**Pattern Recognition and Application**
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**Lecture - 1**
**Introduction**

Hello. Welcome to this course on pattern recognition and applications. So, when you talk about the problem of pattern recognition, let us try to see what is meant by pattern recognition or specifically what is meant by a pattern.

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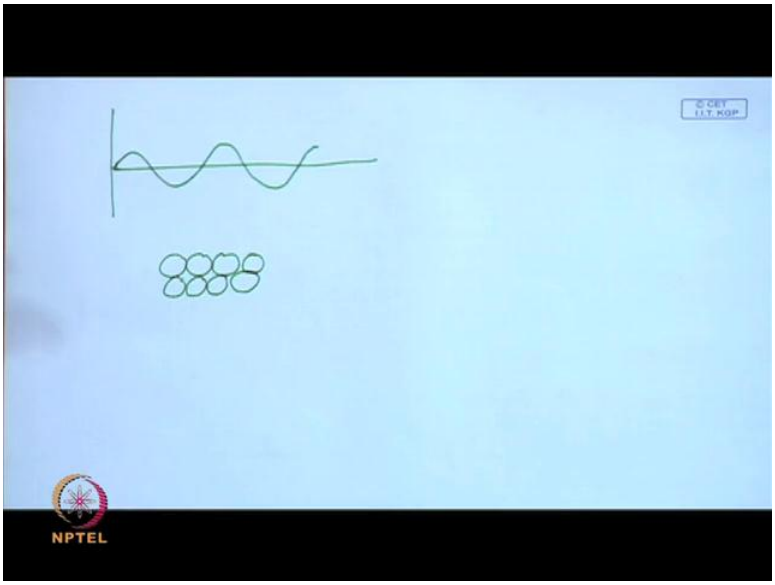


So, if I draw a simple diagram something likes this. This is nothing but a pattern or if I draw diagrams like this, this is also a pattern. So, the problem of pattern recognition is given some signal whether it is one dimensional signal or a two dimensional signal. We want the machine to recognize that particular signal, so that is what the problem of pattern recognition is. Now, let us look at the origin of the pattern recognition problems; pattern recognition, though we talk of problem recognition problems these days, but the problem of pattern recognition is not that new. In fact it started with in the early years with the effort of the understanding intelligence. So, what is meant by intelligence?

We can purely define and intelligence as the ability to comprehend or to understand and profit from experience. So, what do I mean by that ability to comprehend and to understand and profit from the experience? Let us take a very simple example, suppose I

have a sharp object, so if I take the tip of this pen, so I all of you can see this pen. If I take the tip of this pen, the tip of this pen is quite sharp or even if it is sharper than this. Say for example, the tip of a pin which is very sharp and we know that if we touch or if we hit the tip of the pin in that case this hurts our finger. So, that is what is our experience and how do I profit from this experience. The profit is that whenever I come across such a sharp end I will not try to touch it hard, because I know that it will hurt me.

Similarly, if I take the example of fire, you know if I put my finger in the fire, the fire will burn my finger. So, that is the experience and how I profit from this experience is that, whenever there is fire I will not put my finger into fire. So, that is what is my experience. So, as I said that the good way of defining intelligence is to comprehend or to understand and profit from the experience. That is what is intelligence or we can say, also say that it is the capability and to acquire and apply knowledge. So, we should be able to acquire knowledge and I should be able to apply the knowledge that I have acquired. Now, let me show to define pictures.

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So, find that I have 2 pictures in the slide. On the left I have 1 picture and on the right I have another picture. So, if I ask you that can you recognize these 2 pictures, if you have seen it earlier, we will obviously say that this left hand side the picture, which is on the left it is nothing but a painting. To be more specific, if I know I say that it is wall painting in Ajanta caves.

Similarly, if you look at the picture on the right, 1 will immediately say that this is picture of a building. But, some of us would have seen this building or we have seen this picture before. We will say that this is the picture of Parliament house in New Delhi. Some of us will be able to recognize it and the question is if we are able to recognize these pictures then how do we recognize this pictures? Now, if I try to find out the answer to this particular question when I am able to recognize these pictures, then how do I recognize these pictures? The answer is not very new, in fact we have to go back almost 2005 years ago when Plato, who tried to give the answer to this, how do we recognize objects or how do we recognize pictures or how do we recognize patterns?

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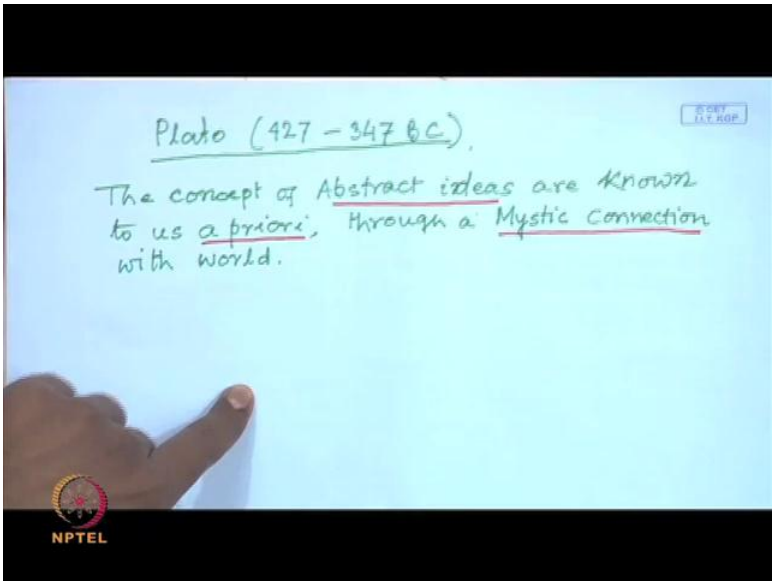


So, it is Plato. I mean it was in 427 to 347 BC, so you find that this is as early as more than 2005 years ago. And that time Plato said that the concept of abstract ideas is known to us a priori through a mystic connection to the world. So, if I write it the concept of abstract ideas are. So, you look at these 2 terms, 1 is abstract ideas, a priori and addition this is another term, which is mystic connection with the world. So, again if you look at these 2 pictures, we said that if we know we can say that this left hand is wall painting in Ajanta caves and the right picture is the picture of Parliament House in New Delhi. So, how do you know it in many cases, we have the pictures of wall painting in Ajanta caves.

In our school level history books, similarly some of us might have seen the Parliament House in New Delhi, or some of us might have seen the images or the photographs of the

Parliament House in New Delhi. So, that means this information or what I say is in this case it is an abstract idea, because I cannot specifically say that why do I recognize this to be a painting in Ajanta caves and why do I recognize or how do I recognize this to be the image of Parliament House.

So, this concept is actual and abstract concept and I can identify it to be a painting in Ajanta caves, or the other 1 to be the image of Parliament House in New Delhi, because this information or this knowledge is already available to me a priori. So, what I am doing is I am making use of this a priori knowledge to recognize this two particular pictures. So, that is why these two terms that abstract ideas and a priori.

These are very important and not only this as I recognize the painting to be a painting in Ajanta caves. That means, this information is embedded or the image of the picture is embedded in my brain in some way. What is that way that is not yet fully understood? So, that is why it is said that through a mystic connection with the world, so these abstract ideas of a priori knowledge are stored in our brain in a very mystic way. It is mysteries that how do we recognize or how do we store that information or later on how do we retrieve that information to recognize certain things. Plato has also concluded that the ability to think is in a priori knowledge of the concepts. So, this is a priori term, which was told by Plato in many ways. Now, let us look at another picture.

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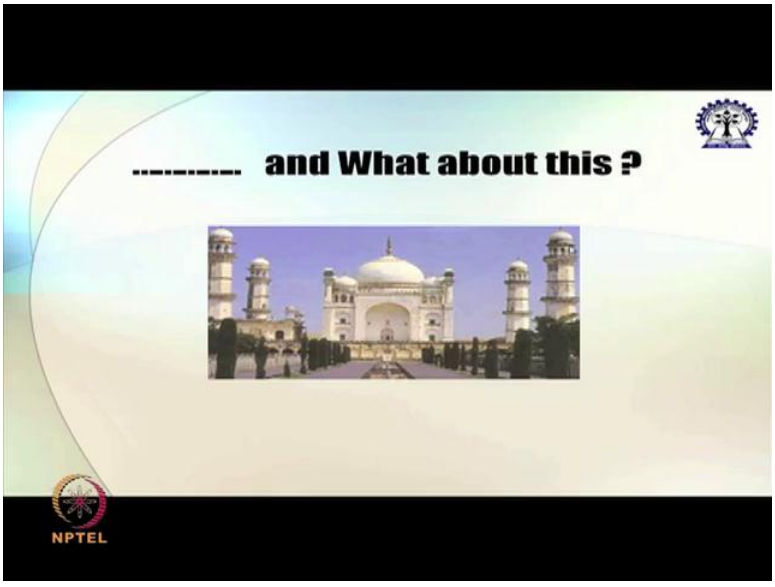

So, picture like this right. So, if we ask you that what is this picture you know that. Most of us have seen that images of some monument like this, which is Taj Mahal. So, if I look at this picture the immediate reaction will be, this is the picture of Taj Mahal.

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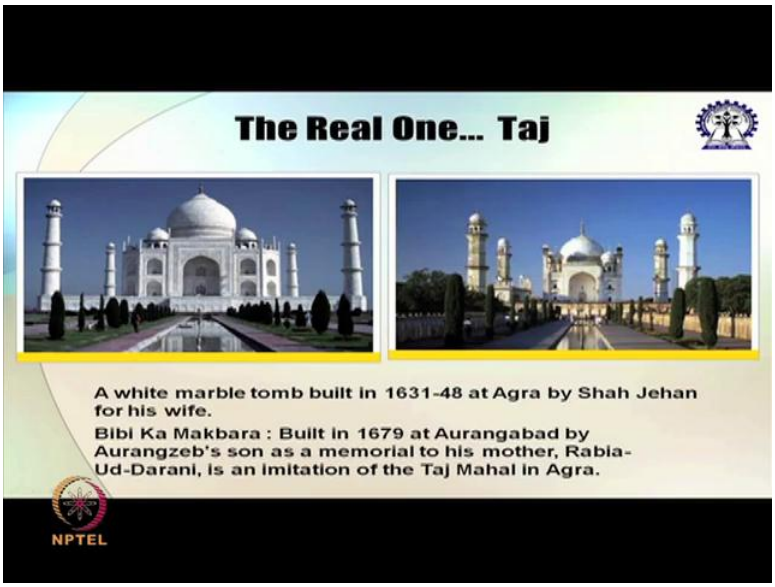


Now, if I show you the next 2 pictures, but you find that the picture on the right is nothing but the picture, we have seen earlier and the picture on the left that is something different. So, when I show you these 2, you will immediately say that picture on the left is the picture of the Taj Mahal, picture on the right is not really the picture of Taj Mahal, but it is a monument, which is very much similar to Taj Mahal. In fact, this monument is what is known as Bibi ka Makbara and it is situated in Aurangabad and which was built by Aurangzeb's son. But, they are very much alike. So, you find this a priori knowledge, which has been proved by Plato is not sufficient we should be able to adopt our knowledge. That means the learning we do have or the knowledge, acquiring knowledge which we employee that much be incremental in nature.

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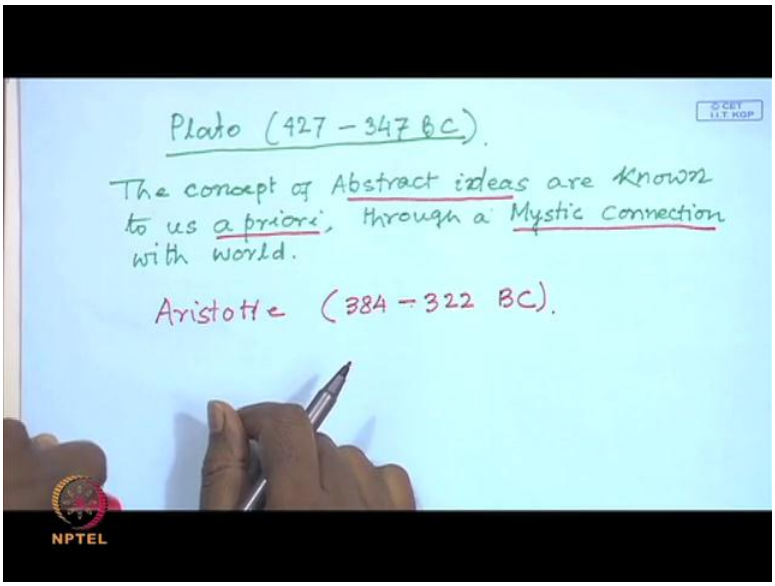


So, as a result Plato's student Aristotle, which was in 384 to 322 BC, you see before Christ, it is almost 2005 years ago. So, Aristotle who was actually Plato's student he did not fully agree the concept of a priori knowledge, which was given by Plato. So, what Aristotle said that it is not only the a priori knowledge, which is very important, but also the ability to learn or to adapt to the changing world, that is also equally important. That means we should be ability to adopt to the changing environment and a learning process must be adaptive. That is we should be able to learn new and new things and we should be able to modify the knowledge that we have already acquired.

So, what is the problem of pattern recognition in that case? So, as we have seen earlier say these 2 figures, they may represent some signal. They may ((Refer Time: 14:00)) represent certain structure and so on. So, the problem of pattern recognition is to identify the underlying structure within a data. So, if I have a given set of data I want to identify the structures within that data and what are the structures that I want to identify? They are the structures, which are known to me a priori, so that is what the pattern recognition problem is.

So, we can define purely the pattern recognition to be the start of structure in the data, so that is what is why patterning recognition. Now, why do I want this pattern recognition, what is the importance of pattern recognition? I want this pattern recognition, so that is

can impart certain power to a machine, so that the machine can work in the same way in which I can do what.

So, I want that the machines should be equally intelligent as a human being and whatever work we do, a machine or a computer should be able to do the same thing. So, what are the different approaches of pattern recognition? So, in this introductory lecture, I will briefly tell about or I will introduce the pattern recognition problem. I will talk about what are the approaches of the pattern recognition problems or to solve the pattern recognition problems during this course of pattern recognition and applications.

Now, coming to the application side the pattern recognition problem or the pattern recognition techniques have applications in various domains. For example take for example, the medical signal analysis. So, each of us have seen that whenever a doctor or medical practitioner have any doubt about the functioning of the heart, whether our heart is functioning properly they prescribe us to go for ECG check up.

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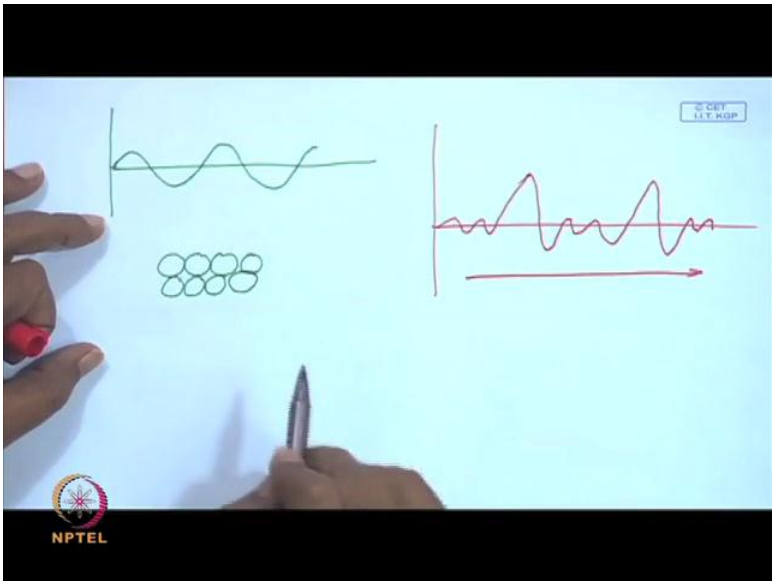


All of you know that when you go an ECG pattern the ECG pattern appears something like this and it is a repeated pattern, so this is nothing but a structure. So, what the doctors do is, they look at these patterns and by looking at these patterns, they try to judge whether our heart function is proper or there is some abnormality in our heart function. So, this is just 1 of the example, for the pattern recognition is very useful.

Similarly, we can have the application of the pattern recognition in speech recognition or in speaker recognition. I can easily recognize the voice of Hemant Kumar and easily recognize the voice of Lata Mangeshkar, I can easily recognize the voice of a star mostly and all those different people. But, all of them are singing, so which is nothing but an acoustic signal, because we discovered it is nothing but acoustic symbol. But, how do you from those acoustic signals, how do you recognize the voice of different persons? So, that is what is speaker recognition problem?

Similarly, I can have speech recognition problem. So, you might have heard about tools like speech to word conversion that speech to word conversion tool is nothing but whatever I am speaking, there is a machine which captures the voice and which is converted into electrical signal processes. That electrical signal extracts certain properties, or called features which I will come to a bit later.

And based on those features the machine tries to extract that which word I have uttered. It is a same concept, which is also used whenever we go for speaker recognition, because whenever I speak or I try to sing a song though I am not a singer. Whenever Hemant Kumar tries to sing a song, there is clear distinction between my voice and the voice of Hemant Kumar, so we can have signal processing techniques to extract those properties or those features from the speech signal.

Using those speeches, we can try, you should be able to recognize whether the voice is from Hemant Kumar or it is a voice of somebody else. So, similarly, in case of machine mission if I have an automated assembly shop, for we want that every operation has to be done by a robot in an automatic way. So, the robot must be capable of seeing what is there in the shop floor that means that the robot must be attached with a vision system, may be a digital camera. So, digital camera takes images of the shop floor, from those images it locates different objects.

Locating different objects is not sufficient, it should also be able to recognize which object is what and based on that it can pick up certain objects, and picks that object in some specific position. So, there also your pattern recognition or object recognition, because objects are also nothing but patterns. So, pattern recognition or object recognition is very useful. So, this problem of the domain recognition problems is quite wide the pattern recognition is applied in various applications, whether we try to

recognize the patterns into 1-dimensional signals or we try to recognize patterns into a two dimensional signal, like images. Now, when I go for such pattern recognition the pattern recognition can be done in 1 of the 2 ways.

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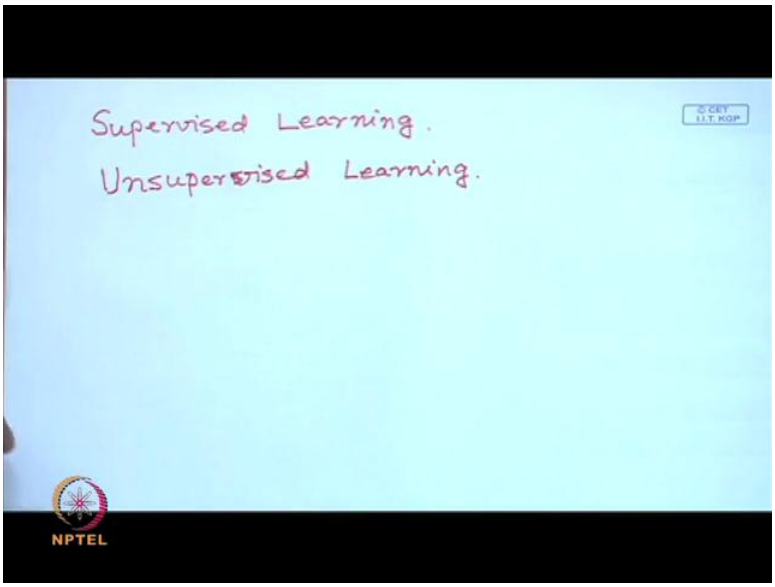


One of the way is called a supervised learning and the other approach is unsupervised, though the problem domains are slightly different. Now, let me just illustrate what is meant by supervised learning.

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Let us take few objects. So, this is asset of objects all of you know, what these are and I have another set of objects something like this. So, if I take the images of these 2 sets of objects they are nothing but patterns. And these patterns are to be known a priori coming, to what Plato said that I had to have a priori knowledge, or a priori information about the information that is have.

How do I have that a priori information? All of you know that this is nothing but and USB drive sometimes called pen drive, which is used to store data. So, I know that these class of objects or these class of patterns are nothing but USB drives or pen drives which are used for storage of data or storage of program or taking back up from a computer.

Similarly, here I have another set of objects or another set of patterns and I know that these are pens with which I can write. So, these are 2 sets of patterns and the knowledge of patterns. I have a priori and how do I acquire this knowledge? Acquiring this knowledge is not a 1 day process, this knowledge has been acquired over the time studying from my child hood when I started writing a, b, C, d, my mother used to take a pen and she used to tell me this you can write and this is how you can write. So, you find that starting from our childhood, we have started learning patterns that is what is a priori knowledge and then I grown up a little bit then I started using these. This USB drives and then there also my teacher or my friends, who have used it before he must have told me that these are USB drives or pen drives with which you can take your data backup or with which you can take a program back up. Then I have started using this USB drives.

So, along with what Plato said that, abstract concepts are known a priori and then what Aristotle said that this concepts that we are learning, the learning must be incremental. That is in the childhood, I have learned about pens when I grown up I learnt about this USB drives. I did not use USB drives when I was child, so I am acquiring this incremental knowledge. So, you can easily see that the pattern recognition problems that we are talking about today that this are not really a recent problem. The problems you have thought of those are analyzed by the philosophers as early as 2005 years ago.

Now, let us come to our problem that when I have these 2 sets of objects. Now, if I put these objects I know that the similarity of these objects with these sets of objects is more than the similarity of this object with this set of objects. So, as a result I will recognize this object, which is now an unknown object to be a pen not to be a USB drive. So, this is

what I mean by supervised learning. So, in case of supervised learning I have to have a priori knowledge and when I get this a priori knowledge, this a priori knowledge is acquired through experience, through observation, through instruction. It can be many ways and during classification, if I am shown an unknown object then that unknown object has to be put into known classes, which are known a priori based on the similarity measure.

So, when I try to classify this object to a pen effectively, what I am trying to do is I am trying to find out the similarity between these object and these sets of objects, and I compute that the similarity of these object with these set of objects is more than the similarity of these object, with these set of objects. So, I recognize this object to be a pen not as a USB drive and this is what is supervised learning.

In case of supervised learning I must have a priori knowledge and that a priori knowledge may be acquired through experience, through observation, through instruction, it can be many ways, okay? And I apply that a priori knowledge to recognize or to classify an unknown object or an unknown pattern, so this is what our supervised learning pattern is. Now, the other category that I said, which is unsupervised learning in case of unsupervised learning nothing is told a priori.

So, what I have is, I have a mixture of all these objects right the problem is something like this I have a mixture of all these different objects. And from this mixture I have to separate the objects into 2 or more groups. So, what I will do is I will try to find out the objects, which are similar and put them into 1 group and objects which are not similar to the objects belonging to that group will be put in other groups.

So, over here I will simply put these objects into 1 group because they appear to be similar, and I will put these objects into another group, because they appear to be similar. So, what I had initially is a set of objects for which I do not have a priori knowledge and what I am doing now is, I find out every pair of objects which are similar and the objects which are similar are put in 1 group. Objects which are dissimilar are put in different groups.

So, doing that if take any 2 objects from a group they must be similar. That means, they have high degree of similarity, but if I take an object from 1 group and another object from another group, they must be dissimilar or the degree of similarity may be very poor.

So, this is a 1 for which I do not apply any prior knowledge is what is known as unsupervised learning, that is what I said.

So, whenever we talk about such pattern recognition problems the pattern recognition problems are categorized in to 2 different types, 1 is supervised learning other is unsupervised learning. In case of supervised learning, we have a priori knowledge of pattern or we have a priori knowledge of objects. And using that a priori knowledge I want to recognize, or I try to recognize or classify an unknown pattern or an unknown object.

In case of unsupervised learning, I have a mixture of objects, I do not have a priori knowledge, but from that mixture of products what I do is, I partition them into different groups for objects within the same group and similar are similar and objects belonging to different groups are dissimilar. So, I have to have some sort of similar image, now again I come back to what Plato said, a priori knowledge is embedded in our brain in some mystic way. It is really a mystery that how the information is actually embedded or stored in our brain and how do we retrieve that information to recognize an object.

Now, you think of our purposes that I want to impart the same level of expertise or the same level of intelligence to a computer or to a computing machine. So, that the computer can walk the same way in which, I walk or the computer should be able to say that this is 1 object this is another object. Though as a human being this is pretty obvious to me, I will simply say that, these two are not same they are different, this is a pen, where as this a USB drive. But, our challenge is that how do we want or how do we expect the computer to do the same thing, the computer to solve the same problem.

So, all of you who have knowledge of computer programming or writing algorithms, you know that if I want the computer to do the same operation, then I must have some description of the objects or the description of the patterns. So, this object should have some description, these objects should have similar description. So, the description or the instance of the description of this object, and the instance of the description of this object they should be different and this is this description what I am calling as feature. So, what are the different types of features that we can have? So, in this course initially we talk about the feature extraction. So, our first topic of this pattern recognition and application lecture series will be feature extraction.

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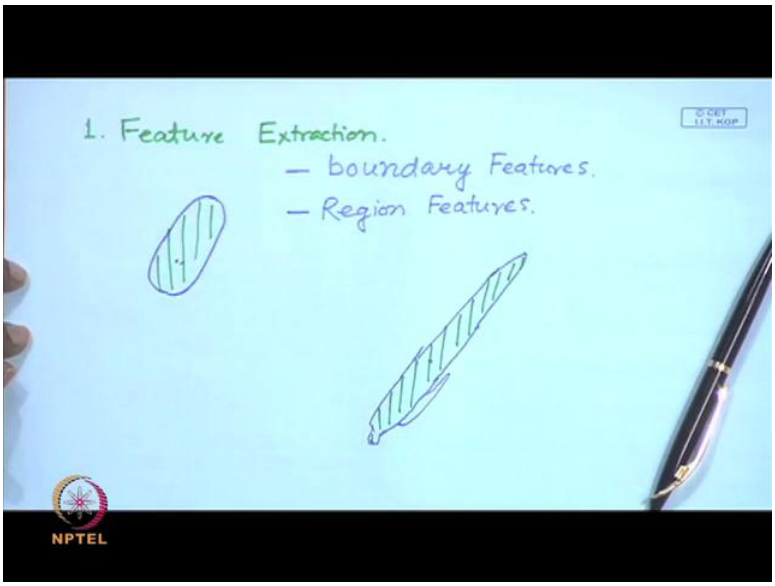


So, what is this feature extraction? So, for example, if I take this device this USB drive and if I take this pen, you find that if I draw the boundary of these 2 defined objects. The boundary of this object will be something like this. Similarly, the boundary of this object will be something like this, right? So, you find that there is clear difference in the boundary, so I can have the features, which are derived, which are extracted from the boundary. Not only boundary, both these objects have a region, which are bounded by the boundary. So, this is the bounding region of the USB drive and this is the boundary region of the pen, so I can have features from these bounding regions, also.

Accordingly, when I talk about features, the features are usually of 2 types, 1 type of feature is known as boundary features and the other 1 is known as region features. So, boundary feature is the feature of the set of features, which can be derived, which can be extracted from the boundary of the object. It has to be argued that whenever it comes to a shape of an object most of the information is actually available on to the boundary.

Whenever we cannot discriminate among different objects or the different patterns using boundary information, only then we go for region features which are obtained from the region enclosed from the boundary. So, what is the boundary based features that we can extract from it? What I can do is I can have this boundary in the digital domain, is nothing but a set of points.

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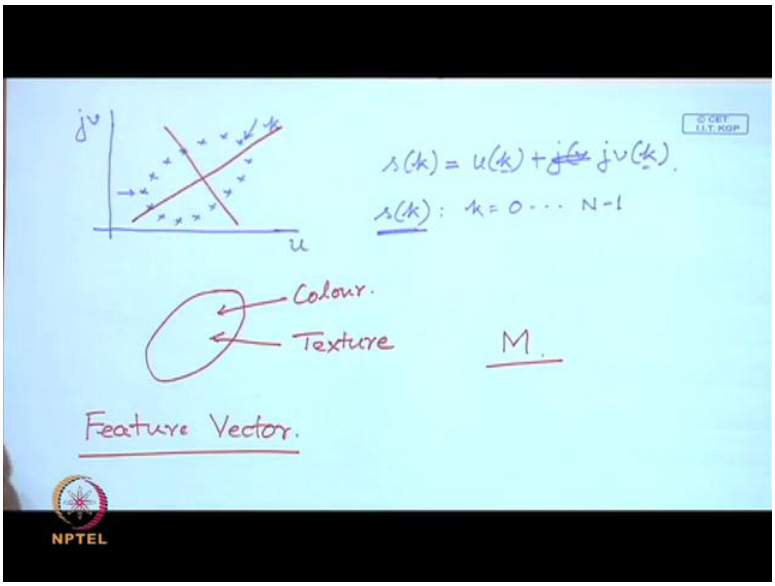


So, what I have is, if I draw it in a two dimension or objects are actually three-dimensional, I can illustrate that with the help of two dimensional figures. So, this boundary is actually nothing but a set of points in a two dimensional space, something like this. So, when I have a set of features like this, I can assume this horizontal axis to be my real axis and the vertical axis to be an imaginary axis. So, given this every point in this boundary can be represented by an complex number say s k which is nothing but u k plus j v k.

I have all these different points for different values of k, so what I actually have if I start scanning this boundary from any of the initial point. What I have is a set of my complex numbers is k, where k varies from 0 to capital n minus 1. If I have capital n in number of such boundary points, so you find that it is nothing but a sequence of such complex numbers. Then 1 of the ways in which the feature can be extracted is that I have a sequence of complex numbers. What I simply do is take the first fully transformed, or discreet fully transformed of this sequence of complex numbers, when I take the discreet fully transformation.

As I have capital in number of samples complex, samples, I have capital N number of discreet fully transformed coefficients. And the magnitudes of those capital N number of discreet fully coefficients itself can describe this particular boundary. So, that becomes a set of feature, so there are various other ways this is just 1 example there are various

other ways in which the feature can be extracted. One of the ways can be that when I have such a boundary I may like to find out the movement of this shape around the principle axis. I will find out the moment of this shape around this axis, and I find out the moment of this shape around another axis, which is orthogonal to the principle axis.

So, I get 2 components, so 1 is moment around the principle axis the other 1 is moment around an axis, which is orthogonal to the principle axis and passing towards the center of gravity of the particular shape so you get another set of feature. This is what is shape feature, so I can have boundary feature, I can have shape feature coming to the regional features, the bounded region will have certain color, it can also have certain texture. So, I can extract the color property which is can call color feature. I can find out, I can extract the texture property which I can call texture feature.

So, this particular object now has different types of properties or set of properties are computed from the boundary are set of properties are computed using the shaping formation like moments, or set of from the color or set of properties from the texture and so on. So, all these different features actually gave me different numerical values and if I put these numerical values in a certain order each of the numerical values gives me some information of this object. When all this numerical values are put in a certain order what I get is a vector right. So, every individual component is feature and all the features take together in a particular order gives me what is called a feature vector.

So, find now that the objects or the patterns are represented by the corresponding vector. So, whenever I have such a vector representation of an object or a pattern my classification becomes very simple. How does it become simple? Because, if the components in my feature vector are say capital M, that is every pattern is represented by an M dimensional vector effectively. What I am doing is, I am transforming the pattern or the object from its special domain or time domain to another space, which is a feature space and because this feature vectors are M dimensional. So, what I have defined is an M dimensional feature space for simplicity, because I will be drawing in the paper.

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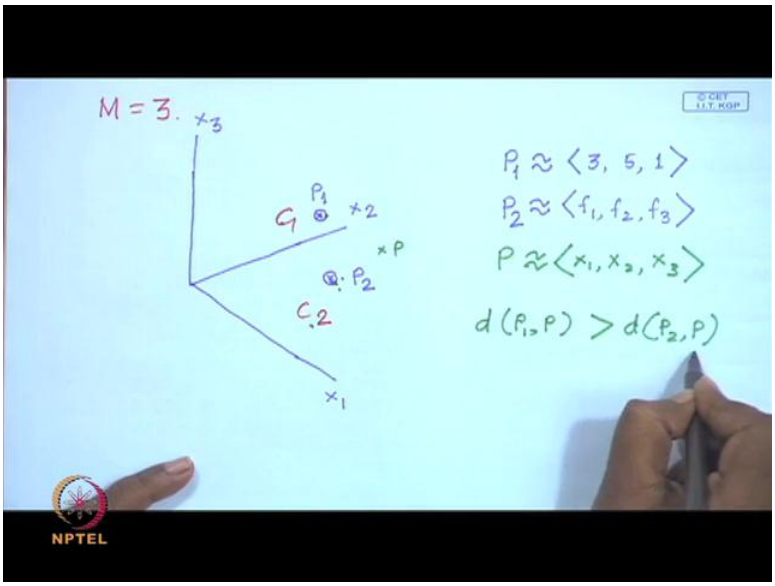


If I assume the value of M to be 3, so I assume M is equal to 3 that means that I have three-dimensional feature vectors for every pattern I have 1 three-dimensional feature vector. Then what is my advantage is whenever I have such feature vectors of say dimension three, what I am effectively doing is I am presenting my pattern in a three-dimensional space, which is nothing but feature space. So, this is my feature 1, let me call it x 1, this is the dimension of x 2, this is the dimension x 3.

So, if pattern P 1 will be represented by a vector, say something like this 3 5 1, which is the feature vector corresponding to pattern P 1 and the moment I have this three-dimensional feature vector. This three-dimensional feature vector is nothing but a point in my three-dimensional space which may be says some where here, so this is the feature vector corresponding to my pattern P 1.

Similarly, I can have a point P 2, which is again represented by a feature vector say f 1, f 2, f 3, but this f 1 will have certain numerical value f 2 will have certain numerical value, f 3 will also have certain numerical value. This pattern P 2 once it is represented by such a feature vector, this pattern P 2 will also be a point in my three-dimensional feature space. Now, look the advantages that once these patterns are represented in the three-dimensional feature space, I can measure the similarity or dis similarity between these two patterns P 1 and P 2.

Simply by taking the distance between these two feature factors, if the patterns P 1 and P 2, they are identical. That means, this P 2 and this point P 1, they should be coincident that if one should be equal to 3, f 2 should be equal to 5 and f 3 should be equal to 1. In other words the distance between P 1 and P 2 should be equal to 0, if P 1 and P 2 are same pattern.

If P 1 and P 2 they are similar pattern they may not be exactly identical in that case. The distance between the corresponding features of vectors, when I compute the distance should be very small. If P 1 and P 2 they are widely different, there is no similarity between P 1 and P 2, in that case the distance between the corresponding feature vectors in the three-dimensional feature space will be very large.

So, if the distance between the feature vectors is small or negligible, we can say that those patterns are similar or they are the same patterns, slight difference in the feature values. That is may be due to measurement error, may be due to fabrication error, but the patterns are same if there is no error, then the feature of vectors must be identical. So, I have different sources of error, I can have measurement error, I can have fabrication error. All this different types of errors may come in which does not make the features of vectors identical, but the feature of vector should be very close that is the distance between the feature of vectors are very small.

So, I can have a measure of similarity, I can decide whether the patterns are similar or the patterns are not similar from the distance between the corresponding feature of vectors. If the distance is very small then they are similar, if the distance is large then they are not similar, so this is my simple rule. Now, let us assume that this point P 1 and this point P 2, they are patterns of two different classes, they are patterns of 2 different classes and these two patterns are known as priori. So, this point P 1 may come from a class of C 1 and this pattern C 2 may come from pattern C 2.

Now, my job will be that given an unknown pattern say P, but this P is also represented by a similar such feature vector something like this say x 1, x 2, x 3. So, my job is that I have this a priori in P 1 and have this a priori in P 2. I know P 1 belongs to C 1, P 2 belongs to C 2. So, my job is that given now unknown pattern P, I have to recognize this pattern or I have to classify this pattern.

So, one simple classification rule can be that, because I have these two known patterns P 1 and P 2. I find out the distance from P 1 to P, I find out the distance from P 2 to P, so what I have to do is I have to find out distance between P 1 and P and I have to find out distance from P 2 to P. So, if I find that the distance from P 1 to P is greater than distance e from P 2 to P that means P 1 this unknown pattern P is more similar to P 2 than to P 1, because the distance between P 1 and o is more than the distance between P 2 and P. So, this unknown pattern P is more similar to P 2 than it is similar to P 1. So, my simple classification rule can be that I will classify or I will recognize this unknown pattern to be a pattern belonging to class C 2.

It will not be pattern belonging to class C 1, so during our course of lectures, initial few lectures we will devote for different types of features and different types of features extraction techniques. Next, we will talk about different types of classification problems. Now, when I, the moment I have come for the classification, we said that we want to represent every pattern by a corresponding feature vector.

So, once a pattern is represented by a feature vector, whether it is temporal pattern like speech signal or the signal coming out of any other source, or it is a special signal like image or video. Video is of course, a spacio temporal signal, because I have different number of frames, the frames are played at a certain rate 30 frames per second and 25 frames per second and so on. So, images are special signal, speech signals are totally temporal signals, videos are spacio temporal signals.

I have special variation, variation along the space I have also variation along the time, so those are actually spacio temporal signals. Now, whatever type of signals or whatever type of patterns I have once, I cover the pattern to feature vector. My classification remains the same, because what I have to do is depending upon the application domain. I have to train my classifier so that it can work in that particular application domain. So what I can do is I can put this pattern recognition problem in a block diagram, something like this.

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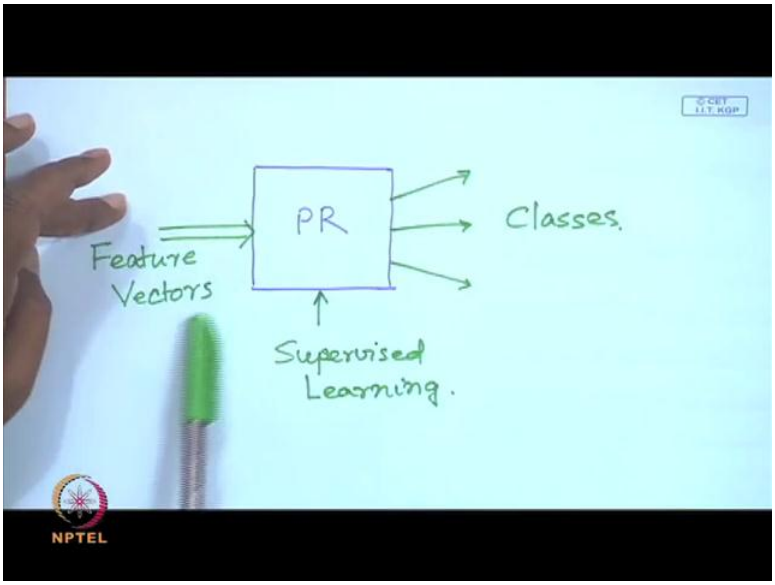


So, I have pattern recognition or a pattern recognizer, let me call it as P R input to this pattern recognition system, will be my feature vectors. So, these are feature vectors and output of the pattern recognition system will be the decision about different classes of this input feature of vector. When I have this pattern recognition system this pattern recognition system must be trained or learned by a supervised learning approach.

So, for supervised learning what I have to do is I have to input a set of feature vectors or different sets of feature vectors for different sets. I must know what class, from which class that particular set of feature vector has come, so that is what is supervised and based on what information I have to train this pattern recognition system. Once the pattern recognition system is trained then given an unknown feature vector. I should be able to say, or this pattern recognition system must be able to recognize to which class this feature of vector should be classified or it should be wrong.

Now, given this shot of a block diagram that this shot of pattern recognition system can now be applied in any domain. It can be used for speech recognition it can be used for speaker recognition, it can be used for object recognition, it can be used for image classification. Now, what I mean by image classification, I can have images of different types; I can have indoor images, I can have images of natural scene, I can have images of a shop floor. If my pattern recognition is properly trained after properly finding out the feature vectors, then this pattern recognition system can be used to recognize or to classify patterns from any domain, right?

Of course, the pattern recognition system for speech recognition is different from the pattern recognition system for objective recognition because the domain knowledge is different. My representation of the feature vectors will be different. So, in this particular course what we will talk about is, we initially we talked about the different techniques to extract the feature of vectors.

What are different types of feature of vectors that can be used, what are different techniques to extract the feature of vectors. And then we will go for different pattern recognition systems or different types of classifiers. Some of the classifiers make use of the statistical properties of the signals or the feature vectors are used using statistical property.

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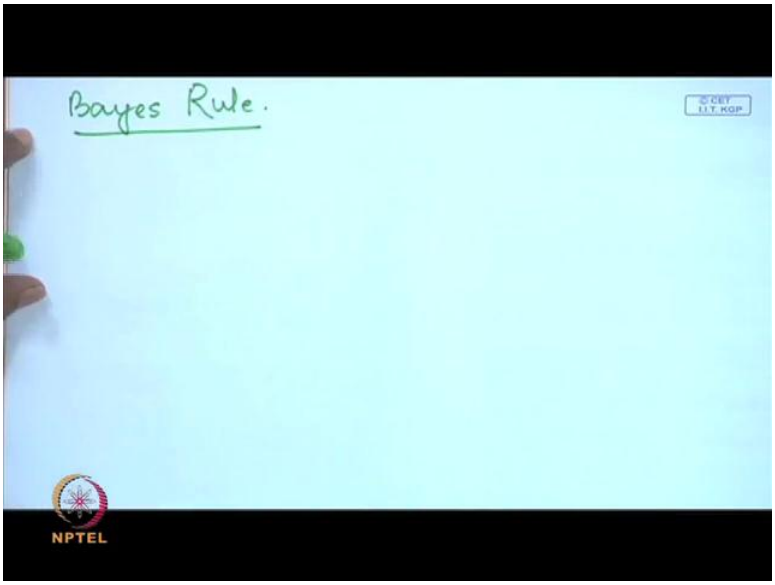


Then we can have probabilistic models of different classes making use of mean and variants of the feature vectors, which we will talk about, when we talk about something called Bayes rule, which is used in statistical classification or statistical classifier. So, there again we can have two different forms of classifier one form of classifier is called a parametric classification technique. Another form classification is called a non-parametric classification technique. So, in case of parametric classification whenever I have a statistical model a probabilistic model of a particular class, we will assume that the probability density function will have a parametric form.

In the sense say for example, a Goshen probability density function that has two different parameters, one is mean other one is variance. When I have feature vectors of multiple dimensions, I will have mean vector and covariance matrix so which of the parameters of probability density function. If I assume the probability density function to be Goshen, but in most of the cases it may so happen that the probability density function, which is exhibited by the samples. They do not follow any particular parametric form.

So, I will have different types of non-parametric classification techniques, so you will have parametric classification techniques. We will have different types of non-parametric classification techniques, then we will also have other types of classification techniques. For example, neural network many of you might have heard of it neural network is an attempt to build machines which can imitate the functioning of our human brain. So, we will also discuss about different types of neural networks, which can be used for pattern recognition or pattern classification.

We will talk about another type of pattern recognition or pattern classification, which is called hyper box classifier then we will also try to combine hyper box classifier with the fuzzy measure. Later on we will combine our hyper box classifier fuzzy measure and neural network to have certain model called funny mean max neural network. So, that is another type of tools fuzzy mean max neural network that can also be used for pattern recognition and pattern classification.

We will also talk about something called support vector machine, so what does support machine vector does is, it defines a plane in my feature space. So, using that plane I can divide the space into two half spaces. So, in one of the half space I will have patterns belonging to one class, in the other half space we will have patterns belonging to some other class.

So, the support vector machine actually tells you that given A set of training features of the training feature vectors, where to put this plane or hyper plane, how to sub divide my feature space into half spaces so that my classification, when I go for classification I can attain minimum error of classification. So, all these different types of techniques for pattern classification we will talk about. Then later on we will also talk about classification of temporal patterns.

So, for example, if I simply put my hand like this or my palm like this it's just a palm, but it is not sufficient. But, if I wave like this, this has certain meaning, if I put it like this it has some other meaning. So, simply palm showing a palm is not sufficient. It is also important that how the palm moves over time, because that can state a meaning so it is a temporal pattern. So, you will also talk about how to recognize or how to classify such temporal patterns. So, these are the different techniques that we will be talking about during this course, on pattern recognition and applications. So, in the next class we shall start talking about the feature extraction techniques.

Thank you.