SEAHA EPSRC CENTRE FOR DOCTORAL TRAINING SCIENCE AND ENGINEERING IN ARTS HERITAGE AND ARCHAEOLOGY

SEAHA Studentship: What lies beneath? High resolution imaging of lichen-covered surfaces at Stonehenge

The EPSRC Centre for Doctoral Training in Science and Engineering in Arts, Heritage and Archaeology at University College London, University of Oxford and University of Brighton, in collaboration with Historic England are seeking applications for a fully funded studentship on the topic 'What lies beneath? High resolution imaging of lichen-covered surfaces at Stonehenge'.
Funded by the Engineering and Physical Sciences Research Council (EPSRC) through the SEAHA Centre for Doctoral Training and co-funded by Historic England the four-year doctoral research project will be supervised jointly by University of Brighton alongside supervisors from Historic England and the company Breuckmann/AICON/Hexagon.

Stonehenge is perhaps the most famous prehistoric structure in the world, dating to the later Neolithic-Early Bronze Age. The monument comprises two geologically-distinct sets of stones. The outer Circle and central Trilithon Horseshoe were constructed using large blocks of *sarsen*. Quite distinct are the smaller *bluestones*, used for structures including the inner Bluestone Circle, Bluestone Horseshoe and 'Altar Stone'.

Much recent research at Stonehenge has centred on understanding the archaeology of the wider 'Stonehenge Landscape'. This has been complemented by new surveys of the monument itself, using a combination of high-resolution laser scanning, photogrammetry and digital imaging to three-dimensionally record the standing and fallen stones. Laser-scanning was undertaken in 2011-12 using, for the time, a state-of-the-art Z+F 5010 laser scanner with a 3.5 mm (at 1 m) beam diameter, capable of mapping surface topography up to 0.5mm resolution. This revealed unexpected new insights into the surface features of the sarsens and bluestones, including the identification of (i) 71 Early Bronze Age axe-head carvings and (ii) variations in the stone dressing techniques used in different parts of the monument.

The survey also highlighted a major limitation of the imaging approaches used, since the laser beam-width struggled to penetrate many of the more dense species of lichen that colonise the stone surfaces and are of ecological importance for the monument. Attempts were made to view the hidden surfaces using the laser intensity and RGB values associated with each laser-scanned point to digitally filter out the lichen from the scan data. However, while this approach was able to identify lichen cover it was not able to 'remove' it without also removing digitally elements of the underlying stone surface. Targeted research is now needed into other technologies that have the potential to see what lies beneath the lichen cover at Stonehenge.

The doctoral project will aim to address the following:
The proposed research programme has two key aims: (i) to evaluate available technologies for the high-resolution imaging of lichen-covered surfaces, using Stonehenge as a case study; and (ii) to assess the potential of these technologies for revealing new archaeological information.
The project takes existing high quality research data generated as a result of English Heritage funding (the 2011-12 laser-scanning dataset), and adds significant value to it in a number of ways. The results will be of use for further unravelling archaeological detail at Stonehenge, and provide data to aid conservation, presentation and management of the site. The outcomes will have wider applicability for Historic England and other heritage custodians (e.g. Historic Environment Scotland, The National Trust), as a rapid non-invasive technique for measuring, sensing and monitoring the microtopography of vegetation-covered stone surfaces at other monuments and historic buildings.

The project will involve the testing of three suites of imaging approaches. The specific methods to be explored will be identified by the candidate during the early stages of the research, but will include:

- Terrestrial scanning approaches that use waveform or first/last return measurement approaches (e.g. produced by Riegl, Topcon);

- Close-range scanning approaches (e.g. structured light scanners manufactured by Breuckmann and laser-based systems from Faro and Leica Geosystems);
- Remotely-sensed imaging approaches (e.g. x-ray, infrared, multispectral and terrahertz imaging).

Following testing on 'control' stones (in Sussex), and in consultation with Alan Cathersides (National Landscape Adviser, HE Planning Group), the candidate will identify up to six panels of lichen-covered surfaces on different stones at Stonehenge for investigation. The test panels will encompass stones with different types of lichen cover, including fruticose (lichen with a shrubby, plant-like structure), foliose (flatter, leaf-like appearance) and crustose (forming a flat 'mosaic' over the surface) varieties. The selected panels will be at different elevations, since higher elevation areas are less affected by the public and also add a degree of methodological challenge for imaging. Two 'control' panels will also be identified, one with graffiti and one currently known to hold no archaeological information.

Each selected imaging approach will be tested on each panel to assess the extent to which it is able to penetrate the lichen cover. Technical analysis of the data will be undertaken using appropriate software, to be identified during the course of the research according to data type. It is anticipated that the project will generate higher-resolution data than the 2011-12 laser-scanning survey. As a result, any newly-revealed surfaces will be subject to detailed analysis to identify any previously undetected archaeological features. Depending upon the success of the testing phase of the research it may then be possible to analyse an entire stone at Stonehenge using the most appropriate technique(s) – a wider survey is likely to be beyond the timespan of a PhD programme.

All equipment necessary for imaging can be accessed through existing links between HE Geospatial Imaging and industry at minimal cost. Software including Geomagic is also widely available at relatively low cost. Appropriate consent will be required to work at Stonehenge and this will need to be applied for by the candidate early in the research process. However, as the work is completely non-invasive we envisage little difficulty in obtaining the necessary permissions. Access to the stones will be negotiated with Dr Heather Sebire, Senior Property Curator (West) for Historic England.

As a SEAHA student, you will have unparalleled access to research infrastructure and expertise across three universities and 60+ heritage, research and industrial partners. In addition to the university doctoral training requirements, SEAHA students take part in an exciting range of cohort activities, ranging from residential events and group projects, to conferences and careers events. Please visit the SEAHA website for details.

Academic entry criteria: You will have a good first degree (min 2:1), and/or excellent grades in a Master's degree, in a subject with significant content in the field of Digital Imaging Science, Remote Sensing, Geoinformatics or related subjects. Such degrees could include Conservation, Material science, Chemistry, Physics, Engineering, Geography, Environmental science or Heritage science. Other science disciplines will be considered.

Training path: The student will be part of the EPSRC Centre for Doctoral Training SEAHA (Science and Engineering for Arts, Heritage and Archaeology). Students will register for the one year MRes SEAHA at UCL in year 1 and then continue to PhD studies for years 2-4 of the studentship. The student will be encouraged to spend time working with Historic England and the industrial partner Breuckmann/AICON/Hexagon.

Enquiries: Please contact the academic supervisor for further information, Dr Matthew Brolly (M.Brolly@Brighton.ac.uk).

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Funding: The SEAHA Studentship will cover home fees and a stipend of up to a maximum of £18,172 per year (current rate) for eligible applicants and a substantial budget for research, travel, and cohort activities. Non-EU applicants are not eligible for funding.

The award will be subject to a Grant Agreement between UCL, and University of Brighton.

Application deadline: Monday 7 August 2017

How to apply:

The application should be submitted by email direct to the UCL SEAHA Manager and not by the UCL online admissions system. **Please email applications to: SEAHA Manager, manager@seaha.cdt.ac.uk**

Your application should include:

- A substantial covering letter (2-3 pages) including:
  - a clear explanation of your motivation for applying for this project
  - a statement of your understanding of your eligibility according to the information provided at: http://www.seaha-cdt.ac.uk/study-with-us/studentships/eligibility-criteria/ and https://www.epsrc.ac.uk/skills/students/help/eligibility/
- A short research proposal (max. 2000 words) taking into consideration the project research questions
- A full CV
- Contact details for two academic references (names, postal and email addresses)
- Proof of meeting the UCL English language proficiency requirements where necessary.

Interviews are likely to take place in Brighton the week commencing 21 August 2017. Please mention in your covering letter if you will not be available at this time. Remote interviews (e.g. via skype) are possible if necessary.