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Description of the research challenges of NICAS

NICAS aims to bring about a new and lasting framework integrating the diverse disciplines of art history, conservation and science. Bringing these disciplines together will make it possible to tackle existing research problems in novel ways, thereby making scientific advances that were not previously possible. In addition, this integration is expected to lead to a vast set of new research questions. The body of knowledge that will be gathered will aid the development of each discipline in isolation, but most importantly will bring about a new research community that operates across and beyond disciplinary boundaries.

The study of cultural heritage objects is highly challenging, as works of art are unique, often composed of heterogeneous materials possessing different histories and mechanisms of ageing and degradation. Scientific research is necessary to understand the appearance, condition and meaning of cultural heritage objects in the past, present and future. Because of the diversity of the data sets used for and generated by this type of research ('messy' data), it can benefit greatly from close collaboration with data scientists. The potential for advances in the research agenda of NICAS in this way is one of the focus points of the present call.

NICAS aspires to assemble global scientific expertise and research from academic institutions, museums and heritage organizations while simultaneously ensuring knowledge transfer within society and to those who safeguard cultural heritage. In addition, NICAS hopes to involve industry in ongoing research by taking advantage of the expertise and technologies that are available in the sector, and at the same time inspiring industry to refine existing and create novel applications and technologies for the general public by acting as 'extreme end users'.

NICAS has formulated four main focus areas or primary research challenges.

1. Technical Art History
The research challenge is to make use of new possibilities in science and technology to confront problems and questions within art history. The ambition is to transform the study of art history through the use of science and technology. Recent developments in the sciences and computational fields will extend the scholarly reach of art historians. Art history in its turn will challenge the sciences for the development of new diagnostic tools or theories. Older art historical questions may be dealt with in new ways, and fruitful new questions will be opened up. The end goal is to reach a better understanding of techniques, procedures for production, and uses of materials that constituted artistic mastery, yet knowledge acquired within the framework of this research challenge will also improve our analysis of the reception and conservation of works of art. The desire is for the development of new tools and new approaches with broad applicability; however, case studies demonstrating feasibility of such integrated approaches constitute logical steps in the process of deepening and expanding art historical knowledge through the integration of science.

2. Conservation Dynamics
The research challenge is to significantly raise the level of conservation practice by bridging the gap between fundamental scientific developments and case-based oriented conservation practice. This theme aims at strengthening the existing ties with related disciplines and involving scientific disciplines in conservation research that as yet have not played a significant role in this field, thereby taking significant steps towards a new and innovative strategies for the conservation of cultural heritage. The end goal is to enable better and/or less invasive treatment options with possible reversibility by developing general methodologies, using novel instruments and applications for treating, protecting and presenting objects. Conservation research can challenge scientists to develop innovative technologies and research questions, while new insights and expertise in the natural sciences in turn can inspire novel solutions in conservation practice. By challenging and

stimulating each other, all disciplines benefit, raising standards and attaining a higher level of applicable knowledge.

3. Diagnostics
The research challenge is the development of new diagnostic tools and technologies (multi-scale and multi-technique) for research of cultural heritage objects. Innovation in this area relies on the development, refinement and integration of existing, new or evolving technologies into the museum and cultural heritage fields. This demands the transfer of scientific and technological knowledge, such as image analysis or feature detection, from diverse fields (such as astronomy, mathematics, materials and structural engineering, physics, chemistry) into cultural heritage applications. The end goal is the development of new and improved diagnostic tools and technologies that will transform the way we can study the integrated history of art objects and safeguard their future. These tools and technologies should foremost consist of minimally/non-invasive imaging, analysis and monitoring technologies, the development of portable, field-friendly diagnostic tools, and technologies addressing sub-micron physical and chemical variation including spatial and depth-resolved 2D- 3D analysis.

4. Material dynamics
The research challenge is to understand and predict the long-term material degradation (ageing) in artworks and other objects we want to preserve as cultural heritage, which eventually should lead to a scientifically sound basis for maintenance strategies and procedures. This research theme aims at developing models based on scientific evidence to depict the past, elucidate the present and predict the future conditions of objects. The end goal is to better, or perhaps even fully understand ageing and degradation phenomena in objects. Specific trends and effects need to be identified, quantified and translated into model parameters and mathematical relations that will aid in maintenance procedures and strategies for the preservation of cultural heritage.

Cultural heritage and data science

The vast amounts and types of data being produced within cultural heritage research calls for the use of data science to make sense of these data. It is therefore advisable, but not compulsory, that projects contain an integrated data science component. This data science component can focus on novel techniques for data collection, data-fusion, analysis, simulation, and visualization, or a combination of these techniques. In the context of NICAS and its objectives, four general themes can be distinguished that seem especially appropriate for research questions at the interface of data science and the cultural heritage field. However, these themes are not meant as exclusive areas of inquiry, and researchers are invited to expand and enrich the mutual areas of study for data science and cultural heritage research in meaningful ways. A particular area of interest is the investigation of novel methods and/or techniques for data collection (physical, chemical, computational, etc.).

1. Making sense of vast data sets
For many questions, information has to be distilled or visualized from data sets that are too large for individual processing. This can either be data pertaining to a large number of objects, or large quantities of data deriving from a single object. Examples of the former are data for a single art object produced with digital photography, infrared reflectography, radiography, macro-spectroscopy, and hyperspectral imaging, ranging from the IR to the X-ray domain, of the latter image sets that are used for (stylistic) comparison, or large numbers of tests that are used to assess and model change in material properties. Data science can be used to process and visualize these data sets in novel ways, in order to make better use of the available data.

2. Making heterogeneous data comparable
An issue related to the size of data sets is the nature of data sets. Often, data sets have been assembled under very diverse conditions using various instruments, making direct comparisons difficult. This is the case for image sets captured in different lighting conditions and camera sensitivity and resolution, but also sample sets that have been prepared and tested in different circumstances and with different parameters. Data science could investigate novel ways in which such data sets can be made comparable, and thus create more possibilities for national and international comparisons of available data sets.

3. Objectifying subjective data
Some of the knowledge that forms the basis of research in cultural heritage is highly subjective, based on individual observations and manual tests that are difficult to reproduce exactly. Data science can aid to reduce the subjectivity of this type of knowledge and to help transform it from case-based observations to more general, objectified data.

4. Hearing in the noise: weighing data with inherent uncertainties
As well as problems with the data that is available, there is the problem of missing or uncertain data. In most cases, our knowledge of objects, their history, and the processes that take place within them, is incomplete. This makes it difficult to properly assess their current state and how this has changed from its original state, but also to project and predict changes in the future. Data science can help to tackle this problem by modelling and correcting for missing data, and to calculate multiple scenarios for the future based on inherent uncertainties.