

## B.3 Supporting Learning in Art History – Artificial Intelligence in Digital Humanities Education

Project

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### 1 Introduction

In recent years and especially in the context of the coronavirus pandemic, digital distance learning increases. But for academic students, the selection of adequate learning materials for educational purposes is becoming more and more complex. This marks only one starting point where the use of artificial intelligence (AI) offers additional value. AI has a great potential to enhance and support research and education in the field of digital humanities (DH). As international organisations have just expressed their thoughts on the subject, AI is the topic par excellence and will decisively shape the future development of educational processes.

This paper discusses potentials and risks of AI in DH education taking art history in higher education as an application example. The knowledge of these helps to initialize AI-supported, digital, successful educational processes. Therefore, the added value AI can have for higher education is shown. Subsequently, the technical possibilities of AI are considered. The following use case focuses on the use of AI for art history students. Finally, research desiderata are postulated.

### 2 Artificial Intelligence in Higher Education

The latest Horizon Report postulates the relevance of AI and machine learning as an emerging technology for academic teaching and learning (Brown et al., 2020). AI in education is not only about educational processes per se. Simplifying administrative tasks helps teachers to focus on the learners. Personalisation of learning material, and thus the tailoring to the individual person, ensures adaptive learning processes. Computer-aided selection supports the balance and objectivity of the learning material. Thus, AI can even lead to the provision of politically truly neutral education that can be less influenced. A very current and important topic, which shows the importance of AI in education, is the analysis of fake news. For example, Guerzhoy, Zhang & Noarov (2019) built an AI-based fake news detector.

The Organisation for Economic Co-operation and Development (OECD) underlines the importance of AI for education: “While most innovation in the past decade related to an increased use of computers and the internet in the classroom, the next wave will be based on AI, or on combinations of AI and other technologies” (Vincent-Lancrin & van der Vlies, 2020, p. 6). Furthermore, the OECD gives an overview about the benefits of AI in education (Vincent-Lancrin & van der Vlies, 2020):

**Application for instruction**

- The personalisation of learning (materials)
- The support of people with special needs
- The provision of learning analytics by chatbots for learners
- The analysis of classroom dynamics incl. feedback and suggestions for teachers
- The help for teaching foreign languages

**Application for system and school management**

- The reduction of dropout by warning systems
- The assessment of new skills

The United Nations Educational, Scientific and Cultural Organization follows the same pattern by dividing between the promotion of personalisation and better learning outcomes and the analysis of data for educational and learning management systems (Pedró, Subosa, Rivas & Valverde, 2019). All these possibilities can also be applied to higher education and support education manager, lecturer and students. The use of AI in education is still in its infancy and has so far been more experimental and local, so that it is not yet used with an uniform scale at system level (Vincent-Lancrin & van der Vlies, 2020). Examples can be found at Pedró, Subosa, Rivas and Valverde (2019, pp.12) and at Brown et al. (2020, pp. 17–18). To further understand the possibilities, it is necessary to look at the technology.

### 3 Artificial Intelligence – Technology

Different fields in the DH, especially those dealing with texts and spatial information, have undergone a “quantitative turn”, incorporating computational and quantitative methods as parts of their methodology (Manovich, 2015). With the advent of deep neural networks, disciplines operating on visual data have adopted corresponding methods, where a few years ago, many of the respective data analysis tasks were already subject of research in these fields using traditional machine learning approaches like e.g. Support Vector Machines (SVM) (Misumi et al, 2016) or Random Forest (Jafarpour et al., 2009, Čuljak et al., 2011). Nowadays, neural networks offer the advantage that visual features such as sharpness, RGB colors or edges in images do not have to be predefined, but are detected and used for classification by the network itself.

This hugely increases the number of applications where data-intensive methods can be employed: where conceptualizations of data have been highly unclear before, where manually creating classifications in visual feature space would otherwise be difficult, or where the amount of data to be processed is prohibitively large (Niebling et al., 2017).

The increasing amount of digital preservation in libraries and museums enables the protection and the usage of cultural memory for the society (Ross & Hedstrom, 2005). Still, challenges such as poor metadata quality or usability difficulties hamper a keyword-based search for non-experts (Münster et al., 2018). Therefore, neural networks can be useful for the classification, automatic metadata assignment or content-based recommendation of digitized art. Systematically imaging arts in the museums and other arts in general can lead to generate very valuable data, which can be used for documenting paintings digitally. Visual data extracted from paintings can be used to train artificial neural networks to recognize copies or different reproductions of a painting, or even paintings created in a similar style. Once images are recognized, a digital support system can deliver systematically organized information of the painting to the student. Examples of this information would be revealing the artist's creative process, the painting's restoration history, inform strategies for its conservation and preservation, importantly, and present an artwork in new ways to the public without harming its original message (Rodrigues, 2020).

Elgammal et al. (2018) have conducted a comprehensive study of several of the state-of-the-art convolutional neural networks (CNN) applied to the task of style classification on 67K images of paintings, and analyzed the learned representation through correlation analysis with concepts derived from art history. They found that the networks could place the works of art in a smooth temporal arrangement mainly based on learning style labels, without any a priori knowledge of time of creation, the historical time and context of styles, correlations or relations between styles (Elgammal et al, 2018).

Through the use of deep neural networks, Sigaki et al. (2018) have been able to show transitions in painting styles, which they classify as linear/haptic to painterly/optic (before and after Modern Art) and painterly/optic to linear/haptic (the transition between Modern and Postmodern Art), showing that each of these historical periods has a distinct degree of entropy and complexity. Recent research examples show the classification of styles of different paintings (Lecoutre et al., 2017), classification of genres (Sandoval et al., 2019) or the prediction of painting properties like aesthetic, sentiment and memorability (Cetinic et al, 2019). Further, Messina et al. (2019) built a content-based artwork recommendation system using neural networks.

CNNs can be used for spotting words, which lead to read text (Sebastian, 2018). This technology can be used for translating ancient languages to modern languages for example this technology can be used to translate ancient Greek to modern Greek. It can be a very useful tool for an art history student to read and understand ancient objects.

Another important field in art history is digital art. These can be computer products from hand painted pictures or solely computer based artworks (Candy, Edmonds, & Poltronieri, 2018). Whether it is hand painted or solely computer based, when it is in image format, it is possible to process them by using pretrained artificial neural networks such as VGG16, AlexNet etc. for image retrieval tasks. When retrieving these images metadata which relate to the images can be added. Therefore, such systems will help art history students to learn about digital arts.

Jiang & Kim (2019) presented an artwork painting identification method for panorama based on adaptive rectilinear projection and optimized ASIFT (Affine Scale-Invariant Feature Transform). Moreover, a group of computer scientists at Sangmyung University, Seoul, South Korea did successful research on art painting identification by using artificial CNNs (Hong & Kim, 2017). These findings can be used to develop computer applications to identify images of the paintings and to give historical information on them. For art history students, this has added value, as such a system will be able to fetch categorized information on the history of the artwork directly onto the student's personal computer or mobile device.

Vasisht (2018) built an artist identification system by using CNNs. It is available on Github to use under GNU General Public License v3.0 (Vasisht, 2018). It can process hundreds of images of paintings at a time and print out the names of the painters and the titles of the paintings. Such systems can reduce the searching time and efforts of art history students.

#### **4 Artificial Intelligence supporting Learning Art History**

In the field of art history, AI is greatly able to support the learning process. During their studies art history students have to gain knowledge about the whole timespan of the history of art. The aim is to be able to date and classify stylistically any work of art. To achieve that competence it is necessary to view as many artworks from any time period as possible. Therefore, books are an important research source. But in times of corona it becomes difficult to consult books in libraries. Furthermore, the number of books in university libraries is limited, so that not every student has a chance to read them before exams. In this context online access to images of artworks gains more importance. In recent years more and more images of artworks appear on the internet, but often they lack metadata (artist, date, title etc.), come with insufficient or even incorrect information.

To solve this dilemma the application of AI has great potential: Artificial CNNs can be used to identify a painting by using computer vision technology and to then provide information about the painting such as who is the painter, year of origin, title, material, size, collection, location of display etc.

Painting recognition with the help of AI has been a developing research area for a few years. A broad overview on the state of the art in this field give Sandoval et al. (2019). The task to recognize a specific object with machine learning techniques can be processed very successfully, whereas the task to identify a semantic problem – the style of a painting for example – still needs to be developed (Sandoval et al. 2019). Identification of the style of a painting is the very expertise of art historians. As the number of images available on the internet is growing fast, it would be helpful for computers to learn “how to label unknown images and recognize their artistic styles” (Sandoval et al. 2019, p. 41771). In their paper Sandoval et al. “propose a new two-stage classification algorithm which offers further improvement of the patch-based style classification results” (Sandoval et al. 2019, pp. 41772–41773). Their aim is to classify the style of a painting using four data processing steps (ibid.). As a result, they found that the quality of the underlying database is of great importance for the classification outcomes. Furthermore, their “findings indicate that for stylistic art analysis the best results are achieved when local patch-based analysis is combined with the holistic analysis of the entire image” (Sandoval et al. 2019, p. 41779).

Projects like this clearly show how the application of AI can support the enrichment of metadata. Taking this as a basis it would be of great added value to implement online tools like digital research environments to make images and their metadata easily accessible to art history students (Messemer 2020, pp. 307–319). As a next step it is necessary to develop tools to interact with these images and the data – to create personal digital collections of images of artworks, to annotate, to share etc.

## 5 Implication

As shown in this paper, AI can improve higher education in different ways: It can highly contribute to the learning process and to the learning management. This was exemplified for the field of art history in regard to identifying paintings by using computer vision technology.

In recent years, several research projects were undertaken in the field of painting recognition. These researches are a basis for developing virtual research environments supporting art history students to gather knowledge about artworks, getting online access to them and offering students a personalized platform to learn and share information with fellow students and teachers.

At least since the coronavirus pandemic, when libraries are mostly closed, it gets clear that digital access to study material is of essential importance. Furthermore, computer vision can be used to enrich metadata of digital files of artworks, which are decisive to clearly identify artworks and to provide correct information about them – the basis for sound research and learning.

As the German Education Report 2020 describes, the increasing relevance of artificial intelligence and algorithms for everyday life makes computational thinking skills increasingly important (Autorengruppe Bildungsberichterstattung, 2020). Therefore, the development of digital tools in education for learning is an important task, which can be effectively supported with the help of AI.

## Literature

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