**DEPARTMENTOFINFORMATIONTECHNOLOGY**

**MADRASINSTITUTEOFTECHNOLOGY ANNA UNIVERSITY – CHENNAI**

**AD23402 COMPUTE-VISION APROJECTREPORT**

**MEAN-SHIFT SEGMENTATION**

**SUBMITTEDTO:**

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# SubmittedBy:

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**Meanshift segmentation in COMPUTER VISION**

### ****TITLE & AIM:****

**Title**  
**Mean Shift Image Segmentation for Image Analysis**  
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**Aim**  
To study and implement the **Mean Shift clustering algorithm** for image segmentation and to understand its advantages over conventional segmentation techniques.

### ****PROBLEM STATEMENT & THEORY****

**Problem Statement**  
Image segmentation is a crucial step in image analysis, object detection, and scene understanding. Traditional segmentation methods often depend on predefined cluster counts or specific distribution assumptions. The challenge lies in segmenting complex images accurately without requiring such prior assumptions.

**Theory and Concepts**  
Mean Shift is a **non-parametric**, **iterative clustering algorithm** that detects the modes (peaks) of a data distribution using kernel density estimation. Unlike K-means, it does not need prior knowledge of the number of clusters and is capable of identifying clusters of **arbitrary shape**. Key concepts include:

* **Kernel Density Estimation (KDE)**  
  Estimates the density of data points in a feature space.
* **Mode Seeking**  
  Each data point (pixel) is iteratively shifted toward the densest area in its neighborhood, converging at a mode (local maximum).
* **Feature Space**  
  Combines color and spatial information to determine similarity among pixels.

### ****ALGORITHM:****

**Mean Shift Algorithm**

**Input**: A set of pixels in a feature space  
**Output**: Clustered image based on density modes

**Steps**:

1. **Initialization**:
   * Assign each pixel fif\_ifi​ its initial mean mim\_imi​.
2. **Iteration** (for each pixel):  
   a. Place a kernel/window WWW around mim\_imi​.  
   b. Compute the centroid of all points within WWW.  
   c. Shift mim\_imi​ to the new centroid.  
   d. Repeat until the mean shift is less than a threshold ϵ\epsilonϵ.
3. **Clustering**:
   * Once convergence is achieved, assign each pixel to the corresponding mode.
   * Pixels with the same mode are grouped into the same cluster.

This process is repeated for all pixels in the image to generate a segmented output.

### ****RESULTS AND SUMMARY****

**Results**  
Visual comparisons between Mean Shift, K-means, and Graph Cut show the following:

* **Mean Shift Output**: Smooth segmentation with fewer artifacts and sharp boundaries.
* **K-means**: May result in abrupt and less coherent segments due to fixed cluster counts.
* **Graph Cut**: Performance depends heavily on parameter tuning and often lacks flexibility.

**Summary**

* **Strengths**:
  + No requirement for predefined number of clusters.
  + Handles arbitrary-shaped clusters.
  + Provides smooth and visually appealing segment boundaries.
  + Robust against image noise and outliers.
* **Limitations**:
  + Computationally expensive due to iterative nature.
  + Sensitive to bandwidth (kernel size) selection.
  + Struggles with scalability for high-dimensional data.

### ****CONCLUSION****

**Conclusion**  
The Mean Shift algorithm offers a powerful, flexible approach to image segmentation by identifying clusters through local density peaks. Its ability to handle irregular cluster shapes and robustness to noise makes it superior to many traditional clustering techniques. However, the high computational cost and sensitivity to bandwidth highlight the need for optimization, especially for large-scale or real-time applications. Despite these challenges, Mean Shift remains a valuable tool in image analysis, object tracking, and scene understanding.