$I(x,y)$. Example in the fig. below.

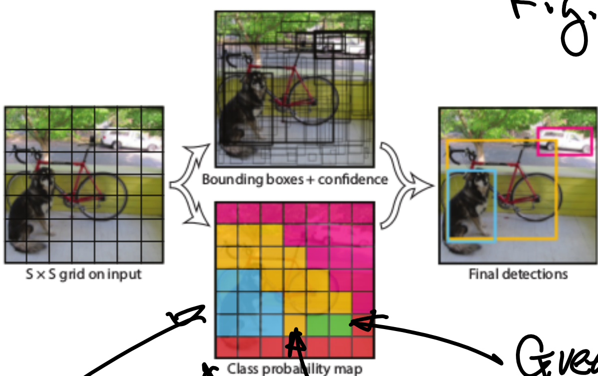

Fig. 1.

Green; Class 4.

Blue: Segmentation for Class 1

Yellow, Class 3

Pink: Segmentation for Class 2

Objective:

To Find/Define Probability Distribution Map for each Class.

$$Prob(class1) = \left(\text{Pixels belong to Class1}\right) \Big/ \text{Total No. of pixels of } I(x,y) \quad \dots (1)$$

from the given Condition in Fig. 1

Since,

$$\left(\text{Pixels belong to Class1}\right) = 8 * \underbrace{(S \times S)}_{\text{pixels One Grid}} = 8S^2$$

Total No. of Pixels of $I(x,y)$ $= 7 * 7 \times S \times S = 49S^2$

Hence,

$$Prob(Class1)_{Blue} = \frac{8\cancel{S^2}}{49\cancel{S^2}} = \frac{8}{49}$$

Next,

$$Prob(Class2)_{Pink} = \frac{25}{49}$$

$$Prob(Class3)_{Yellow} = 14/49$$

$$Prob(Class4)_{Green} = 2/49$$

Note: To verify the Calculation, we should have the following property:

$$\sum_{i=1}^{4} Prob(C_i) = 1 \quad \dots (2).$$

from Our Calculation,

$$\sum_{i=1}^{4} Prob(C_i) = Prob(C_1) + Prob(C_2) + \dots + Prob(C_4)$$

$$= (8 + 25 + 14 + 2)/49 = 1.$$

The Next Step for the Probability Distribution Map Calculation:

Segmentation, e.g. A Technique to allow us to classify

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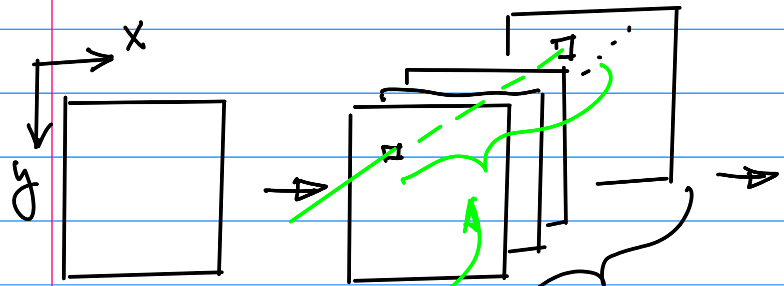
Objects into one of the class i.



$I(x,y)$

feature Layers.

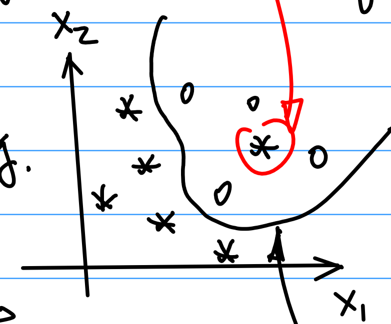
$f_i(x,y)$

$i=1,2,\cdots,N$

Fig.2a

Cluster Finding.

Fig.2b. mis-classification



$\vec{X}(x_1,x_2)$.

Decision Making Function.

Segmentation of the $I(x,y)$

Classification of objects

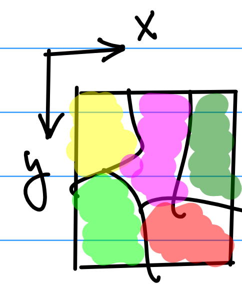
Form Feature Vector(s)

2022F-101-cmpe258-note-2022-11-1 (4).pdf

$$\vec{X}=(x_1,x_2,\cdots,x_N) \quad \cdots (3).$$

introduce Subscript.

$$\vec{X_i}=(x_{i1},x_{i2},x_{i3},\cdots,x_{iN}) \quad \cdots (3\text{-}b)$$



$I(x,y)$

Fig.2c

Ref: for k-mean Cluster Classification.

1. 2022F-101-cmpe258-note-2022-11-1 (4).pdf
2. github, 2022S, Search Keywords "kmean", Two Relevant References
   - PPT. — Formulation.
   - Hand Calculation.

Nov. 7th (Tue).

Note 1. Midterm Exam is scheduled on Next Tuesday (14th). Please Bring Your Laptop Computer to the Class on Monday.
Review and Q&A Session on Thursday.

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Note1. Ref1. General Background → Eqn (1).

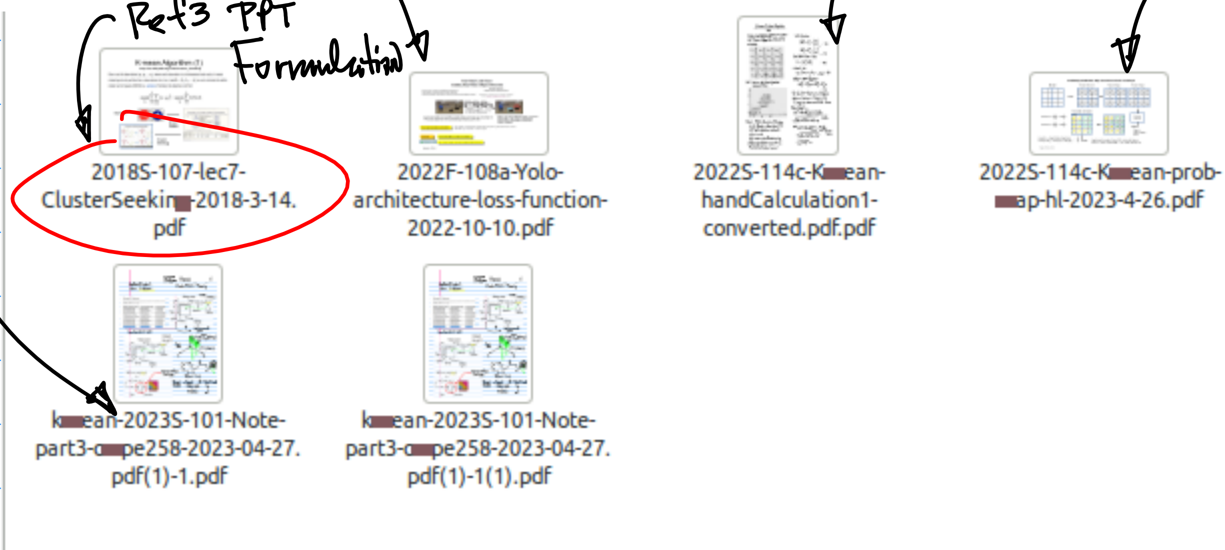
Ref4, Hand Calculation

Ref2.

Ref.5.

Ref3 PPT

Formulation



Example: Formulation.

Ref.2. Lecture Notes

Ref.3. Notation

$$\underset{S}{\mathrm{Argmin}} \sum \sum \|\vec{x}-\vec{\mu}_i\|^2$$

$$S_i^{(t)} = \{\vec{x}_p : \|\vec{x}_p-\vec{\mu}_i\|^2 \le \|\vec{x}_p-\vec{\mu}_j\|^2, \forall j,\ j=1,2,\cdots,K, \text{ and } j \ne i\}$$

$$\vec{x} = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}, \quad \vec{\mu}_i = \begin{pmatrix} \mu_{i1} \\ \mu_{i2} \end{pmatrix}$$

$$\vec{x}-\vec{\mu}_i = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} - \begin{pmatrix} \mu_{i1} \\ \mu_{i2} \end{pmatrix} = \begin{pmatrix} x_1-\mu_{i1} \\ x_2-\mu_{i2} \end{pmatrix}$$

Check iteration of the Computation.

Convergence. → if converges, then stop

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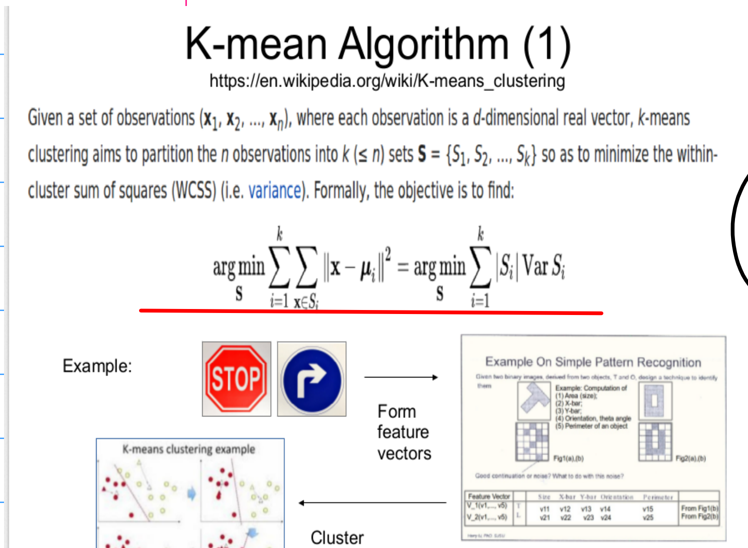


Note 1. Note 2 Squared Distance

$$\arg\min_{\mathbf{S}} \sum_{i=1}^{k} \sum_{\mathbf{x} \in S_i} \|\mathbf{x} - \boldsymbol{\mu}_i\|^2 = \arg\min_{\mathbf{S}} \sum_{i=1}^{k} |S_i| \operatorname{Var} S_i \quad \ldots (3)$$

a. "Argmin" minimization

b. "S" Domain, Scope" of the minimization

Example for $\|\vec{x} - \vec{\mu}_i\|^2$,

if $\vec{x} = (x_1, x_2)$, $\vec{\mu}_i = (\mu_{i1}, \mu_{i2})$

then

From Ref 2. (my lecture Notes) $\|\vec{x} - \vec{\mu}_i\|^2 = \left(\sqrt{(x_1 - \mu_{i1})^2 + (x_2 - \mu_{i2})^2}\right)^2$

$$= (x_1 - \mu_{i1})^2 + (x_2 - \mu_{i2})^2 \quad \ldots (4)$$

Example: K-mean Cluster Algorithm.

First, Notation. Note 1. Vectors

Given a set of observations ($\mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_n$),

e.g. $\underline{X}_1 = (x_{11}, x_{12}, \cdots, x_{1N}) \quad \ldots (1)$

first observation

For $\underbrace{\underline{X}_i}_{\text{observation } i}$ $\quad x_{ij}$,

Component j for the Observation i

Note: if for d-dimensional vector, then Eqn(1) has its N = d

K-mean

partition the n observations into k (≤ n) sets $\mathbf{S} = \{S_1, S_2, \ldots, S_k\}$

$\{\underline{X}_i \mid i = 1, 2, \cdots, N\} \quad \ldots (2)$

K-Classes.

S_i for Class i

Note 3. "$\sum_{x \in S_i}$" Notation $\sum_{i=1}^{M} x_i$

Summation for each & every x as Long as it is from the set S_i

Note 4: from Eqn (3), we have

S_i : Collection of vectors $\underline{X}$ belonging to Class i

Note 5: $\sum_{i=1}^{k} \Rightarrow$ to cover the Collection of all Classes.

Note 6: $\vec{\mu}_i$ { ① $\vec{\mu}_i = (\mu_{i1}, \mu_{i2}, \cdots, \mu_{id})$; ② Cluster for the Class i }

So, with the Objective Function defined, Now Let's take a look at the following Equation for Computation.

$1 \leq j \leq k$ covers all the different classes.

Hand Calculation Example

Given the following feature vectors use Kmean Algorithm to find the clusters.

$x_1=\begin{bmatrix}0\\0\end{bmatrix}$ $x_2=\begin{bmatrix}1\\0\end{bmatrix}$ $x_3=\begin{bmatrix}0\\1\end{bmatrix}$ $x_4=\begin{bmatrix}1\\1\end{bmatrix}$

$x_5=\begin{bmatrix}2\\1\end{bmatrix}$ $x_6=\begin{bmatrix}1\\2\end{bmatrix}$ $x_7=\begin{bmatrix}2\\2\end{bmatrix}$ $x_8=\begin{bmatrix}3\\2\end{bmatrix}$

$x_9=\begin{bmatrix}6\\6\end{bmatrix}$ $x_{10}=\begin{bmatrix}7\\6\end{bmatrix}$ $x_{11}=\begin{bmatrix}8\\6\end{bmatrix}$ $x_{12}=\begin{bmatrix}6\\7\end{bmatrix}$

$x_{13}=\begin{bmatrix}7\\7\end{bmatrix}$ $x_{14}=\begin{bmatrix}8\\7\end{bmatrix}$ $x_{15}=\begin{bmatrix}9\\7\end{bmatrix}$ $x_{16}=\begin{bmatrix}7\\8\end{bmatrix}$

$x_{17}=\begin{bmatrix}8\\8\end{bmatrix}$ $x_{18}=\begin{bmatrix}9\\8\end{bmatrix}$ $x_{19}=\begin{bmatrix}8\\9\end{bmatrix}$ $x_{20}=\begin{bmatrix}9\\9\end{bmatrix}$

$$S_i^{(t)} = \{x_p : \|x_p - m_i^{(t)}\|^2 \leq \|x_p - m_j^{(t)}\|^2 \ \forall j, 1 \leq j \leq k\} \quad \ldots (1)$$

Ref 2022S-114c-Kmean-handCalculation1-c

Note 1: A set of Feature Vectors

$S_i^{(t)}$ — (t): Captured at Step t; i: Class id: ith Class

$S_i^{(t)} = \{\vec{X}_p \quad\}$

index, $p = 1, 2, \ldots$ just like Notation i, j, or k

$S_i^{(t)} = \{\vec{X}_p : \quad\}$

Condition

$\|\vec{X}_p - \vec{m}_i^{(t)}\|^2$

Distance (Squared) at time (t) to the Cluster of class i

Sol: Step 1. Define $K=2$ per Heuristics. Expert Knowledge

Note: "0" Initial step.

Let cluster "1" Class 1

$\vec{m}_1^0 = \vec{x}_1 = \begin{pmatrix}0\\0\end{pmatrix} \ldots (1)$

$\vec{m}_2^0 = \vec{x}_2 = \begin{pmatrix}1\\0\end{pmatrix} \ldots (2)$

Initial Arbitrary Values

And Arbitrarily assign Feature Vectors into 2 Classes.

Step 2. Use Eqn (1) To Compute the distance

$\|\vec{X}_p - \vec{m}_i^{(t)}\|^2$

Now, check the Hand Calculation that I made and posted on the class git, e.g. Ref. 4.

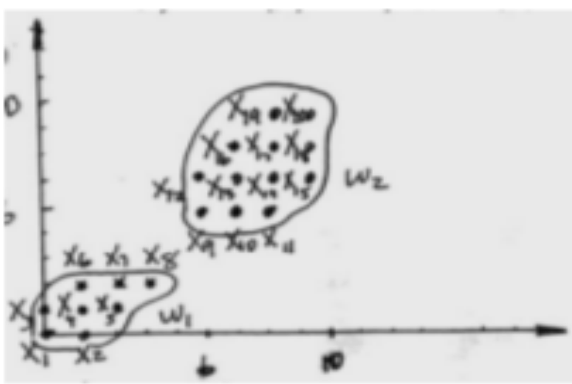
K-mean Cluster Algorithm

HL

Given the following feature vectors use K-mean Algorithm to find the clusters.

$$x_1=\begin{bmatrix}0\\0\end{bmatrix}\; x_2=\begin{bmatrix}1\\0\end{bmatrix}\; x_3=\begin{bmatrix}0\\1\end{bmatrix}\; x_4=\begin{bmatrix}1\\1\end{bmatrix}$$
$$x_5=\begin{bmatrix}2\\1\end{bmatrix}\; x_6=\begin{bmatrix}1\\2\end{bmatrix}\; x_7=\begin{bmatrix}2\\2\end{bmatrix}\; x_8=\begin{bmatrix}3\\2\end{bmatrix}$$
$$x_9=\begin{bmatrix}6\\6\end{bmatrix}\; x_{10}=\begin{bmatrix}7\\6\end{bmatrix}\; x_{11}=\begin{bmatrix}8\\6\end{bmatrix}\; x_{12}=\begin{bmatrix}6\\7\end{bmatrix}$$
$$x_{13}=\begin{bmatrix}7\\7\end{bmatrix}\; x_{14}=\begin{bmatrix}8\\7\end{bmatrix}\; x_{15}=\begin{bmatrix}9\\7\end{bmatrix}\; x_{16}=\begin{bmatrix}7\\8\end{bmatrix}$$
$$x_{17}=\begin{bmatrix}8\\8\end{bmatrix}\; x_{18}=\begin{bmatrix}9\\8\end{bmatrix}\; x_{19}=\begin{bmatrix}8\\9\end{bmatrix}\; x_{20}=\begin{bmatrix}9\\9\end{bmatrix}$$

Sol. We can plot these feature vectors below



Step 1. Define Number of Cluster $K=2$ Based on Heuristics (the plot of the feature vectors).

Let $K=2$

And make initialization by arbitrarily select 2 points $\vec{x}_1$, $\vec{x}_2$ as the cluster Center

Let cluster

$$\vec{m}_1^{\,0}=\vec{x}_1=\begin{pmatrix}0\\0\end{pmatrix}, \quad \cdots (1)$$

$$\vec{m}_2^{\,0}=\vec{x}_2=\begin{pmatrix}1\\0\end{pmatrix} \quad \cdots (2)$$

And let Class 1 be

$$C_1: (\vec{x}_1, \vec{x}_3) \quad \cdots (3)$$

class 2 be

$$C_2: (x_2, x_4, x_5, \cdots, x_{20}) \quad \cdots (4)$$

Step 2, Use Equation

$$\|\vec{x}_p-\vec{m}_i\| \leq \|\vec{x}_p-\vec{m}_j\| \quad \cdots (5)$$

for $\vec{x}_p$ from Class i to regroup feature Vectors in Class i to j if Eqn (5) does not hold. Hence

From Class C_1,

$$\|\vec{x}_1-\vec{m}_1^{\,0}\| = \left\|\begin{pmatrix}x_{11}\\x_{12}\end{pmatrix}-\begin{pmatrix}m_{11}\\m_{12}\end{pmatrix}\right\| = \qquad m_{11}=x_{11},\; m_{12}=x_{12}$$

$$=\sqrt{(x_{11}-x_{11})^2+(x_{12}-x_{12})^2}=0$$

And

$$\|\vec{x}_1-\vec{m}_2\| = \left\|\begin{pmatrix}x_{11}\\x_{12}\end{pmatrix}-\begin{pmatrix}m_{21}\\m_{22}\end{pmatrix}\right\| = \qquad m_{21}=x_{21},\; m_{22}=x_{22}$$

$$=\sqrt{(x_{11}-x_{21})^2+(x_{12}-x_{22})^2}$$

$$=\sqrt{1^2+0^2}=1$$

Continue to Carry Out the Computation, see this 3 page handout, till Converges. → e.g. $m_i^{(t+1)}=m_i^{(t)}$.

then No New Grouping. Stop the Computation.

Nov. 9 (Th).

Example: Hand Calculation of the K-mean.

Note 1. Calculation of A cluster.

Suppose we have cluster μ_i defined as

$$\mu_i = \frac{1}{M}\sum_{j=1}^{M} \vec{x}_{ij} \quad \ldots (1)$$

Suppose

$$\vec{x}_i = (x_{i1}, x_{i2}, x_{i3}, \ldots, x_{ip})$$

p-dimension.

$$\mu_i = \frac{1}{M}\left(\vec{x}_{i1} + \vec{x}_{i2} + \cdots + \vec{x}_{ip}\right)$$

$$= \frac{1}{M}\left[\begin{pmatrix} x_{i11} \\ x_{i12} \end{pmatrix} + \begin{pmatrix} x_{i21} \\ x_{i22} \end{pmatrix} + \cdots + \begin{pmatrix} x_{ip1} \\ x_{ip2} \end{pmatrix}\right] \quad \ldots (1\text{-b})$$

$\downarrow$ for C_i, class i, drop the sub "i" for the simplicity

$$= \frac{1}{M}\left[\begin{pmatrix} x_{11} \\ x_{12} \end{pmatrix} + \begin{pmatrix} x_{21} \\ x_{22} \end{pmatrix} + \cdots + \begin{pmatrix} x_{\cancel{p}1} \\ x_{\cancel{p}2} \end{pmatrix}\right] \quad M$$

$$= \frac{1}{M}\begin{pmatrix} x_{11} + x_{21} + x_{31} + \cdots + x_{\cancel{p}1} \\ x_{12} + x_{22} + x_{32} + \cdots + x_{\cancel{p}2} \end{pmatrix} \quad M$$

$$= \begin{bmatrix} \dfrac{x_{11} + x_{21} + x_{31} + \cdots + x_{\cancel{p}1}}{M} \\ \\ \dfrac{x_{12} + x_{22} + x_{32} + \cdots + x_{\cancel{p}2}}{M} \end{bmatrix} \quad M$$

for $P = 2$

$\downarrow$

$$\mu_i = \begin{pmatrix} \dfrac{x_{11} + x_{21}}{2} \\ \dfrac{x_{12} + x_{22}}{2} \end{pmatrix} \quad \ldots (1\text{-c})$$

Note 2. Per Heuristics / Human Expert Knowledge, K is defined Accordingly.

Note 3. Initialization that Requires $\vec{\mu}_i$, for $i = 1, 2, \ldots, K$

select $\vec{\mu}_i$ By Heuristics.

Then, Calculation Based on the following formula,

$$S_i^{(t)} = \{ \quad \}$$

$\downarrow$

$$\{\vec{x}_p : \underbrace{\text{conditions}} \}$$

$\downarrow$

$$\{\vec{x}_p : \|\vec{x}_p - \vec{\mu}_i\|^2 \le \|\vec{x}_p - \vec{\mu}_j\|^2, \ \forall j, \ j = 1, 2, \ldots, K\} \quad \ldots (2)$$

Now, Check the convergence.
By Comparing

$$\vec{\mu}_i^{(t+1)} = \mu_i^{(t)}$$ Step at t

for $i = 1, 2, \ldots K$

from the given condition & our Initialization,
e.g. we have

$$C_1 = (\vec{x}_1, \vec{x}_3)$$

$$\mu_1' = \frac{1}{M} \sum_{i=1}^{M} \vec{x}_i \Big|_{M=2}$$

$$= \frac{1}{2}\left(\vec{x}_1 + \vec{x}_2\right) \quad \ldots (3)$$

where $\vec{x}_1$ is equal to the 1st feature vector in C_1
$\vec{x}_2$ is the 2nd feature vector.

Hence,

$$\mu_1' = \frac{1}{2}\left[\begin{pmatrix}0\\0\end{pmatrix} + \begin{pmatrix}0\\1\end{pmatrix}\right]$$

$$= \frac{1}{2}\begin{pmatrix}0\\1\end{pmatrix} = \begin{pmatrix}0\\\frac{1}{2}\end{pmatrix}$$

Now, Check

$$\|\vec{x}_p - \mu_1'\|_{p=1} = \left\|\begin{pmatrix}0\\0\end{pmatrix} - \begin{pmatrix}0\\1/2\end{pmatrix}\right\|^2 \quad \ldots (4)$$

$$= \left\|\begin{pmatrix}0\\1/2\end{pmatrix}\right\|^2 = \sqrt{0^2 + \left(\tfrac{1}{2}\right)^2}^{\,2} = \frac{1}{2} \quad \ldots (4\text{-}b)$$

And

$$\|\vec{x}_p - \vec{\mu}_j\|^2_{j=2} \quad \ldots (5)$$

where

$$\vec{\mu}_2 = \frac{1}{M} \cdot \sum_{i=1}^{m} \vec{x}_i \Big|_{M=18}$$

$$= \frac{1}{18} \sum_{i=1}^{18} \vec{x}_i$$ Sub "i" match the Class C_2

$$= \frac{1}{18}\left[\vec{x}_2 + \vec{x}_4 + \vec{x}_5 + \vec{x}_6 + \cdots + \vec{x}_{20}\right]$$

$$= \begin{pmatrix}5.67\\5.33\end{pmatrix}$$

Hence

$$\|\vec{x}_p - \vec{\mu}_2\|^2_{p=1}$$

$$= \|\vec{x}_1 - \vec{\mu}_2\|^2 =$$

$$= \left\|\begin{pmatrix}0\\0\end{pmatrix} - \begin{pmatrix}5.67\\5.33\end{pmatrix}\right\|^2 \quad \ldots (6)$$

Therefore

Eqn (4-b) < Eqn (6)

Similarly, $\vec{x}_3$ Can be verified to Satisfy Eqn (2), → Stays in C_1.

Nov. 17th (Th)

Road map for the 2nd half of the semester:

Semantic segmentation to move from YOLO bounding boxes based DCNN technique to Pixel by Pixel based DCNN called Yolact.

If time permits, we will discuss LSTM (Long Short Term Memory) technique, based on the mathematical formulation of Markov Processes.

Note 1. Ref. on ChatGPT fine tuning.

Note 1. PPT, introduction

- 2023F-104-#190c-9a-chatGPT-API-YZ-HL...
- 2023F-104-2-API_Key (copy).json
- 2023F-104-3-requirements.txt
- 2023F-104-4-test_fine_tuning (copy).py
- 2023F-104-5-train-cti-data (copy).jsonl

Note 2.

json line file to capture the training data.

```
configure_logging()
Terminal: Local × + ⌄
├── GPT_Fine_Tuning
│   ├── API_Key.json
│   ├── CMPE244
│   ├── requirements (copy).txt
│   ├── test_fine_tuning.py
│   ├── train-cti-data.jsonl
│   └── train_fine_tuning.py
├── GPT_Fine_Tuning (1).zip
├── GPT_Fine_Tuningoutput.log
├── hello-the-world
│   ├── API_Key.json
│   ├── chatgpt-2023-10-27.yml
│   ├── ChatHistory.json
│   └── GPTWithHistorySaved.py
├── others
```

NOtethis folder consists of the sample code

```yaml
#-------------------------------------------
# CTI One Corporation
# for Chat-GPT
# Version x0.1
# Coded by: Youran Zheng, 2023-10-27
# Create a Anaconda environment;
# Open a terminal, then
# $ conda env create -f chatgpt-2023-10-27.yml
# Activate the Anaconda environment: $ conda activate chatgpt
#-------------------------------------------
name: chatgpt-2023-10-27

dependencies:
  - python==3.7.1
  - pip
  - pip:
    - openai==0.27.9
~
~
```

Sample example of the .jsonl file as the training data file

From this example, the user is for the part of posting questions, and the asistant is for the part of answer. So, you can modify this sample accordingly to integrate with your Q&A of your training data.


```
Terminal: Local
{"messages": [{"role": "system", "content": "You are Johnny, the CTI One technical support for W100."}, {"role": "user", "content": "Answer the following technical question: What is W100 product?"}, {"role": "assistant", "content": "W100 is a smart walker. It walks up to you when you call it.\n"}]}
{"messages": [{"role": "system", "content": "You are Johnny, the CTI One technical support for W100."}, {"role": "user", "content": "Answer the following technical question: How do I start using W100?"}, {"role": "assistant", "content": "Please first use smart phone to upload your photo to the W100 smart walker.\n"}]}
{"messages": [{"role": "system", "content": "You are Johnny, the CTI One technical support for W100."}, {"role": "user", "content": "Answer the following technical question: How do I set up W100 environment?"}, {"role": "assistant", "content": "Make sure you power up the Wi-Fi router provided in the package and then use your smart phone apps to activate W100 system by initializing it.\n"}]}
{"messages": [{"role": "system", "content": "You are Johnny, the CTI One technical support for W100."}, {"role": "user", "content": "Answer the following technical question:\nSymptom: Battery not charging\nProbable cause: Charger not working"}, {"role": "assistant", "content": "Please replace the charger of W100\n"}]}
{"messages": [{"role": "system", "content": "You are Johnny, the CTI One technical support for W100."}, {"role": "user", "content": "Answer the following technical question:\nSymptom: Battery not charging\nProbable cause: Battery connec
```


Please walk through the sample code, training and testing code as references for your design.
Note: It is mandatroy requirement to have this ChatGPT API capability integrated into your semester long project.

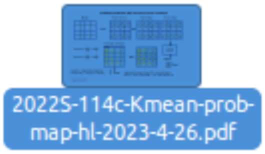
Note: Project assignment for the implementation of Yolact DCNN.

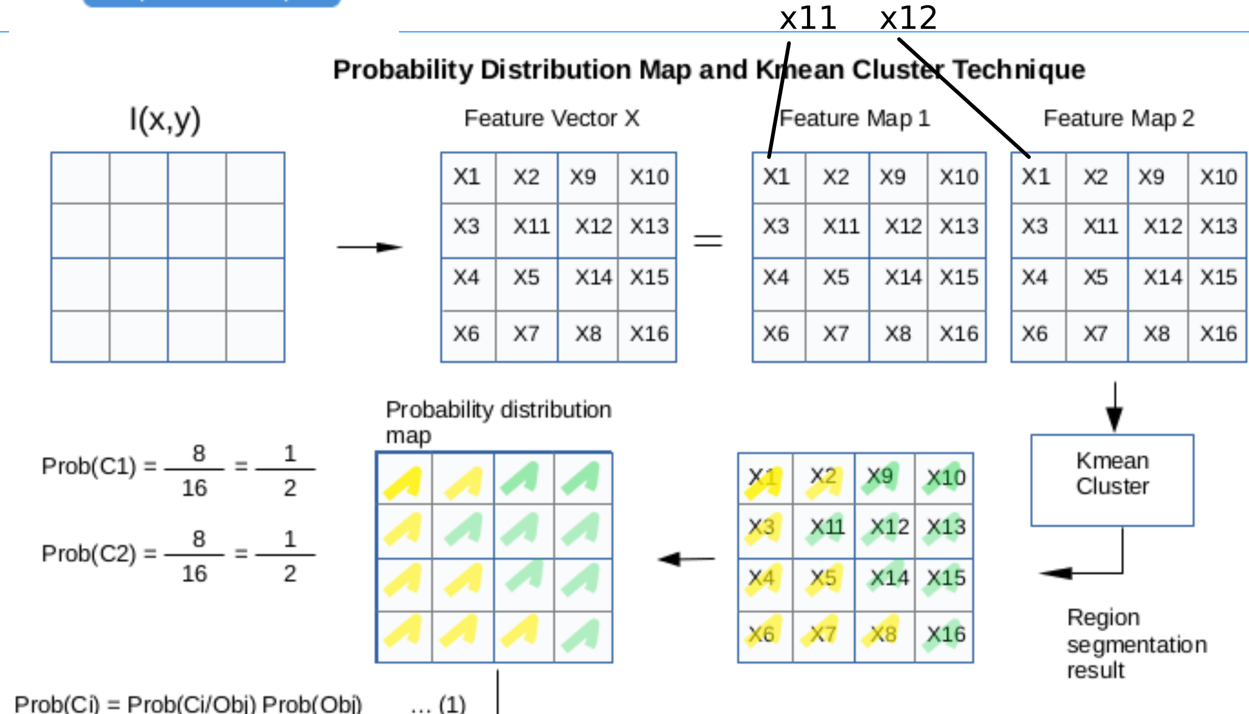
references:
1. Readme on github provides the source github and instructions to build the executable.

The readme document ID: 2022F-107 ~ on the github.

2. The requirements will be posted on Canvas and it is due on Dec. 3rd (Sunday).

Example: K-mean technique for the probability distribution map calculation.





Consider Semantic Segmentation
ref 1. on the github

1- 

CMPE258 PART II

Nov.10,22

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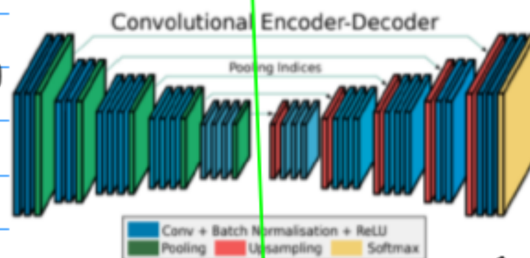
Now, Discussion On Semantic Segmentation.

Bounding Box Based Object Recognition (YOLO) → Pixel Based Object Recognition

Fig.3



Example:

Before v.s. After.

Deep Convolutional Neural Network:

Decoder:

Encoder: