SECANTO – The SECtion ANalysis TOol

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ABSTRACT

Describing and comparing artefacts are time consuming activities. Take for example hand-made ceramics from the Iron Age. In The Netherlands, about a dozen archaeologists have published comprehensive overviews of Iron Age excavations, containing many hundreds images of such ceramics. Finding a particular vessel shape involves leafing through about 30 pounds of relevant literature. And once a look-alike is spotted, how good is the similarity? The next publication may very well contain a better one.
The Secanto system addresses the problems described above. The system compares shapes in an objective, repeatable way and is able to find good look-alikes of ceramic vessels. The user can enters her/his data through a simple point-and-click screen and within two minutes all candidates out of a data base of 900 images are found.

1. INTRODUCTION

Describing and comparing artefacts are time consuming activities, especially when the objects under study are from pre-industrial times. Such artefacts were not made according to well-formalised production schemes and therefore cannot easily be captured in typologies. Take for example hand-made ceramics from the Iron Age. In The Netherlands, a dozen archaeologists have published comprehensive overviews of Iron Age excavations, containing many hundreds images of such ceramics. Finding a particular vessel shape involves leafing through about 30 pounds of relevant literature. And once a look-alike is spotted, *how good* is the similarity? The next publication may very well contain a better one. But, better according to what criterion? There are no tools available to do objective comparisons between an object under study and the (schematic) drawings from literature. Published typologies are usually presented as *statements* ('…figure X shows type A…'), often impressive monuments of years of persevering craftsmanship, but they lack operational capabilities to enable the reader to a) determine whether her/his real life object fits in a certain typology and b), if so, which type it belongs to. Archaeologists are assumed to master this piece of craftsmanship by repeatedly going through the literature, until their typological assignments do not differ too much from those of their colleagues who work under the same paradigm.
The Secanto system addresses the problems described above. The system compares shapes in an objective, repeatable way and is able to find good look-alikes of ceramic vessels. The user can enters her/his data through a simple point-and-click screen and within two minutes all candidates out of a data base of 900 images are found.
This paper provides a short description of the usage of the system, how the images data base is searched and the user interface.

2. THE SECANTO DATA BASE

The foundation of the Secanto system is a data base, containing the low resolution images of (currently) more than 900 profiles of hand-made ceramic vessels from The Netherlands and Northern Germany dating from 500 BC – 400 AD. To obtain the data base records for the vessels, the images from the original publications (Abbink, 1999; Bloemers, 1978; Diederik, 2002; Van Es, 1965, 1968; Van Heeringen and Van Trierum, 1981; Van Heeringen, 1987, 1989; Reichmann, 1979; Taayke, 1987; Tol *et al.*, 2000) were scanned with a resolution of 200 bpi. These scans were converted to black and white bitmap images with a height of about 150 pixels. Rotational symmetry along the central vertical vessel axis is assumed, and ears and handles are ignored. Apart from the graphical data the height of the vessel, the site, the type (according to the original author), the overall shape (see fig. 1) and the context (grave or settlement) are recorded.

3. COMPARING SHAPES

The main functionality of Secanto is searching particular vessel shapes, based on objective, repeatable comparisons. To do this, a so called comparison engine is necessary, to do the required comparisons. Now there are basically two methods to compare (images of) objects. The first method involves defining a number of parameters which describe the objects sufficiently. Typical examples (for ceramic vessels) of such parameters are ratios like height/diameter, angles, etc. For an example see Mom (2003). The values of these parameters are compared and based on the (relative) differences it is decided whether the objects look alike or not.

However, this reductionistic method entails several problems. The parameters are often heavily correlated and by using weighting schemes subjectivity is introduced. Also, some parameters are not always available because the artefact is broken and only sherds are left.

The second method does not use parameters, but the images are compared *directly* without the in-between step of measuring parameter values: one uses a comparison engine which produces one value only, a direct measure for the (dis)similarity of the two objects compared. Such 'holistic' methods are implemented in the Secanto system.

There is actually only one demand posed on a good comparison engine: that the results (formulated as 'Object A does look like Object B', 'Object A does not look like Object C' and 'Object A looks more like Object X than like Object Y'), in general are in line with the expectations of the user. As an example, see fig. 2 (a set of vessels that look alike, according to the Secanto comparison engine) and fig. 3 (a set of vessels that do not look alike). The dissimilarity matrix is given also.

In Secanto two alternative comparison engines are implemented which operate by shifting sections over each other until either (a) the sum of the squares of the surface curvature distances (indicated in figure 4 with arrows) has reached a *minimum* value, or (b) the total overlap of the two sections has reached a *maximum* value. Method (a) gives by far the best result for ceramic vessels. Method (b) is currently used for objects like stone axes.

Secanto provides an additional number of options that add extra intelligence to the comparison process. In the first place the user can choose from several characteristics to be kept 'fixed' during the comparison process (resulting in a pre-comparison scaling process). For example, the height of the vessels can be set equal, resulting in a rescaling of one of the vessels. For searching the current data base, which contains complete profiles only, this is the preferred setting. Keeping other parameters fixed (like the wall width or the surface area) is only relevant for comparing objects like axes, rims etc., not for ceramic vessels. Also, if the diameter of the vessel is known then this information can be used in the comparison process. Thirdly, the distance between the inner surface curves can be taken into consideration, or not. This option is used for 'rim-only' comparisons, for complete vessels it usually does not improve the results.

4. DISTANCES

Each comparison between two vessels gives one value which is independent of their sizes. When this comparison value is zero then the two vessels are 'the same', except for (maybe) their size. The larger the comparison value, the larger the dissimilarity. These characteristics of the comparison process would easily seduce the user to think in terms of *distances* between the vessels and indeed this analogy looks quite appropriate as long as one does not forget that the space in which these distances are measured is very non-Euclidian and also very dependent on the objects in the set under study. This means that two-dimensional representations of vessel groups as shown in figs. 2 and 3 should always include the dissimilarity matrix as the image usually is distorted.

5. SHAPE GROUPS AND REPRESENTATIVES

The images in the data base are grouped together in so-called shape groups. These were created by the system itself (see the flow sheet in fig. 5).

First, the data base was filled with 20 profiles which were divided in three groups, according to the typology of the original author. Next, a dissimilarity matrix was calculated for these vessels. It appeared that a distance of 20 was a good choice to distinguish between look-alikes and non-look-alikes. Next, for each of the three shape groups the vessel that was the 'best representative' of the group was determined, based on the sum of it's distances to all other vessels in the group. The other images to be added to the data base were compared with these representatives only, not with the other members of the group. When the distance between the new image and a representative was less than 20 then the new image would become a member of the shape group. If there were *no* representatives that fulfilled this requirement then the new image was put in the 'Special Shapes' group. However, when the new image found in this group three other images with a distance less than 20, then these three images were removed from the Special Shapes group and a new shape group was created. This process resulted in 30 shape groups, and 87 images remaining in the Special Shapes group. In fig. 2 such a shape group is shown: image 6 is its representative, and therefore in the middle of the other images.

6. FINDING LOOK-ALIKES

When the user wants to search the data base to see whether a certain vessel has look-alikes, first the shape of the vessel under study must be entered. This is done using a point-and-click facility to enter the circumference of the vessel profile, based on a digitised drawing (see fig. 6) or digital image.

About 20 points usually suffice. Next, the image is compared with a special group: the group that contains the 30 representatives of the shape groups. The search takes about a minute and the result is given on the screen (fig. 7). A dark red colour indicates that there is no good fit (distance > 20). While a green colour indicates a distance <= 20.

Clicking the representative will open a screen that shows details about the image and the representative (fig. 8). These details have been calculated during the comparison.

Once a matching representative is found, one can search the corresponding shape group by using the 'Refine' option (fig. 7, right upper corner). All images in the shape group that fulfil the <=20 criterium are selected, and the user can use the 'Vessel Cat Walk' screen to compare her/his vessel with the vessels found in the data base (fig. 9).

7. OTHER SECANTO ISSUES

This paper only mentions complete vessel profiles. However, some preliminary experiments with 'rim only' sherds indicate that Secanto can also provide a useful contribution when no complete vessels are available. Currently a collection of 160 rim sherds of native pottery, excavated at the Roman castra near the Hunerberg in The Netherlands, is being studied using Secanto to find rims that are alike.

Other types of objects for which Secanto data bases are currently created are Mesolithic flake axes (see e.g. V. Mom and J. Andresen, 2005) and Neolithic arrow points. There are also plans to use Secanto to study some existing typologies to compare the Secanto groupings with the more intuitive type schemes.

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FIGURES

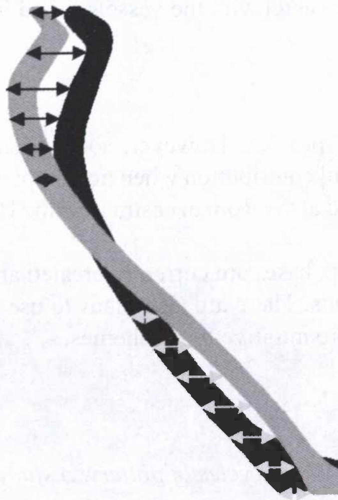

Figure 1 – The system itself was built in HTML embedded JavaScript to enable usage over the Internet.

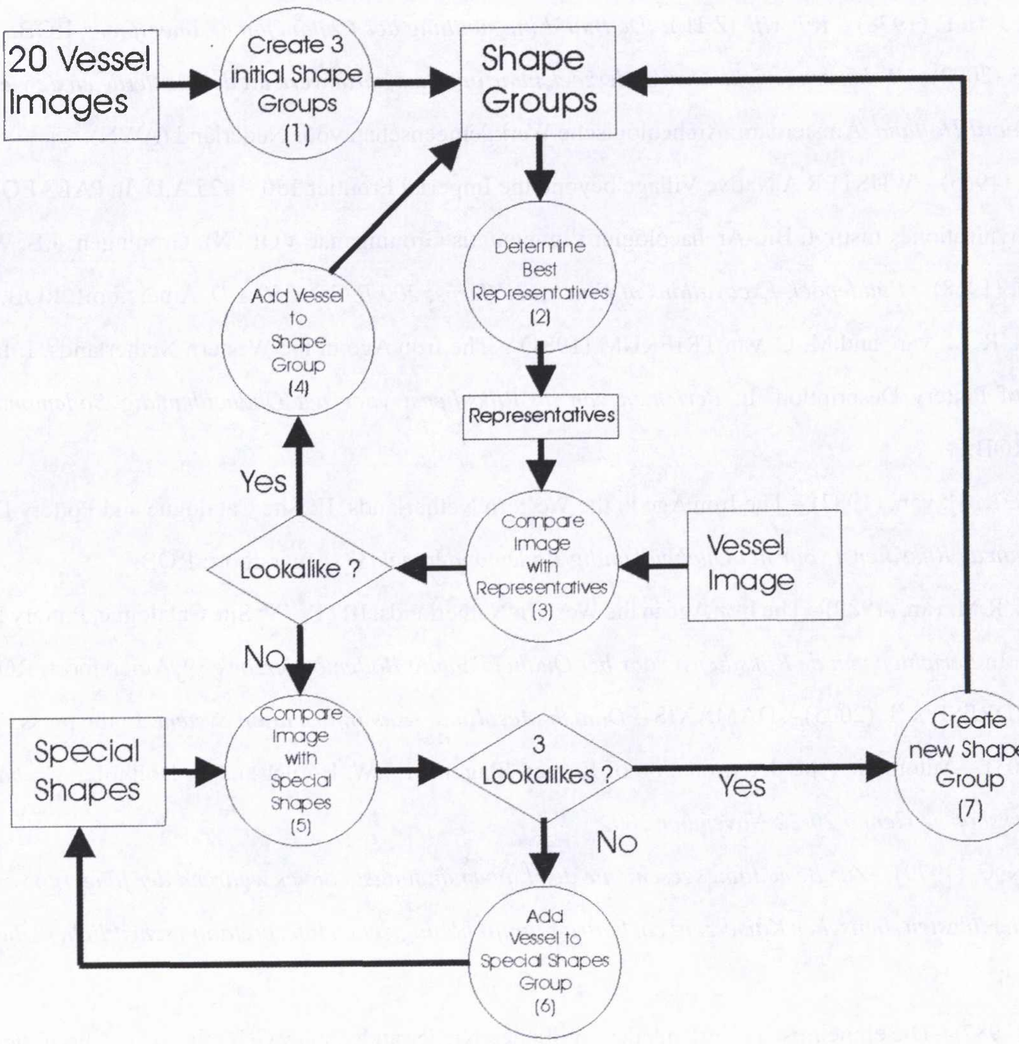

Figure 2

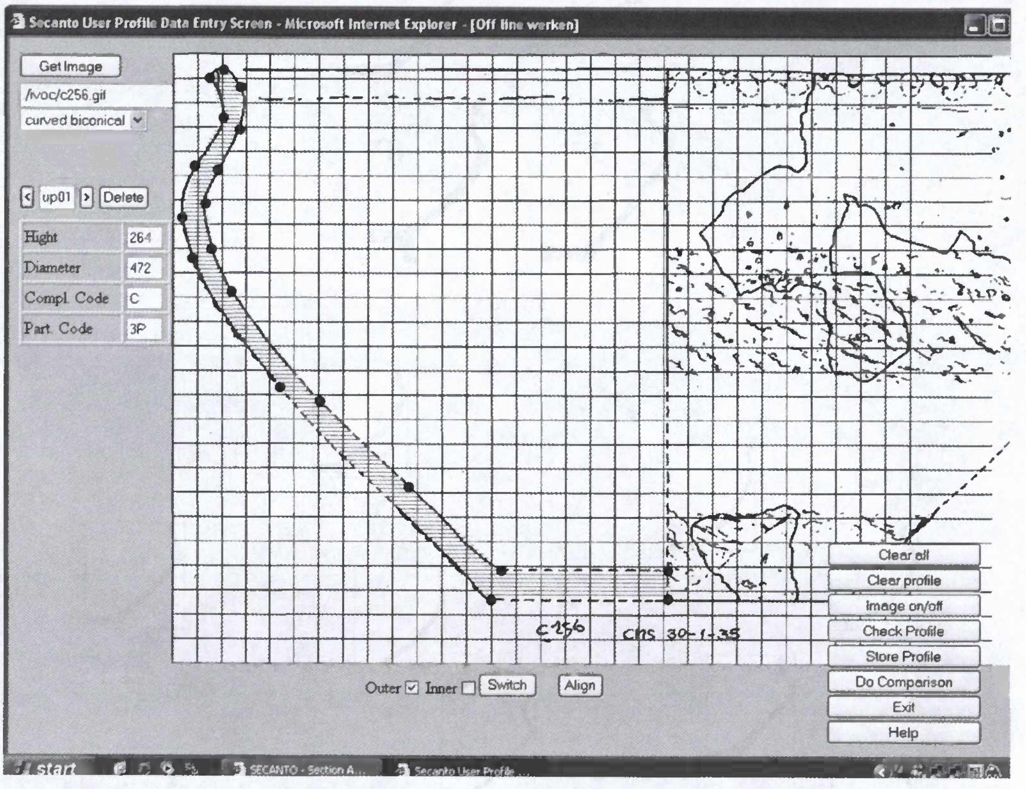

Figure 3

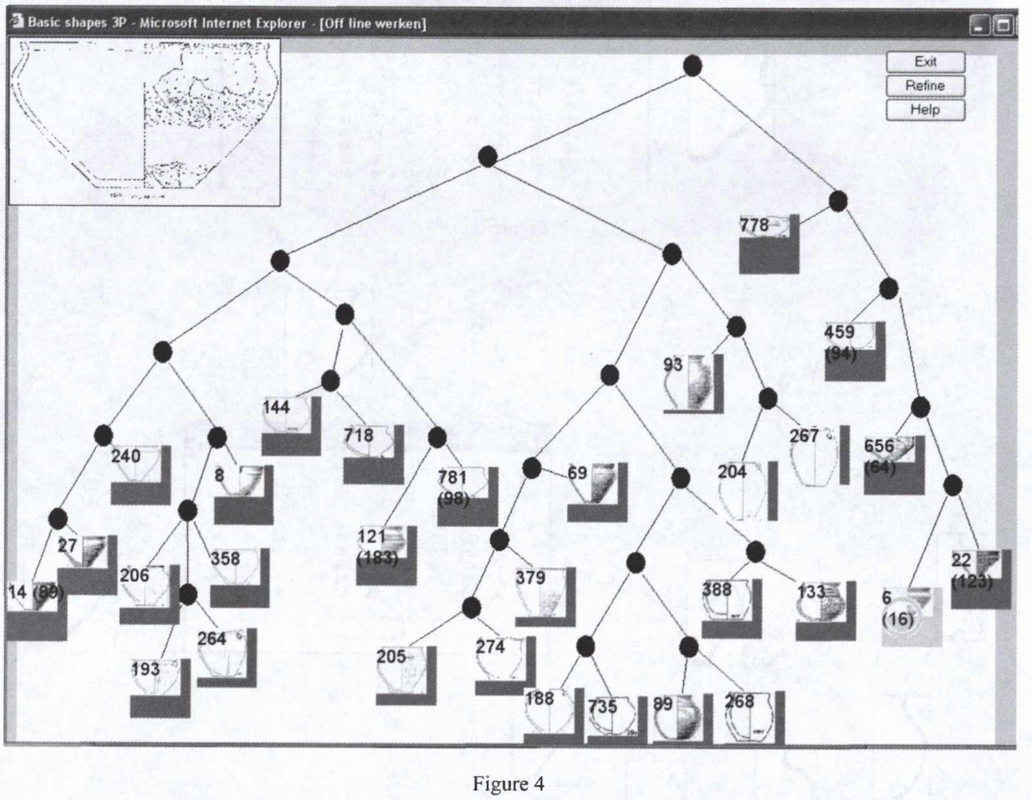

Figure 4

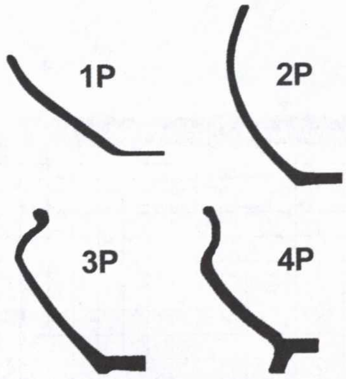

Figure 5

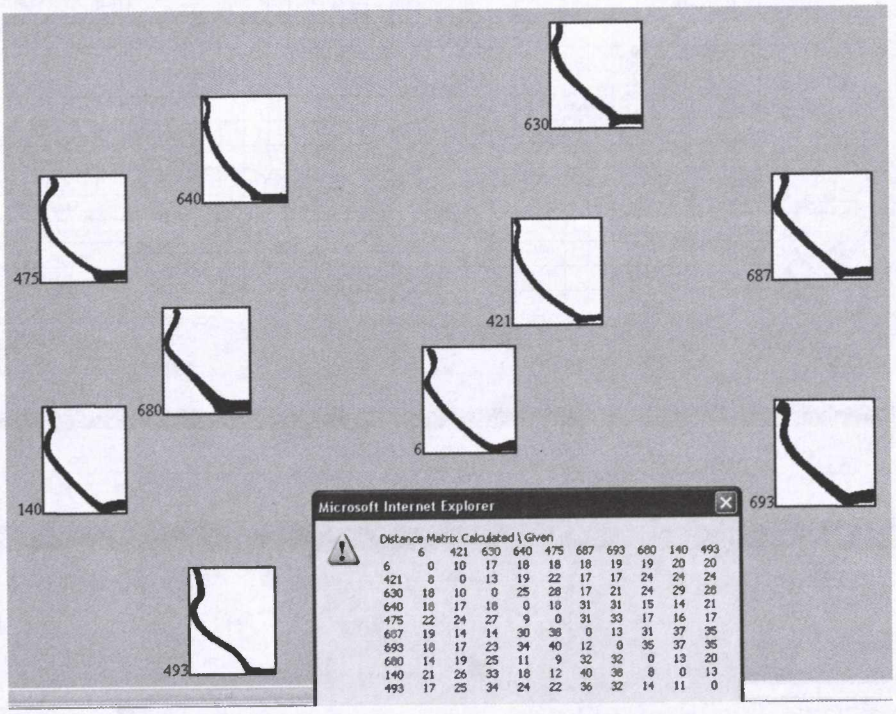

Figure 6

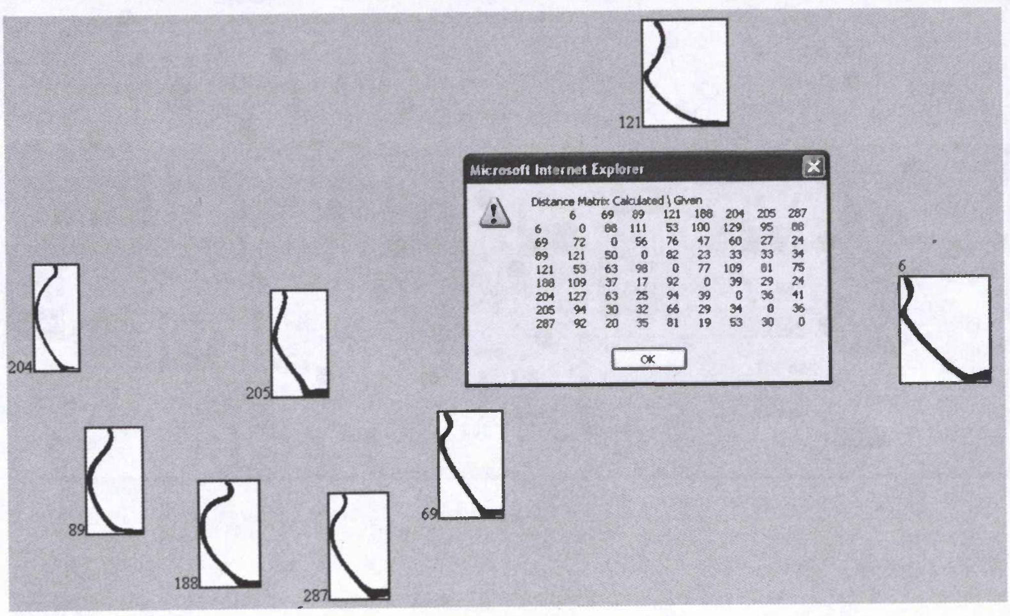

Figure 7

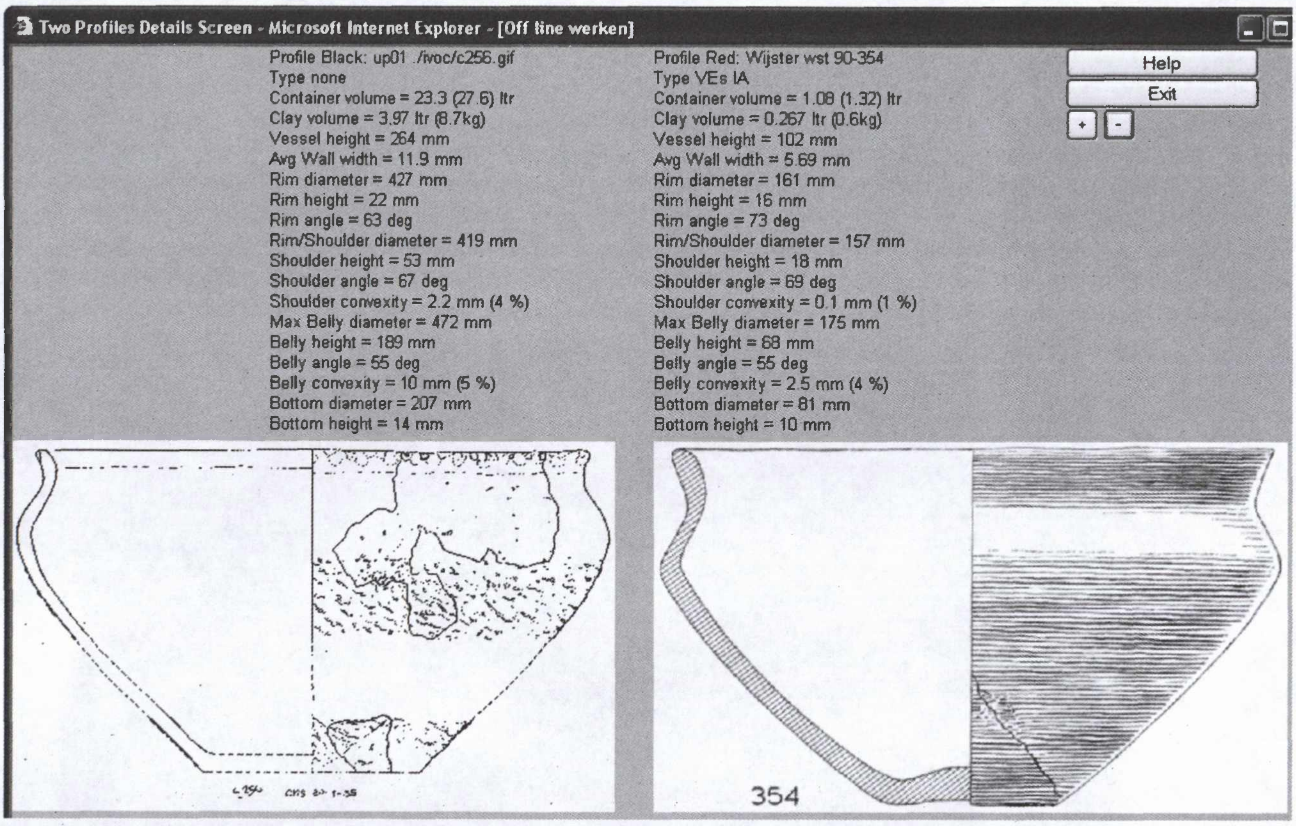

Figure 8

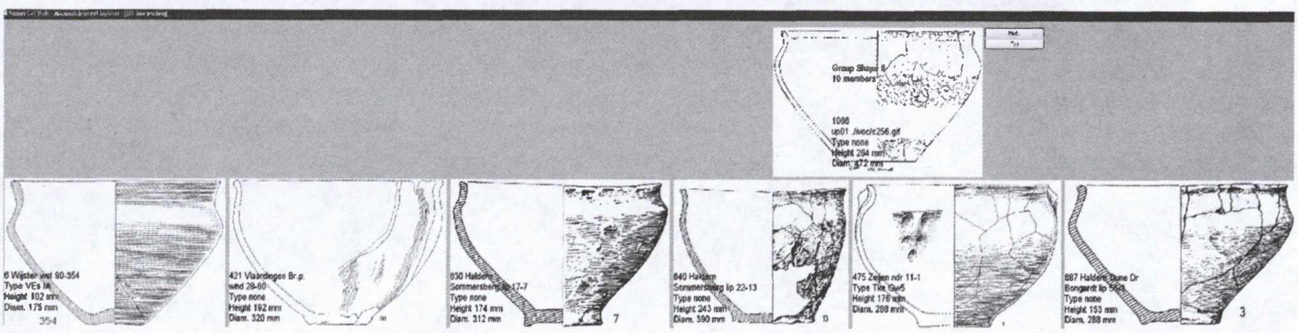

Figure 9