1. Problem
   - Objective:
   - Segment videos using sparse coefficients and graph regularization.
   - Applications:
     - Tracking
     - Supervoxel and superpixel segmentation
   - Efficient clustering

2. SegTrack 2011 Dataset
   - Diverse array of videos with various amounts of objects, object sizes, and backgrounds.

3. Motivation
   - Attempts to track image patches in a video using sparse coding with and without graph regularization yielded very different results and demonstrated that graph regularization can improve accuracy by exploiting the geometric interpretation of the data.

Sparse coding without regularization (Total outlier ratio: 31.86%)

Sparse coding with graph regularization (Total outlier ratio: 1.65%)

4. Framework
   - Input Video:
   - Learn overcomplete dictionary B:
   - Obtain coefficient matrix S via graph regularized sparse coding:
   - Compute data matrix X:
   - Compute similarity (W), degree (D), and laplacian (L) matrices of X:
   - Obtain cluster coefficient matrix S:
   - Hierarchical clustering was used.

5. Algorithm
   - Input: Image volume Ω, cuboid size q, sparsity constraint T_0, number of clusters c.
   - Output: Cluster indices Θ
   - For t = 1 to (dim(Ω) / 3) do:
     - X ← Cuboids in Ω, where X_i is the column-wise vectorization of the i-th cuboid
     - B ← min_δ ||X − BS||_F^2 s.t. ∀i, ||x_i||_0 ≤ T_0
     - L ← D − W; where W_{ij} = I_{x_i∈Ω(x_j)} * e^{-|x_i − x_j|^2 / σ^2}
     - L_{ij} = \{\sum_j W_{ij}; i = j \circ \text{ otherwise}
     - S ← min_δ ||X − BS||_F^2 + α Tr(SLS^T) + β \sum_i ||f_i||_1
     - Θ_t ← Cluster S
     - t ← t + q
   - End for

6. Results
   - We tested our framework against sparse coding without graph regularization and obtained the following results:

Without Graph Regularization: Regularization:

7. Future Work
   - Further testing needs to be performed to prove the benefit of this framework. On a side note, there are a lot of clustering algorithms but none that fully exploit the sparse graph-regularized data generated through our method. Max-Voting has proven useful in exploiting the distribution of elements in graph-regularized sparse data, as seen in section 3, and so further research in creating our own clustering algorithm that utilizes Max-Voting as the main criterion for computing clusters could be worthwhile.