# Buddhist Murals of Kucha on the Northern Silk Road. A Follow Up on Semi Automated Annotation Using RCNNs.

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The Buddhist cave complexes in the region of Kucha, located on the northern Silk Road (in the Xinjiang Uyghur Autonomous Region, China) house impressive wall paintings dating approximately from the 5thto 10thcenturies. The first evidence of a past Buddhist culture was discovered at the beginning of the 20th century. It was a sensation when various Buddhist cave complexes were discovered. At that time, the first photographs of the actual state of the caves were taken and pieces of the paintings were extracted from the caves by western expeditions and transferred to the respective national museums. Sales and losses due to war led to the fact that nowadays fragments of the murals are spread all over the world, making it very difficult to assign it to the individual caves of origin (Further information: Yaldiz 1987; Popova 2008; Dreyer 2015).

Our project has taken on the task of documenting and describing the murals *in situ*and the individual pieces available worldwide and, with the help of historical photographs, of virtually reinserting them into their original context. [1]

We make use of modern possibilities of the Digital Humanities in that not only an extensive textual description of individual scenes is carried out, but also the pictorial contents of the painted representations are recorded and enriched with digital methods. For this purpose, the digital image annotation tool Annotorious [2](see figure1) is used to annotate the content with a taxonomy comprising about 1,000 entries. The generated research data is freely available online. [3] The pictorial annotation not only enables non-experts to recognise the identified pictorial elements, it also serves as evidenceand warrants traceability vis-à-vis other researchers, since the proof must be provided directly in the image. The focus is not on creating a completely annotated corpus, but rather on describing all elements that are or could be important for an identification ofthe respectivescenes.

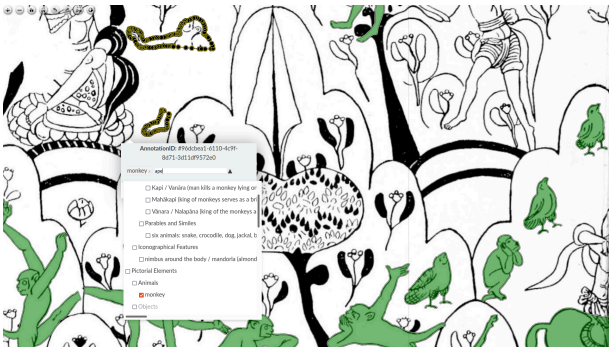

Figure 1: Annotating a Monkey with Annotorious

However, annotating is a very extensive and time-consuming task. Many objects have to be annotated repeatedly because they appear in many images in changing contexts. Also, there are sometimes several images of a painting from different perspectives or times available.

Thus, there is a great need to at least semi automate the process of annotating similar or same objects. However, transferring annotations is difficult. Even if photographs of the same objects are available, changed viewpoints and different lenses may cause the photographs to be distorted. It is hardly possible to perform this task automatically using conventional computer vision methods.

For this reason, the project trained region based convolutional neural networks (RCNNs) [4]using the annotations already made, in order to be able to perform at least parts of the annotation process semi-automatically in the future.

So far, RCNNs have been used in the Digital Humanities mainly to identify, locate and order objects in images (see for example: Howanitz et al. 2019; Arnold/Tilton 2019; Duhaime 2019; Helm et al. 2021). Their use for semi-automated annotation was first tested by the author in a poster presentation at the DH-Conference of last year. [5] The large number of annotations made our project perfect for such an endeavour: Nearly 10,000 polygons already exist, which have been used in a total of nearly 11,500 annotations (a polygon can be linked to several elements of the taxonomy). Some objects have been annotated over 500 times.

However, there are also some problems to be considered. For example, there are two fundamentally different types of imagery: Photographs (historical and modern) and drawings of some paintings. Since these categories of images are very different, they were also separated for the training.

The experiments of the last years poster presentation have showed, that the mAP $_{IoU=0.75}$[6]could be increased up to 0.599 for drawings, which is a satisfactory result for a semi-automatic annotation. Photographs performed worse, mainly due to the bad state of preservation of the paintings and also due to the limited number of photographs. (Radisch 2022). To evaluate the experiments, the poster and those test images which are freely available can be viewed online. [7]

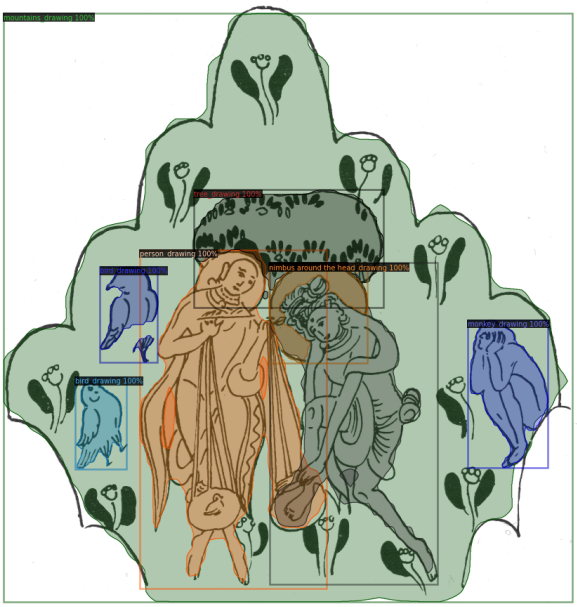

Figure 2: Example for RCNN-output.

Currently, we are conducting some more experiments, mainly on photos, to improve their performance. However, though results are promising, one problem still remains. Even the best results although they looked already like a comparable annotation had fuzzy edges (see figure 2). This does not meet the standards of our project; it actually could even increase the work of an annotator if annotations have to be corrected manually. This problem was hence addressed in the implementation of a first prototype. The functionality is the following: If a user wants to make a new annotation, he or she can look up proposed annotations, which where found by the RCNN. The user can directly accept or reject these annotations. He or she also has the possibility to modify the proposed annotation by moving single points. To address the fuzziness, the user also has the option to use a tool that automatically aligns all points of an annotation to the closest contours in the picture. This significantly reduces the fuzziness as seen in figure 3.

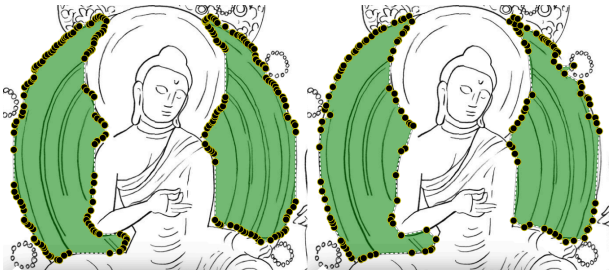

Figure 3: Pre- and post example for contour allign.

Whether the newly implemented semi-automated workflow can really safe time stillhas to be determined. The newly implemented prototype therefore tracks the time a user needs to annotate both manually and with the help of the proposed semi-automated work flow described above. Both, the results of this time assessment and the prototype of our workflow will be presented in our poster.

# Notes

1. https://www.saw-leipzig.de/de/projekte/wissenschaftliche-bearbeitung-der-buddhistischen-hoehlenmalereien-in-der-kucha-region-der-noerdlichen-seidenstrasse/introduction/kucha-murals. The Project has its own series «Leipzig Kucha Studies». The first book is: Konczak-Nagel/Zin 2020.
2. https://recogito.github.io/annotorious/
3. https://kuchatest.saw-leipzig.de/
4. The project uses for this purpose detectron2 (Wu et al. 2019).
5. There is also another project, following a similar approach: (Kipke et al. 2022).
6. This measurement indicates the Mean Average Precision at a minimum matching of a region with the gold standard of 75%.
7. https://github.com/erikradisch/examplePics/

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