Semester Project

Conceptual Design

Paintings Denoising and Anomaly Detection Using Auto-Encoders

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INTRODUCTION

The task at hand is to build neural networks to remove high-frequency noise from images and to do anomaly detection. The solution will utilize the concept of auto-encoders (AE), which are self-supervised neural networks that can learn to encode and decode input information. The goal is to train neural networks to effectively remove noise from the inputs while preserving the important details and semantic information and to robustly detect abnormal images.

METHOD

1. Datasets

(1) The Fashion MINST dataset consists of a training set of 60,000 examples and a test set of 10,000 examples. Each example is a 28x28 grayscale image associated with labels from 10 classes. This is a great dataset to start with.

(2) The Edvard Munch Paintings dataset contains a collection of 1769 color paintings created by Norwegian painter Edvard Munch. Each example has a different image size. With much less and more complicated data than the Fashion MINST, this is a good example of a more realistic situation to test the practical application of AE.

(3) The Van Gogh Paintings dataset contains a collection of 2050 color paintings created by a Dutch post-Impressionist painter Vincent Willem van Gogh. This dataset set will be used for the anomaly detection task, as an abnormal image mixed with the Edvard Munch Paintings dataset.

2. Model training

AE is trained to reconstruct an input image by encoding it into a lower dimensional latent space and then decoding it back to its original form. The model will be trained in two modes to gradually explore the power of AE:

(1) the basic mode that will be trained only on the original image (*e.g.*, encode the original image/graph and reconstruct it from the latent space);

(2) the denoising mode that will be trained using the noisy image as input and the original image as output;

(3) the anomaly detection mode that will be trained using the Edvard Munch Paintings dataset only (the normal image), then use the trained model to reconstruct the mixed data of the Edvard Munch Paintings dataset and the Van Gogh Paintings dataset (the abnormal image). The hypothesis is that the abnormal image will have a higher reconstruction error so we can classify a painting as an anomaly painting if the reconstruction error surpasses a fixed threshold.

The first step in building the network will be to select the appropriate neural architecture for the encoder and decoder. A common choice for the encoder is a Convolutional Neural Network (CNN) for image inputs. The decoder can be a transposed version of the encoder, which would mirror its architecture. Once the architecture has been selected, the next step is to train the network. This is done by minimizing a reconstruction loss function, which measures the difference between the original input signal and the reconstructed output.

RESULTS (EXPECTED)

After training the network, the performance can be evaluated by measuring the reconstruction error on a test set and comparing it to the original input images. Visual inspection can also be used to confirm the effectiveness of the network in removing the noise while preserving the important details. Additionally, the quality of the reconstructed images may be measured using other quantitative metrics, which needs further investigation. As for the anomaly detection task, various classification task metrics can be utilized, *e.g*., accuracy, etc.