Location Based Distributed Spectral Clustering for Wireless Sensor Networks

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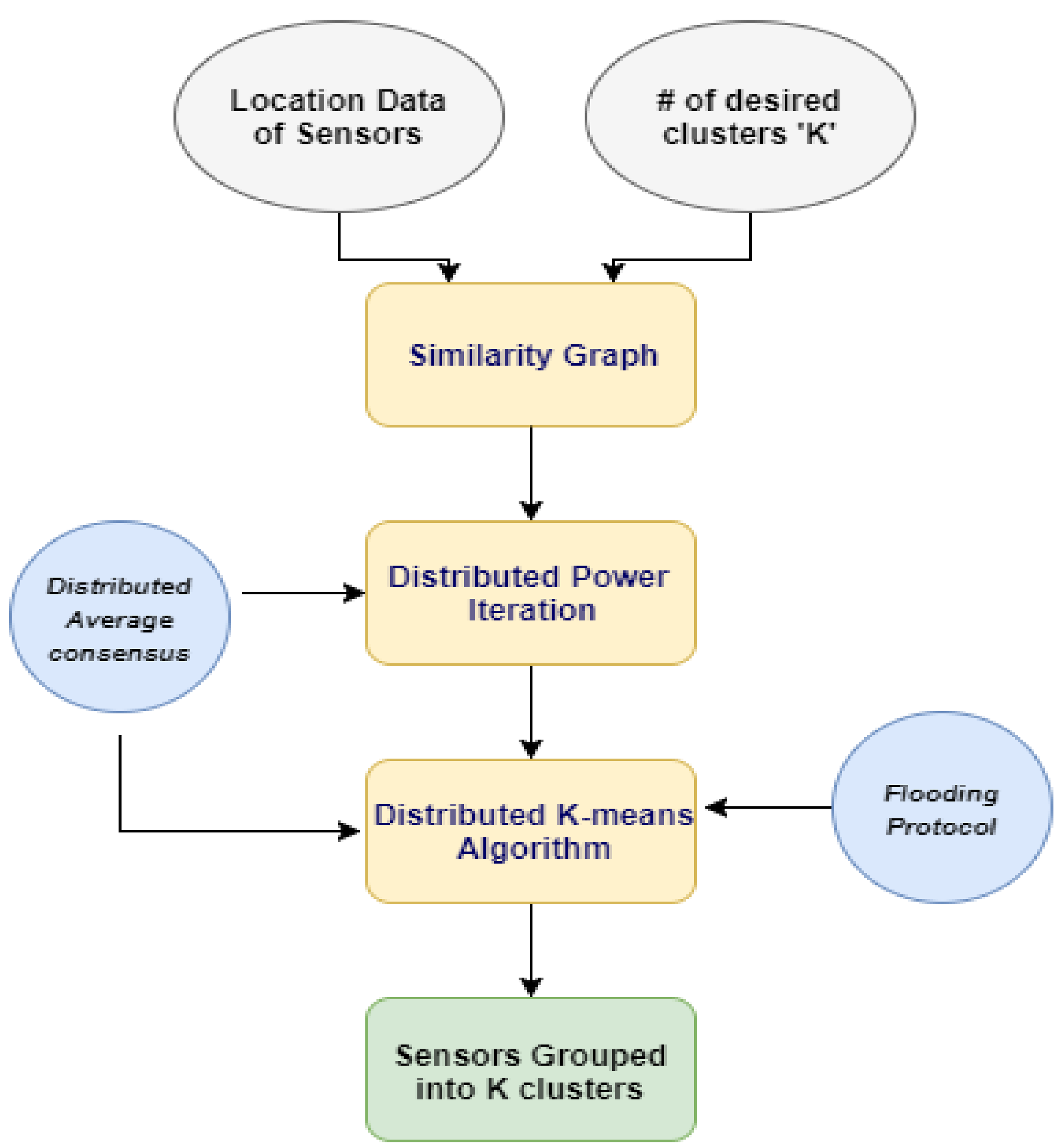
MOTIVATION & APPLICATIONS

- ❑ Data aggregation for machine learning and data mining applications in WSN creates a bottle neck at fusion center.
- ❑ Fully Distributed processing is effective in terms of
  - Memory and power management
  - Communication Bandwidth and Fault tolerance
- ❑ Applications
  - Environmental monitoring
  - Military and surveillance
  - Habitat monitoring & precision agriculture
  - Data Labeling

ALGORITHM FLOWCHART



FIEDLER VECTOR COMPUTATION

- ❑ Matrix transformation : $W = I - \alpha L$
- ❑ Matrix Deflation : $Z = W - \frac{1}{N} 1 1^T$
- ❑ Power Iteration : $u^{t+1} = Z\, u^t / ||Z u^t||$

DISTRIBUTED SPECTRAL CLUSTERING

- ❑ Input for the algorithm is the Location co-ordinates of sensors and number of clusters K
- ❑ Similarity Graph : Naturally induced by communication radius of the nodes ∈ and location of the nodes.
  - All nodes whose pairwise Euclidean distance is less than are assumed to be connected.
- ❑ Distributed Power Iteration : To compute the Fiedler vectors of the graph Laplacian of the similarity graph in a distributed way.
  - $g_i^t = u_i^t - \alpha \sum_{j \in N_i} (u_i^t - u_j^t) - u_{avg}^t$
  - $u_i^{t+1} = g_i^t \,/\, ||g^t||$
  - All the nodes converge to the Fiedler vector of L.
- ❑ Distributed K- Means : To cluster the N nodes into K groups by taking Fiedler vector as the input.
  - $\rho_{ki} = |\, u_i - \mu_k |$
  - Assignment Step : $index = \underset{i}{\operatorname{argmin}}(\rho_{ki})$
  - $C_k = \{\, u_i \,|\, i \in index = k \,\}$
  - Update Step : $\mu_k = avgconsensus(\, C_k \,)$
  - Flooding protocol is used to broadcast the centroids

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SIMULATION RESULTS

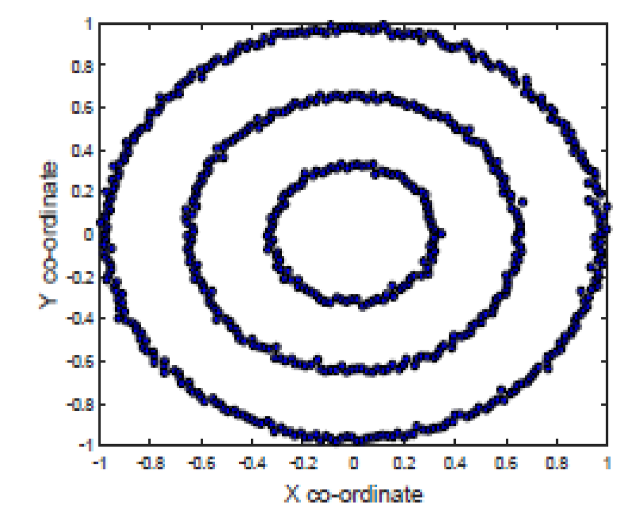

Figure 1: Synthetic data of 2-D sensor locations.

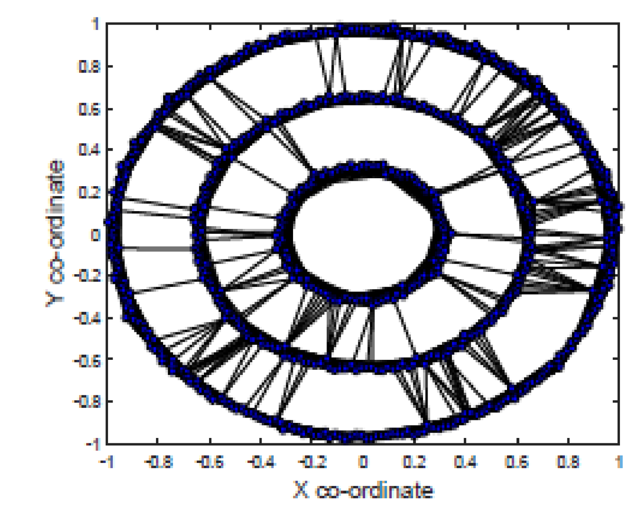

Figure 2: Similarity graph, $\epsilon = 0.3$.

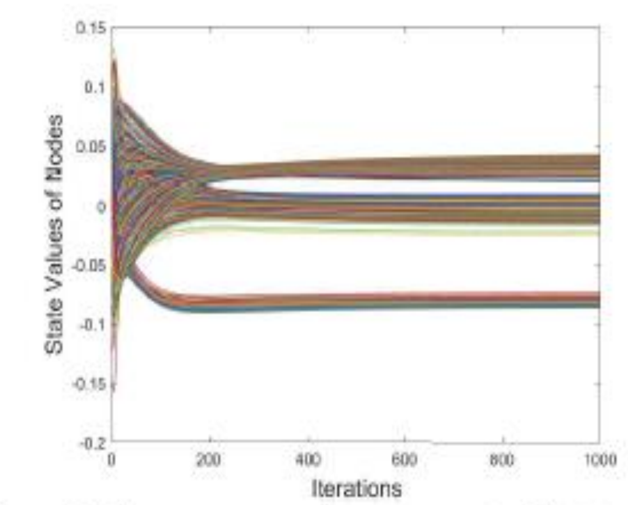

Figure 3: Convergence of nodes to the Fiedler vector.

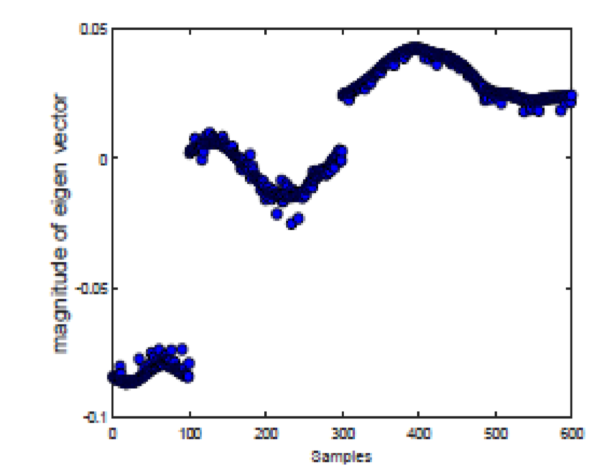

Figure 4: Fiedler Vector computed by Algorithm 1, $\alpha = 0.02$.

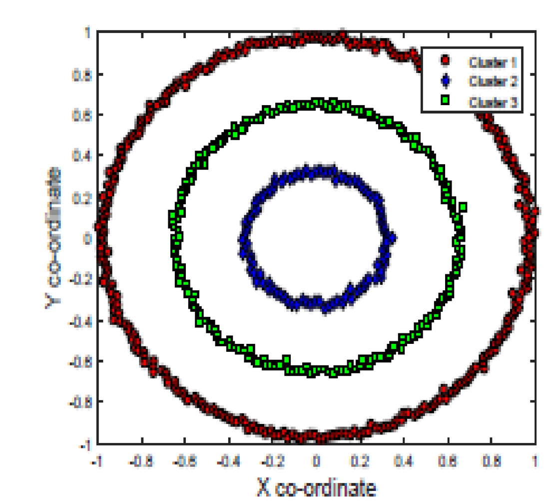

Figure 5: Result of distributed spectral clustering, $K = 3$.

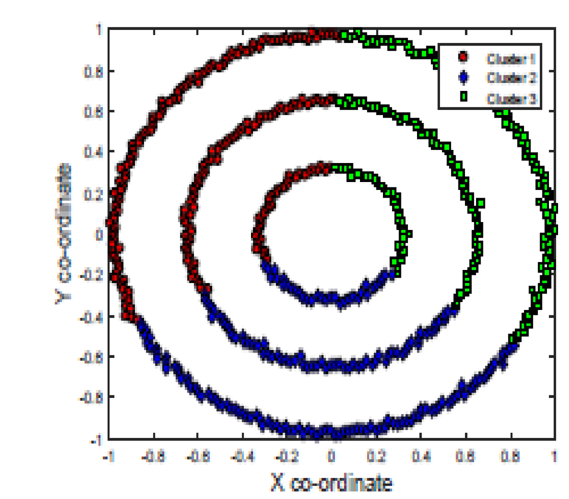

Figure 6: K-means clustering on the dataset in Fig. 1, $K = 3$.

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