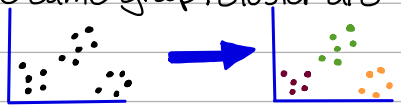
Clustering - Kmeans

- **Clustering**: a grouping / assignment of data points such that data points in the same group / cluster are: • Similar to each other • dissimilar to objects in other groups



- **Applications**:
  - outlier detection / anomaly detection
    - data cleaning/processing, credit card fraud, spam filter, etc.
  - Feature extraction
  - Filling Gaps in data
    - infer probable vals for gaps in data
- Clusters can be ambiguous > could have very diff. clusterings depending on parameters
- **Types of Clustering**:
  - Partitional > each object belongs to exactly one cluster
  - Hierarchichal > a set of nested clusters organized in a tree
  - Density Based > defined based on local density of pts
  - Soft Clustering > each pt is assigned to every cluster w/ a certain probability
- **Partitional Clustering**:
  - goal is to minimize inner cluster distance (how close pts are in a cluster), such that each data pt belongs to exactly one cluster & maximize the distance btwn other clusters. This is Hard Clustering
- **Cost Function**: $\sum_{i}^{k} \sum_{x \in c_i} d(x, \mu_i)^2$
  - a way to evaluate & compare solutions
  - want to find an algorithm to reduce cost
- **Kmeans**: given $\mathbf{X} = \{x_1, \dots, x_n\}$ dataset $\mathbf{d}$, the euclidean dist., & k. Find k centers $\{\mu_1, \dots, \mu_k\}$ that minimize the cost function $\sum_{i}^{k} \sum_{x=c_i} d(x, \mu_i)^2$
  - when $k=1$ (1D) or $k=2$ (2D) its easier & when it goes past 2D it becomes NP-Hard
  - **Kmeans (Lloyd's Algorithm)**
    1. Randomly pick k centers $\{\mu_1, \dots, \mu_k\}$
    2. Assign each pt to its closest center
    3. Compute new centers as the means of each cluster
    4. Repeat 2 & 3 until convergence
    - minimizes w/in cluster sum of squares
  - **Kmeans weakness**:
    - must specify k (need predetermined # of clusters); Sensitive to outliers (they can distort centroids)
    - doesn't work well w/ non-spherical or overlapping shapes → assumes convex