Master thesis topic (Masterproefonderwerp)	Deep reinforcement learning for paint loss detection
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References (Referenties):

A. Choudhary. A hands-on introduction to Deep Q-learning using OpenAI Gym in Python, 2019, https://www.analyticsvidhya.com/blog/2019/04/introduction-deep-q-learning-python/

1. L. Meeus, S. Huang, N. Žižakić, X. Xie, B. Devolder, H. Dubois, M. Martens, A. Pizurica, Assisting classical paintings restoration: Efficient paint loss detection and descriptor-based inpainting using shared pretraining, 2020.
2. F. Ryosuke, N. Inoue, T. Yamasaki. PixelRL: Fully convolutional network with reinforcement learning for image processing, 2019.

Description of the problem (Probleemstelling)	Digital painting analysis is becoming increasingly important since digitization of artworks becomes a common practice. Museums are digitizing their collections mainly for the purposes of archiving and dissemination. With the rapid development of imaging sensors and various imaging modalities, the interest in scientific analysis of paintings is growing. It is now possible to zoom in on the tiny details of the painting or the brushstrokes, revealing structures that could never have been noticed by the naked eye. Digital image processing techniques show potential for forgery detection, detection and analysis of deteriorations (e.g., caused by ageing), detection of underdrawings and retouching as well as in providing a simulation for physical restoration and conservation treatments. Currently we are witnessing a major conservation and restoration campaign of the Ghent Altarpiece (het Lam Gods) that started in 2012. One of the main aspects of the treatment, supported by an international commission of experts, concerns uncovering Van Eyck's original paint to the extent which can be safely carried out. The paintings were covered over centuries with disfiguring retouchings, overpainting and varnishes. Certain decisions regarding the conservation and restoration treatment benefit from multidisciplinary research and image processing could significantly help in this regard. Convolutional neural networks-based methods have achieved excellent results [2] on large-scale supervised semantic segmentation, in which we assume that pixel-level annotations are available. For such models to work we need a large amount of pixel-level annotations that may require costly human labor. Producing damage surveys as part of condition reports prior to and during restoration treatments is often a tedious and time-consuming work for the art restorer. The potential of deep learning for automatic paint loss detection in paintings to facilitate condition reporting and to support restoration treatments has already been well investigated [2]. Reinforcement learning, as a machine learning method, has gained attention as a method to learn a labelling policy that directly maximizes the learning algorithm performance. One of the recent articles [3] proposed a new algorithm aka reinforcement learning with pixel-wise awards (pixel RL) for image processing. As suggested in [3], the proposed method can be applied to different image processing tasks that require pixel-wise manipulations. Our goal is to employ the proposed pixel RL model for paint loss detection of multimodal data (see Fig. 1).

Goal of the thesis (Doelstelling)	The main research challenge in this thesis will be to develop innovative semantic (pixel-wise) classification methods that make use of multimodal data (including visible, infrared and X-ray scans) taken before and during the conservation treatment. The research group GAIM already has the deep learning based software for crack and paint loss detection, which will serve as a starting point. The main objective of the thesis will be automatic detection and segmentation of the paint losses that are revealed in the intermediate stages of the conservation treatment (when the areas of retouching and overpaint are removed by the art conservators) by using recently introduced pixel RL model [3]. As this model is perfectly suited for image processing tasks that require pixel-wise manipulations, the student should extend this model making it applicable to processing of multimodal data of artistic paintings. Initially, the student should study and understand the theory behind the representation learning and deep (reinforcement) learning in particular. In this regard a minicourse will be organized at the beginning of the semester in order to familiarize student with the topic and to provide him/her with the necessary literature and code. This work will be performed in close collaboration with painting conservators from KIK/IRPA that are conducting the restoration of the Ghent Altarpiece in the Museum of Fine Arts (MSK) in Ghent.

Figure 1: The central part of the panel *the Adoration of the Mystic lamb*. The marked paint loss regions on the left are virtually inpainted in the right with the current technique of GAIM. Image copyright: Ghent, Kathedrale Kerkfabriek, Lukasweb; photo courtesy of KIK-IRPA, Brussels.