Final Project Proposal - Team 6 (Light Blue)

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For our final project, we will create a tutorial (Category 3 of Final Project Options) on Generative Adversarial Networks (GANs) entitled '**GANs and their Applications**'. We chose to produce this tutorial because GANs are powerful machine learning algorithms that not only have important applications but also have captured public attention due to their pivotal role in the creation of 'deep fakes'. GANs are neural network-based generative models that combine methods from unsupervised as well as supervised machine learning to produce highly realistic replicas of the data used to train them. For example, in the case of deep fakes, GANs have been trained on large volumes of public image and video data to produce realistic videos of important public figures or fake nude images of celebrities, both applications with nefarious consequences. On the other hand, many positive applications have also come out of research into GANs. For example, GANs can be trained using the paintings of a number of famous artists to produce style transfer algorithms to convert any image into a painting in the style of a user's artist of choice. This creates the possibility of a variety of positive applications in photo and video editing. Motivated by these powerful applications and the versatility of GANs, we decided to produce this tutorial as our final project.

Our tutorial will cover the principles and features of a simple Generative Adversarial Network. We will discuss how GANs use deep learning methods, like convolutional neural networks to perform generative modeling i.e. modeling the conditional probability of the input, given a target variable. We will explain how GANs are designed to automatically discover and learn patterns using an adversarial learning approach where a discriminator (typically a deep neural network) attempts to identify fake samples produced by a generator. At first, the generator produces samples that are easily separable from the real data but as the generator learns and improves, it begins to produce better samples that the discriminator has to adjust to. This creates an adversarial process between the discriminator and generator in which both learn and improve simultaneously. This continues until both are quite strong but the generator's output is so similar to the real data that the discriminator can no longer identify it. This generator is then used to produce samples that are very similar to the training data. In our tutorial, we will provide a detailed overview of the architecture of a simple Generative Adversarial Network along with the mathematical modeling involved in developing the GAN. Additionally, we will showcase (as a demo) the implementation of the generator model and the discriminator model of the GAN on the popular Fashion-MNIST dataset.

The Fashion-MNIST dataset (https://www.kaggle.com/zalando-research/fashionmnist) is a collection of clothing item images divided into training (60,000 images) and testing (10,000 images) sets. Each image is a 28x28 grayscale image, associated with a label from 10 classes of clothing items against a white background. We intend to train our GAN on this data to generate fake samples belonging to classes of our choice. We chose this dataset as it helps showcase the abilities of a GAN in a clear manner without any data cleaning or augmenting challenges that can confuse novice users. Once demonstrated, we will explain how the algorithm can be applied to more sophisticated datasets. GANs are immensely popular in research and applications in fields like computer vision, image processing, and other related fields; they find extensive application in image augmentation, object detection, image editing, and data generation. In our tutorial, while we intend to focus primarily on the data generation application of GANs, we will also give an overview of the other applications. We will additionally introduce several different kinds of GAN models and showcase some of their successful use cases. We will then cover the advantages and the possible limitations of GANs to illustrate how and when to use these models.