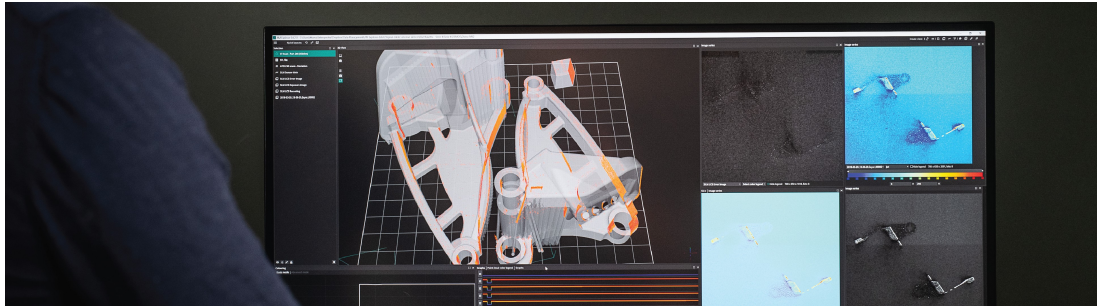


Additive manufacturing anomaly detection - Industry collaboration with Interspectral



Additive Manufacturing (AM), also known as 3D printing, is transformative for industrial production, enabling innovative designs and reducing waste. It's key to Industry 4.0 and an important development area for Sweden. Companies are expanding the use of AM from prototyping to full scale production. However, the technology remains costly and time consuming, requiring intricate quality inspections. Thus, process optimization and defect detection are crucial for AM's full scale industrialization. This thesis project collaborates with [Interspectral AB](#), which has recently made breakthroughs in the AM market through their software, AM Explorer.

► Your tasks

In this project, you will implement and evaluate methods for image-based anomaly and defect detection in AM. The focus will be on methods that are trained in an unsupervised fashion because they have demonstrated great benefits from the advances in deep generative modeling. With models such as normalizing flows or generative adversarial networks, it is possible to learn a comprehensive representation of the distribution of the training data. This can be used during test time for measuring the distance of data samples to the learned distribution.

► Your profile

We are looking for 1-2 students with a background in image processing and machine learning. While not required, having previous programming experience and fluency in for example C++, broad knowledge of frameworks and working skills within visualization will be beneficial.

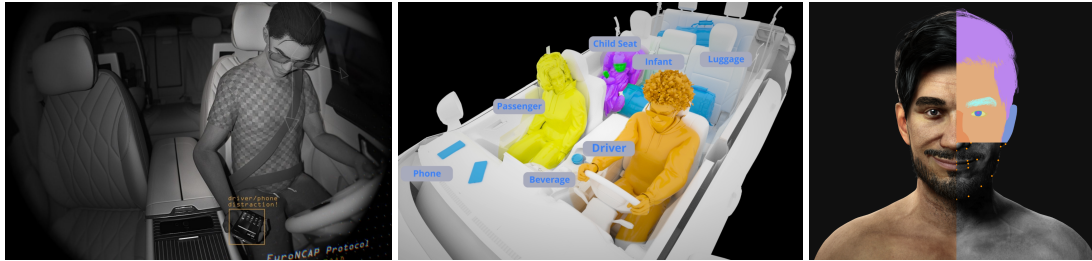
► Opportunities

For the right candidate there are opportunities for further development both as an engineer and as an industrial PhD. Join us in shaping the future of Industry 4.0 and become part of a team dedicated to creating innovative solutions and driving continuous growth and development!

► Information

Research group: [Computer graphics and image processing](#)
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Keywords: · *anomaly detection*, · *machine learning*,
· *industrial collaboration*
Level: Master

ML with human-centric synthetic training data



With the ever-increasing needs of data for training of deep neural networks, synthetic training data has emerged as an important component for the next-generation machine learning (ML) supported AI solutions. This allows for generation of large volumes of training data with precise control over image content and annotations, making it possible to customize content according to a large range of specifications. One important application area is within computer vision, where images with detailed annotations (depth, per-pixel labels, object positions, etc.) are very difficult to collect.

Devant (<https://www.devant.ai/>) has developed a highly customizable approach for image generation using photo-realistic rendering. With a focus on faithful and modular generation of humans, synthetic data can support applications within road safety and any other human-centered application.

► Your tasks

In this project, you will explore the capabilities of synthetic training data for deep learning-based applications, investigating what components in the image generation pipeline are of most central importance for training of deep neural networks in computer vision. Located at Devant, you will be working in close collaboration with experts within computer graphics, VFX, and ML. You will also work in collaboration with the research unit in computer graphics and image processing at Linköping University, Campus Norrköping, which is exploring new techniques for how to make the best use of synthetic training data.

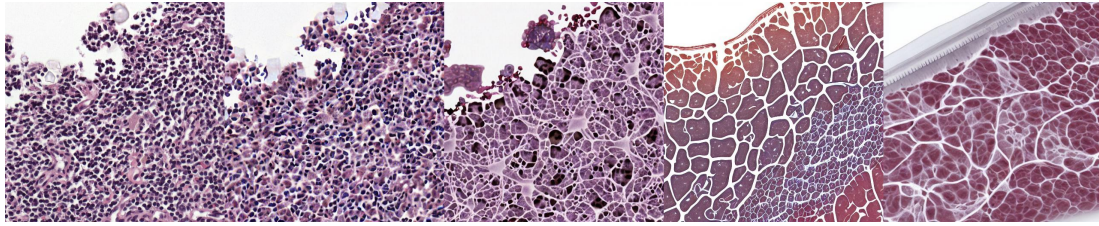
► Your profile

We are looking for 1-2 students with a background in computer graphics and machine learning. You have a great interest in possibilities for using image generation to elevate AI-based solutions, and working in the intersection of industry and academic research.

► Information

Research group: [Computer graphics and image processing](#)
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Location: Devant, Norrköping
Keywords: · *machine learning*, · *deep learning*, · *computer graphics*
· *industrial collaboration*
Level: Master

Data augmentation via synthetic image generation



Digital pathology patch (leftmost) transformed by a generative diffusion model.

Training robust artificial intelligence (AI) algorithms require immense amounts of high-quality data. However, collecting large and diverse medical data often is unfeasible due to the high costs associated with the data collection as well as the fact that some types of diseases are very rare. This results in a serious challenge for development of AI solutions for medical applications. A potential solution for alleviating the problem is to make extensive use of data augmentation techniques, boosting the diversity of available data for training. While conventional methods for data augmentation could improve performance, they are also limited. With the breakthrough in synthetic image generation by means of generative deep learning, there is a large potential in using these for advanced strategies for data augmentation.

► Your tasks

The aim of the project is to evaluate different data augmentation strategies and assess if they results in improved performance and robustness of the AI algorithms. You will explore data augmentation methods based on various classical image processing (such as rotation, zooming, colour jittering, etc), the state-of-the-art image generation networks called generative diffusion models (GDMs), and the combination of both. The methods will be tested with natural image datasets (MNIST, CIFAR10) as well as digital pathology datasets. You will have the opportunity to have weekly supervision by the experts of the field, get hands-on experience with deep learning methods, and enjoy the flexible working environment of academia.

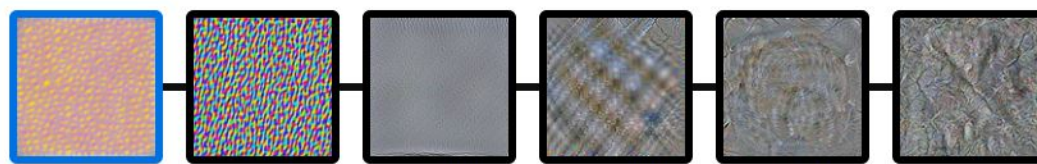
► Your profile

We are looking for 1-2 students with background in image processing and machine learning. You have a great interest in image generation and artificial intelligence, and in the applications within medicine.

► Information

Research group: [Computer graphics and image processing](#)
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Location: The division for Media and Information Technology, Campus Norrköping
Keywords: · *machine learning*, · *deep learning*, · *image generation*, · *medical imaging*
Level: Master

Visualization and importance sampling in deep learning



Machine learning has made great progress over the last decade, specifically within deep learning where artificial neural networks can model complex relationships between different types of data. When a neural network is trained, each data sample is usually given the same weight, or importance. However, in most cases this is not optimal. Many samples are simple, and do not contribute to the optimization, while others could have a negative impact on the model. Thus, with a strategy for measuring the importance of individual data samples, the training can be made more efficient and provide a better model. Also, information about sample importance can be visualized and used to provide an understanding for how data impacts the model training.

► Your tasks

You will work in close collaboration with researchers within the field. You will investigate different strategies for importance sampling and hard example mining, and use different types of visualization for analyzing the results. The aim of the project is two-fold. First, the investigated techniques for importance sampling can improve model performance and decrease training times. Second, by analyzing and visualizing the sample importance across the dataset, an increased understanding can be formed regarding how the dataset should be composed. Such information is an essential building block in a human-in-the-loop machine learning pipeline focusing on training data, where the information can be used to improve the data in an iterative manner.

► Your profile

We are looking for 1-2 students with background in visualization and machine learning. You have a great interest in artificial intelligence and the possibilities for understanding and improving deep learning by means of data analysis and visualization.

► Information

Research group: [Computer graphics and image processing](#)
Contact person: [Gabriel Eilertsen](#) - gabriel.eilertsen@liu.se
Location: The division for Media and Information Technology,
Campus Norrköping
Keywords: · *machine learning*, · *deep learning*, · *data analysis*,
· *information visualization*
Level: Master

Rendering with non-parametric data-driven BRDF model

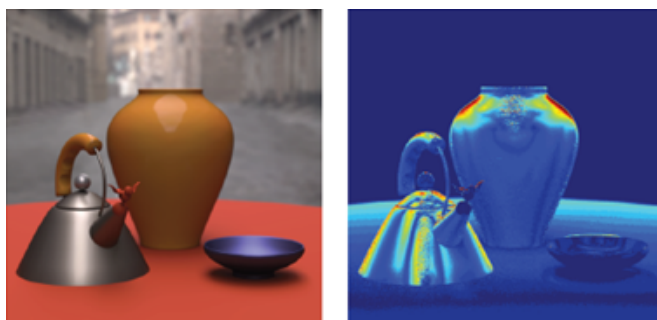


Photo-realistic rendering requires accurate modeling of the appearance of real-world materials using the bidirectional reflectance distribution function (BRDF). There are various ways to model BRDFs, and in practice due to their compact and flexible form, analytic BRDF models are often employed to estimate the surface properties. However, these models despite being efficient for rendering, are not very realistic. Measured BRDFs on the other hand can accurately model a realistic appearance, but they are often computationally expensive and consume significantly more memory, which makes them impractical for real-world applications. It has been shown, however, with sparse modeling of measured BRDFs, a non-parametric model can be defined that reduces the dimensionality of the BRDF, and therefore the rendering cost. Sparse modeling enables rendering speeds competitive with analytical models while admitting realistic modeling of BRDFs.

► Your tasks

You will explore how non-parametric sparse BRDF modeling can be utilized for realistic rendering. You will modify an existing ray tracer such as PBRT/Mitsuba or write your own ray tracer to employ the non-parametric BRDF model and analyze the capability of this model for fast and realistic rendering. The source code and required tools for sparse BRDF modeling is available. An analysis of how the parameters of sparse modeling affect the quality and efficiency of rendering is required as well.

► Your profile

We are looking for 1-2 students with a background in machine learning and computer graphics.

► Information

Research group: [Computer graphics and image processing](#)
Contact person: [Saghi Hajisharif](#) (saghi.hajisharif@liu.se) and [Ehsan Miandji](#) (ehsan.miandji@liu.se)
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Keywords: · *machine learning*, · *rendering*, · *BRDF*,
· *sparse representations*
Level: Master

Large-scale image exploration for data-centered machine learning



Data sets with millions of images are used for training machine learning models. The variety and quality of the images can have an important effect on the performance of the model. It can be hard to know which type of images would improve the model performance. Furthermore, it can be difficult to browse a large number of images as only a few can be viewed on a screen at the same time. Each image can also have a range of meta-data, such as labels describing the image content, that are important for searching and analysis.

► Your tasks

Investigate ways of exploring large-scale image data sets using [semantic hierarchical image explorer \(github.com/Sparkier/Hierarchical-Image-Explorer\)](https://github.com/Sparkier/Hierarchical-Image-Explorer) as a starting point. There are possibilities to focus on both backend development, for example, automatic label error detection based on image content analysis, and frontend development, for example, interaction techniques or how a group of images should be represented visually with a limited number of pixels.

► Your profile

We are looking for 1-2 students with an interest in visualization and machine learning. Experience in web and/or Python programming is a plus.

► Information

Research group: [Computer graphics and image processing](#)
Contact person: [Daniel Jönsson](#) - daniel.jonsson@liu.se
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Keywords: · *visualization*, · *web development*, · *machine learning*
Level: Master

A learning-based video compression with sparse representation and entropy coding

Video streams constitute a large part of the daily internet traffic. A one hour long video at 4K resolution and 25 frames per second requires about 2TB of storage if no compression is applied. As a result, it is of utmost need to find solutions to intelligently transfer/use such large amounts of data. Modern video codecs have enabled the streaming of video data over the internet, in real-time, e.g., in a video call, or as demanded, such as YouTube video streaming or Netflix movies. In recent years, there have been some attempts to the standardization of machine learning approaches in video codecs such as MPEG video coding for machine (VCM) standards for machine-to-machine (M2M) or machine-to-human (M2H) communications, as well as JPEG AI, and JVET Neural Network Video Coding (NNVC). This project aims to employ an unsupervised machine learning approach for encoding and decoding a video using sparse representations and applying fast and accurate quantization and entropy coding on the resulting sparse coefficients.

► Your tasks

Explore using machine learning methods to develop a codec for video streaming. The codec consists of both an encoder and a decoder. You will use an unsupervised machine learning method, named AMDE, to learn a sparse representation of the dataset from a training set. The video frames are then transformed into sparse coefficients which are then quantized and further compressed using an entropy coding algorithm such as Huffman coding. You will carry out an analysis of the quality of the codec in terms of compression efficiency and encoding latency in comparison with state-of-the-art video codec approaches. The source code and required tools for utilizing AMDE will be provided.

► Your profile

We are looking for 1 student with an interest in machine learning, image processing, and computer graphics.

► Information

Research group: [Computer graphics and image processing](#)
Contact person: [Saghi Hajisharif](#) (saghi.hajisharif@liu.se) and [Ehsan Miandji](#) (ehsan.miandji@liu.se)
Location: The division for Media and Information Technology,
Campus Norrköping
Keywords: · *machine learning*, · *image processing*, · *compression*, · *rendering*
Level: Master

Fair Feature Extraction for Generative Models

Synthetic data, artificially generated datasets replicating real-world events and statistics, plays a crucial role across various domains. Its primary function is to create datasets for training and testing AI models, offering several key advantages. Synthetic data is essential when privacy and regulatory concerns arise, particularly in sensitive fields like healthcare, where confidentiality is paramount. Moreover, synthetic data bridges the gap in challenging scenarios where obtaining real data is challenging, such as accidents. It simplifies the data labeling process, streamlining the creation of extensive training datasets, and saving time and resources. However, using synthetic data introduces unique challenges, especially regarding biases present in the source data. To address these challenges, this project adopts the intersectionality perspective, considering the multifaceted nature of individuals' identities, including factors like race, gender, sexual orientation, and more, which can influence experiences of privilege or discrimination. Biases can disproportionately affect marginalized groups, leading to unfair outcomes and incomplete data about various identity facets, hindering our understanding of these populations.

► Your tasks

In this project, your tasks will involve exploring machine learning techniques to extract important features from real-world datasets. These features encompass sensitive attributes, their relationships with proxy attributes, and the outcome variable, indirectly contributing to bias. You will leverage these features to influence the generation of synthetic data using deep generative models or diffusion models. The effectiveness of the generated data is evaluated using fairness metrics, and privacy-preserving measures. Located at FairAIData, you will be working in close collaboration with experts in machine learning. You will also work in collaboration with the research unit, computer graphics, and image processing, at Linköping University, Campus Norrköping, which is exploring new techniques for how to make the best use of synthetic training data.

► Your profile

We are seeking 1-2 students with a background in data processing and machine learning for this project. This research opportunity provides a bridge between academic study and potential career opportunities, both within the University and in the corporate sector.

► Information

Research group: [Computer graphics and image processing](#)
Contact person: [Saghi Hajisharif](#) - saghi.hajisharif@liu.se
Location: FairAIData, Norrköping (hybrid)
Keywords: · *generative models*, · *machine learning*,
· *industrial collaboration*, · *fairness*
Level: Master