

Ph.D. evaluation report

Ph.D. candidate: Sunita Saha

Title of thesis: Automated Identification of Changes from Cultural Heritage Surfaces

External Examiner/Opponent:

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Evaluation of thesis

The submitted thesis is part of the research carried out in an EU project, CHANGE- (*Cultural Heritage Analysis for New Generations*). The Thesis features a multidisciplinary topic, which is undoubtedly relevant for the CH sector, covering topics of interest in technology, ICT, and conservation science.

The monograph includes a review of research on this topic, the motivation to conduct research in selected directions, and the results on simulated and real data, conclusions, and future works. The thesis has 142 pages, with 112 References cited.

Considering the fact that Cultural Heritage (CH) objects change continuously with respect to time, there is a high demand to assess these changes to perform better documentation and plan for conservation treatments on time. The thesis presents the need to develop automated methods to perform segmentation in 3d and Reflectance Transformation Imaging (RTI). There exist several challenges to perform the change monitoring, its quantification, and visualization of the changes. The research challenges are identified and presented in Chapter 1. The specific objectives of the research work carried out in this thesis is also included in this Chapter.

Chapter 2 covers the review of related literature and background required to follow the core part of the thesis. The topics included are sufficient to follow the research and implementation presented in the thesis. The scientific needs and gaps are identified through a literature survey that in fact underlines the need to address the specific research objectives presented in Chapter 1. In addition to state-of-the-art research on this topic, this chapter lays down the theoretical background of segmentation, imaging systems, and the change in appearance workflow. To support the explanation, a case with altered, and reference is used throughout the chapter.

Chapter 3 & 4 presents the core part of the research conducted: the development of change-based segmentation methods, and assessment of appearance changes. The chapter is well structured to follow the underlying theory, and implementation of algorithms. The main contributions; *change-based-segmentation* and *supervised segmentation of RTI appearance attributes* overtime, which is useful for monitoring conservation treatments, condition evaluation, acidic responses, and

environmental monitoring, are well described. The implementation was first demonstrated on a mockup sample with known references. Another important and interesting highlight of these two chapters is the case studies presented. These sections elaborate on the application of the developed techniques on CH objects and evaluate their usability.

Chapter 5 Conclusions, reflect the research contributions and how the objectives are achieved.

The candidate has a very good overview of what directions to further investigate in this topic in the future.

A bibliography, including 112 references, is cited in the thesis.

Some minor weaknesses of the Thesis to mention:

In the beginning of Chapter 2: Literature review, can include more citations to cultural heritage publications/projects. The title of Chapter 2 is Literature review; however, the Chapter also offers a comprehensive background supporting the proceeding chapters (3,4 & 5).

The case studies mentioned are in an abstract form; more details (including data) can be useful for the audience. This is not a major weakness, as more information is included in research publications.

Sunita Saha has published in 11 peer-reviewed journals and conferences. This includes four journals and seven conferences. In addition, she also contributed to two book chapters (one under preparation). Out of three accepted journal publications (Sensors, Heritage Science), Sunita is the first author of all of them. Sunita is the first author of six out of seven conference publications. Overall, the research work is disseminated in the best possible way to the scientific community, both in the technology and heritage science sectors. The publication record indicates that Sunita has contributed significantly to the development of scientific methodology, experiments, and writing research papers. The amount of work conducted in three years of time is outstanding. All the publications feature high scientific quality and contribute to the knowledge; although they differ in originality and impact to knowledge, being some of them has more relevance.

The thesis is well-structured, the methodological approach is sound, the figures and illustrations are sufficient, Conclusions are coherent and supported by research data. The research objectives and outcomes are disseminated in the best possible way that is understandable for a multidisciplinary audience. The candidate clearly demonstrates research and dissemination skills in her research field. Overall, the Thesis is a comprehensive scientific work of an international standard. The acceptance of the research outcomes in high-quality journals and conferences makes the candidate qualified for Ph.D. with distinction.

The candidate's contributions can be very well-identified and are enough for Ph.D. thesis. As an opponent, I highly recommend this thesis for public defence.

Gjøvik, Norway
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