Automated classification of petroglyphs

Markus Seidl [a,*], Ewald Wieser [a], Craig Alexander [b]

[a] Media Computing Group, St. Pölten University of Applied Sciences, Austria
[b] McDonald Institute for Archaeological Research, University of Cambridge, UK

ARTICLE INFO

ABSTRACT

In this paper, we address the problem of automated petroglyph classification in a large real-world dataset. The dataset which contains more than 1000 petroglyphs is based on tracings from the UNESCO world heritage site Valcamonica, Italy and is expert-classified into two parallel typologies. For automated classifications of petroglyphs we utilise a combination of existing shape descriptors and a recently developed graph-based petroglyph descriptor. We achieve good classification results. We evaluate how the results can be incorporated into the daily work of archaeologists. We demonstrate that our tools can clearly enhance the process of manual classification.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

On rock panels all around the world petroglyphs have been pecked, scratched and carved. The classic documentation method is time consuming manual contact tracing on transparent sheets. With the rising availability of affordable 3D scanning techniques (e.g. Alexander et al., 2015), more and more rock surfaces containing petroglyphs will be scanned and subsequently be available digitally as highly detailed 3D scans. (Semi-)automated segmentation (a computer vision term for, in this case, separating anthropogenic markings from the natural background surface) of these 3D scans has the potential to replace classic tracing, or at least to transfer it to the digital domain, as the time consuming task on the rock is moved to the laboratory and is strongly computer supported. We have proposed methods for automated segmentation of high resolution 2D images of petroglyphs (Seidl and Breiteneder, 2012) and are currently working on methods for 3D scans. The analysis step subsequent to segmentation (or, classically, tracing) is classification of the petroglyph shapes into typology classes, which is also a time consuming task. In contrast to the segmentation task, the automated classification of petroglyph shapes has attracted some research recently (Zhu et al., 2011; Deufemia et al., 2012; Deufemia and Paolino, 2013). We recently proposed and evaluated a novel graph-based shape descriptor for petroglyphs (Seidl et al., 2014). Results on a small evaluation dataset show that the combination of our descriptor with other descriptors yields very good results.

In this paper we want to investigate two questions. First, whether our approach generalizes to a larger dataset and second, whether the results can be incorporated into the workflow of petroglyph documentation. The dataset used to train and test our algorithms contains more than 1000 single petroglyphs. It consists of 2D data derived from the digitisation of contact tracings made by archaeologists directly from the engraved rock surfaces. As the part of the rock surface containing a single petroglyph is usually relatively flat, our classification algorithms can be transferred to 3D scans of rock surfaces containing petroglyphs. There is no occlusion within the 3D scans created from a view from the direction normal to the rock-surface tangent plane. Hence, we lose no information relevant to image classification by collapsing the 3D data to a 2D form. Obviously for many other purposes the third dimension is crucial but the lack of occlusion and the nature of our algorithms renders it superfluous to the classification task.

We describe the site from which our data originate and the petroglyph typologies we use in Section 2. We describe the annotation tool which we developed for expert annotation and our dataset in Section 3. In Section 4, we describe our automated classification approach and related work. In Section 5, we extensively evaluate the petroglyph descriptors on our dataset. Section 6 presents some thoughts about the value-in-use of our tools while Section 7 presents our conclusions.

2. Valcamonica and the Pitoti

In 1979 Valcamonica became the site of Italy's first-ever UNESCO World Heritage site. The Alpine valley, running southwest-northeast from Lago d'Iseo to Edolo and then east to Passo del Tonale, is home to at least 100,000 (and possibly more than

* Corresponding author.
E-mail address: markus.seidl@fhstp.ac.at (M. Seidl).

200,000) petroglyphs (Anati, 2004; Arcà, 2009; Marretta, n.d.). These images date to many periods but there is broad agreement that 70–80% of them date to the Iron Age – the 1st millennium BC.

The petroglyphs first came to scholarly notice in 1909 when Gualtiero Laeng wrote about the site now known as the Massi di Cemmo to a committee on ancient monuments (Marretta, 2008; Poggiani Keller, 2009). Much work occurred during the 1930s and most sites now known were at least identified if not well-documented. From the 1950s onwards, Emanuel Anati has been engaged in the study of the Valcamonica petroglyphs, first under French auspices and subsequently as founder and director of the Centro Camuno di Studi Preistorici in Capo di Ponte, Valcamonica. It is fair to say that Anati has done more than anybody else to bring the petroglyphs to the notice of the world. In recent years the Valcamonica research of the Centro Camuno has been led by Umberto Sansoni and Silvana Gavaldo. Other researchers, often initially associated with the Anati group, have also been active in the valley: Andrea Arcà, Angelo Fossati, Alberto Marretta and Ausilio Priuli *inter alia*.

Typical figurative petroglpyh motifs include armed figures, deer (Fig. 1), granaries/huts (Fig. 2), the so-called *oranti* (praying figures/stylised anthropomorphs), *palette* (small shovel-like objects: see Fig. 3), footprints and more abstract geometrical forms.

Pitoti – properly pitòti – is the Camunian dialect word for the petroglyphs, the name that local people used for the images before the arrival of archaeologists and antiquarians. The exact meaning of the word is unclear, even to native speakers of the dialect, but embraces concepts of puppets, games, jokes, naughtiness and simplicity.

In order to be useful analytically, all data must be organised and archaeological data are no exception. In the case of petroglyphs that organisation activity takes the form of classification by period and type. It is perhaps obvious but bears repeating that typological classification is a necessary precursor to analytic treatment of the petroglyphs but is not an end in itself: a typology tells us nothing except perhaps which subjects were foremost in the minds of its creators.

In Valcamonica a chronological sequence has been established on the basis of style, superimposition and the portrayal of parti-cular items of material culture (Anati, 1960; de Marinis, 1994). The major flaw in this chronology is precisely its temporal focus – it essentially ignores the possibility of spatial variation in form in favour of treating all variation as intertemporal. For some of us, the recognition of spatial variation and its integration into the Valca-monica story remains one of the greatest open research issues (Marretta, 2007).

There is not one single typological classification in use in Valcamonica although Anati (1975) provided a wide-ranging

Fig. 1. Deer petroglyph (Photograph ©Hamish Park, used with permission).

Fig. 2. Granary/hut petroglyph (Photograph ©Hamish Park, used with permission).

attempt based primarily on form and style. He grouped the petroglyphs into 5 broad groups, labelled A to E. Group A was, for example, anthropomorphs. Within each of the 5 groups there were between 3 and 6 subgroups – Group A(v) contained horse-men, for example. Within each of these subgroups there were between 3 and 19 particular types. In total, Anati's 1975 typology has 158 individual types grouped into 21 mid-level categories (the subgroups A(i)–E(v) mentioned above) and 5 high-level categories (the groups A–E).

However, new forms of petroglyph have come to light since Anati devised his typology. The 3D-Pitoti project has chosen to use two parallel typological schemes for the classification of the petroglyphs.

The first, and more traditional, scheme is an expansion by one of the current authors (Alexander) of a classification scheme used in the most recent large-scale site publication, that of Campanine (Sansoni and Gavaldo, 2009). The Campanine area is unusual in that it has many medieval petroglyphs along with the more common pre- and protohistoric forms. As such, it was necessary to add certain pre-medieval categories in order to make the typology useful for all areas of Valcamonica. The implemented typology has 135 primary classes (e.g, Armed Figure with Helmet, Sword and Shield; Birds; Introbio-Lovere Knives) that are grouped into 18 secondary classes (e.g. Weapons, not wielded; Structures; Animals). These are further grouped into 6 tertiary classes (e.g. Material Culture; Natural World; Geometrical Forms) which in turn are grouped into 3 periods: Prehistoric/Protohistoric; Medie-val and post-Medieval; Not Securely Datable.