Table of Content

Image Segmentation

Introduction

Problem Definition

One common application of machine learning that allows images to be divided into multiple groups in a simplified and meaningful way is segmentation. Image segmentation can be used in many different areas; surveillance, medical applications, visualization in augmented reality systems, optimization of communication requirements or a pre-processing step for many detection and recognition tasks. Segmentation can be implemented using supervised, unsupervised, or combinations thereof, posing challenges in different requirements, outputs, applications and performance. In this case, the segmentation routine application is recommended for the basic task of finding areas in an image consisting of pixels that can be used as a pre-processing step for object detection and tracking. K-Means algorithm was chosen to accomplish this assignment.

Step into Artificial Intelligence

Artificial intelligence is the simulation of intelligent behaviour in machines. This includes hardcoded rules that allow computers to play games like tic tac toe against humans. It also includes methods which try to evaluate some states a few steps in advance. Machine learning is a branch of artificial intelligence that gives machines the ability to perform a task from experience without explicitly being programmed to perform the tasks. They are many types of machine learning. However, the three main types are supervised learning and supervised learning and reinforcement learning.

Supervised Learning

Supervised learning is the machine learning tasks of learning a function that maps and inputs to an output based on example, input output peers. Recognising cars, bicycles and pedestrians on a road or translating sentences from a language to another language are basic examples for supervised learning. Since output was specified that desired to be associated with a particular input, it is said that this data is labelled. To use supervised learning an entire set of data is needed. In case where something like 100 sample space, in practise more than 100 sample space are needed. The training supervised learning model is 80% of this sample space. It is usually called as bits of the data. It is hoped that the model would learn to map the sample, improve its knowledge about the sample based on training data. All that needed to be done is provide examples. One way of doing this would be to split its pairs into sets of inputs and expected outputs and send the inputs into the model. The model is asked to produce outputs for these inputs and compare the model outputs with the expected outputs. The model then is asked to make adjustments to its understanding based on which outputs it got wrong at first.

The perceptron Algorithm

It is one of the earliest machine learning models. And although today there are many more sophisticated algorithms, many of the components from perceptron can be applied elsewhere. For instance, weight updates, learning rates and bias nodes are all components used by many of the more advanced artificial intelligence methods. The threshold function that used interceptions can be compared to activation functions used in neural networks.

Neural Networks

Neural networks form the foundation of deep learning and have been used in many of the recent state of the artificial intelligence systems. One example is convolutional neural networks, which are a special type of neural network that have been used by self-driving cars to recognize other cars and pedestrians on the road. Another special type of neural network is the Transformer, the GPT3 model introduced by open A.I. in 2020, uses transformers to generate text so realistic it's difficult to distinguish from text written by a human.

Unsupervised Learning

Unsupervised machine learning finds patterns in data and its applications are customer segmentation, document clustering, image grouping and anomaly/fraud detection. Machine learning that looks for previously undetected patterns in a dataset without pre-existing label and with minimal human supervision is called unsupervised learning. Algorithms covered in this learning are clustering algorithms and dimension reduction algorithm. K-Means algorithm belonging to clustering algorithms was used for this assignment. Goal of unsupervised machine learning is to find patterns in data which a point is a vector in d dimensions. Data point often called feature vector as each entry represents a feature.

Hierarchical Clustering Algorithm

Hierarchical clustering is a connectivity-based approach and bottom up approach called agglomerative and top down approach called divisive. Results depend on the distance measured used. In bottom up approach, each data point starts as its own cluster and nearby clusters are repeatedly combined until all points in single cluster.

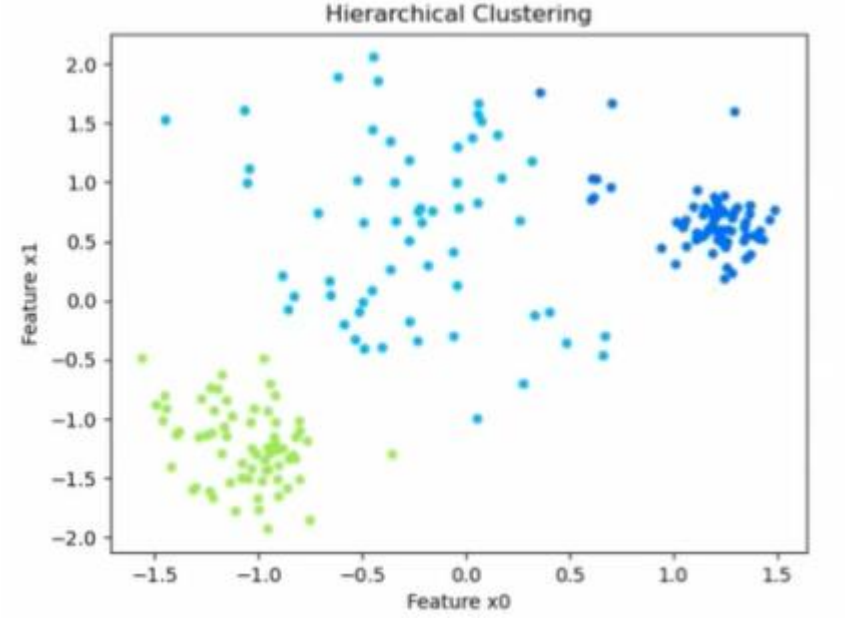

Figure 1 - Hierarchical Clustering

DBSCAN Clustering Algorithm

DBSCAN is an acronym for Density Based Spatial Clustering of Applications with Noise. DBSCAN is density-based clustering approach grouping close points into clusters and classifying points in low density regions as noise.

K Means Clustering Algorithm

During the assignment process this algorithm was used and used as; find several random points for clusters, group those clusters according to distance to random points, find the mean

of the clusters and regroup clusters according to mean of the first clusters to verify the truth of the random selected points.

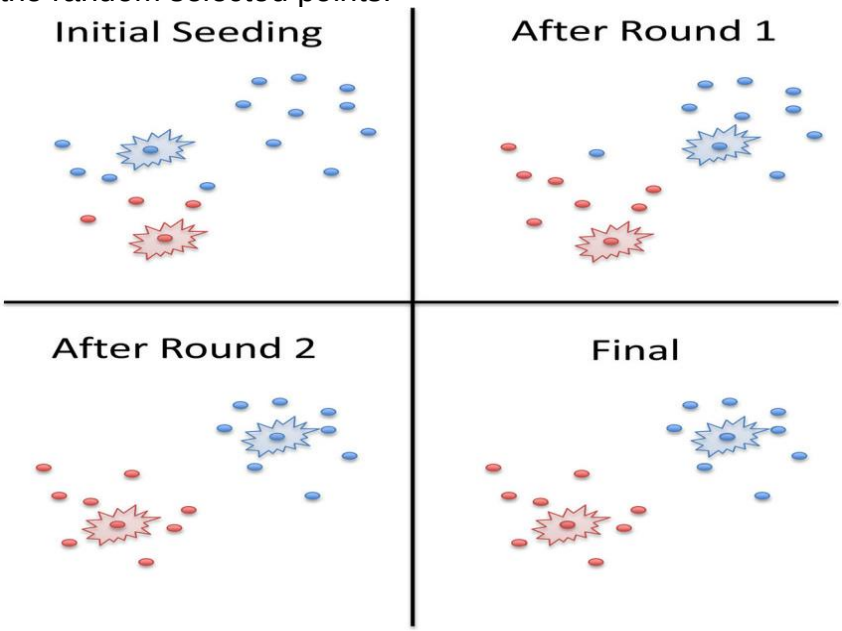

Figure 2 - Visualisation of Used Algorithm

In this implementation, numbers of randomly chosen numbers for colours refer to K value. K value increases as numbers of randomly chosen numbers for colours increases. Some of the images that are obtained from this implementation are in the following 5 figures.

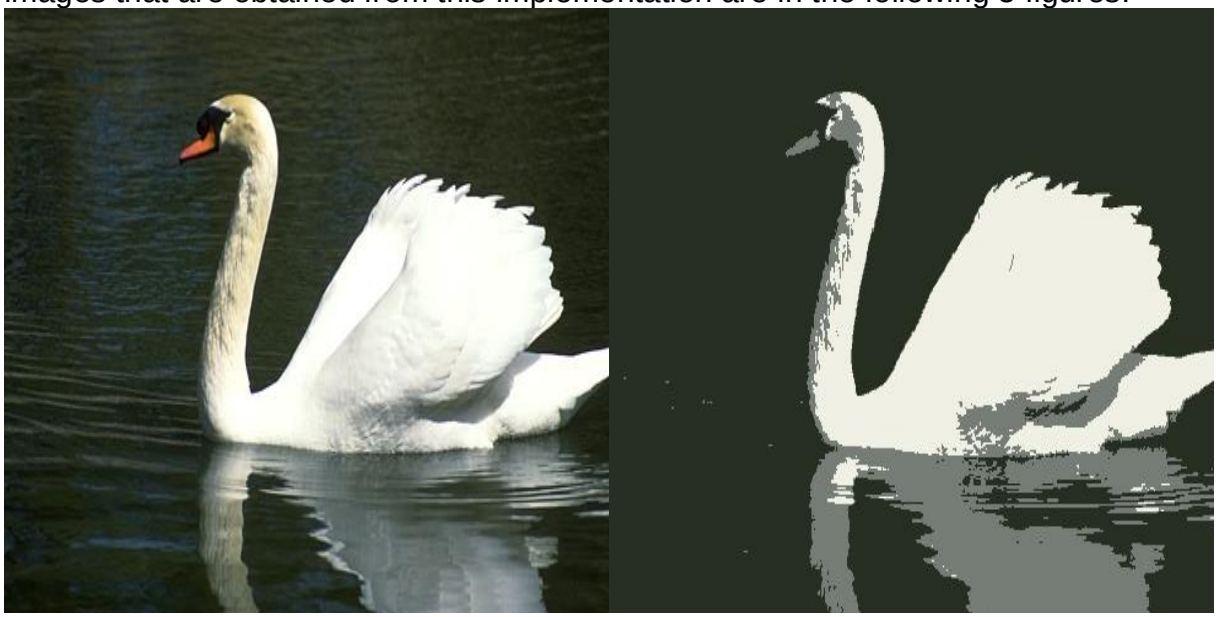

Figure 3 – Original vs Segmented Images of 8068

Figure 4 - Original vs Segmented Images of 81066

Figure 5 - Original vs Segmented Images of 100039

Figure 6 - Original vs Segmented Images of 101027

Figure 7 - Original vs Segmented Images of 181021

Number of colours that refer to K value change the smoothness of the segmented images. The higher value of K the smoother images. To prove this statement, K-Means algorithm was implemented in a different way on python. Exactly the same results occurred from this implementation.

A segmented image was randomly chosen from both implemtations and 3D scatter pot of clusters is shown in figure 12. It can be easily said that there 5 colours were clustered in the figure, in this case image named 100007.jpg.

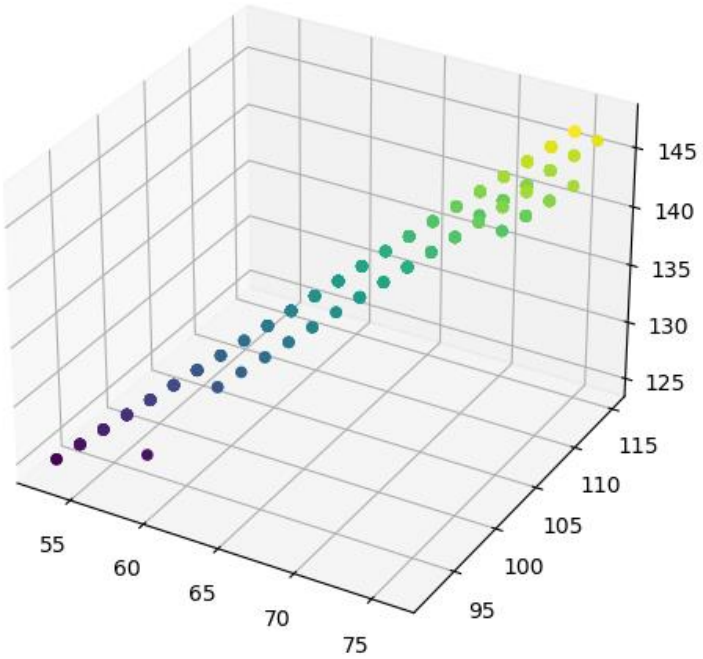

Figure 8 – 3D Cluster Analysis of Image 100007

The colours of dots in the figure do not refer to colours in the segmented image. They just refer there are many colours as the number of colours in the figure 12 and this number is also equal to number of clusters. To visualise cluster number K an image was chosen randomly and these cluster numbers are shown in the figure 13. In this case, randomly chosen image is 156054.jpg.

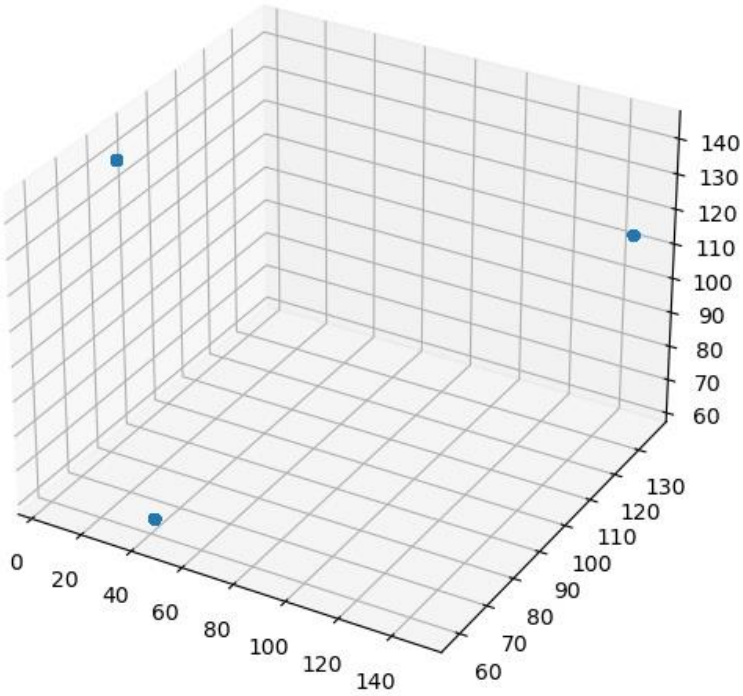

Figure 9 - Cluster Numbers of Image 156054

For cluster number of K is 3 there are obviously 3 cluster means and this image, it can be easily understood that mean of one cluster (on top left) has almost zero red, 100 green and 135 blue. The same assumption can be done for the rest two by just reading the axis values of the points. Segmented image of 156054 is shown in figure 14 to prove this statement.

Figure 10 - Segmented Image of 156054

From the figure above it can be seen that there are 3 colours such as mentioned for figure 13. The first cluster number refers the blue area on this image.

Gaussian Mixture Model Clustering

Gaussian mixture model is a distribution-based approach to identify clusters in the dataset and is a “soft” clustering method. For every data point probability of belonging to each cluster is computed and a point is assigned to cluster with highest probability. Probabilities depend on normal distribution probability density function of clusters.

Comparison of Clustering Algorithms

Quality of clustering are divided into two groups; well clustered and poorly clustered. Well clustered means that points within clusters are near to each other and clusters are well parted. However, if points within clusters may be far apart and clusters close together and this case is named as poorly clustered. K-Means and Gaussian Mixture Method perform similarly. However, K-Means faster than Gaussian Mixture Method. In case of DBSCAN, density affects the corresponding single cluster points and it is slower than K-Means and Gaussian Mixture Method. According to these advantages and disadvantages of these algorithms, K-Means was the best algorithm to use during this assignment.

Conclusion

For machine learning algorithm there are three main algorithms; supervised, unsupervised and reinforced learning. Supervised learning is a of learning a function that maps and inputs to an output based on example, input output peers. Unsupervised learning is a type of machine learning that looks previously unobserved patterns in a dataset with no established labels and with a minimum supervision of human. Furthermore, mix of supervised and unsupervised learning algorithms can be used for machine learning. During this assignment K-Means algorithm of unsupervised machine learning was used because of some advantages over the rest of algorithms.