INDIAN INSTITUTE OF TECHNOLOGY MADRAS

NPTEL

National Programme on Technology Enhanced Learning

Pattern Recognition

Module 01

Lecture 01

Principles of Pattern Recognition 1
(Introduction and Uses)

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Hello this is Professor C.A. Murthy from ISI Kolkata and Professor Sugandu Das from IIT, Chennai. We are both responsible for the lectures of pattern recognition in the empital phase 2 program. Thank you. Good Morning to you all. This is the lecture on, we are going to give forty lectures on pattern recognition, the responsibility of this lectures is given to Professor Sugandu Das, IIT, Madras and myself I am C.A Murthy, from Indian Statistical Institute, Kolkata.

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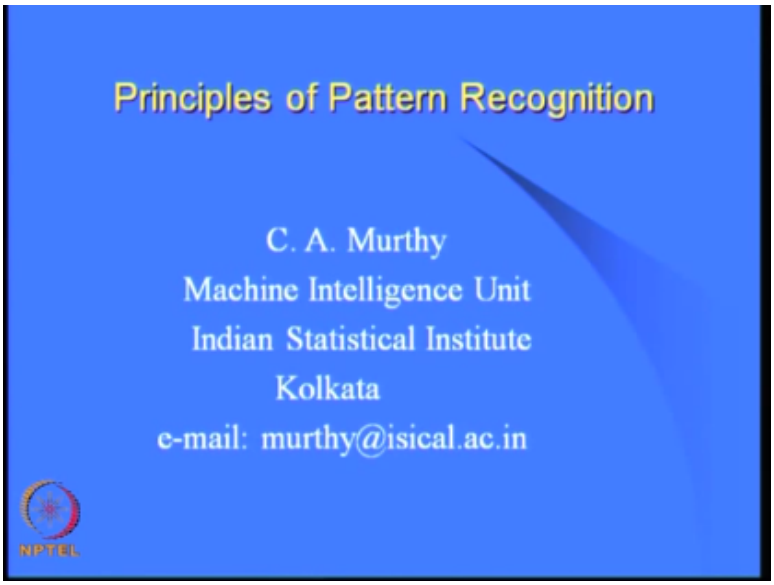

Before I start going into the details of the subject pattern recognition let me actually tell you the uses of pattern recognition and why it is necessary to learn pattern recognition. For that let me tell you a few examples, I start with the example of finding criminals or identifying criminals from photographs. Let us say you are an inspector in a police station and you have records of the criminals.

Let us say the number of such records is of the order of say 1 lakh and at some place a new crime was committed and someone has taken a photograph of the criminal who had committed the crime. The photograph comes to you. Now your responsibility is to see whether this photograph is one among the existing photographs that you have in your database. Now let us say your database has 1 lakh photograph, what is the meaning of having 1 lakh photographs?

For each individual or for each criminal there you would say, you would write the name of the criminal, may be the height, the sex, the finger prints, the photograph and also the types of crimes that he or she commits. So for each criminal probably there is a page giving all these details. So if you have 1 lakh criminals you have 1 lakh such pages. So now you have one photograph so you would ask probably one of your people to get all these 1 lakh pages which are put in a file, the file size may be like this.

So you would take the first page look at the photograph and the photograph that is given to you, no it is not matching, take the second one, it is not matching, third, it is not matching. How many times you are going to do it? Note that your eyes after doing this sort of checking for around 50, 60 photographs, your eyes will lose the sensitivity to differentiate between two photographs. Then in such a case naturally a human being is sort of incapable of going through all these 1 lakh photographs to find out whether the criminal is existing in the database or not.

So you would like a machine to do this job. Now how does a machine do this thing? This has simply too many components. The first thing is this information has to be recorded, it must be stored as a file, that is the first one and like that you need to store the photographs or the information about this 1 lakh criminals. Then after that what you are going to is when a new photograph comes you are supposed to do the matching. now how does one do the matching for each photograph, are you going to go through all these photographs in your database, is there any way you can reduce or you can say that these photographs I need not see them, I need not check them, is there any way that you can do this thing? Yes you can do this.

For example, say the height of the criminal that is the photograph that is given to you then that one who has taken the photograph if you says that the height of the criminal is say less than 5 feet, 6 inches, he is not really tall, he is less than, his height is less than 5 feet, 6 inches. Now in your database who saw your height is more than let us say 5 feet, 7 inches you need not look at their photographs, right?

Secondly suppose the person, the one who is there in the photograph is a male, you need not go through the photographs of all the females. So basically what you are doing is that you are putting some constraints or you are finding the features of, features corresponding to this photograph. In computer language basically you are making a tree corresponding to this database. So that you can do the identification faster, you can do the identification faster.

Now note that I used one word feature, sex of the person is a feature, height is a feature. You can features of many types. For example, the colour of the hair, the colour of my hair is grey and that can be a feature. Colour of eyes, colour of skin. Apart from height, weight and there are many other such things you may also have colours, you may also have very, many features depending on the problem at hand. The problem that I told you is known as face recognition problem.

The literature on pattern recognition, this problem is known as face recognition problem. Let me tell you some more examples, One example is regarding classification of pixels in satellite images. I hope you are aware of what a satellite image is. The satellite takes the photographs of earth, depending on the type of satellite and depending on the uses the resolutions of the images that it is taking it varies.

India has a satellite, Indian remote sensing satellite. It has several versions. IRS 1A, IRS 1B, IRS 1C. Let me talk about one version where the resolution is 36.25 metres. That is each pixel on an average occupies 36.25 multiplied by 36.25 square metres area. On an average each pixel occupies this much area. Usually these images are multi spectral images, that is for each location on earth you have four images taken at the same time, these images correspond to the wave lengths, blue, green, red and infrared.

Now your problem is for whatever pixels that are there. I hope all of you understand the meaning of the word pixel. I was mentioning to you, I was asking you a question whether you know what a pixel is?. I assume that you know what a pixel is so I am going to proceed further. The main problem in satellite, one of the main problems in satellite image is classification of pixels. You are given the photograph of areas on earth.

The photograph may consist of let us say it has 512 rows and 512 columns. So basically it has 512 by 512, these many pixels. 512 is number of rows, 512 is number of columns, so usually they have these many pixels. As I was mentioning to you every location it has a four images corresponding to every location. That is you have these are known as multi spectral images and using those four images you are supposed to classify each pixel to one of the land cover types.

What is the meaning of a land cover type? A land cover type is, maybe the pixel is corresponding to a water region on earth. The pixel maybe corresponding to a hilly region on earth, maybe there is a building on the location of the pixel. So these are the land cover types. Now how many land cover types you may

have? Well there are simply too many. You may have water, then among the pixels corresponding to land you may be having pixels corresponding to vegetation where you have rice fields.

And then you can have open spaces; that is barren land, you may have one particular category which is known as concrete structures where you have many, where you have buildings present, and you may have forest, you may have hilly regions, you may have snow like if you go to Himalayas or some such places you may have snow, you might be having sand if you go to the desert area you will find sand. Similarly if you go to the sea area there also you will find sand. So here I mentioned some land cover types.

Then, and the question is for the given region under consideration how many land cover types it may possess, and once you know the land cover types the number of land cover types then the next question is how do you classify each pixel to one of the land cover types? Before I come to the procedure of classification there is a valid question why do I need to do it? What is the use of doing this classification? Well it has many uses. Let me tell you some of the civil uses.

The government may be interested in knowing how much of forest area may be getting depleted every year because that has long term impact. Now if you ask human beings to do it due to several reasons you may be not be getting accurate estimate of this. Someone may want to give, may want to say that more forest area is getting depleted. Someone may give, someone may say that though quite a bit of forest area is getting depleted he may say that well the area that is getting depleted is not really much depending on one's own bias towards a specific situation. You might be interested in planning something.

For example here in Chennai you are planning to construct or maybe construction has already started for about a metro. Surely when people did this thing, when people have made this plan surely they must have looked at the soil content, where, at what place you should build this thing, whether you have barren land or not or how much money is to be given if you have to find that particular thing, okay and when you want to make a route then you should see how much time it may be taking?. So basically you need to know the complete zoology of that location. Now if you want to do it on a massive scale then again you need to do, you need to use machines to do it.

On a massive scale many of these things you need to have machines to do it. That is very much necessary. Now this is one use, there are many uses from the point of view of a military. Suppose you want to know in the border areas the amount of construction that is taking place in your neighbouring country. This every government would be interested in knowing since it has implications on the defence capabilities of the government.

So you would really like to know what concrete structures or what new structures are connecting up in the border areas. Now it is difficult for you to send always people to find out what new constructions are

taking place. Rather if you take photographs of those places and find it out automatically it will be helpful to you and like that one can think of many, many uses.

How much of, how much area is devastated in the floods? How does one know it? You might have the photographs of that region before the floods, you might be having the photographs of the region after the floods and you can look at the differences between them, you can do pattern recognition to find out that the amount of area that was devastated by floods. It may be because of, it may floods can be one of the things you might have earthquakes, you might have drought.

Like that you can have several other such natural calamities for which you will be needing this sort of information. Satellite images is one example where you need to use pattern recognition. Let me tell you there are very many other many examples. One other example that I would like to mention here is example, corresponding to the human intelligence.

Look at this. This is a chalk piece. Okay, now you see what I am doing. I get down this steps, I just put the chalk piece on the floor. The chalk piece is now there on the floor. Now suppose I ask anyone of you, I myself, suppose I have to walk on this floor. Now what I would just to I would just walk like this. Okay, I do not, I know this is a chalk piece and I also know that it is not dangerous. So I just walked over this. Now I know that this chalk is not dangerous, but instead of this chalk suppose there is a snake here.

Then surely I would not walk like this. Surely I would not walk like this. So basically I have made a differentiation between what a chalk is and what a snake is. The purpose of a chalk and what a snake can do and I would make a decision about whether I should cross or I should move over the chalk piece or I should move over the snake.

Now suppose instead of me a human being you want the same thing to be done by a robot. Now how does a robot do this thing? But before we go about how does a robot does this the main question is why do we want to make a machine to do this job? There are several reasons for it. Let me tell you one of the reasons. Suppose you would like to send a rocket to Mars, Jupiter, Saturn, or any one of these planets. Now surely you cannot send a human being to that place because the atmosphere there whatever it is it might not be suitable for a human being, so a human being may die.

So initially you would like to send a machine to those the places to investigate, to understand about the general nature of the soil, general nature of whatever may be the atmosphere etcetera. And you cannot send a human being so you would like to send a machine there. Now when a machine is placed in that alien region on a planet this machine is supposed to navigate the entire region. It should be able to move from one place to another, so how does the machine move? That is the problem for which I was giving you this example.

Now let us see how does a machine move. You see when I am asked to move from one place to another on this floor I just moved, there are some steps, I just went up the steps and I just came down. Now when a machine, when it sees the whole scenario first it needs to know what is what. That means it needs to know that this is a camera, this is a TV screen, this is a bulb here and this is a table, this is a laptop, that is blackboard, all these things it needs to know, it needs to know the uses, it also needs to know whether any one of these things its harmful to it, it needs to know somehow all these things.

Now how does it do it? How does know it? Now a whole stuff literature is there on this problem. You have the whole of image processing, computer vision and a few other aligned subjects depending on the applications on hand; you have many subjects which are trying to tackle this same problem. The main subjects are image processing and computer vision and you have a few other subjects. Medical imaging is one subject where people, where the doctors and the image processing people they are trying to see what is happening inside the body, there are many machines available which take photographs or which sense the, which sense what is there inside our body.

You have x-rays, you have several types of scans, you have ECG, EEG, etcetera, okay and all these things. Earlier, in fact in India even now also the human beings would interpret all these things and they would give their judgments about the properties or the about the decision of the human being under consideration, but then these are very costly. If you have a machine which does, once the photograph or once the scan is given to the machine if it automatically says that at this place this portion is not proper so that is to be rectified.

If a machine says this then the, we will be spending less on this thing. Rather if you want a human being to say this thing then on the doctor we will be spending more money whereas machines we will be spending less money. This is about medical imaging and we also have as I said the usual recognition of objects like what is a table, what is a chair, how does one define what a table is, how does one define what a chair is, how does, how do you know that what is a chair, what is a table?

Apart from these things, apart from all these objects one also needs to know the relationship between these objects. For example, let us just see, for example in different rooms the location of switches that is at different places you will be having. Generally when you enter the room in some rooms the switchboard may be put on the right hand side, in some other room the switchboard may put on the left hand side of the door, okay.

Now whether it is put on the left hand side or the left hand side, in whatever side it is, it is basically a switchboard; that is what this robot should understand. If you are looking at what all the things the robot needs to understand you will actually look at the whole gamut of what we see and understand. You see the

whole entire earth, whatever objects that we see, you want a machine to know what that objects is, this is only one part of it, there is another part.

Look at this table, this is hard, this surface is hard, I know it, but look at the carpet or look at this place, this carpet is not hard so when I walk and on a carpet I will be slightly more careful than when I walk on a hard surface. When this robot is put in a alien conditions in say Mars, on Mars or say Jupiter or Saturn, one of these planets if it needs to move from one place to another place it needs to know that the place that is moving, the floor, it is not soft. How does the robot know it?

Suppose you are asked to stand in front of a hill and then you are asked, okay, would you like to climb the hill, then you will say well I think I can climb the hill because I am sure that I can come down the hill. Some person may say no, no, no, I do not want to climb because I may not be able to come back properly, I may not be able to climb the whole hill also properly. These decisions we make without actually doing the job. Now here the robot in on a planet, say Jupiter, Saturn or Mars whatever may be the planet, it must be able to make the decision.

When it looks at the terrain it needs to know whether there is a valley there or a hill, it needs to understand that it is a hill or a valley and once it understands it, it also needs to make a judgment about whether it can move up the hill or down the valley, so that if it is moving down the valley it must be confident to be able to be come up. Now all these are actually part of pattern recognition where the main input, the system is a set of images. The main input in a system is a set of images. If you look at the problem of identifying each and every thing that we see you will understand it is an entire gamut of what pattern recognition is.

And if I say that you need to know the interrelationship between the objects that also need to be stored in the computer then you would see not only just identification of the objects but also something more. Look at the name, pattern recognition, you are supposed to recognize patterns and the patterns may be existing at many, many places. If you look at the gamut of the set of problem that I mentioned you will see practically very many subjects coming into the whole spectrum of the subject pattern recognition. What is the meaning of subjects coming into it?

Let me ask you a question, how do you solve a problem in mathematics? How do we think? Pattern recognition people want to model the thinking process, the human brain. There is a subject which is known as neural likeness where the first algorithm of neural likeness which is actually known as single layer or spectrum or in those days algorithm was known as a spectrum. It tries to mimic the thinking of human being so that it does the classification. So if you want to also understand how a human thinks and

that you want to put it in the brain of the computer then what is that you want to achieve in this subject pattern recognition?

We actually want to achieve everything that a human being can think logically, we want to achieve everything that a human being can think logically, can make logically. What is logic? The world logic has several implications. Let me tell you the general implications that we have in computer science literature. Basically the logic that we follow there is what is known as binary logic. 01, a statement is either true or it is not true, there is nothing in between that, but let us look at human beings, is there a statement, is it always true or is it always not true?

Dose not there is exist anything in between that? For a human being it is not necessarily true that something is true or false, only these two possibilities that is not a case for a human being, there is generally something in between these two possibilities for in many, many applications. Let me give an example, you say that he is a good man but is he really good always? You would say no, or he is it bad always, and you would say no, then what is this good and bad?

You are not giving complete, completely bad, that is zero to him or completely good you are not giving the value one to him, you are giving something in between, 0 and 1. Like that in all human, in all dealings of human beings we tend to use these sorts of adjectives and we actually have our own logic also when we use these adjectives. For example when I am teaching I am teaching one specific way, my statements need not be always mathematically precise but the people who are sitting in front of me they do understand even if the statements are not mathematically precise but for a machine you have to always give precise and perfect statements.

So there is a difference between what a machine needs and what, how a human being thinks, so even this gap we would like to bridge in pattern recognition. Then you try to look at what are the, what is the complete gamut of problems in pattern recognition. I think I gave you the uses of pattern recognition, now the next topic I will try to go into how does this subject work? I will go into the mathematics part of it slowly. I was mentioning to you the whole gamut of problems in pattern recognition, so let me tell you the gamut of problems.

Human beings have eyes to see something and to know what is what, human beings have ears with which we hear and we understand what the other person is speaking and we also understand who is speaking depending on the pattern of speech. We have nose which smells and by smell we understand quite a bit about the object under consideration, and we also have tongue.

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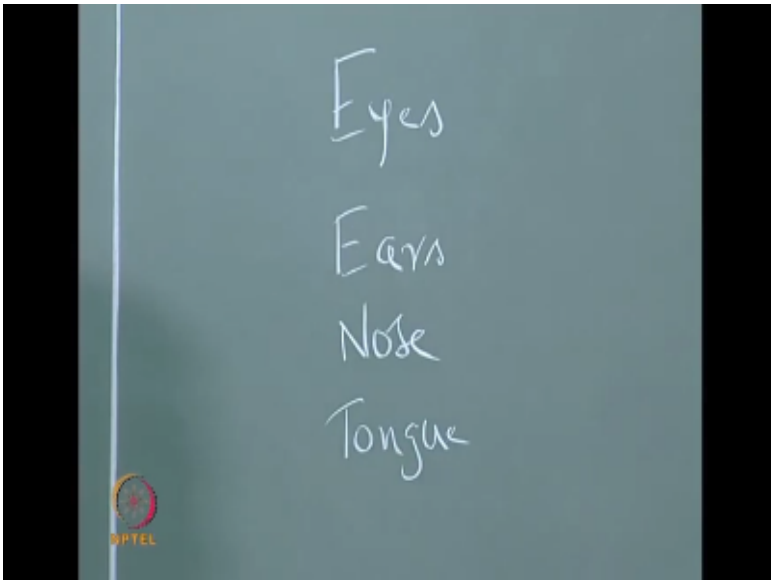

Which tells you that taste of an object okay, and we also understand whether an object is hard or soft when we touch it. So let me just write hard/soft.

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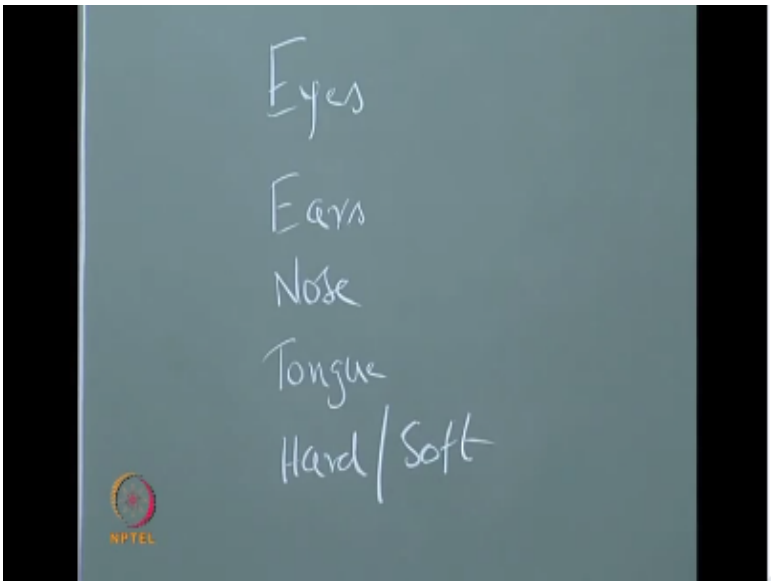

These are the five basic senses of a human being, with eyes we see and understand what an object is, with ears we hear and understand what the person is speaking and we smell on object and we understand some of its properties, we taste and we also understand whether an object is hard or soft by just touch. These are the basic five senses of a human being. Now once we get input from these five senses the input from these five senses it goes to our brain and our brain does analysis.

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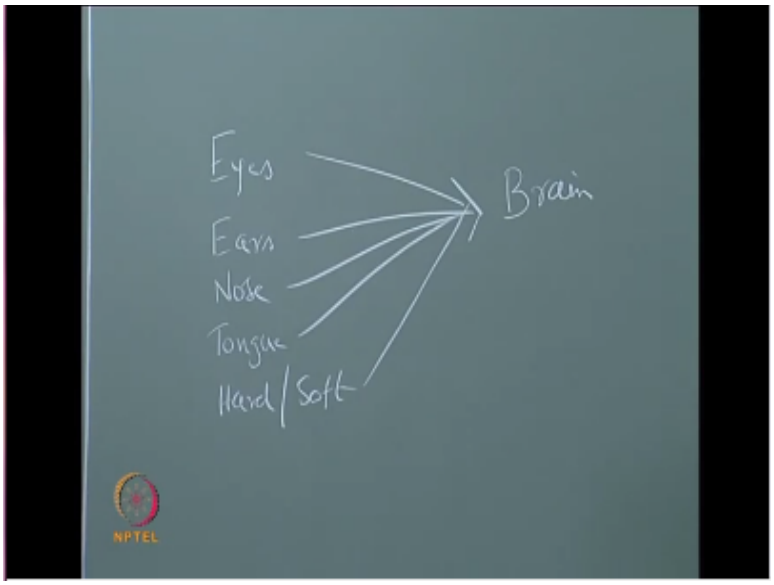

And it gives some output. We want to put this whole process in a machine. Apart from all these things human beings have one another characteristic. What is that? Human beings learn, what is the meaning of learning?

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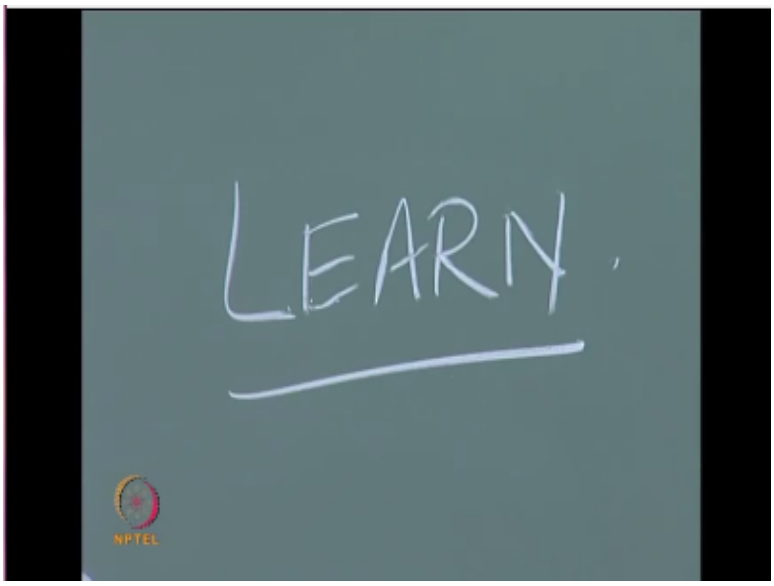

Well there are several examples for the meaning of learning, okay, let me just give you just one small example. This is my fourth or fifth time I have come to Madras, this city Chennai. Suppose a person does not know anything about Chennai and he is given an address and is he asked to find, he is asked to go to a particular location, find a particular house or flat and this person has never been to Chennai, then how does this person find it? If you ask this question to anyone of the people and even though the person has not been to that specific place under consideration the person is confident he will be able to find it out, how?

The person is confident that he will be able to learn about that particular thing even though he has not seen it, he has not read about it, this thing, this confidence and the process with which this person goes about learning about that particular phenomena and that particular thing under consideration, this is an example of learning and there are in fact very many such examples of learning. So this sort of thing also we would like to put into the computer, this is also we are understanding about the patterns that is existing in the nature.

So once you put the process of learning and you put all these things then basically what it is that we are trying to do? We are actually making a machine which somehow is replacing human being. Human beings apart from all these characteristics they also have one other characteristic; that is we people are emotional so when we are emotional many times we may not able to be think logically. Now if you make a machine and if you make it without any emotions then that machine would be a much better machine than a human being, it does not have the negative characteristics of a human being, this is the ultimate aim of this subject. The ultimate aim is to make a machine basically to be a computer which have all this.

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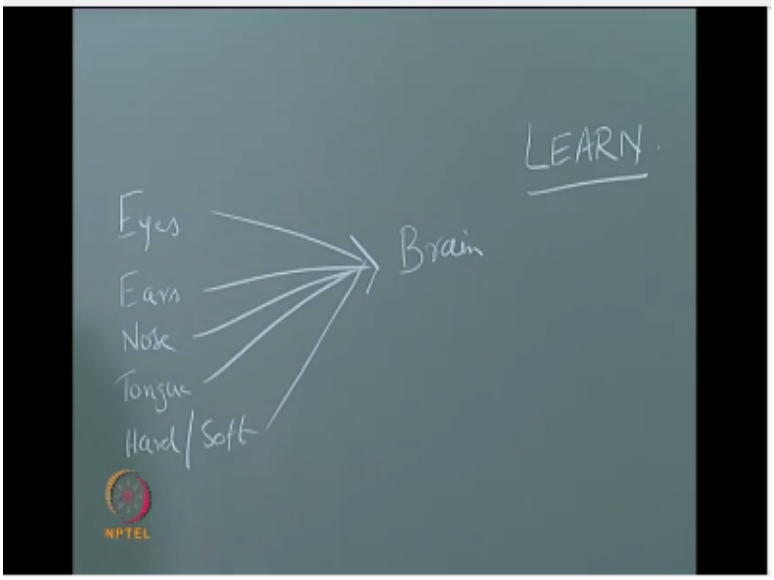

I should say faculties because these faculties human beings possess and you would like to devise one such machine so that it can walk, it can speak, it can hear, it can see, and it is able to know how an object smells and it also, it must also know whether an object is hard or soft, all these things you would like to number one, simulate, number two model in the machines. This is the ultimate goal of this subject pattern recognition. That means practically everything under the sun it is a part of this subject.

Practically everything under the sun is a part of this subject and look at the aims of the subject, it is enormous. You would like to recognise patterns wherever they are in whichever phenomena so the aims are enormous, there are naturally several, several subjects which came out of this which have become independent subjects now like image processing, computer vision, neuro networks, fuzzy logic and other subjects like medical imaging, some things regarding biomedical engineering and if you look at the thinking process, modelling thinking process that is extremely complicated and till now the number of good results on this really very, very small.

The subject is still in the nascent stage so it is enormous and you have too many uses of this. Now looking at the whole gamut of problems what is it that we are going to talk in these lectures? Looking at the whole gamut of problems the literature that is existing in the subject is in mathematics terminology it is only epsilon. I hope you understand the meaning of epsilon.

Epsilon in mathematics is used as a very, very small quantity, it is greater than zero but it is very, very small quantity; that is looking at the whole gamut of problems the results that are existing, they are really very, very small, it is only epsilon. Now within that epsilon in our lecture series we will cover epsilon. I

hope it is clear, let me tell you once again within that epsilon in our lecture series we will cover epsilon, that is which is very, very small and very insignificant portion.

The number of journals associated with pattern recognition and other derived subjects, it is at least 15 if not more international journals, so you have vast amount of literature available on several different problems in this subject. So with this brief introduction I hope I have made you understand what the uses of this subject are, in my next lecture I will start going into the mathematics portion of this subject, thank you.

End of Module 01 – Lecture 01

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