structure is represented with UML notation by a large hollow arrowhead (see Figure 1). This structure can be either a hierarchy (e.g. one generalization concept with its specialization concepts beneath it) or a lattice (e.g. more than one generalization concept having one or more specialization concepts in common).

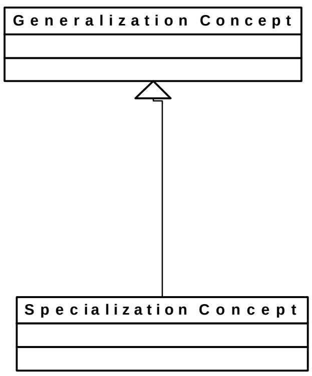

Figure 1. Generalization-specialization structure

A concept is a whole concept in a whole-part structure with a set of one or more part concepts. If the whole concept can be considered to be made up of, or a container for, or a collection of, the part concepts. There is not implicit relationship between the attributes of the whole concept and those of the part concept. Figure 2 is an example of the UML representation of a whole-part structure. A small diamond is put next to the whole concept.

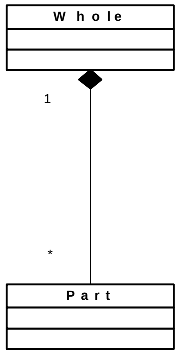

Figure 2. Whole-part structure

The collection-member form of the whole-part structure is especially useful for mental model abstractions, when either the "whole" or "part" is a logical concept rather than the concept representing a "touchable" entity.

Generalization-specialization structures and whole-part structures can be combined together in versatile ways to represent more complex structures.

Figure 3 depicts the proposed Shroud image formation process ontology conceptual model represented in the UML notation described above.

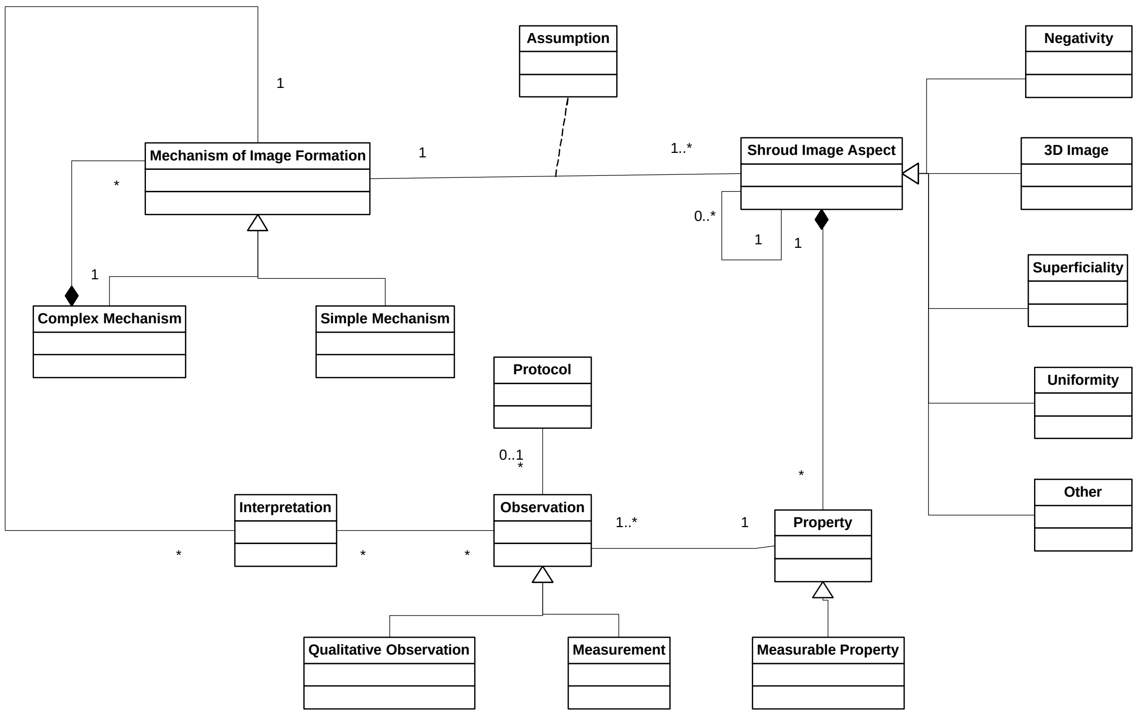

Figure 3. Conceptual Model of Shroud Image Formation Issues

For the sake of understandability by non-experts in the notation, we will explain textually what is described graphically in the conceptual model.

A mechanism of image formation may be a simple or a complex mechanism. In the case of a complex image formation mechanism, it can be described by a composition of simple mechanisms. So a complex mechanism can be considered a hybrid mechanism.

A mechanism of image formation can explain some Shroud image aspect. This explanation may have some assumptions associated to it.

A Shroud image aspect is a quality feature that characterizes the Shroud image as different from paintings, burial cloths, photos or other representations. Specific Shroud image aspects are its negativity, three dimensional image, superficiality and uniformity. Negativity is a well-known Shroud aspect discovered by Secondo Pia photographies in 1898. Three dimensionality is an aspect noted by Vignon in 1902 but tested more recently using VP-8 Image analyzer and other digital image processing techniques. By three dimensionality, we mean that there is a high correlation of image shading with cloth-body distance. It is noteworthy that the correlation seems to be valid for skin, hair, eyebrow, and beard but not for blood images and fire damage [8]. By superficiality, we mean that discoloration effects contributing to the Shroud image do not penetrate below the level of surface fibrils of the threads comprising the weave of the cloth. Uniformity means that the entire Shroud image was formed by the same image formation mechanism. Thermography proved that emmittance of the image was the same in all areas. Spectra and photography confirmed this observation [12]. Other represents some new aspect to be discovered. Aspects may be consistent with other aspects.

Each Shroud aspect is described by several properties that can be observed either by measurement or qualitative observation. Examples of measurements are the spectral reflectometer curves taken directly from the Shroud body image by STURP [6] [10]. An example of qualitative observation is: “nothing in the image moved with the water” [12].

A protocol is the method by which observations were made. Observations yield the experts interpretations regarding the validity of the image formation mechanism and the assumptions made to explain the image formation mechanism. Interpretation is a complex issue based on scientific method. Interpretation can be supported by expert’s opinion, laboratory tests of image formation mechanisms, or computer simulation models when the complexity of the image formation process and assumptions requires the computer modeling of the physical phenomena involved in the process.

The important consequence of the ontology application is that every ontology item: image formation mechanism, assumption, aspect, property, observation and interpretation have to be clearly identified and related avoiding ambiguities and misinterpretations.

4. Some examples of ontology application

To illustrate ontology applicability, three image formation mechanisms proposed in the literature are analyzed here. The analysis is intentionally incomplete because as proposed in the conclusion a multidisciplinary approach is needed. Chemistry, physics, and other disciplines experience have to be provided by the research team members. Not only the image aspects are important to select an image formation mechanism as candidate.

It is important to notice that the “images” produced using the mechanisms proposed are no tested so completely as Shroud image, so we are not able to guarantee that similar quantitative observations are produced.

Table 1 illustrates the ontology applicability for the systematic analysis of three image formation mechanisms or processes supported by the scientific community to explain the image on the Shroud. It can be shown that none of these image formation mechanisms can explain completely all the observations related to the Shroud image and Shroud aspects. Observations in images produced in laboratory using the proposed image formation mechanisms should be consistent with the observations on the Shroud showed in the observations column of the table.

The first image formation mechanism presented in the table below, is ultraviolet radiation as proposed by Jackson. In radiation transfer, the carriers of information propagate along straight line paths, usually as photons. Typically radiation propagation is Lambertian, so it is independent of the direction of transmission. Jackson observed that if the Shroud drapes overall body lying in a horizontal or supine position, image points align vertically above the corresponding body part. The mechanism involved in producing the image must have had the property of transferring information in the vertical only direction so it is direction dependent. Jackson opinion is that gravity could have achieved this [9].

Rogers and Arnoldi described the second image formation mechanism presented in the table below. They proposed a complex mechanism combining vapor diffusion and Maillard reactions as color-producing reactions that involve several reaction paths and products. Many of the final products of Maillard reactions are identical to those produced by caramellization of sugars. The structures that produce the color are conjugated double bonds just as hypothesized from the STURP observations. The mechanism requires a corpse. The ammonia and many of the decomposition amines rapidly undergo Maillard reactions with any reducing saccharides they contact. Such reactions offer an explanation for the Shroud image color. Image resolution is a “natural consequence” of the image formation process [11]. Rogers and Arnoldi propose that vapor diffusion parallel to the cloth´s inner surface would follow Graham´s Law of diffusion and high Maillard reaction rates would limit the spread of reactive amine vapors. Image densities would fall off rapidly away from the body, increasing resolution.

The third mechanism presented in the table below, is based on using metal bas-relief encoding distance information of a human body shape. The encodement process would be performed by the bas-relief builder. The bas-relief is heated and pressed into a stretched cloth, forming a scorched image. This mechanism suggested by Ashe [1] may explain Shroud image aspects as negativity and 3D Image but is not consistent with the observations of no changes in the structure of flax fibers and undistorted cellulose cristals [12].

Mechanism of Image Formation	Assumption	Shroud Image Aspect	Property	Observations
Radiation	Low intensity radiation and vacuum UV and limited time for image formation process and gravitational effects and body enveloped between folded halves of the Shroud	Negativity	Image intensity levels	Scanned image pixels
		3D Image	Image resolution Relief	Finger resolution Lips resolution (0.5 cm in Shroud) No side image Lateral distortion
		Uniformity	Image emittance	Emmitance measures
		Superficiality	Thickness	Colored layer is 200-600 nanometers thick in Shroud No image under blood stains
Difussion-based	Maillard reaction and postmortem body temperatures and the cloth have to be removed from the body before liquid decay products appeared	Negativity	Image intensity levels	Observations should be similar those required radiation mechanism
		3D Image	Image resolution Relief	Observations should be similar those required radiation mechanism
		Superficiality	Thickness	Observations should be similar those required radiation mechanism
Bas-relief	Hot metal bas relief body shape and limited time for image formation and contact pressure	Negativity	Image intensity levels	Observations should be similar those required radiation mechanism
		3D Image	Image resolution Relief	Observations should be similar those required radiation mechanism

5. Conclusion

Ontological analysis clarifies the structure of knowledge. Given a domain, such as Shroud image formation, its ontology forms the heart of any system of knowledge representation for that domain.

The proposed ontology would be useful as a foundation for Shroud scientific community communication and a better understanding and validation of the proposed image formation processes.

The conceptual model is complemented with some examples of the different concepts instances. This application of the ontology conceptual model is intentionally incomplete.

New image formation mechanisms will be researched and discussed strictly from image aspects and properties and no support will be derived from extraneous speculations.

The author proposes the creation of a committee to manage the knowledge generated in Shroud research regarding image formation mechanisms. This committee will use the ontology as the baseline for validation of proposed image formation theories.

The use of ontologies for other research areas such as Shroud dating or forensics would be also of paramount importance.

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