• Cover page with the project title and the names of the group members with their student IDs

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Image Segmentation Using K-means Clustering, Gaussian Mixture model and Expectation Maximization

ENCS 6161

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• Abstract

Sun:

In this paper we combine the largest minimum distance algorithm and the traditional K-Means algorithm to propose an improved K-Means clustering algorithm. This improved algorithm can make up the shortcomings for the traditional K-Means algorithm to determine the initial focal point. The improved K-Means algorithm effectively solved two disadvantages of the traditional algorithm, the first one is greater dependence to choice the initial focal point, and another one is easy to be trapped in local minimum

GMM-EM: A commonly used tool for estimating the parameters of a mixture model is the Expectation–Maximization (EM) algorithm, which is an iterative procedure that can serve as a maximum-likelihood estimator. The EM algorithm has well-documented drawbacks, such as the need for good initial values and the possibility of being trapped in local optima. Nevertheless, because of its appealing properties, EM plays an important role in estimating the parameters of mixture models. To overcome these initialization problems with EM, in this paper, we propose the Rough-Enhanced-Bayes mixture estimation (REBMIX) algorithm as a more effective initialization algorithm.

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• List of abbreviations in alphabetical order

Anyone:

Example 1: List of Abbreviations for a Medical Research Paper

AIDS - Acquired Immune Deficiency Syndrome BMI - Body Mass Index CVD - Cardiovascular Disease DM - Diabetes Mellitus HIV - Human Immunodeficien

• List of symbols

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List of Symbols for a Physics Thesis

a - Acceleration c - Speed of Light E - Energy F - Force G - Gravitational Constant h - Planck's Constant m - Mass p - Momentum r - Radius v - Velocity

• List of Figures

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a - Acceleration c - Speed of Light E - Energy F - Force G - Gravitational Constant h - Planck's Constant m - Mass p - Momentum r - Radius v - Velocity

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**1. Introduction**

**Sun**

K-means: The k-means algorithm is a commonly employed traditional clustering method that involves a division approach. Its similarity calculation entails determining the distance between a data object and the cluster center, and then dividing the distance from the cluster center into a cluster. This process is repeated until the criterion function converges. The algorithm's time complexity is O(nkt), where n is the total number of objects, k is the number of clusters, and t is the number of iterations. It is highly efficient; however, it has some limitations. Specifically, it can only handle numeric data, cannot process categorical data, is highly sensitive to exception data, and cannot handle clusters with non-convex shapes.

GMM:

**2. Scope and objectives of the project**

Zunao

The scope of this project is to perform image segmentation using concepts, ideas, and techniques covered in the course. The project objectives are as follows:

1) Learning the K-means algorithm: The K-means algorithm is a clustering technique used to partition a set of data points into K clusters based on similarity. The project aims to implement the K-means algorithm and its variations to gain proficiency in unsupervised learning techniques.

2) Learning Gaussian Mixture Model (GMM) and Expectation Maximization (EM): Gaussian Mixture Model (GMM) is a statistical model that uses a mixture of Gaussian distributions to represent a given set of data points. Expectation Maximization (EM) is an iterative algorithm used to estimate the parameters of a GMM. The project objective is to learn how to implement GMM and EM algorithms.

3) Implementing Image Segmentation: Image segmentation is the process of dividing an image into multiple segments or regions based on similar characteristics such as color, texture, or intensity. The project aims to apply the K-means algorithm and GMM/EM algorithms learned in objectives 1 and 2 for image segmentation.

4) Fitting 2-D Gaussian Mixture Data: The objective of this project is to learn how to fit 2-D Gaussian mixture data using the GMM and EM algorithms learned in objective 2.

By achieving these objectives, this project aims to provide a comprehensive understanding of the unsupervised learning techniques used in image segmentation and their practical applications, as taught in the course. It also aims to provide hands-on experience in implementing these techniques using Python and relevant libraries such as scikit-learn and OpenCV.

**3. Detailed methodology and implementation**

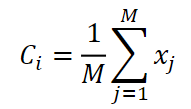
3.1 k-means methodology: Sun

e.g. K-means is a clustering algorithm that aims to group data points based on similarity. It selects K centroids and assigns data points to the nearest centroid, iteratively updating the centroid's position as the mean of its assigned data points. The process repeats until convergence. K-means is commonly used for tasks such as customer and image segmentation, but its performance can be affected by the initial centroid choice, and it may not always produce the optimal solution.

It is a distance-based clustering algorithm that divides data into a number of clusters in numerical attributes.

1. Determine the number of clusters K and the number of maximum iterations.

2. Perform the initialization process K midpoint cluster, then the equation of centroid count feature:

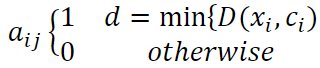


Equation 1 is done as much as p dimensions from i = 1 to i = p

3. Connect any observation data to the nearest cluster. Euclidean distance spacing measurements can be found using equation 2.



4. Reallocation of data to each group based on comparison of distance between data with each group's centroid [9].

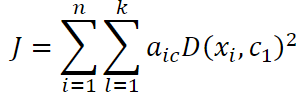


5. Recalculate the cluster midpoint position.

It is the value of the membership of point xi to the centres of the group c1, d is the shortest distance from the data xi to the group K after being compared, and c1 is the centre of the group

to 1. The objective function used by this method is based on the distance and the value of the data membership in the group. The objective function according to MacQueen (1967) can be

determined using equation.



n is the amount of data, k is the number of groups, ai1 is the membership value of the data

point xi to the c1 group followed a has a value of 0 or 1. If the data is an anngota of a group, the value ai1 = 1. If not, the value ai1 = 0.

6. If there is a change in the cluster midpoint position or number of iterations <the maximum 18number of iterations, return to step 3. If not, then return the clustering result.

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3.2 k-means implementation:

Zunao

1. Grayscale image segmentation with histogram

The first step is to load a grayscale image and compute its intensity histogram. The histogram is then reshaped into a 2D array of pixel intensities, and a user-defined number of clusters (K) is chosen.



Cluster centroids are initialized using the intensity histogram, and pixels are assigned to clusters based on their intensity values. The centroids are then updated by computing the mean of each cluster, and the process is repeated until convergence.

Finally, the segmented image is obtained by assigning each pixel to the closest centroid and visualized alongside the original image. The implementation uses OpenCV for image loading and manipulation, numpy for numerical computations, and matplotlib for data visualization.

3.3 GMM-EM methodology: Sun

1. g. the GMM-EM (Gaussian Mixture Model - Expectation-Maximization) methodology is its application in image segmentation, where the algorithm is used to group pixels with similar intensity values into distinct regions, allowing for the identification and extraction of objects or features of interest in the image.

3.4 GMM-EM implementation: Zunao

**4. Experimental results**

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**5. Conclusion**

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**References**

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**Appendices**

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