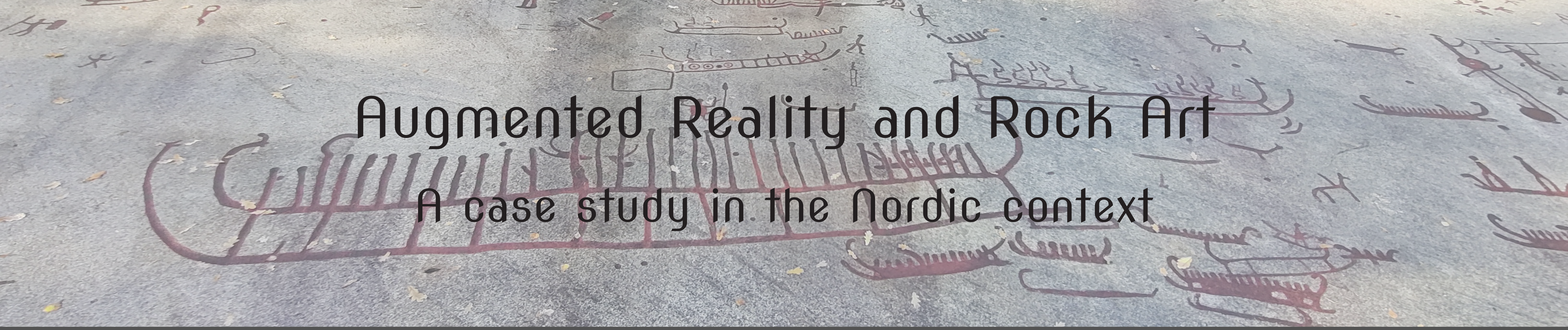

Augmented Reality and Rock Art

A case study in the Nordic context

BACKGROUND

Swedish Bronze Age rock art (1700-500 BC) constitutes one of the world's richest and best-preserved prehistoric legacies. Rock art holds abundant information about ancient ideology, society, and technologies. In Sweden, there are more than 20,000 rock art sites with over 20,000 ship images, over 4,000 human-shaped figures, over 250,000 cup marks, thousands of animals, and many other motifs. Many of the rock art in the World Heritage area of Tanum, for example at the Vitlycke panel, stand out in bright red on almost white panels. However, so far there is no clear evidence that petroglyphs were painted during the Bronze Age. Painting the rock art is done to visualize the heritage to visitors and to protect the carvings from being destroyed. A concrete example of this danger is the destruction of the famous skier in Lillehammer, Norway, by youths that felt it was not visible enough. However, there are definite shortcomings that cast doubt on the presumed benefits of painting the engravings.

The conservation of tangible cultural heritage aims to maintain the condition of the heritage object stable, while minimally intervening with it. The principle of minimal intervention has been prominent in the conservation field for decades, and it signifies doing only minimal changes to objects that are necessary to ensure their existence and preservation. The actions taken in conservation should be those that best serve the heritage object in question. Three prominent categories of integrity are historical, aesthetic and physical. When these concepts are intervened with, it can change the way an object conveys authentic messages, and furthermore affect the experience it gives to the viewer (Muñoz Viñas 2009, 48–49; Muños Viñas 2005, 65–67). The adaptation of virtual technology for the visualisation of rock art is a way to maintain the integrity of these heritage objects, while adding information onto them virtually.

AIM

The aim with this study is to discuss both how digital methods could be used to augment painted rock panels with information and accentuates stages of their creation, and how digital layers could be added on top of unpainted motifs as both a substitute to painting the physical panel and to visualise different interpretations. As a case study we have developed an application where we explore Augmented Reality (AR) as a system for delivering topical digital content in real time on top of two rock art panels in Vitlycke, Sweden. In the case of using AR for visualisation, the particular interest is markerless image detection, where a device through image recognition of natural features tracks its position in the environment, as it does not require any physical additions placed onto the heritage site. The technology thus allows the interpretations to be served in a digital form and the physical environment be kept untouched, aligning itself with the values of conservation. The exposed position of the panels in combination with the Nordic climate offers challenges for these types of applications, and we evaluate different methods and approaches to mitigate this.

TANUM CASE STUDY

Our research examines two rock art panels in Tanum, Vitlycke and Runohällen, as a case study to test digital methods to augment or substitute the use of paint and demonstrate differences between the motifs. The motifs of Vitlycke are painted with red colour and the ones in Runohällen are left unpainted. The panels are located on slanted surfaces collecting leaves and snow and are often wet due to water seeping from the surrounding forest floor. As most panels are not regularly maintained, there is a risk that they are covered when a visitor comes to see them. The rock surface is weathered smooth, therefore it does not have recognisable features that keypoints could be extracted from. The petroglyphs in Tanum are located on comparatively smooth panels which are filled with many clusters of petroglyphs from different time periods. As we are focusing on distinguishing the closely located petroglyphs from each other, we decided to discard the use of GPS for identifying individual petroglyphs. Instead, our method relied on the use of natural feature detection, but rather than extracting the key points from the surrounding granite surface, we used the individual, silhouette-like petroglyphs as our image targets.

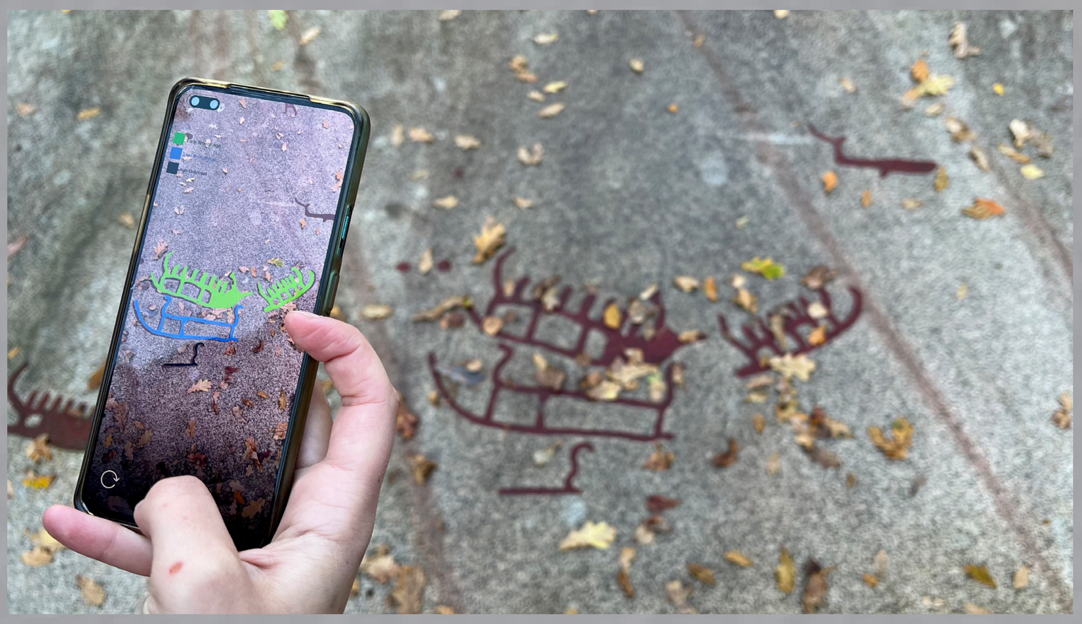

Figure 1. The application recognises the target covered in leaves.

METHOD WITH AUGMENTED REALITY

For this study's reference libraries, we have chosen to use ARKit developed by Apple and ARCore developed by Google. They both offer full access to all necessary functions free from license costs and lets us develop for iOS and Android simultaneously using AR Foundation in Unity. Both ARKit and ARCore support 2D image tracking, device tracking, plane tracking, and light estimation. We used the same code base for both applications and worked with them simultaneously to be able to control that our results were platform- and device-agnostic. The applications use 2D image tracking for natural feature detection. This entailed building a reference image library storing photographs of the petroglyphs themselves. The virtual overlays were produced from the images used in the reference image library. We isolated the shapes of the petroglyphs on a transparent background and divided these into Early Bronze Age, Late Bronze Age, and Unknown based on available data (figure 4). We then applied colour schemes to the petroglyphs to help differentiate between them. These overlays were then used as textures on simple 3D planes of the same dimensions as the corresponding images in the reference image library.

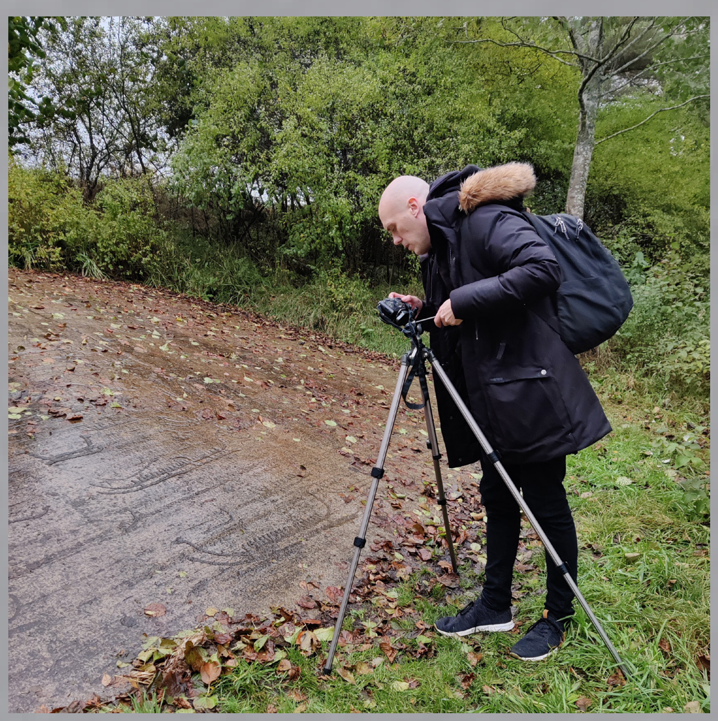

Figure 2. Westin documenting Runohällen petroglyphs.

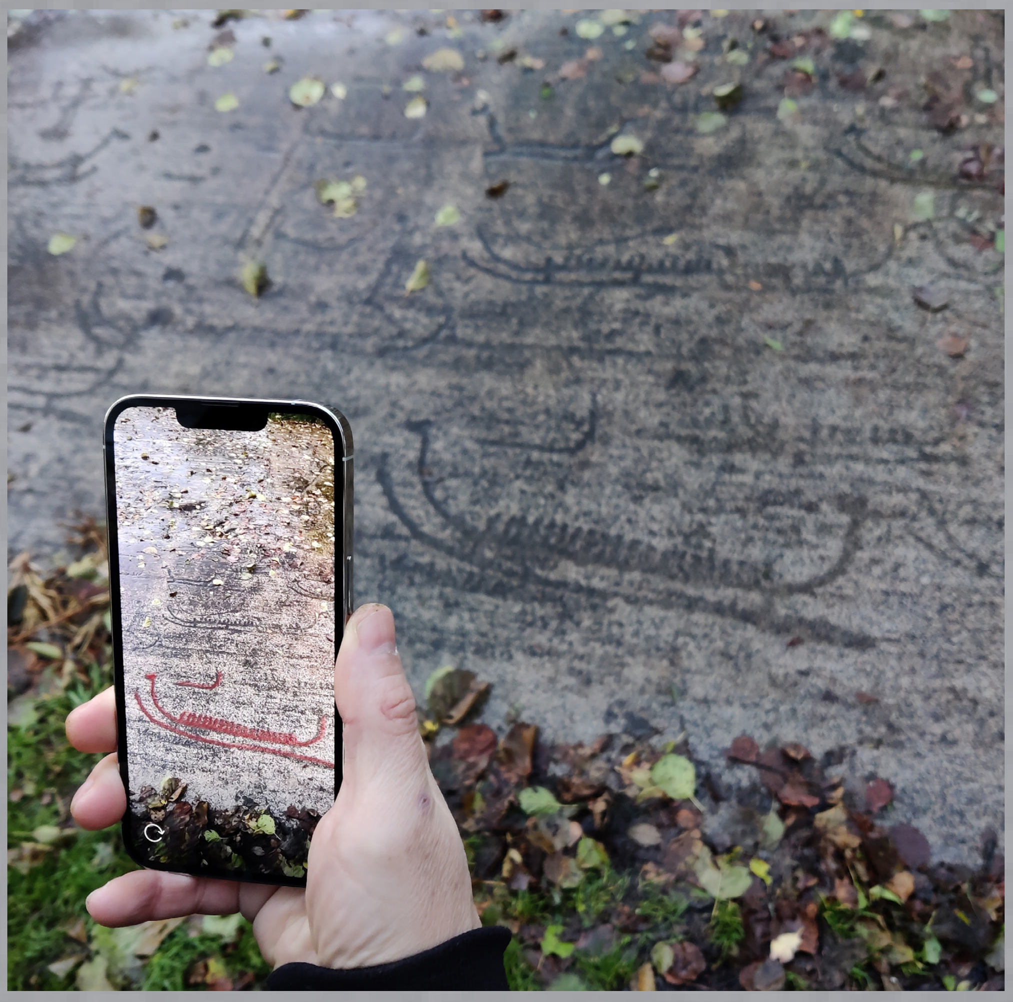

Figure 3. The image recognition works on unpainted petroglyphs.

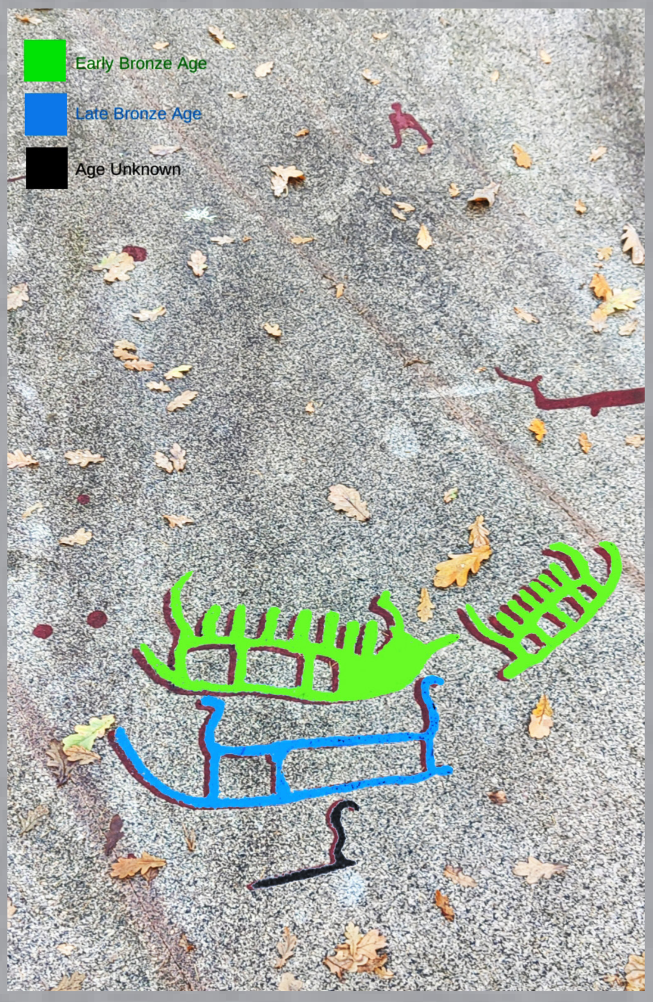

Figure 4. The petroglyphs were visualised in colours.

For painted petroglyphs, the application was able to recognise the rock art with three different types of reference images, being most stable with the use of images from captured a 3D model. Once a match was made between an image in the library and the live camera feed, the application was able to superimpose the virtual overlays. However, there were issues with flickering when the target rock art was too large to fit entirely in the camera view. The best result for recognition was a cluster of rock art, where several carvings were captured together in the reference image: the recognition in this instance was both fast and stable. With the cluster, the application was able to recognise it from several different angles, from up to 2.2 metres distance. The recognition continued to work even when we covered the carvings partly in leaves or poured water over it to simulate different conditions (figure 1).

While the unpainted petroglyphs were not easy to make out even for the human eye, the applications could successfully recognise the unpainted carvings and were able to maintain the virtual content without flickering (figure 3). This indicates that even unpainted rock art can have enough features for markerless detection, mainly due to the carvings being slightly accentuated by moistness and dirt, and are therefore applicable as targets for AR applications. However, due to time limitations we have not tested all the possibilities of how well the recognition will work in conditions that vary dramatically from the conditions under which we captured the photographs for our reference image libraries, such as different daylight, dry versus wet weather, and when the rock art is covered with leaves.

DISCUSSION

A limitation we found in these experiments, is that the image recognition works in only relatively close distances and the results are varying. We found that the distance for target recognition varied between 1.5 to 2.2 metres distance. Since the distances are quite small the application would not be able to recognise the rock art that is located on higher parts of a panel, which can extend to more than a 4 metres from the viewer's position. Furthermore, if not actively upkept, the petroglyphs are covered by leaves in the autumn, and possibly snow during the winter. Hence, image recognition of individual petroglyphs need to be augmented with other techniques to make the visual interpretation of the panels fully accessible. To tackle the issues of unreliability, one could consider the use of a hybrid technique of markerless and marker-based recognition, with discrete markers placed away from the rock art. Other possibilities include using a *Diorama*: a panoramic 360 degrees photograph that reacts to the orientation of the device. Another possibility which we call *Place*, lets the user project a photorealistic 3D representation of the panel scanned using structure-from-motion, at the correct scale, in their own environment. The last suggestion is that the user can bring up a handheld virtual reality representation of the historic environment of the panel based on a 360 degree photograph, but here completed with sound recordings of the place.

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