Executive MTech Programme in Data Science and AI

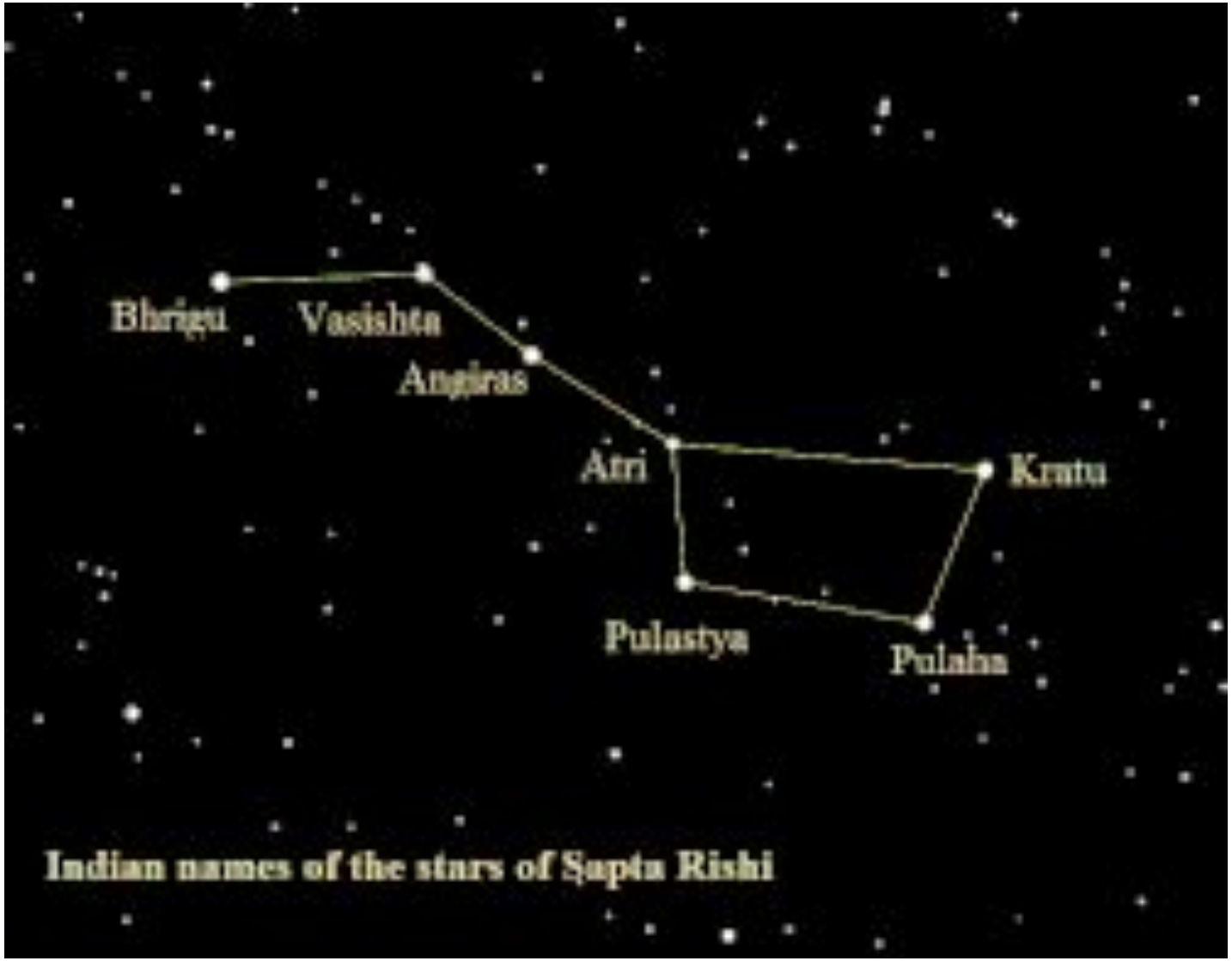
Pattern Recognition

-Dr. Harkeerat Kaur
Assistant Professor
Computer Science and Engineering
IIT Jammu

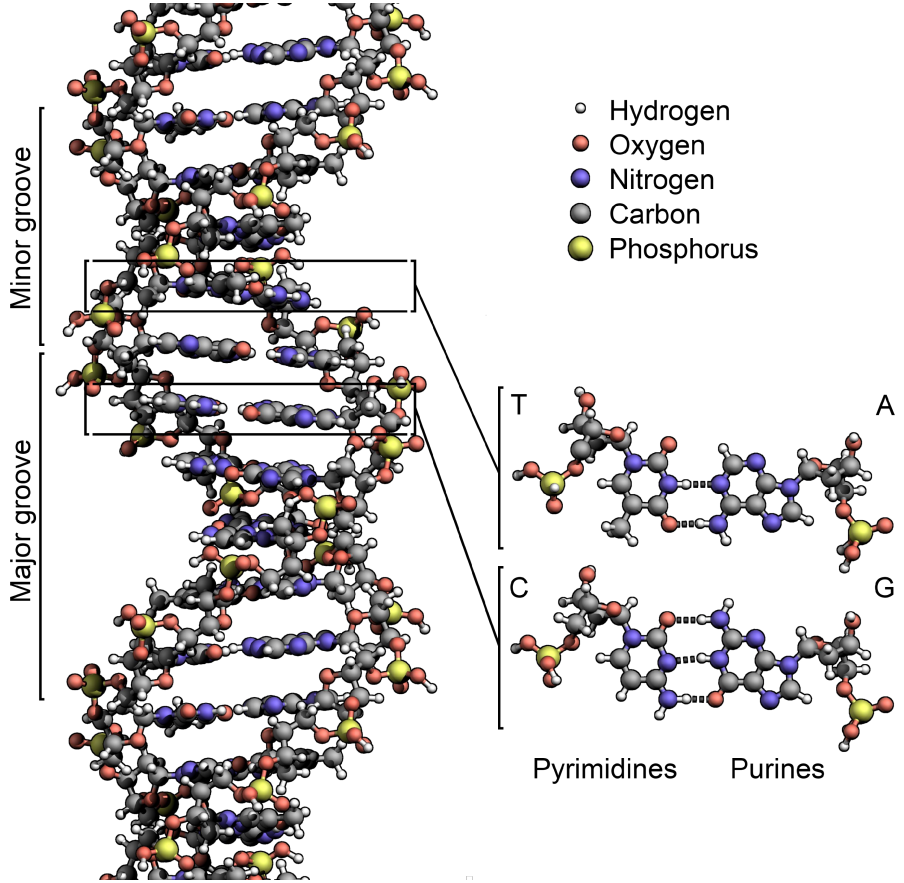
Pattern Recognition

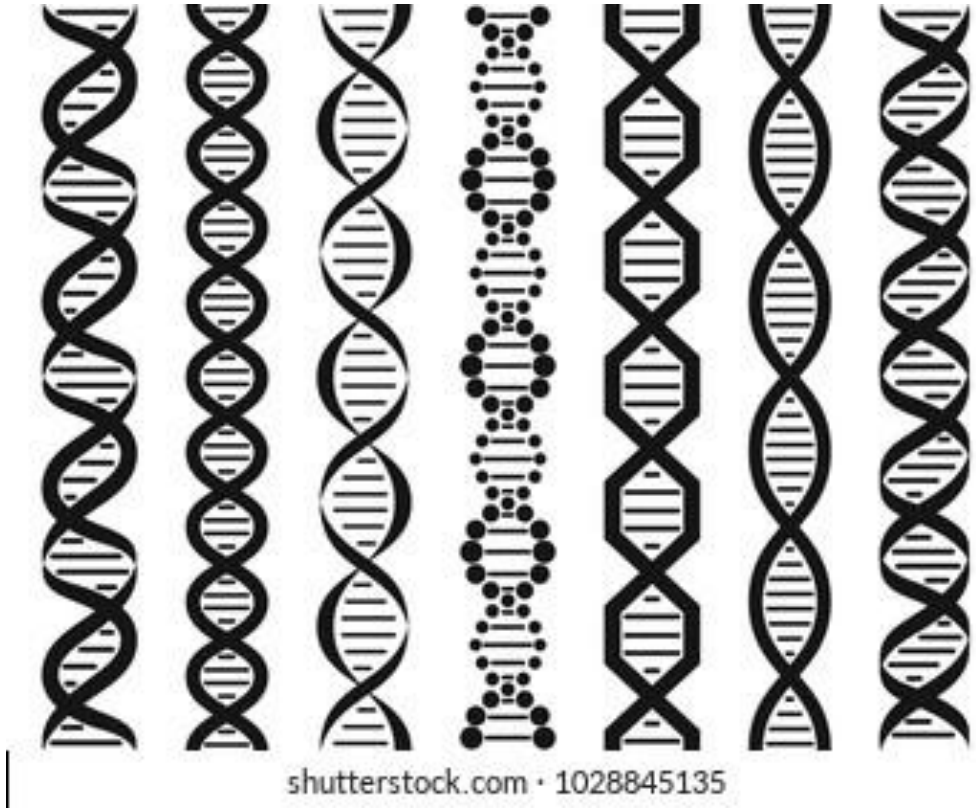
- **Pattern recognition** is one of the most important functionalities for intelligent behavior and is displayed by both biological and artificial systems.

Saptarishi constellation



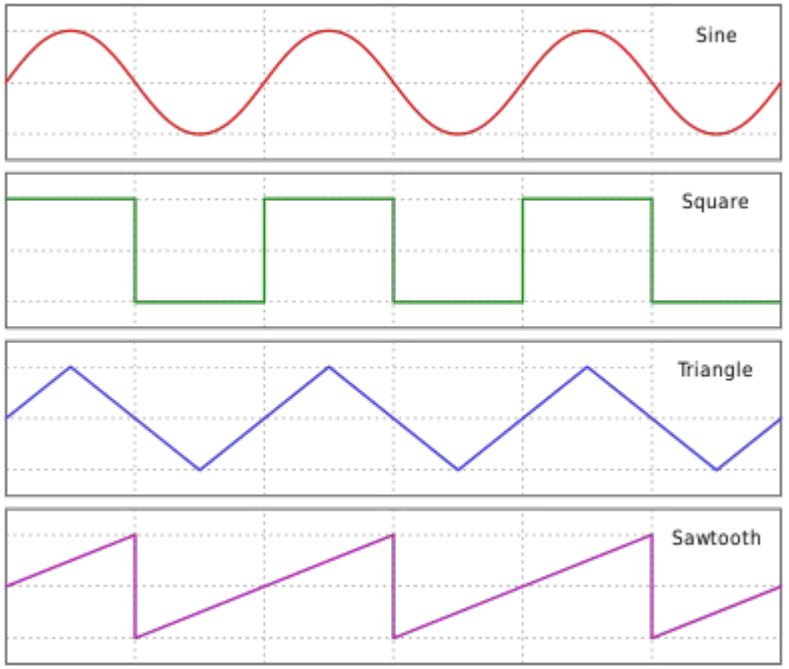
DNA patterns



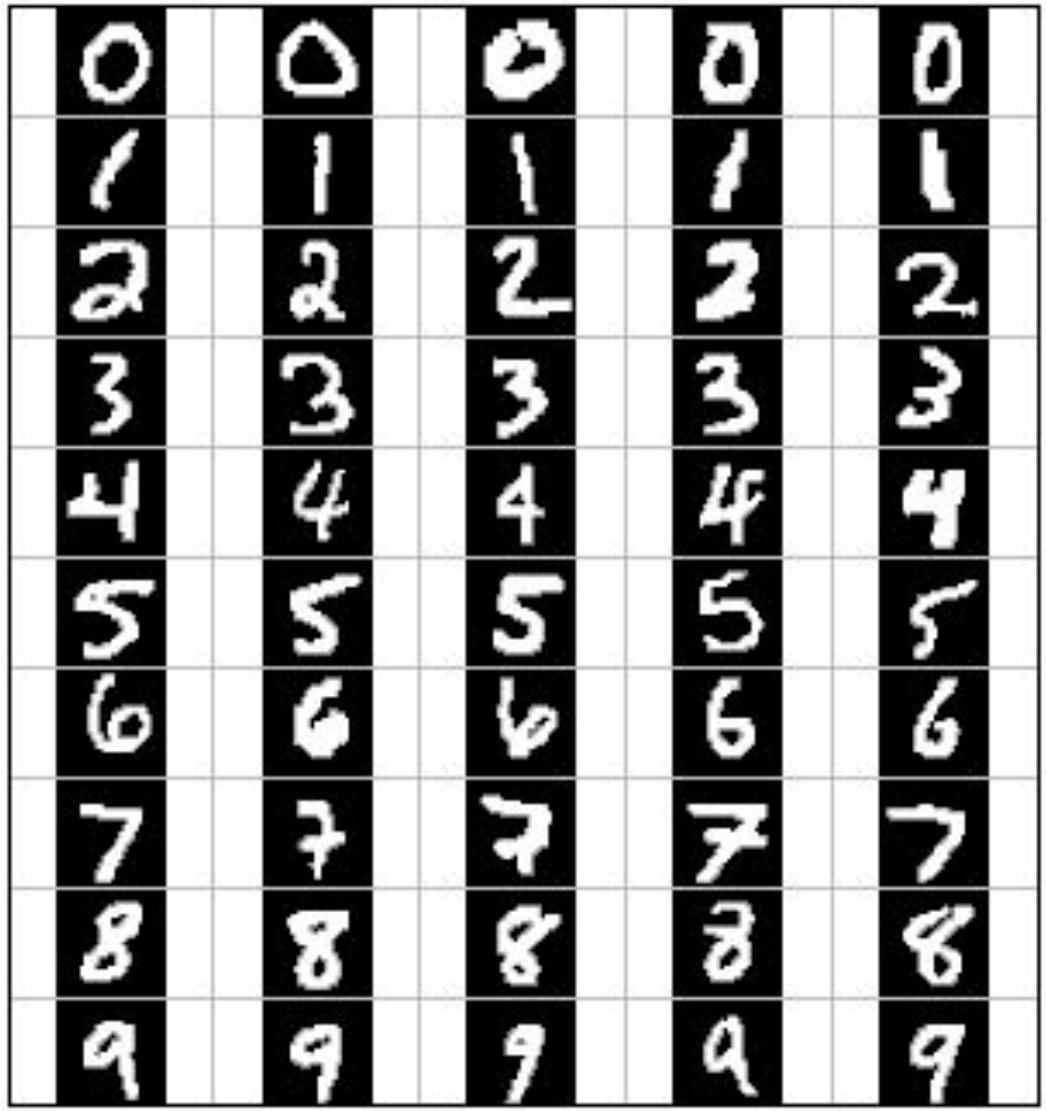


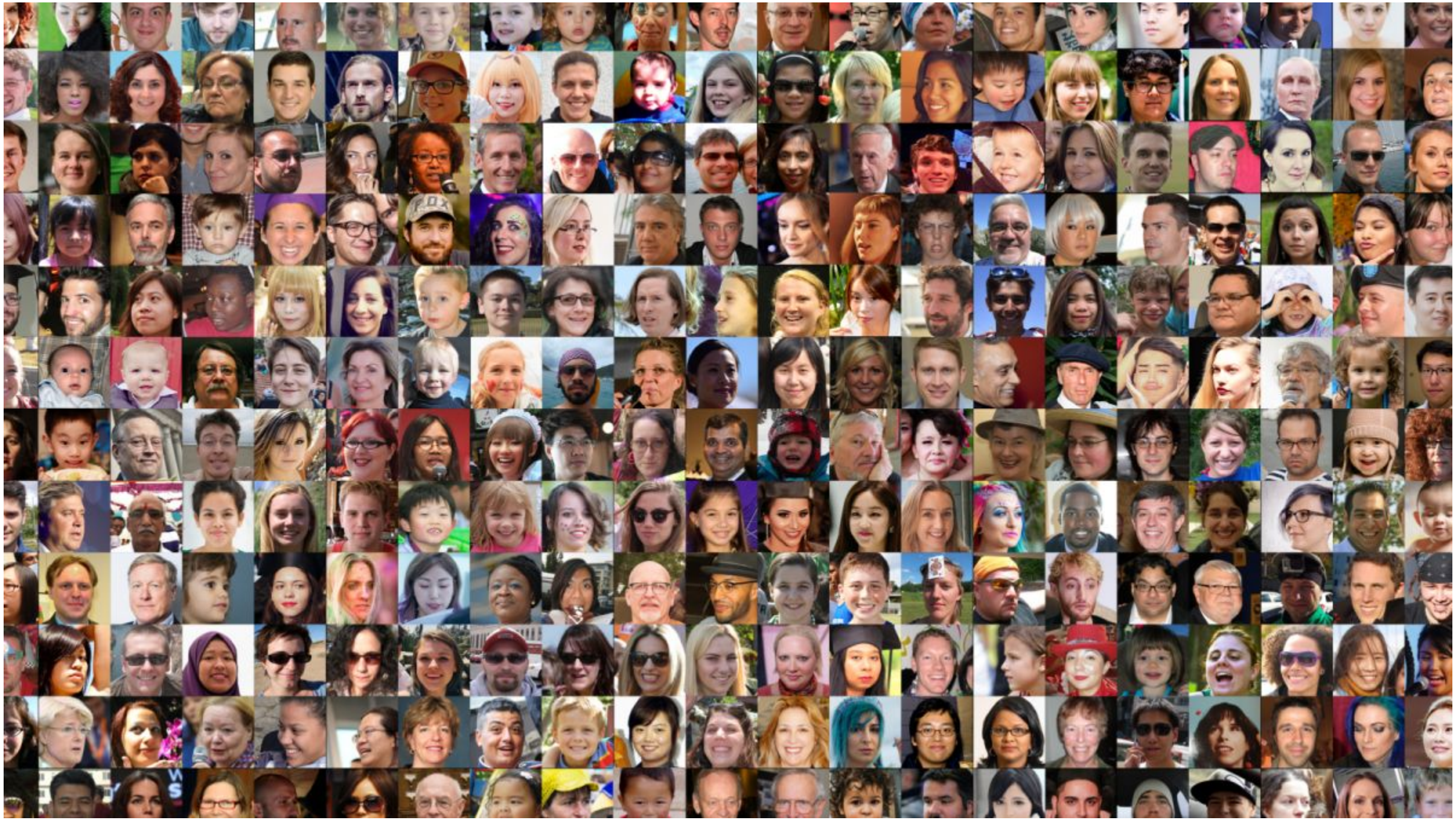
Patterns

- Everything that we see or recognize is because of some apriori knowledge stored in our brains.
- The basic patterns are based on how often something gets repeated or in other words it is based on the periodicity of something which repats itself without any change.

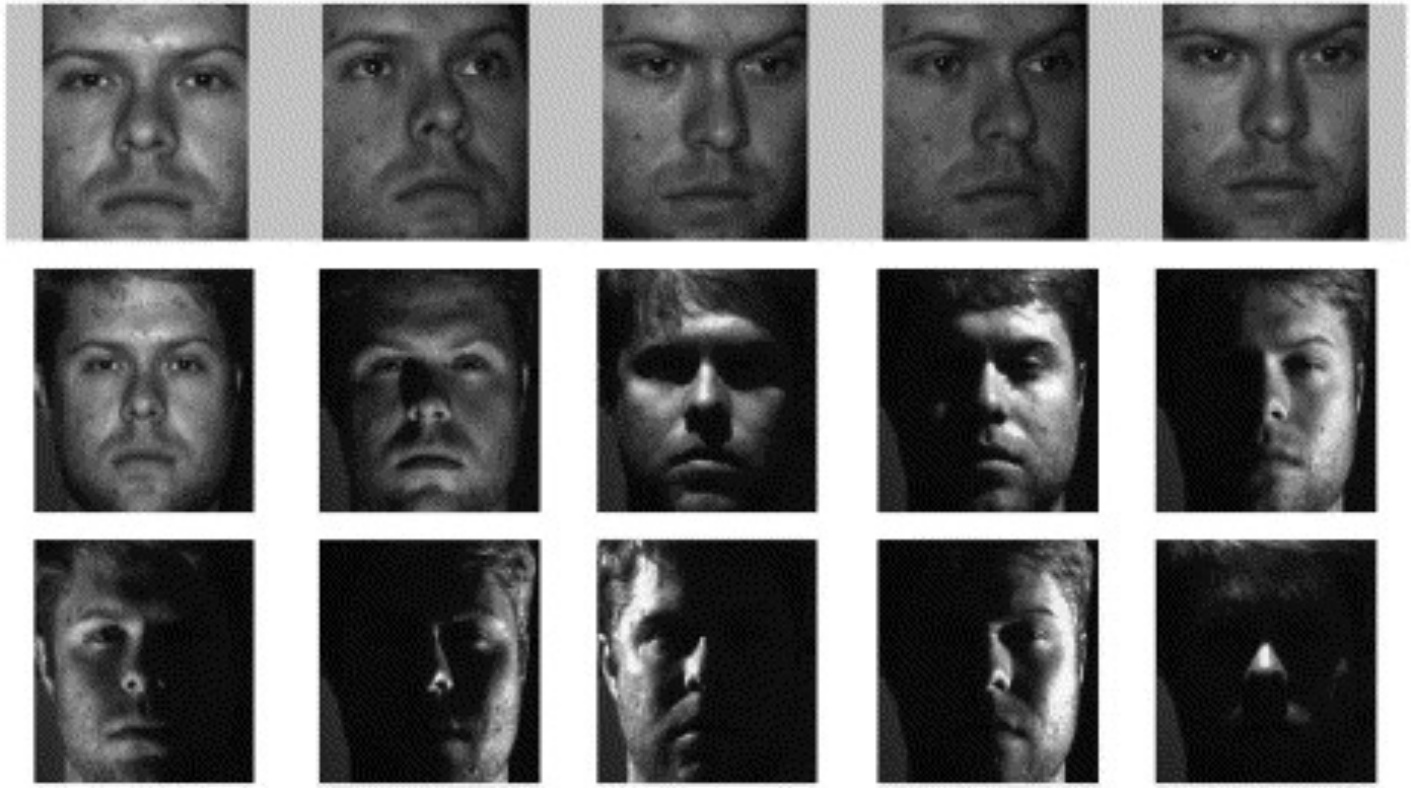


Digits

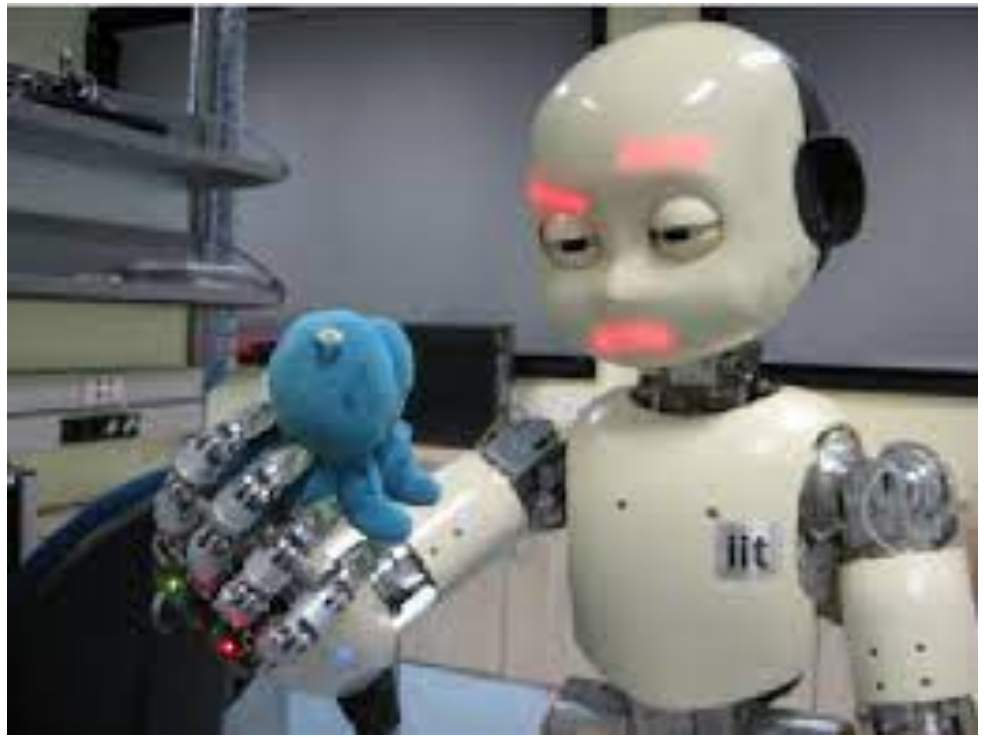




Face recognition

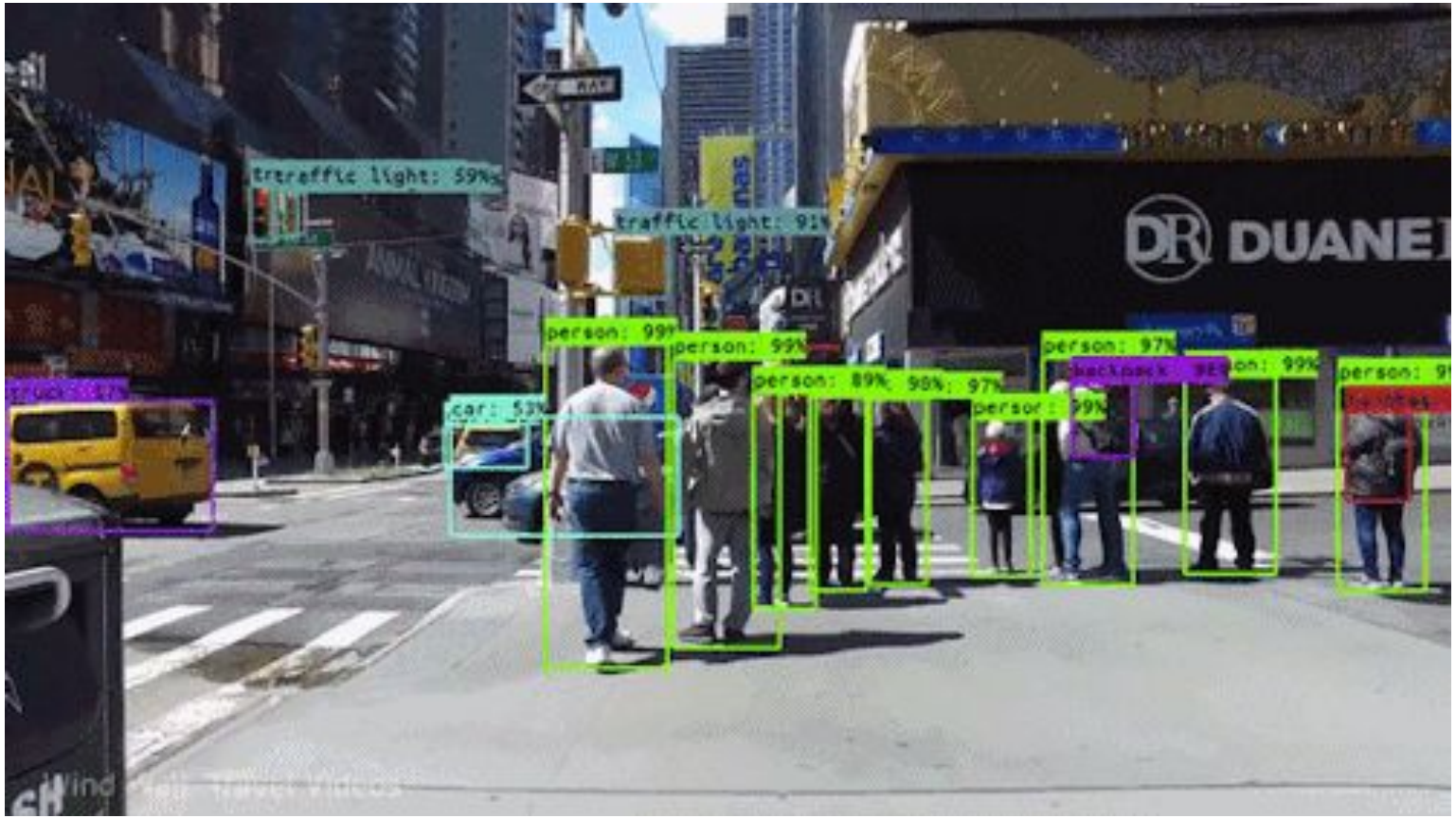


Robot


iit


greens 0
coffee mug 0
lime 1
sponge 1
potato 0
coffee mug 1
food jar 2
lime 0
food can 0

Self driving cars



Applications

- Medical applications
- Speech recognition
- Object recognition
- Quantum physics
- Anomaly Detection

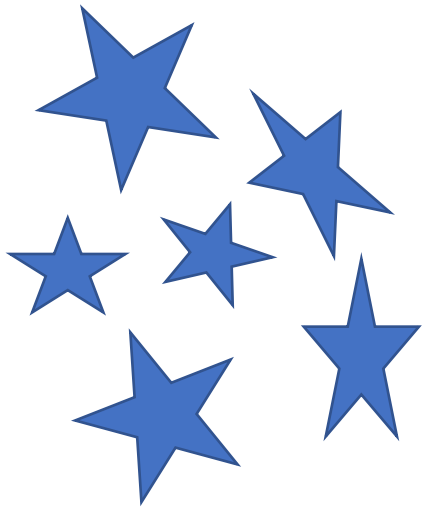
Goal of pattern recognition

- Impart human intelligence to machines for being able to identify, recognize, predict behaviors/ patterns.
- Automatic discovery of regularities in data through the use of computer algorithms
- Pattern recognition systems have four major components:
  - Data acquisition and collection,
  - feature extraction and representation,
  - similarity detection and pattern classifier design,
  - and performance evaluation.

Types of learning

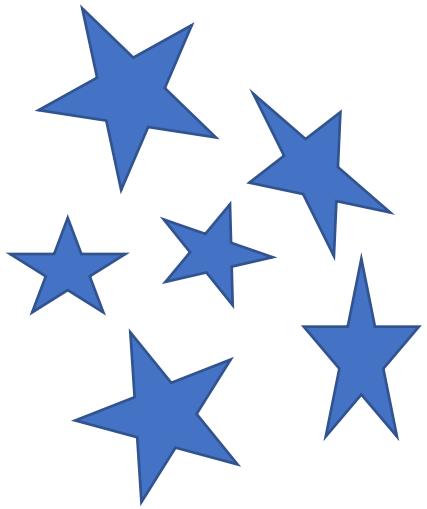
- Supervised Learning
- Unsupervised Learning

Supervised Learning

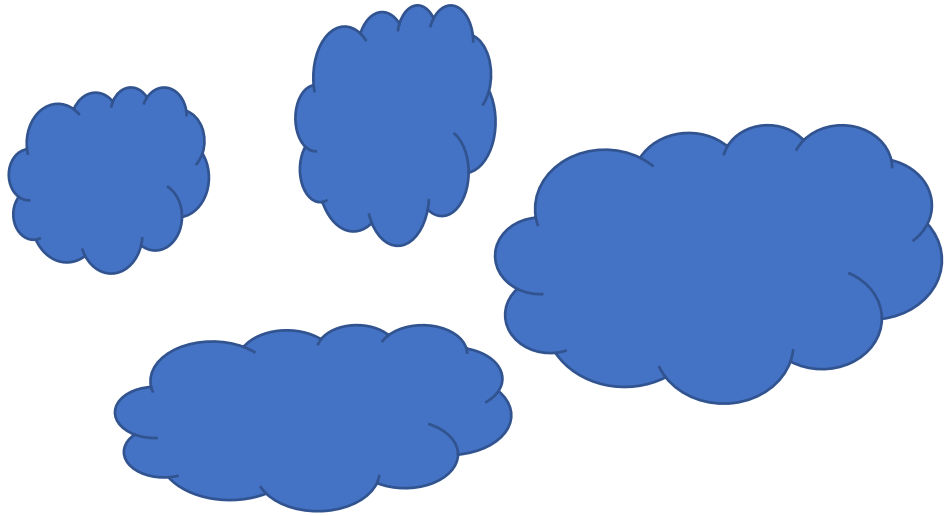


- Set of stars

Supervised Learning



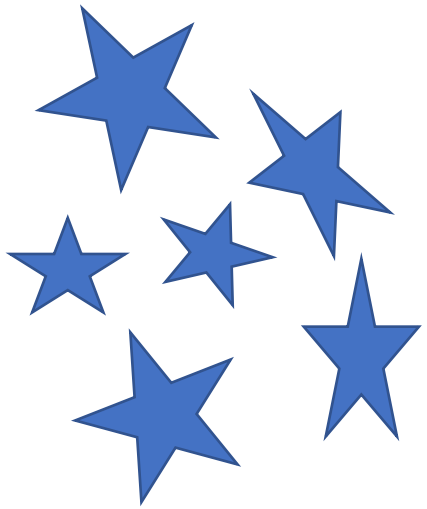
- Set of stars



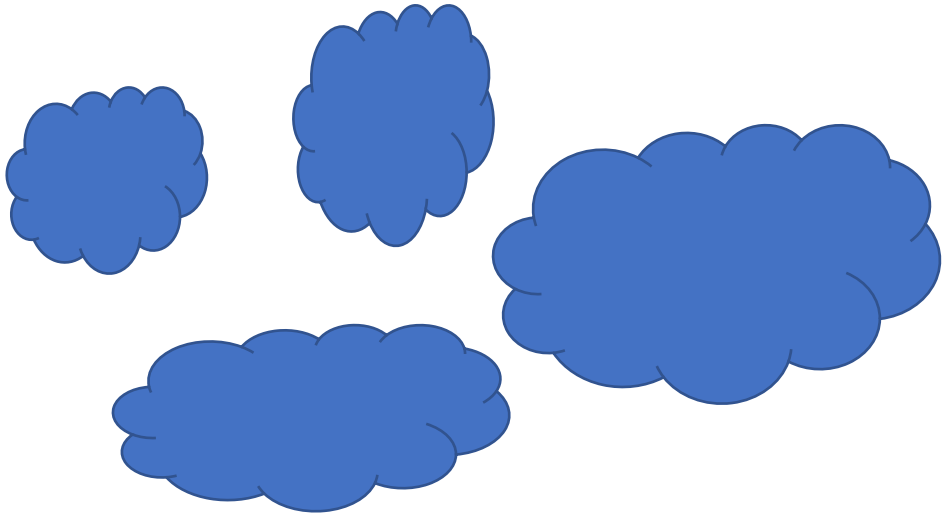
- Set of clouds

Data with predefined labels

Supervised Learning

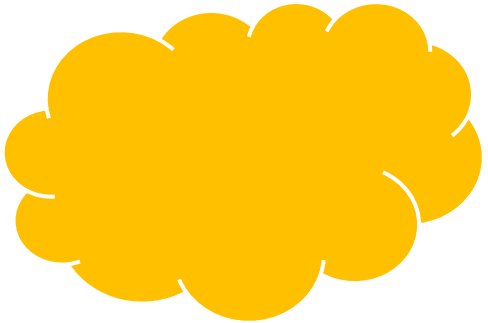


- Set of stars



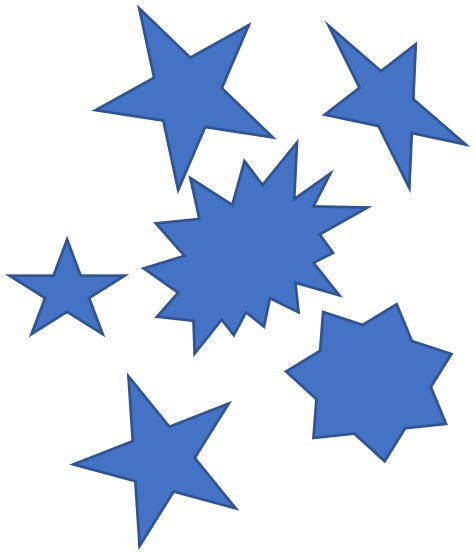
- Set of clouds

Testing……

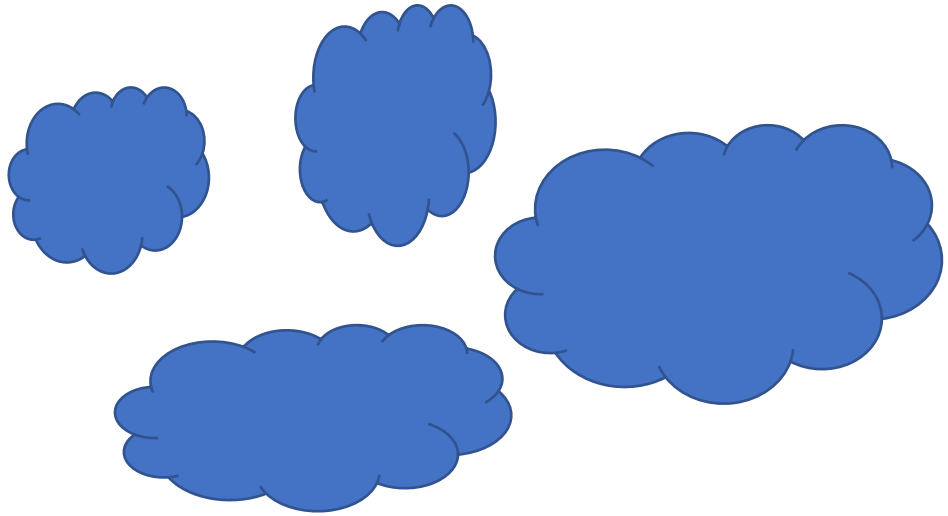


?

Supervised Learning



- Set of stars

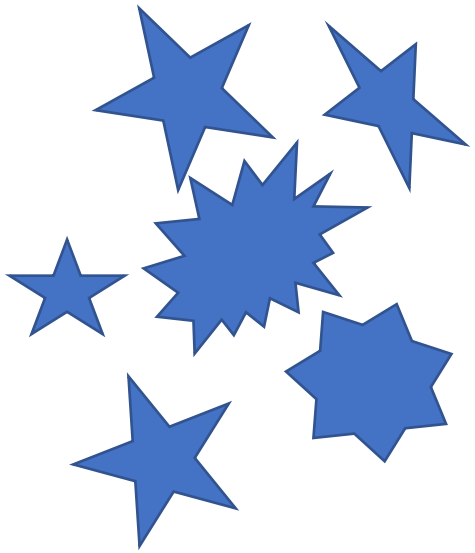


- Set of clouds

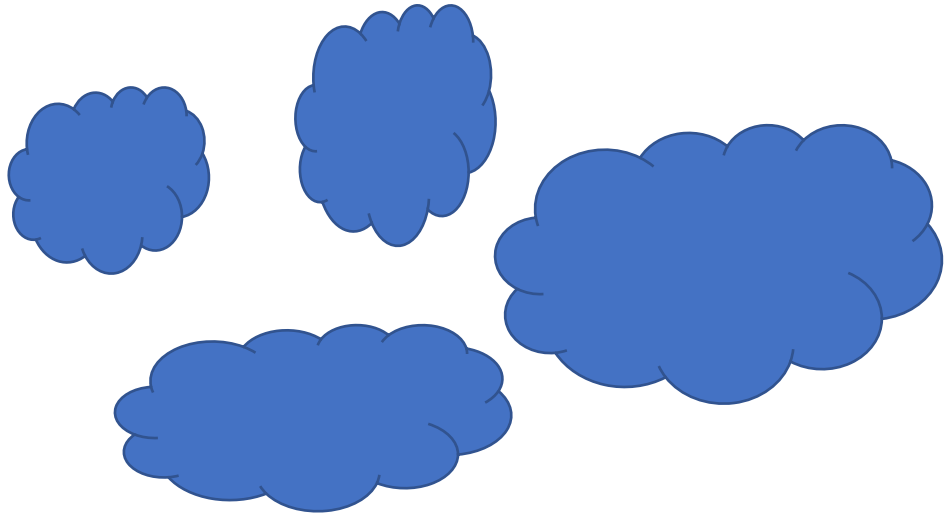
Testing……

?

Supervised Learning

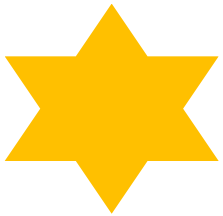


- Set of stars



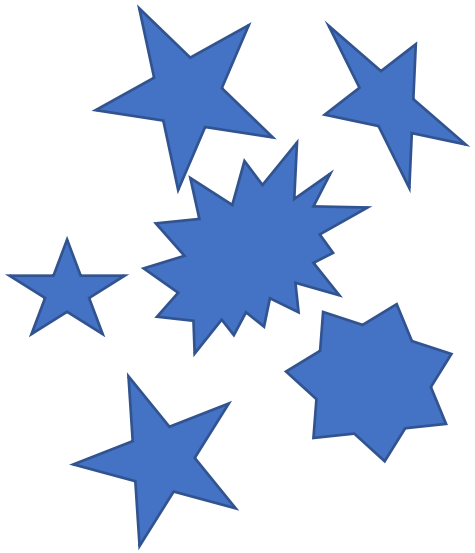
- Set of clouds

Testing……

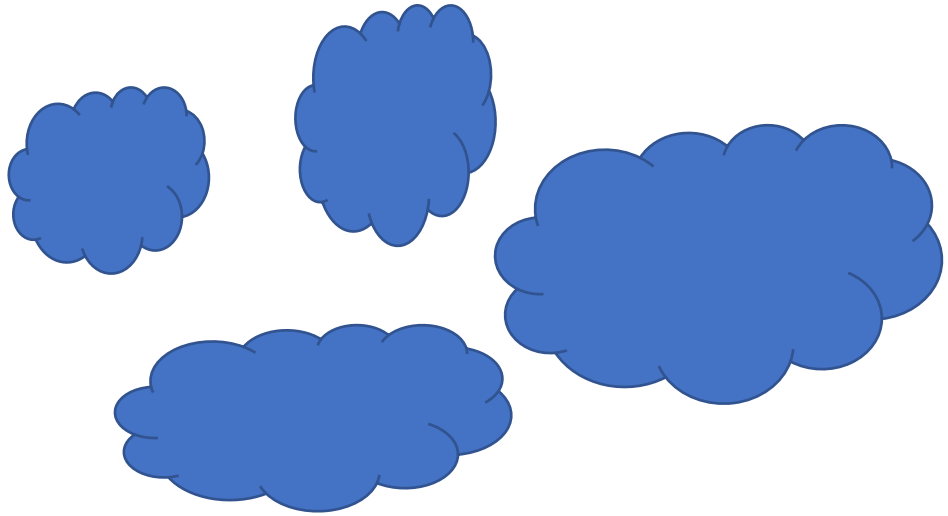


?

Supervised Learning

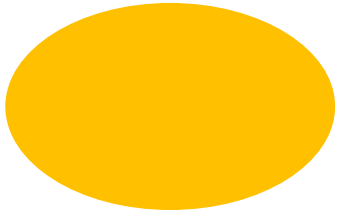


- Set of stars



- Set of clouds

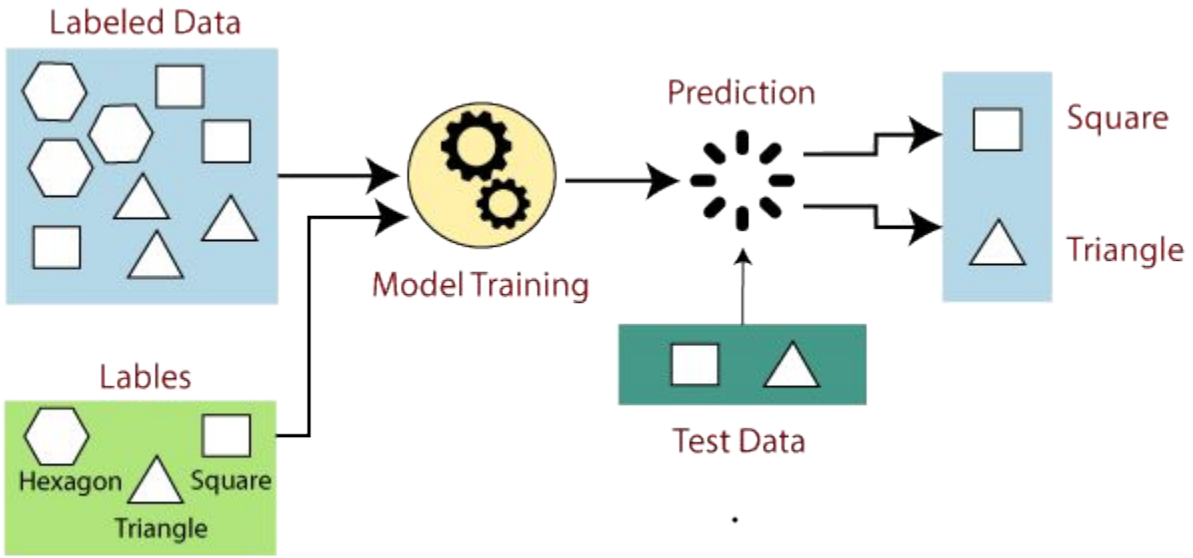
Testing……



?

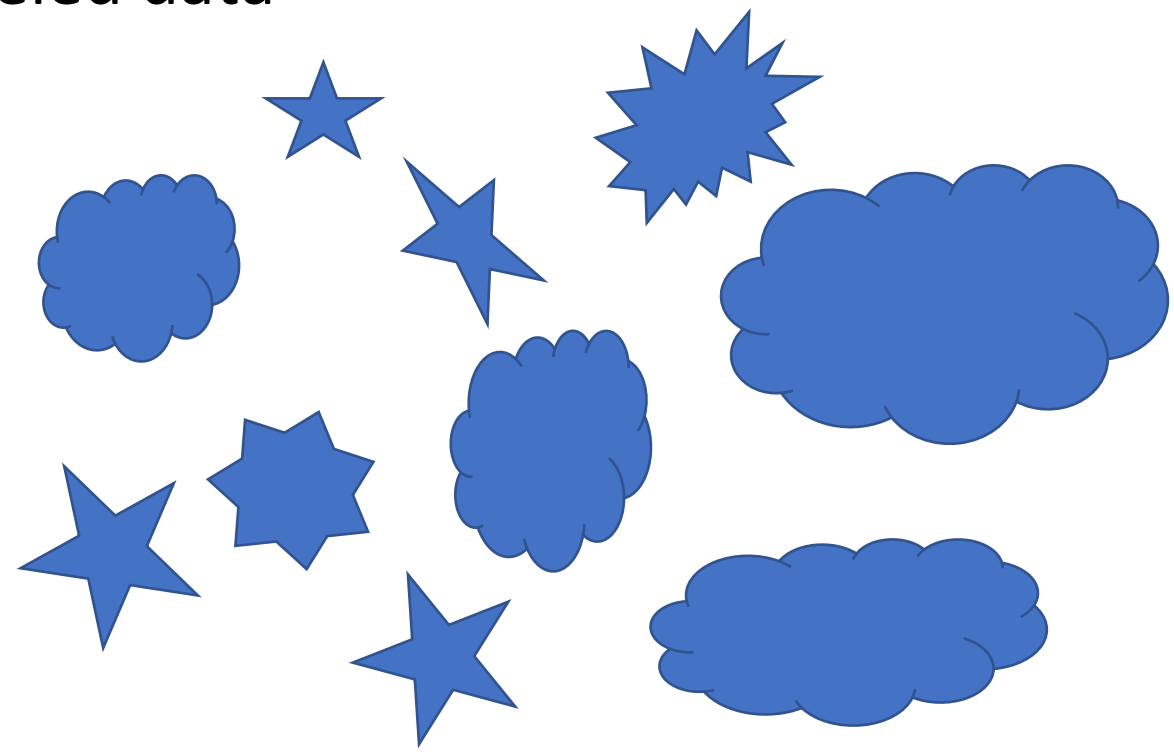
Supervised Learning

- The dataset of objects and their corresponding labels are known
- Predict the new object label based on this apriori



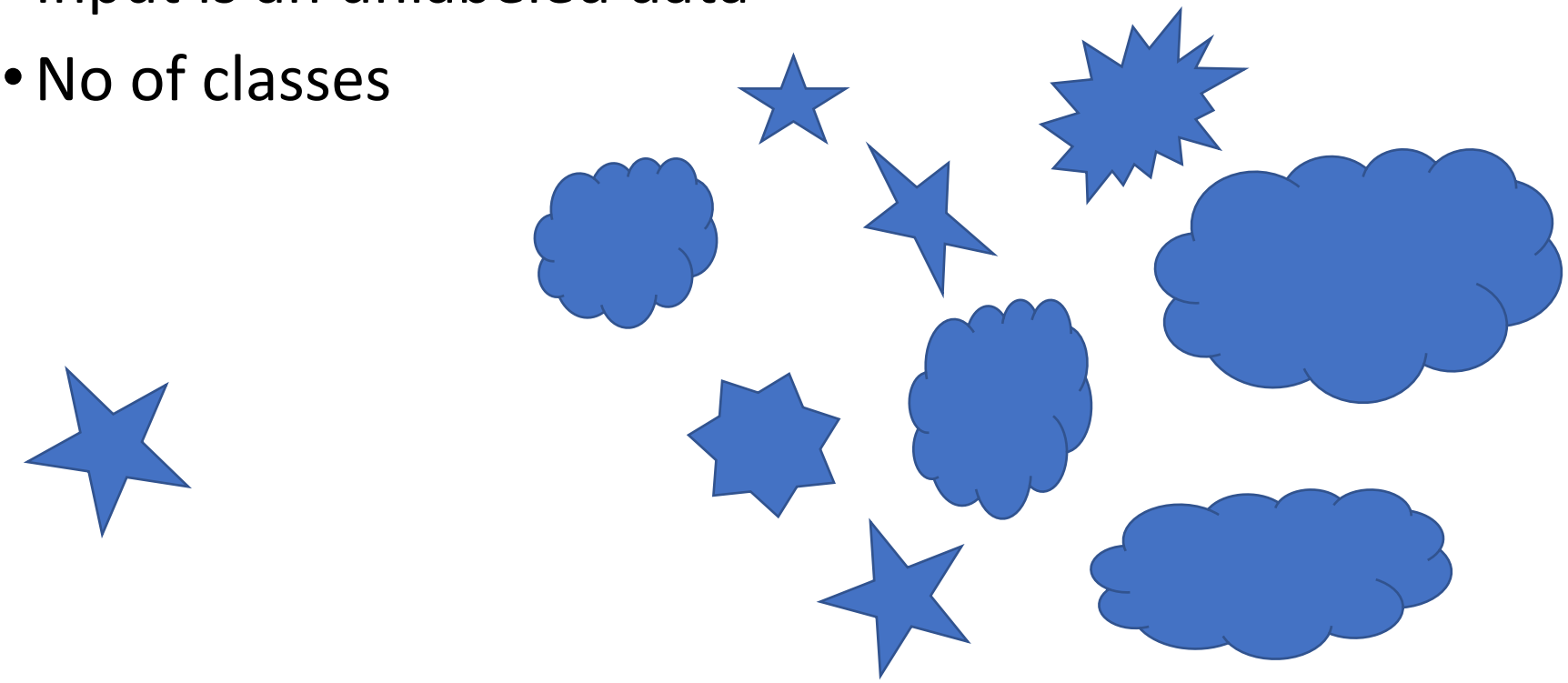
Unsupervised Learning

- Input is an unlabeled data
- No of classes



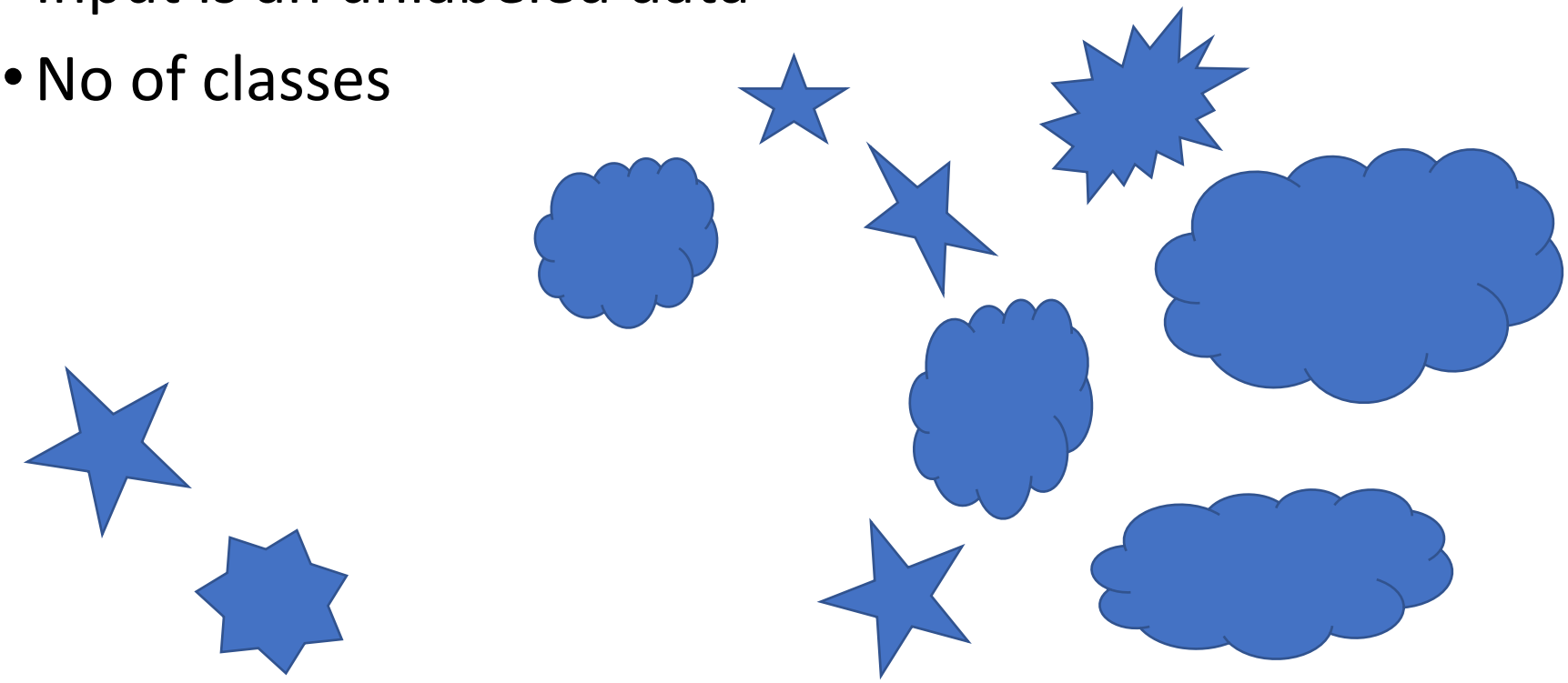
Unsupervised Learning

- Input is an unlabeled data
- No of classes



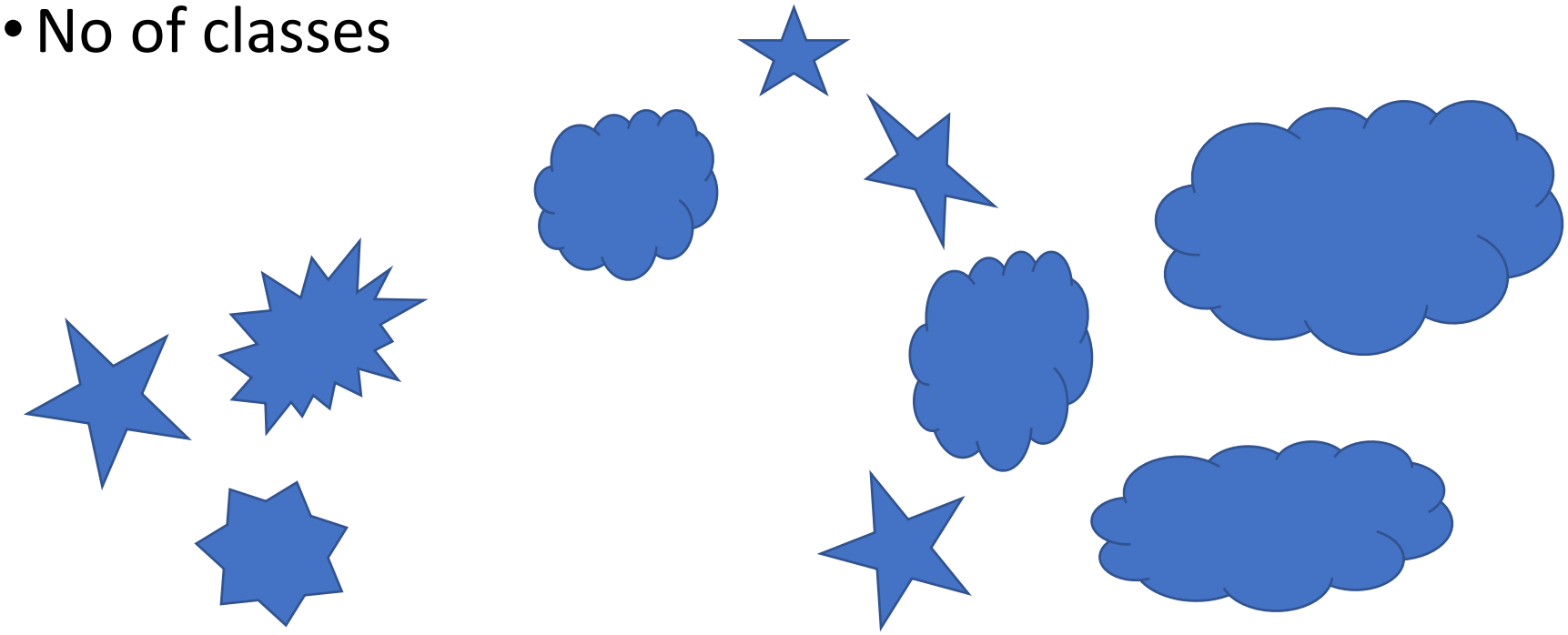
Unsupervised Learning

- Input is an unlabeled data
- No of classes



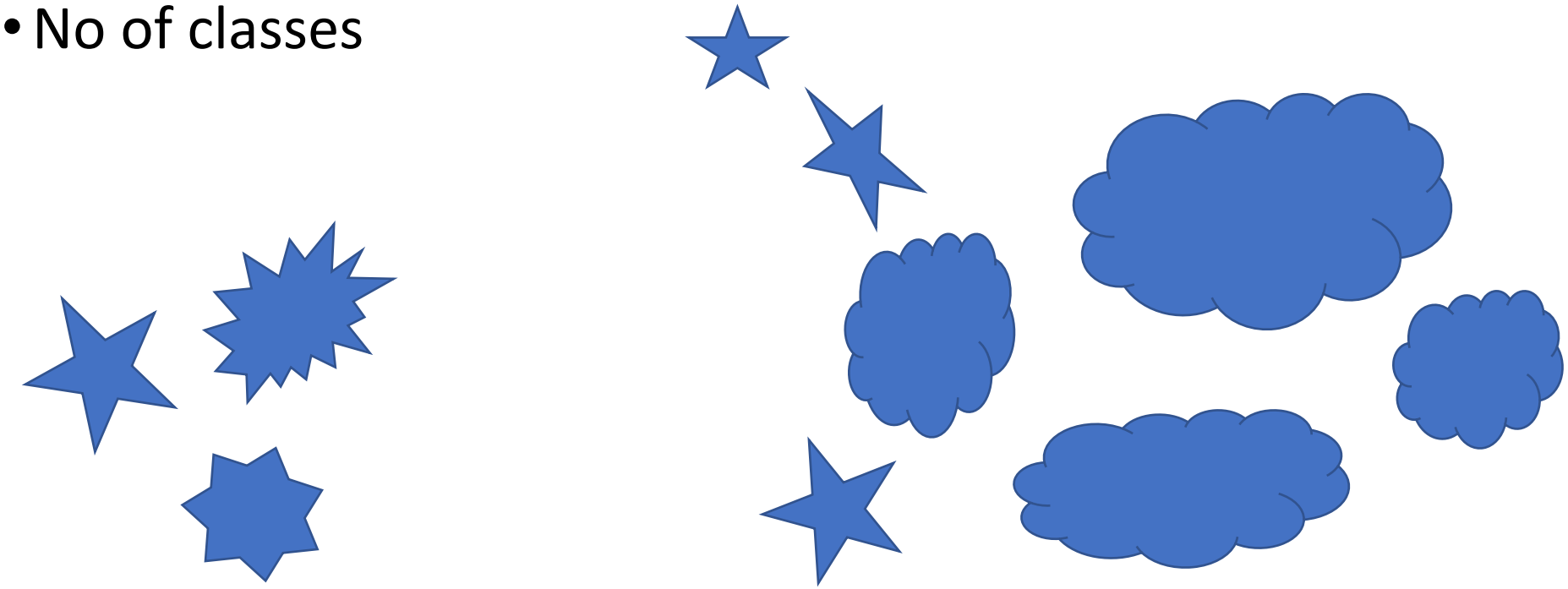
Unsupervised Learning

- Input is an unlabeled data
- No of classes



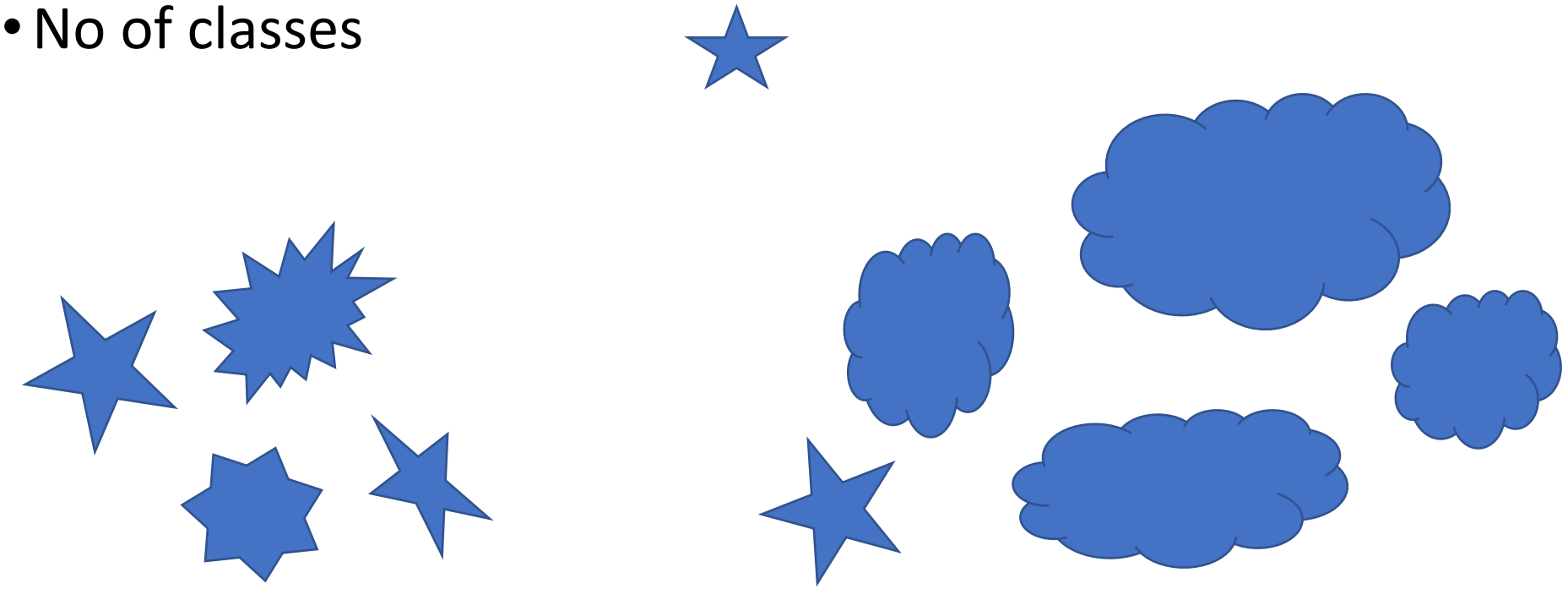
Unsupervised Learning

- Input is an unlabeled data
- No of classes



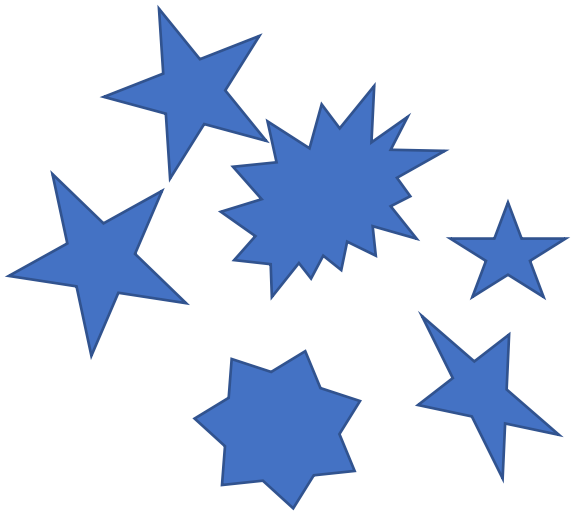
Unsupervised Learning

- Input is an unlabeled data
- No of classes

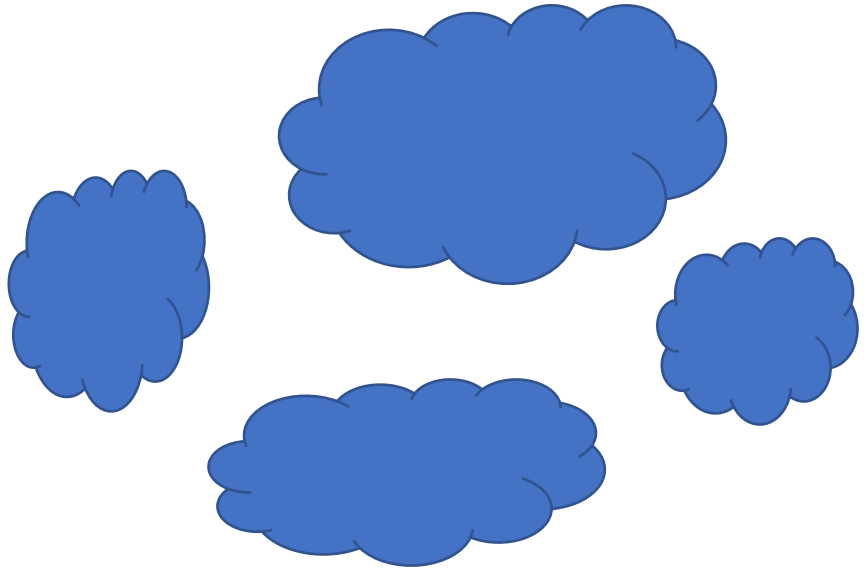


Unsupervised Learning

- Input is an unlabeled data
- No of classes



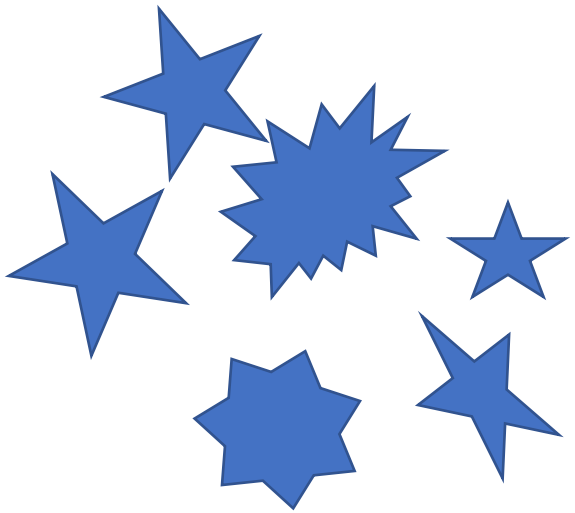
Class label 1



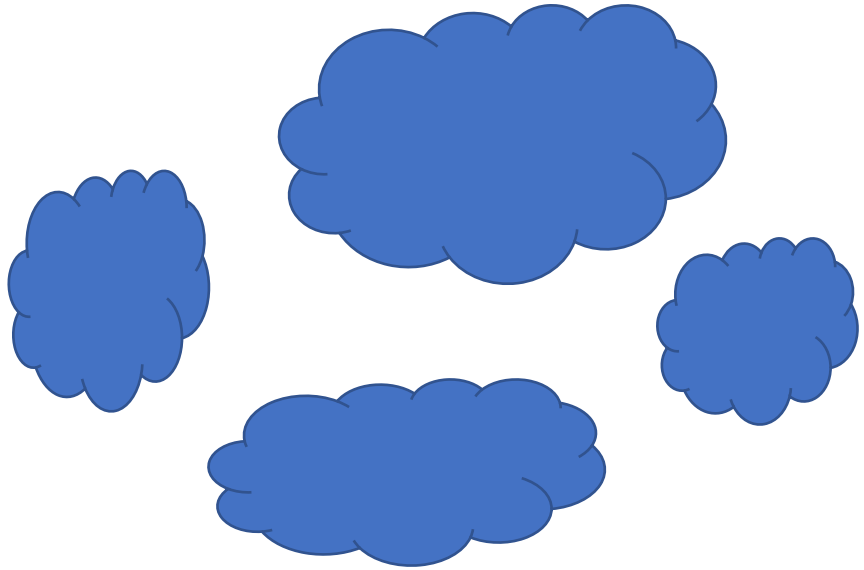
Class label 2

Unsupervised Learning

- Input is an unlabeled data
- No of classes



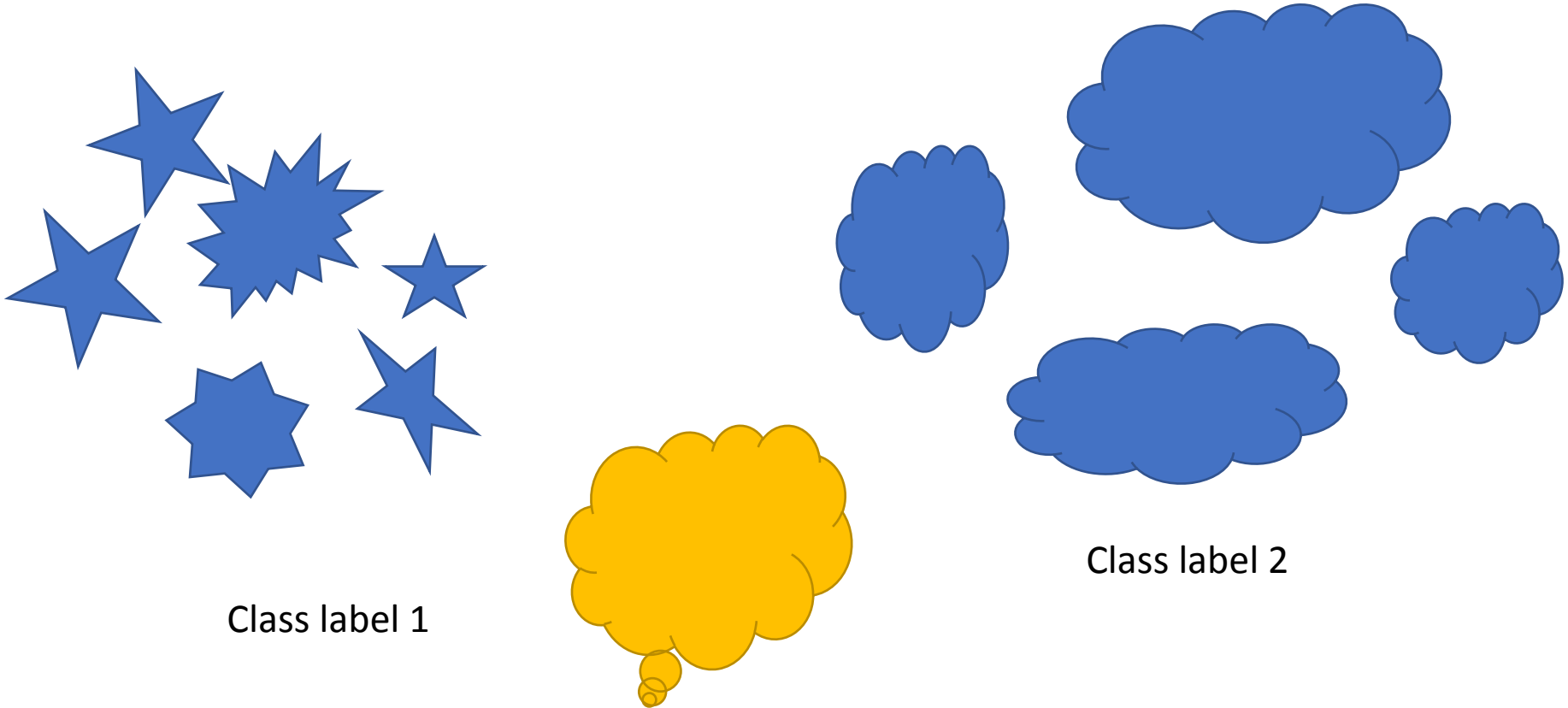
Class label 1



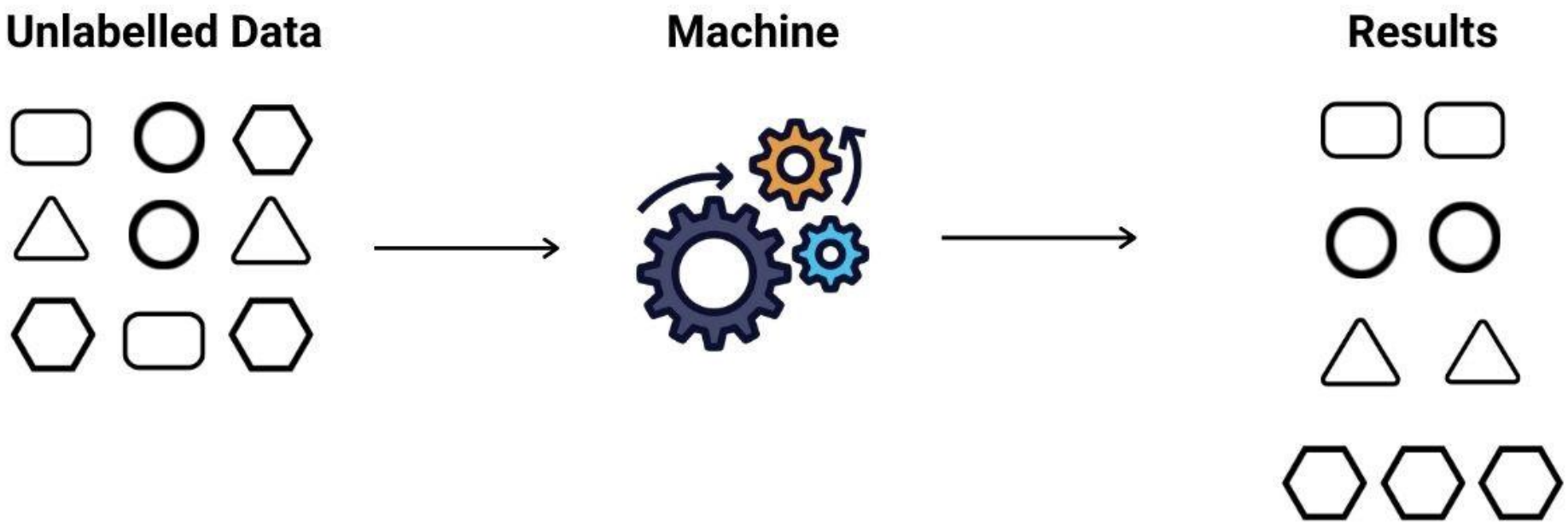
Class label 2

Unsupervised Learning

- Input is an unlabeled data
- No of classes

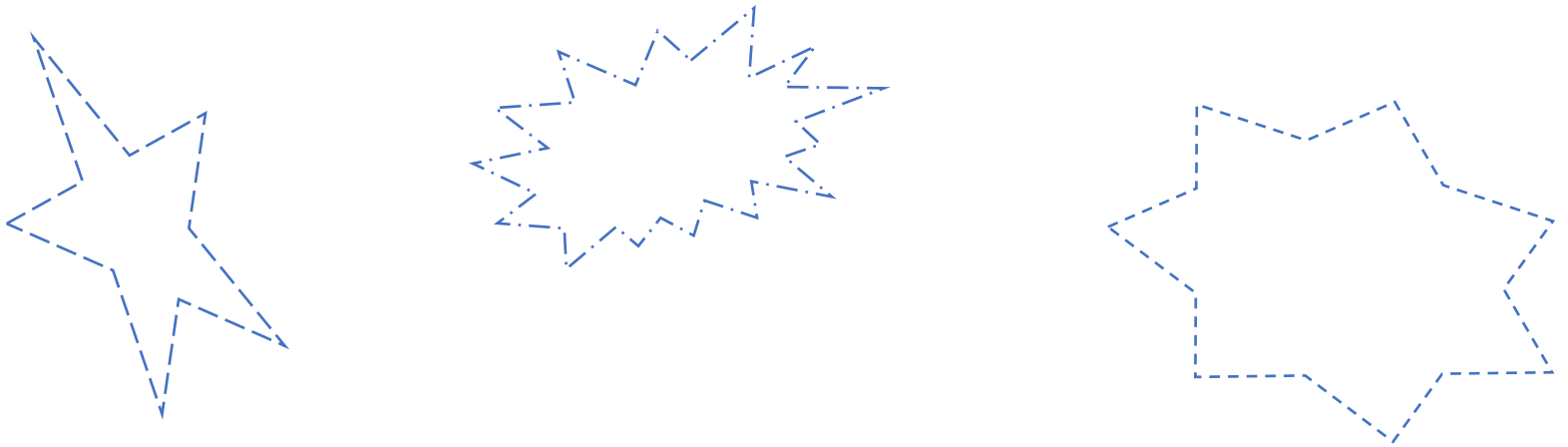


Unsupervised Learning



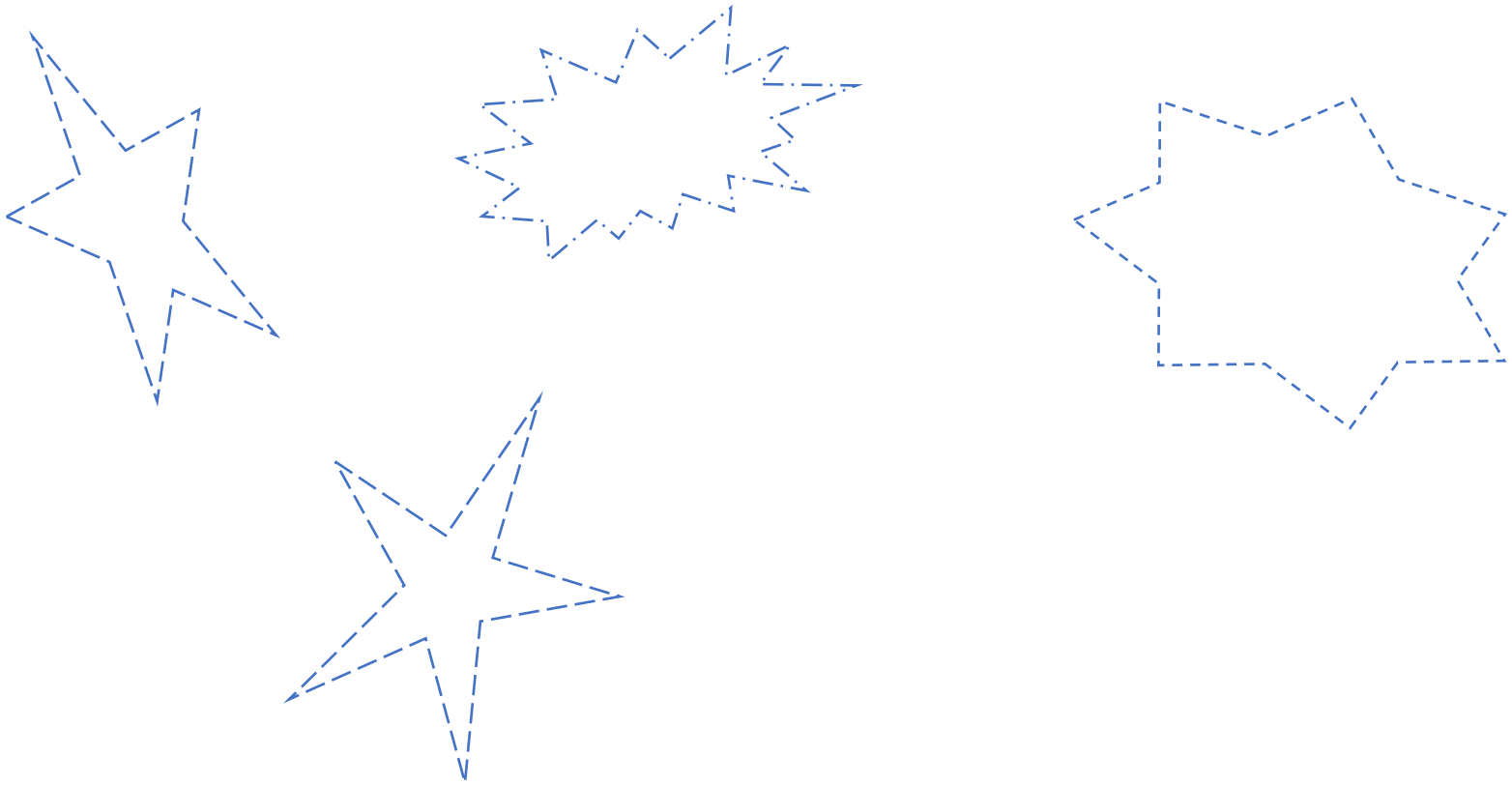
How??

- Each object has a particular shape…..



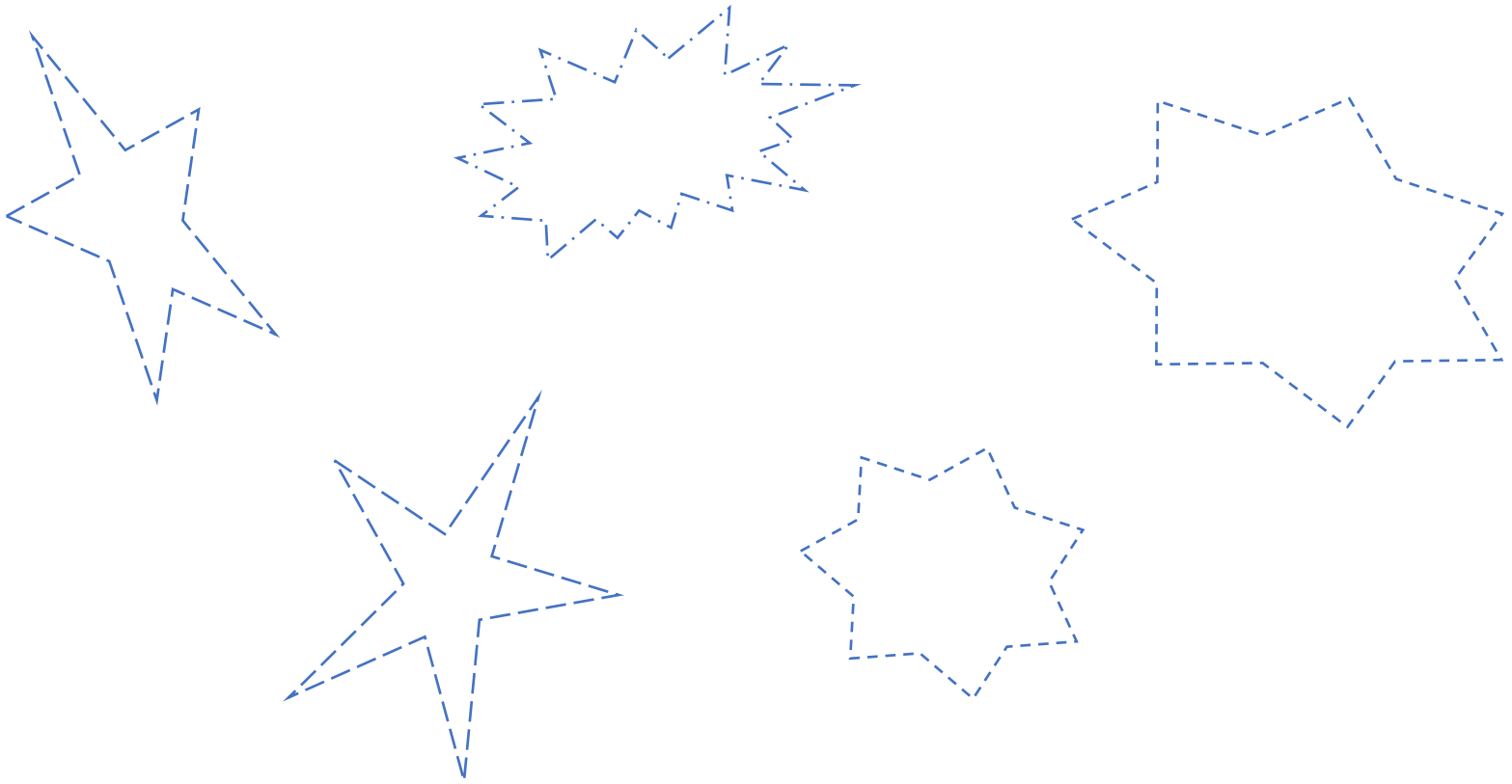
How??

- Each object has a particular type of boundary…..



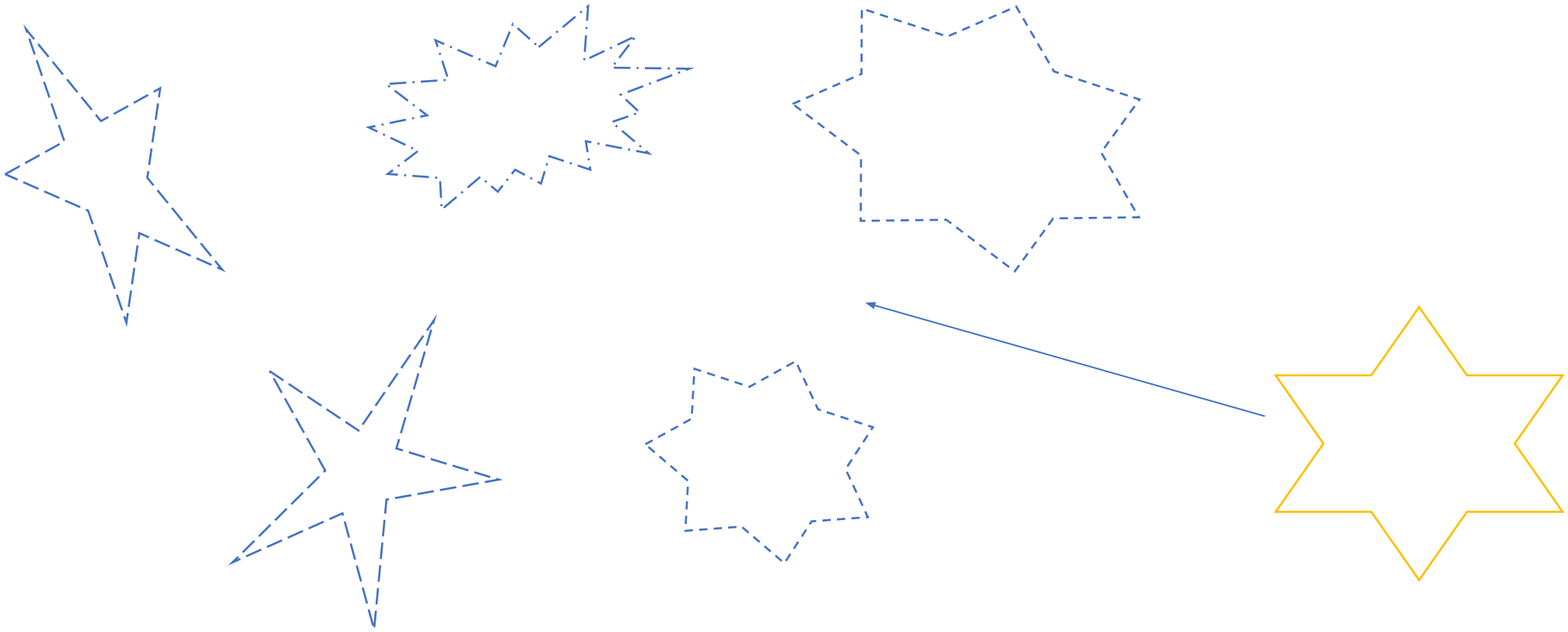
How??

- Each object has a particular type of boundary…..

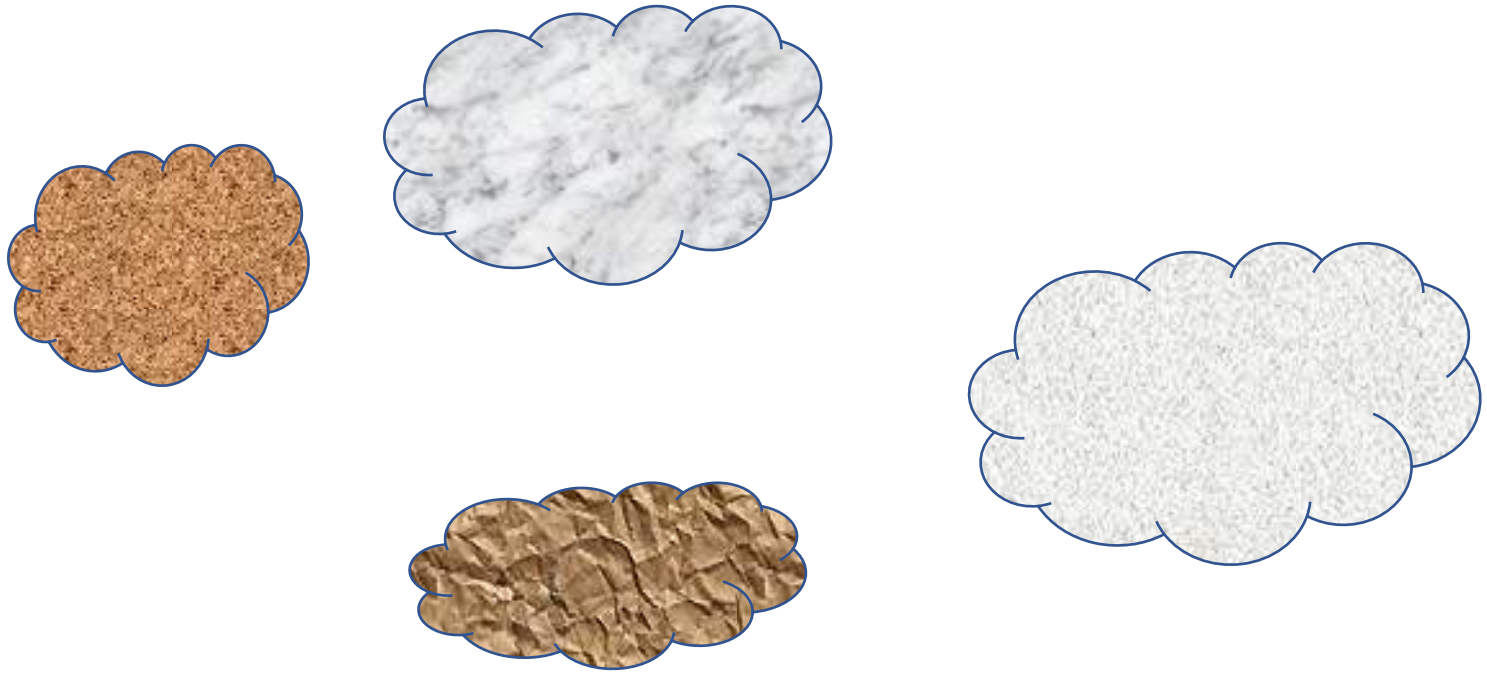


How??

- Each object has a particular type of boundary…..



How??

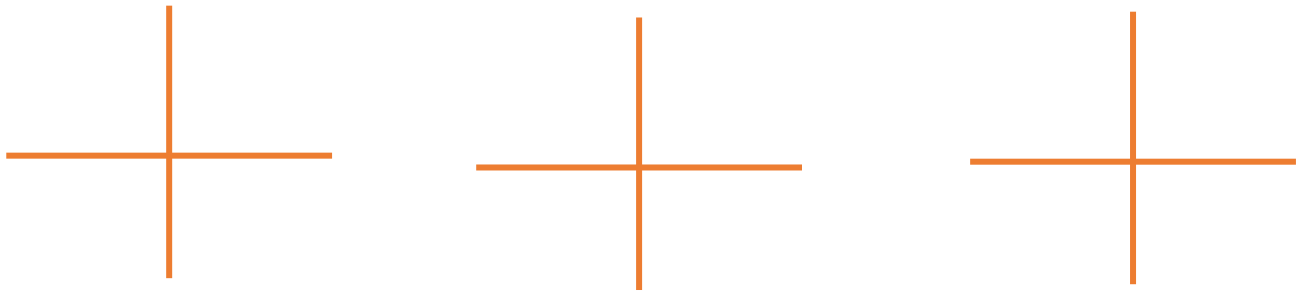


Features

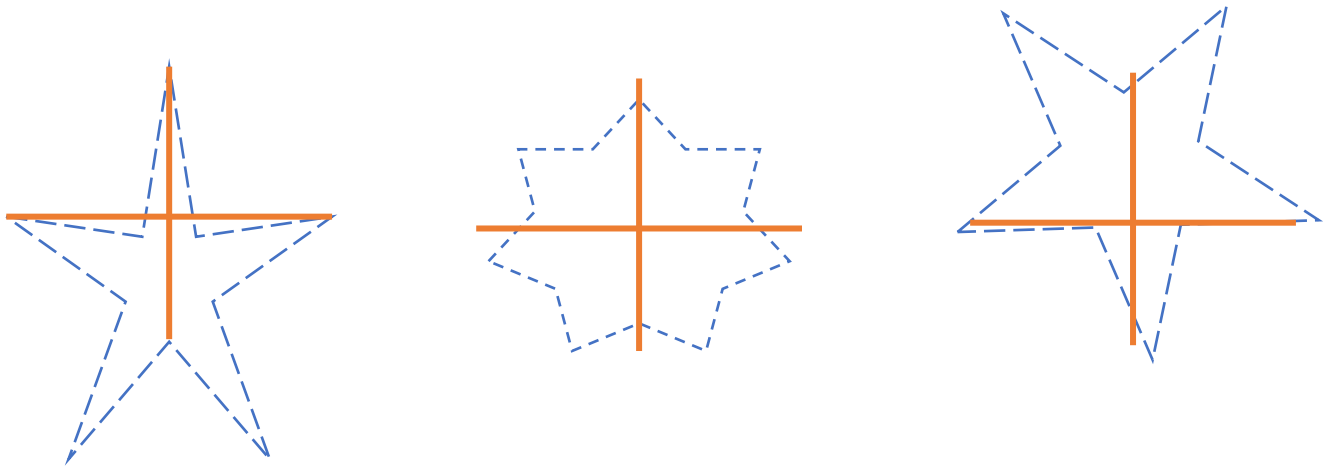
Numerical Descriptors that define important object parameters

- Shape
- Texture
- Color
- Area
- Curvature

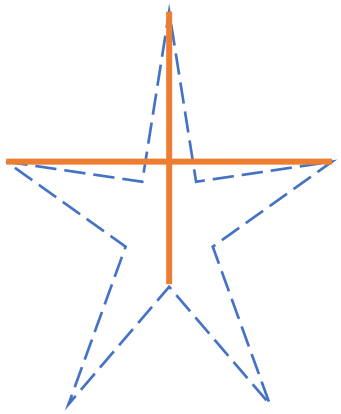
Features



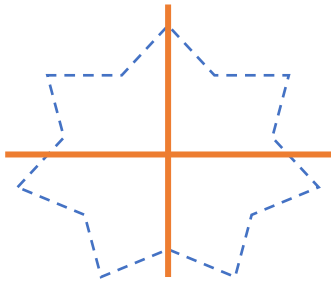
Features



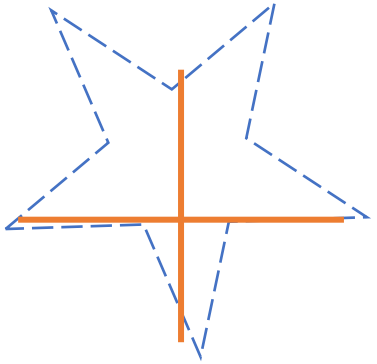
Features



F1=[3, 5]

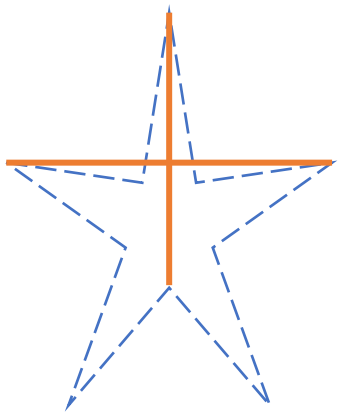


F2=[3.5, 4.5]

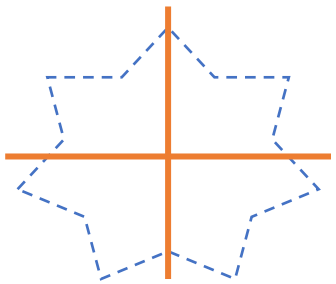


F3=[4, 4]

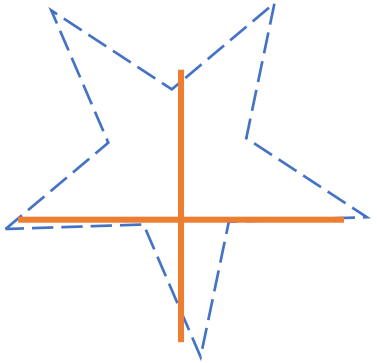
Features



F1=[3, 5]

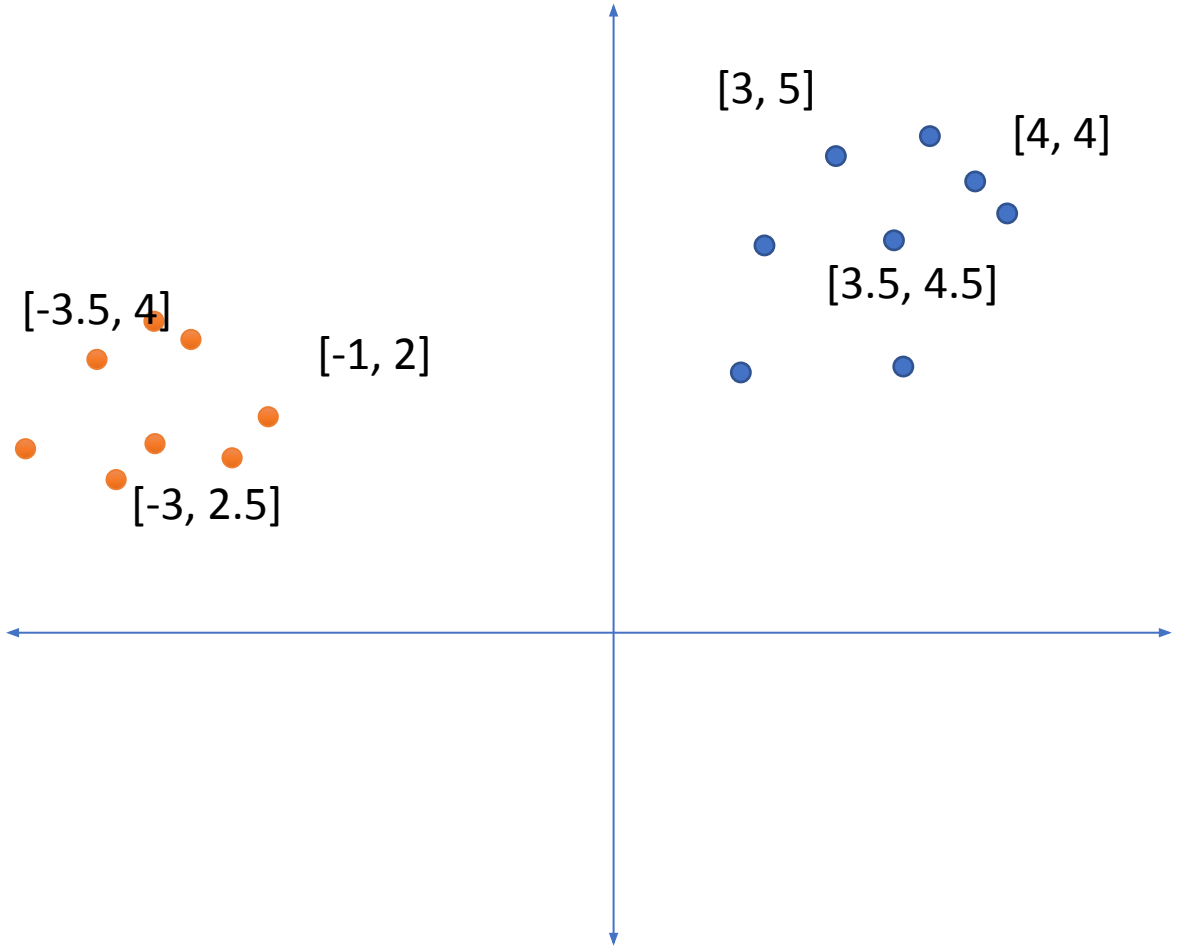


F2=[3.5, 4.5]



F3=[4, 4]

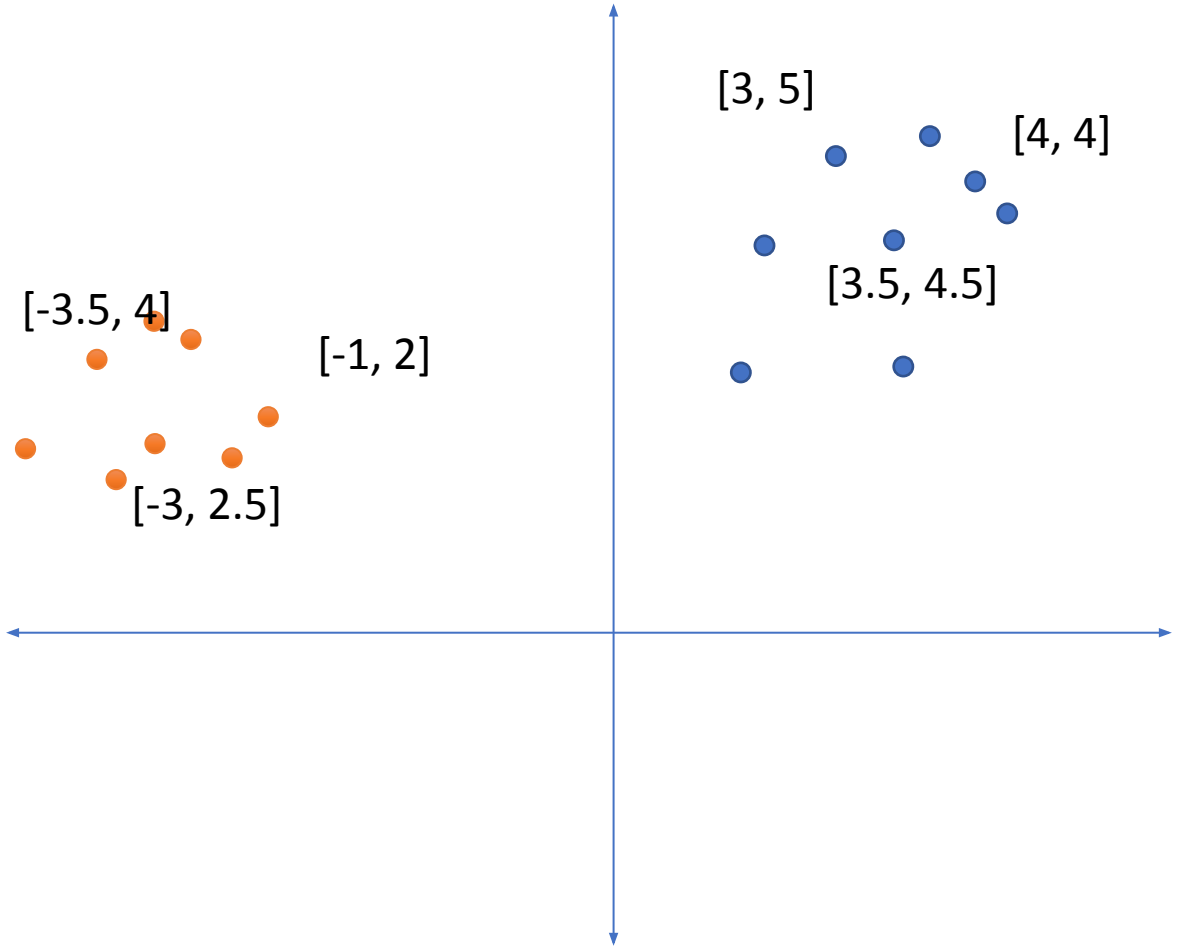
Features



F1=[3, 5]

F2=[-1, 2]

Feature Classifier



F1=[3, 5]

F2=[-1, 2]

F3=[1, 3].....?

Two Schools of Thought

1. Statistical Pattern Recognition

   The data is reduced to vectors of numbers and statistical techniques are used for the tasks to be performed.

2. Structural Pattern Recognition

   The data is converted to a discrete structure (such as a grammar or a graph) and the techniques are related to computer science subjects (such as parsing and graph matching).

Major Components

- Pattern recognition systems have four major components:
  - Data acquisition and collection,
  - feature extraction and representation,
  - similarity detection and pattern classifier design,
  - and performance evaluation.

Reinforcement Learning

- Learning may be defined as the process by which an activity originates or is changed through reaction to an encountered situation which is not due to “native” response tendencies, maturation, or temporary states of the organism.
- In addition, pattern recognition systems are successful to the extent that they can continuously adapt and learn;

Course Content

Detailed Contents		
Module no.	Topic	No. of hours
1	Bayes Decision Theory: Minimum-error-rate classification, Classifiers, Discriminant functions, Decision surfaces, Normal density and discriminant functions, discrete features	6
2	Parameter Estimation Methods: Maximum-Likelihood estimation: Gaussian case; Maximum a Posteriori estimation; Bayesian estimation: Gaussian case	6
3	Unsupervised learning and clustering: Criterion functions for clustering; Algorithms for clustering: K-Means, Hierarchical and other methods; Cluster validation; Gaussian mixture models; Expectation-Maximization method for parameter estimation; Maximum entropy estimation	8
4	Nonparametric techniques for density estimation: Parzen-window method; K-Nearest Neighbour method	6
5	Dimensionality reduction: Fisher discriminant analysis; Principal component analysis;	6
6	Linear discriminant functions: Gradient descent procedures; Perceptron; Support vector machines	5
7	Non-metric methods for pattern classification : Non-numeric data or nominal data. Decision trees: Classification and Regression Trees (CART)	5
	Total Lecture hours	42

	Detailed Contents	
Module	Topic	hours
0	Basics of Probability, Random Processes and Linear Algebra (recap): Probability: independence of events, conditional and joint probability, Bayes theorem Random Processes: Stationary and non-stationary processes, Expectation, Autocorrelation, Cross-Correlation,spectra.Linear Algebra: Inner product, outer product, inverses, eigen values, eigen vectors, singular values, singular vectors	
1	Bayes Decision Theory: Minimum-error-rate classification, Classifiers, Discriminant functions, Decision surfaces, Normal density and discriminant functions, discrete features	6
2	Parameter Estimation Methods: Maximum-Likelihood estimation: Gaussian case; Maximum a Posteriori estimation; Bayesian estimation: Gaussian case	6
3	Unsupervised learning and clustering: Criterion functions for clustering; Algorithms for clustering: K-Means, Hierarchical and other methods; Cluster validation; Gaussian mixture models; Expectation-Maximization method for parameter estimation; Maximum entropy estimation	6
4	Nonparametric techniques for density estimation: Parzen-window method; K-Nearest Neighbour method. Sequential Pattern Recognition. Hidden Markov Models (HMMs). Discrete HMMs. Continuous HMMs	6
5	Dimensionality reduction: Fisher discriminant analysis; Principal component analysis;	6
6	Linear discriminant functions: Gradient descent procedures; Perceptron; Support vector machines	5
7	Non-metric methods for pattern classification : Non-numeric data or nominal data. Decision trees: Classification and Regression Trees (CART). Artificial neural networks: Multilayer perceptron - henceforward neural network. A brief introduction to deep neural networks, convolutional neural networks, recurrent neural networks.	7
	Total Lecture hours	42