Learning-based rendering using a 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

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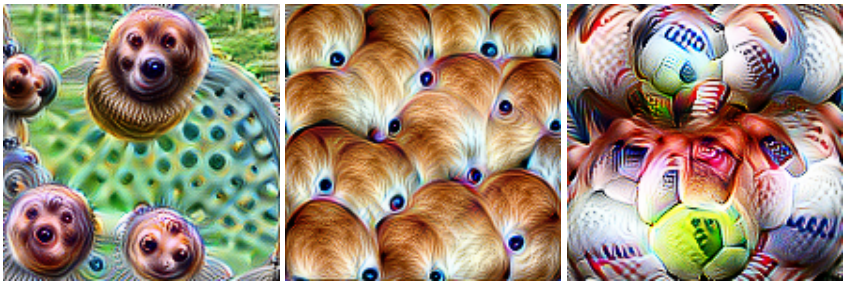
Keywords: · *machine learning*, · *rendering*, · *BRDF*, · *sparse representations*
Level: Master

Neural network feature visualization



Feature visualization answers questions about what a neural network — or parts of a network — are looking for by generating examples. If we want to understand individual features, we can search for examples where they have high values as exemplified in the images above. However, they can be hard to interpret and the correctness of current implementations are questionable due to a lack of ground truth comparisons. Furthermore, the initial implementation for the technique is based on the outdated Tensorflow 1, which does not even run anymore.

▶ Your tasks

Investigate different techniques for generating feature visualizations. For example, by optimizing for a given set of values instead of only the high values. Also try to create verifiable visualizations that can serve as a basis for Tensorflow 2 and/or PyTorch implementations.

▶ Your profile

We are looking for 1 student with an interest in machine learning and visualization.

▶ Information

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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

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Keywords:	· *machine learning*, · *image processing*, · *compression*, · *rendering*
Level:	Master