# UNIVERSITY OF WASHINGTON

## AMATH 482 A WI 20: COMPUTATIONAL METHODS FOR DATA ANALYSIS

### Homework 5


## Abstract

The goal of this project is to analyze and sort different images with machine learning. We take images of different clothes and analyze their frequencies. We take different properties of the frequency function and try to find similarities for the same clothes. Now we can take those similarities and use them as data for training our program to look for these properties in new test data to classify their types.



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# 1 Introduction and Overview

To produce a signal we can use edge detection for the images and obtain matrices with simplified data which can be used to train.To deconstruct the signal we can use a Fourier transform and look at the frequencies produced by such. These frequencies can be compared and used to make differences between different types of clothes. The properties obtained from the frequencies can be used to find clusters in a multidimensional function. In this case we used 60 000 training samples to train our neural network. With the trained network we tried to validate a set of 10 000 new images and calculated the accuracy.

# 2 Theoretical Background

## 2.1 Fourier Transform

The general idea behind the Fourier Transform is to obtain a spectrum of a given function. The most common use is to analyze a signal over time and transform it into the frequency space to find all frequencies which build that signal. To get the signal for the Fourier transform the easiest way is to do edge detection.

### 2.1.1 Continuous Fourier Transform

**Definition** of a Fourier Transform for a given function

$$\hat{f}(k) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} f(x)\, e^{-ikx} dx \tag{1}$$

and can be inverted back with

$$f(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} \hat{f}(k)\, e^{ikx} dk\ . \tag{2}$$

Instead of transforming the given function it can be decomposed in *sin* and *cos* terms with **Fourier coefficients (Fourier series)**

$$f(x) = \frac{a_0}{2} \sum_{k=1}^{\infty} \left[ a_2\ cos(kx) + b_k\ sin(kx) \right] \tag{3}$$

with

$$a_k = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x)\ cos(kx)\ dx \quad k \geq 0 \tag{4}$$

$$b_k = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x)\ sin(kx)\ dx \quad k > 0\ . \tag{5}$$

### 2.1.2 Discrete Fourier Transform

To calculate our function we have to discretize our space:

$$x \in \mathbb{R} \rightarrow x \in \{x_0,\ x_1,\ x_2,\ ...,\ x_{N-1}\} \tag{6}$$

this gives us new terms for the Fourier transform

$$\hat{x}_k = \sum_{n=0}^{N-1} x_n e^{-\frac{2\pi i k n}{N}} \tag{7}$$

$$x_k = \sum_{n=0}^{N-1} \hat{x}_k e^{\frac{2\pi i k n}{N}} \tag{8}$$

$$\tag{9}$$

## 2.2 Edge detection

Edge detection is a method to find boundaries of an object in an image. It looks at 'jumps' of brightness in the image. These jumps are chosen as boundaries and saved in a matrix.

## 2.3 Classification

The mentioned methods were used to analyze the given train data and chose barriers for the given clothes (T-shirt/top, Trouser, Pullover, Dress, Coat, Sandal, Shirt, Sneaker, Bag, Ankle boot) in a 3D space. With these given barriers a set of test data was used to find out if the clothes are classified correctly.

## 2.4 Supervised machine learning

The idea of supervised machine learning is to take a data set and use it to train a neural network. The system finds similarities by comparing huge amount of data and learns to detect these properties in new given data. This way we work with training and test data to validate our network.

# 3 Algorithm Implementation and Development

At first the data set are loaded into the file. Multiple samples from different cloth types are used as training data set. These signals are prepared with edge detection to calculate their Fourier transform. The Frequencies are analyzed and the best options for properties are picked to distinguish different types. These properties are used as the variables in the multi dimensional space. With a new set of data with known types these properties are tested for their accuracy.

# 4 Computational Results

No useful results were made.

# 5 Summary and Conclusions

The system behind the neural network was not understood. A possible solution could have been doing a PCA and LDA combination to chose barriers and use them for classification. Since this was not the goal no useful results were made.

# 6 Appendix A: MATLAB functions used and brief implementation explanation

## 6.1 Cell Array

Cell Array is a data type which can be indexed with $k$, where $k$ lets us access any kind of data (a number, another array or a matrix e.g.) and use it in a loop.

## 6.2 Scatter3

Scatter3 lets us display dots in a 3D space with given $x, y$ and $z$

## 6.3 Function: point_to_line_distance

This function was used to calculate the barriers. The used 'distance' was a mixture of distance (given by this function) between data point and the line along the direction of the highest variance of the training data and the distance between the mean of the training data and data point.

# 7 Appendix B: MATLAB codes

```
clear all, clc, close all
    load("fashion_mnist.mat")
    y_train(1)
```