Image Processing - UNIT-5

1) explain the two class problem in Bayes Decision theory.

→ The Bayesian decision theory refers to the statistical approach based on the tradeoff quantification among various classification based on the probability

→ Statistical pattern recognition focusses on the statistical properties of patterns that are expressed in probability densities.

→ Bayes theorm

The probability of A and B are represented by P(A|B)

$$\therefore P(A|B) = \frac{P(B|A) \times P(A)}{P(B)}$$ → Bayes theorm of probability

→ Here A, B are the events or two different classes.

→ we are trying to find the probability of A with the given probability of B.

→ P(A|B) ⇒ posterior probability

P(B|A) → likelihood Probability

P(A) → Prior probability

P(B) → evidence probability.

Example

→ Suppose if we have have a classification problem to classify object 1 and object 2 with the given set of features

$$X = [x_1, x_2, \ldots x_n]$$

→ let 'w' be denote the state of nature where

$w = w_1$ ⟹ for object 1

$w = w_2$ ⟹ for object 2

(here the state of nature is unpredictable)

→ assume the prior values

$P(w_1)$ ⟹ for next object-1

$P(w_2)$ ⟹ for next object-2

→ Feature extraction process

→ process of extracting the features from the image

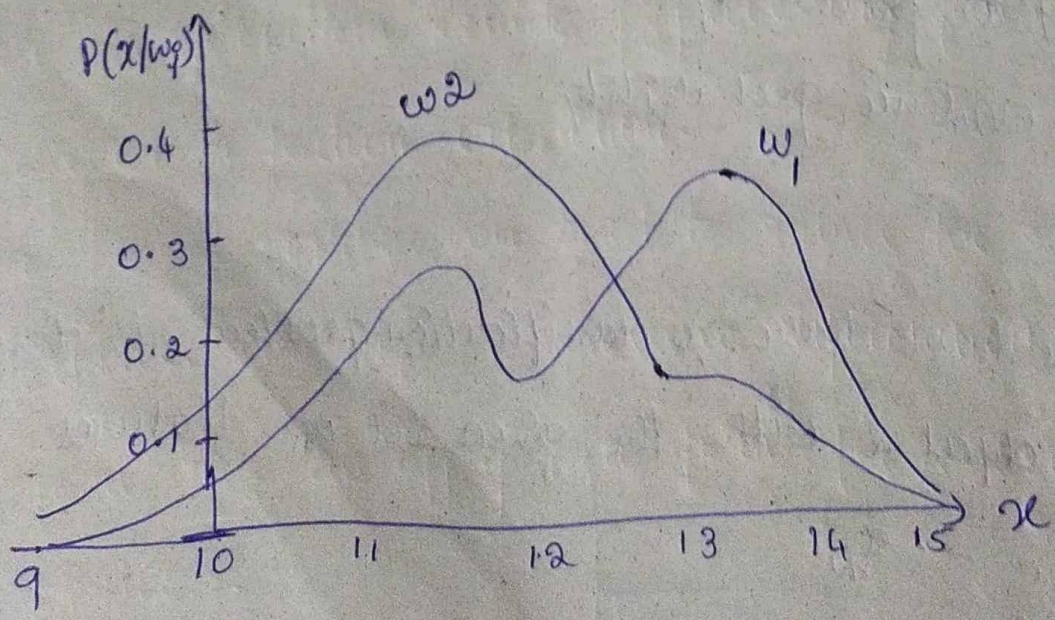
→ suggested set of features for the above example

length, width, shape of an image.

→ The probability distribution function (Pdf) is.

$P(x/w_j)$

→ The probability density function for both the classes are $P(x/w_1)$ and $P(x/w_2)$ as shown below.



$P(\omega_i|x)$ $\Rightarrow$ posterior condition/propability

$P(x|\omega_i)$ $\Rightarrow$ likelihood condition/probability

→ Bayes decision rule

if $P(\omega_1|x) > P(\omega_2|x)$ we would decide that the object belongs to class ω_1 or class ω_2.

2) Discuss the pattern classification carried out using a Statistical classifier

→ Pattern classification is also known as Pattern recognition
→ Each pattern class can be represented by a structural representation or description

→ It is difficult to classify the patterns that contain a large number of features.

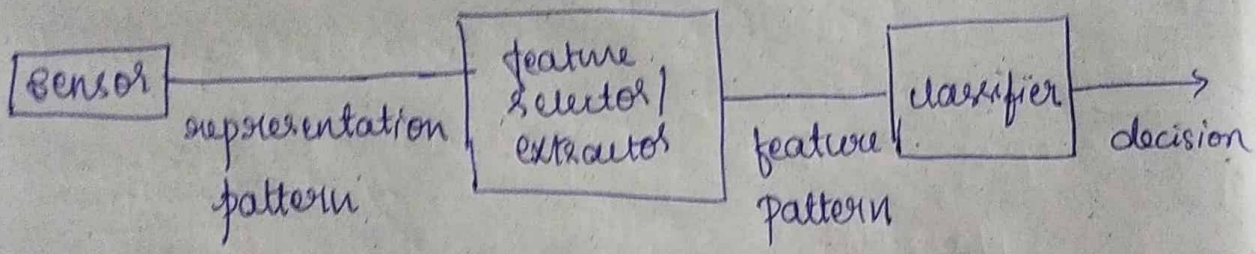


Figure: Pattern classifier

→ The above diagram explains the pattern recognition/ classification procedure

→ The data may undergo several separate transformation stages before a final outcome is reached.

→ These transformations include preprocessing, feature selection or feature extraction.

→ These transformations are used to reduce the number of features, removing irrelevant information and transform into an appropriate form for subsequent classification.

Statistical pattern recognition

1) Formulation of the stages
→ This stage deals with gaining a clear understanding of the aims of the investigation and planning the remaining stages.

2) data collection:
→ This deals with making measurements on appropriate variables and recording details of the data collection procedure.

3) Initial examination of the data
→ deals with checking the data, calculating summary statistics and producing plots for the structure.

4) Feature selection or feature extraction
→ deals with selecting variables from the measured set that are appropriate for the task.

5) unsupervised pattern classification or clustering:
→ deals with data analysis and provides a successful conclusion to a study.

6) Apply discrimination or regression procedures:-
→ The classifier is designed using a training set

7) Assessment of results
→ This involves applying the trained classifies to an independent test set.

8) Intepretation
using the results for further classification.

3) Describe the different performance evaluation Measures used for measuring a classifier

1) Confusion Matrix
2) Precision
3) Recall/sensitivity
4) Specificity
5) F1-Score
6) AUC & ROC Curve

1) Confusion Matrix:

→ Confusion Matrix causes lot of confusions.

→ terms used in defining a confusion Matrix are TP, TN, FP and FN

→ for example: During covid season, the symptoms of the patient (cough, fever, throat-ache) are same as the symptoms ~~during~~ ~~before~~ before or after covid will be same. hence it becomes tricky to the doctor to do the diagnosis.

TP (True Positive)

FP (False Positives)

TN (True Negative)

FN (False Negative)

$$\text{Accuracy} = \frac{(TP + TN)}{TP + FP + TN + FN}$$

2) Precision

$$\text{Precision} = TP / (TP + FP)$$

checks for the true positive out of all that were marked as positive

3) Recall or sensitivity

$$\text{Recall} = \frac{TP}{(TN + FN)}$$

out of all the actual real positive cases, how many were identified as positive.

4) Specificity

$$\text{Specificity} = \frac{TN}{(TN + FP)}$$

out of all the negative cases, how many were identified as negative.

5) F1-score:

$$\text{F1 score} = \frac{2 * (\text{Precision} * \text{Recall})}{(\text{Precision} + \text{Recall})}$$

equal importance given to FP and FN.
→ It is very useful metric compared to "Accuracy".

6) Area Under Curve (AUC) and ROC curve
→ AUC is the area under the ROC curve
→ when we say a model has a high AUC score, it means

the model's ability to separate the classes is very high (high separability)

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4) Explain the two different paradigms of pattern Recognition.

Paradigms of pattern Recognition are

1) Statistical pattern recognition
2) Syntactic Pattern recognition

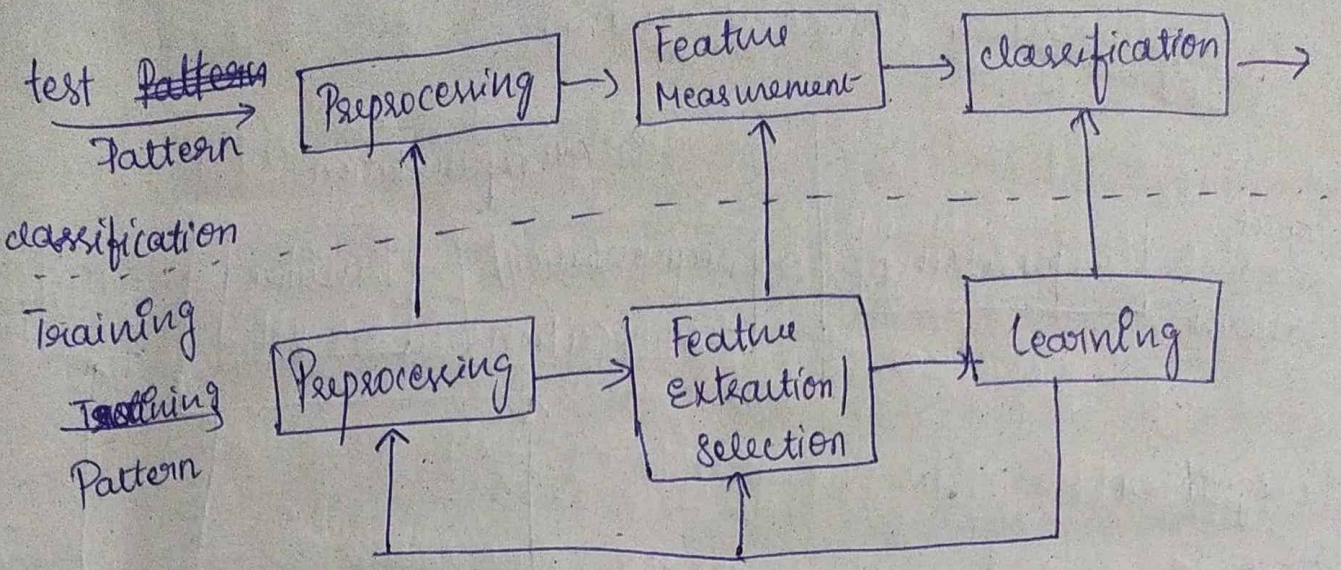
1) Statistical pattern recognition

→ In statistical pattern recognition we use vectors to represent patterns and class labels from a label set.

→ The abstractions typically deal with probability density / distribution of points in multi dimensional trees and graphs.

→ System is operating in two modes.

i.e., Training and classification.



(explain each of them).

2) Syntactic pattern recognition

→ Statistical pattern recognition is straight forward but may not be ideal for many realistic problems.

→ patterns that include relational and structural information are difficult to quantify in vectors.

→ Syntactic pattern recognition techniques uses these relational and structural information for classification.

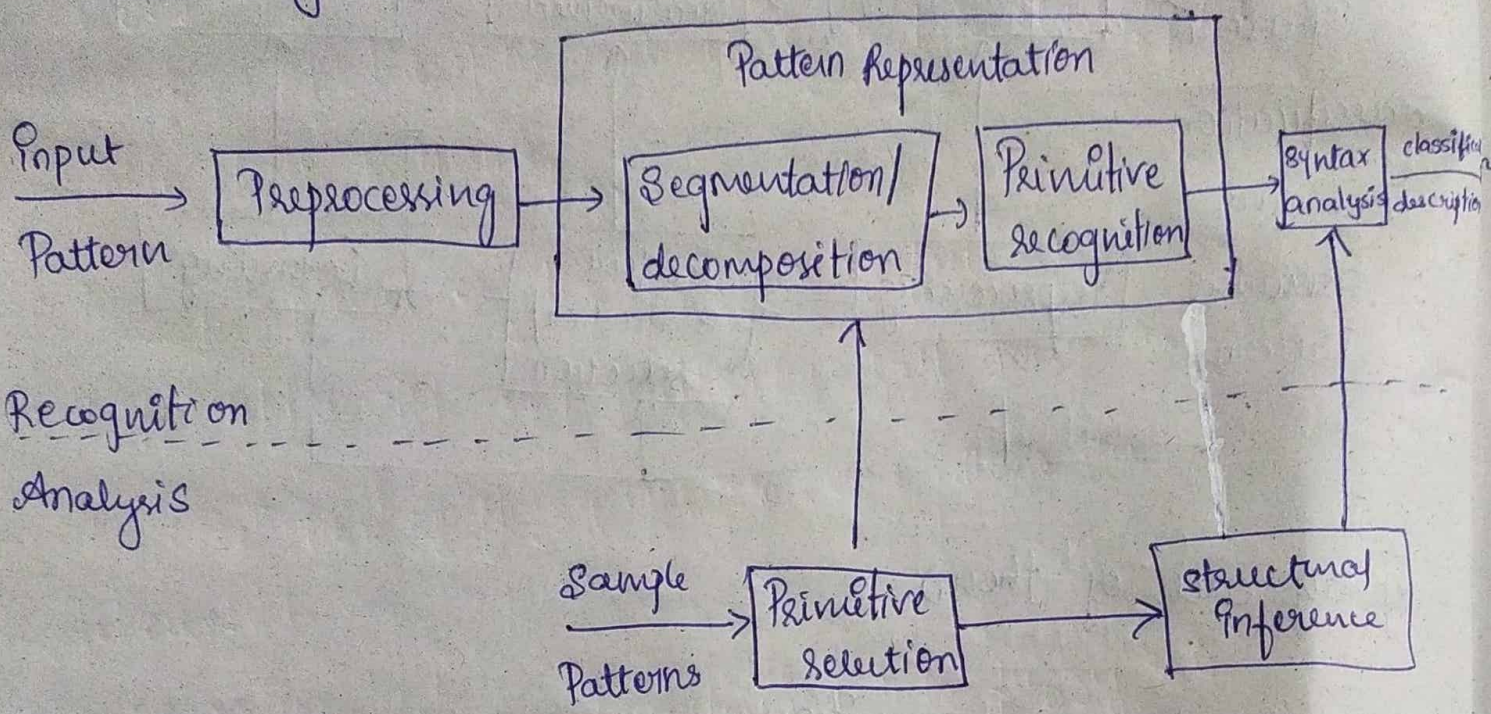
→ Syntactic system consists of two parts

(a) analysis: primitive selection and grammatical or structural inference.

(b) recognition: preprocessing, segmentation or decomposition, and syntax analysis.

→ preprocessing includes the task of pattern encoding filtering, restoration and enhancement.

Syntactic system (Block diagram)



6) Explain Fuzzy Pattern Recognition.

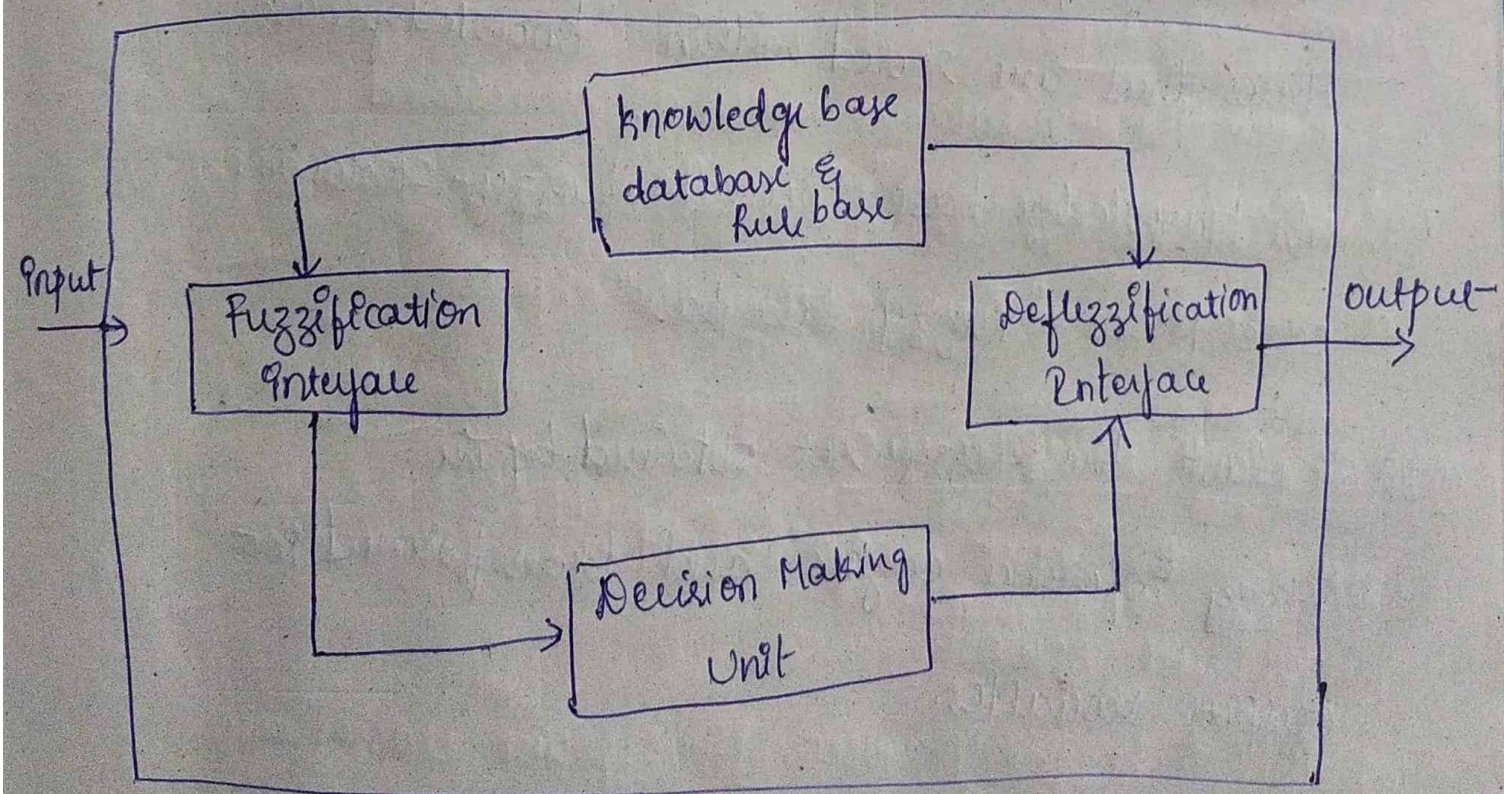
→ Fuzzy pattern recognition is a classical model of pattern recognition, partition a set of patterns into classes depending upon the similarity in features of the patterns

→ In fuzz classification the informal knowledge is used for problem domain.

→ goal of fuzzy classification is

(a) create fuzz "category membership" function. which are then used for classification.

→ The block diagram of fuzzy inference system



→ Fuzzy logic is used for fall detection to determine the ranges of the fall indicators and to classify the possible fall patterns.

→ Fuzzy logic eases the problem of fall detection.

→ It facilitates the recognition of fall patterns.

→ The execution of fuzzy patterns are done as follows.

(1) Input variables are transformed into fuzzy sets within the "Fuzzification blocks".

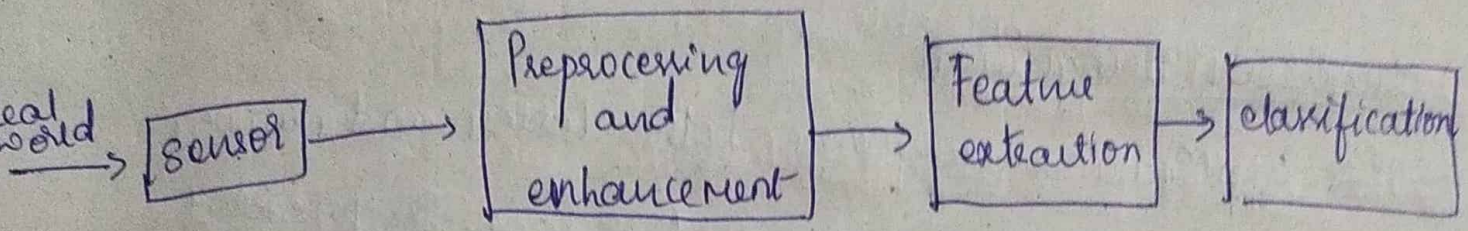
(2) "Fuzzy inference engine" simulates the reasoning process by making fuzzy IF-THEN rules that are stored within "knowledge base".

(3) "The knowledge base" includes fuzzy rules and cases from "Fuzzy data base"

(4) At last the fuzzy set obtained by the "fuzzy inference engine" and transformed into output variables.

briefly explain some applications of pattern Recognition.

Pattern Recognition system



applications are

1) Machine vision :

→ A machine vision system captures the images via camera

→ These images are analyzed to produce the descriptions of images (of objects).

→ for example: in a manufacturing company where the manufatured objects are passed through the camera the images have to be analyzed online

2) Computer Aided Diagnosis (CAD)

→ CAD helps (to assist) doctors in making diagnostic decision.

→ computer assisted diagnosis has been applied in medical field such as x-rays, ECG's, ultrasound images etc.

3) Speech recognition

→ This process recognizes the spoken information.

→ In this the software is built around the pattern recognition system which recognises the spoken text and the result is

translated into ASCII characters which are shown on the screen.

4) Character Recognition

→ This application recognizes both letter and number
→ In this the optically scanned image is provided as input and alphanumeric characters are generated as output.
→ Its major task is to handle the automation and information handling fields
→ It is also used in page readers, zip code, license plate etc.

5) Manufacturing

→ In this the 3D images such as structured light, laser, stereo etc is provided as input and as a result we can identify the objects.

6) Fingerprint identification

→ In this the input image is obtained from fingerprint sensors
→ by this technique various fingerprint classes are obtained and we can identify the owner of the fingerprint.

7) Industrial Automation

→ In this the Intensity or range image of the product as input and by this defective or non-defective product is identified.

explain Fuzzy classification with example

→ In fuzzy classification the informal knowledge is used for the problem domain.

→ The goal of fuzz classification is
(a) create the fuzzy "category membership" function which are then used for classification.

→ The categories.
(a) does not refer to final classes
(b) refer to overlapping ranges of feature values

→ Example
Lightness is divided into four categories.
(a) dark
(b) medium-dark
(c) medium-light
(d) light.

→ conjunction Rule in fuzzy classification is used to merge several category functions corresponding to different features.

→ Limitations of fuzzy methods
(1) Not suitable to use in high dimensions when dozens of hundreds of features are existing.

(2) Not suitable for complex problems

(3) Amount of information user can bring is limited.

(4) poorly suited to change cost matrices.

(5) do not use training data.

Example

fuzzy system to control the operation of a washing machine. such that they controll the washing process, water intake, wash time and spin speed.

Step1: define the linguistic variables and terms for the input:

(1) type of dirt : {Greasy, Medium, No Greasy}

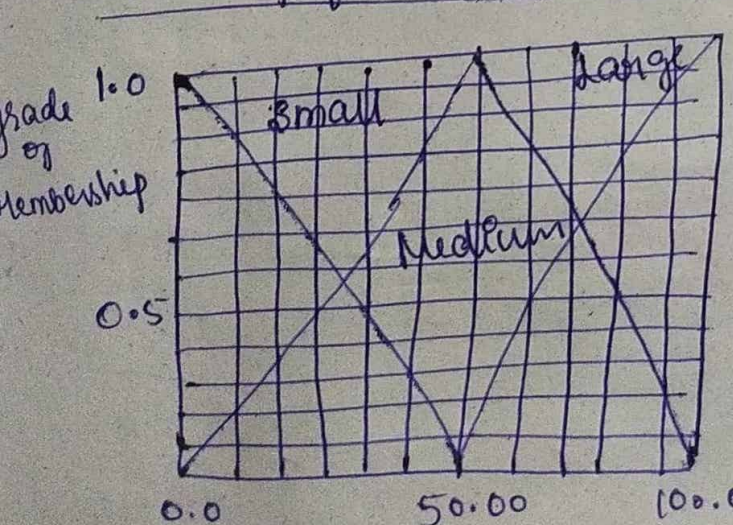
(2) Quality of dirt: { large, medium, small}

For output linguistic variables are

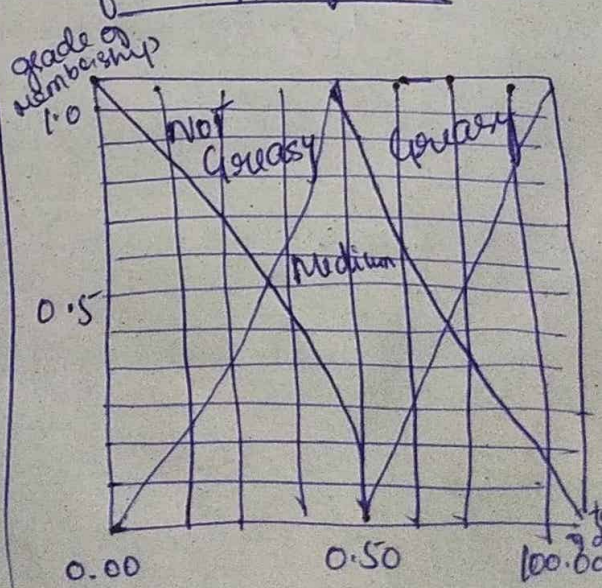
(1) wash time : {short, very short, long, medium, very long}

Step2: construction of Membership functions.

Membership function for Quality of dirt



for Type of dirt



Step3: develop set of rules for knowledge base

(1) if quality of dirt(QD) is small AND Type of Dirt(TD) is Greasy, THEN wash time is long.

(2) if QD is medium AND TD is Greasy:
THEN wash time is long

(3) if QD is large AN TD is Greasy
THEN wash time is very long.

Step4: The fuzzier applies the above rules to perform the fuzz set operations (MIN, MAX) to determine the output of fuzzy functions
based on the output the membership function is developed.

Step5: defuzzifier uses the output memberships to determine the output washing time.

explain fuzzy clustering. explain with example

→ In fuzzy clustering the data is segmented and clusters are defined by grouping related attributes in uniquely defined clusters.

→ A data point in the sample space is assigned to only one cluster and has an identity with it.

→ when partitioning is done in data, the cluster centers are moved and not the data points

→ In this clustering there is a self-iterative process of defining better cluster centers in each iteration.

→ The most well known methods and commonly used portioning method is k-means algorithm.

→ Here k-denote the number of cluster seeds initially provided for this algorithm.

→ Here input parameter is taken as k and its partion set of M objects into k clusters.

→ The center points are calculated by computing the Euclidian distance between a data point and the cluster center to add item into one of the cluster resulting in high intra cluster and low intra cluster.

$$d_k = \sum_n \left| x_g^k - c_g^g \right|^2$$

d_k : is the distance of the k^{th} data point

n : is the no. of attributes in the cluster

x_g^k : is g^{th} value of the k^{th} data point

c_g^g : is the g^{th} value of the g^{th} cluster center.