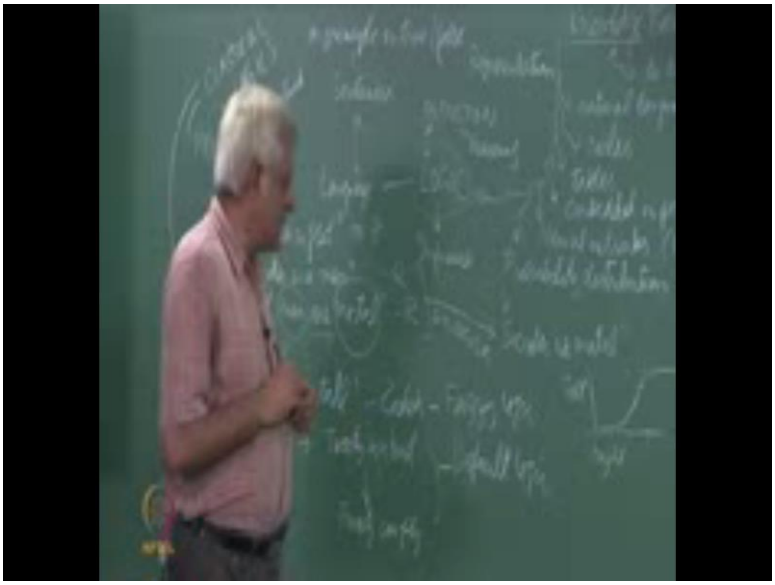
**Artificial Intelligence**
**Prof. Deepak Khemani**
**Department of Computer Science & Engineering**
**Indian Institute of Technology, Madras**

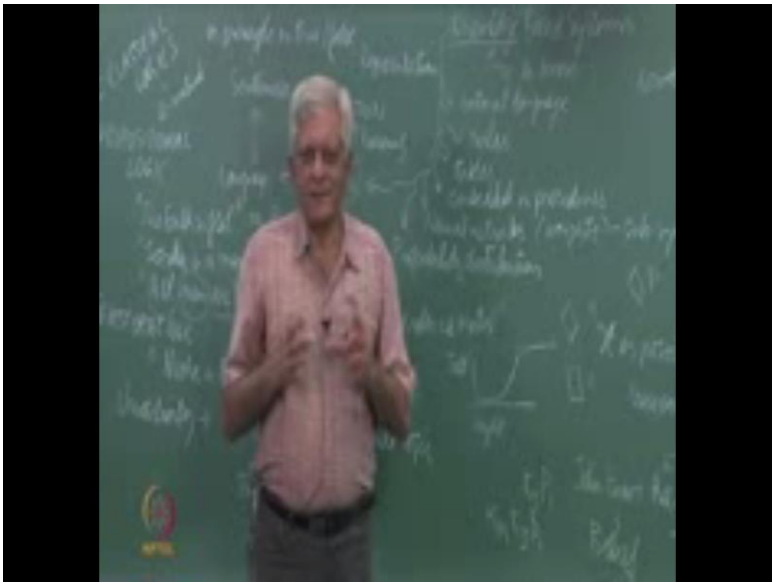
**Lecture - 41**
**Knowledge Based Systems**

So far in this course, we have looked at mostly search base methods and 1 form of the other. But if you look at human beings; human beings are essentially knowledge base creature by this I mean that we do not we very rarely do search all we well rare rarely do tried and other unless off course you are doing research or something which is the different matter. But by enlarge in everyday activity we look at a problem or we look at a situation and we instinctively do something.

And when say instinctively what I really mean is that we already have lots of experiences toward in our heads and we also have lot of rules that we have acquired over a period of time. We know exactly what to do. For example, if you it is raining and if you happen caring and a umbrella you instinctively open it. You do not plan and say that if you open in umbrella and keep it over your head then you will not get wet. In fact, you do not even reason about a goal saying that you have a goal of not being wet. So, lot of time we simply use knowledge. So, we want to now spend the rest of the semester looking at knowledge based approaches. In particular we will look only at a specific kind of knowledge representation which is logic base, but let us start off with the more general representation.

(Refer Slide Time: 01:36)





So, essentially you can associate the word knowledge bit to know that you know you know facts you know how to solve problems; you know how to play tic tac to you know how to ride a bicycle. All kinds of things are known to you essentially. And if a agent is to interact in a with it is world or with it is surroundings in an intelligent way. Then an agent needs to represent its surroundings create a model of its surroundings if you all and reason with that model. Not necessarily a model which reflects how the world is around us but some form of representation which helps us solve problems. So, if we remember that we had said that when these philosopher 2 three hundred years ago they were

wondering about what is mind? What is thinking? They said Hume and deccart 10 hobs they said thinking is meaningful; meaningful manipulation of symbols. So, if you recall this we are sought coming to this approach of what we mean by thinking.

Off course, when we did search we also did meaningful manipulation of symbols in the sense that we created a represent representation of the state space. We created the representation of the move and we move sought did some manipulation which would take us from the start state to the goal state. But now, we are talking in the more general sense so manipulation of symbols also we call the physical symbol system hypothesis which we had talked about in the very beginning saimon and newel. They said the ability to manipulate physical symbol systems is sufficiency to create intelligent behavior and what we meant by physical symbol systems? So, symbol systems of first we understand these are structures of symbols by physical what they meant was that they obey some kind of laws of reasoning. So, which is also serve ties of a this idea of manipulation of symbols know only question that remains is about meaningful.

We will try and get some insides into this as we progress not necessarily today, but may be in the next week. But let us focus on the fact that what we mean by thinking is representation of our situation or the world or the surroundings and the goals and the desires and anything. And thinking basically means manipulation of those representations if you sought of bring it down to simple computer science term. It basically means we want to do some kind of representation data structures we want to device and wherever we have data structures we need to have algorithms. So, manipulation of symbols would be done by algorithms and in that sense the word physical fits in there is that is that we have well defined ways of manipulating symbols which obey some laws. Essentially what is the kind of knowledge that we carry in our heads? So, simplest is natural language; natural language is a medium for representing knowledge and even exchanging knowledge essentially.

Of course, it is started off as a media of a exchanging, but as people device means of writing and printing books. It also became a means of representing knowledge so that somebody else could read it as a different point of time. Why do not we use natural language as a representation mechanism for knowledge? The main reason has we

probably have discussed earlier is that it is ambiguous it is not straightforward to understand what 1 is saying in an ambiguous un ambiguous passion essentially. Because languages is so first of all we can so say the same thing in many different ways. And secondly if you express something if you utter something for example, if I say she walked over towards a terminal. It is not clear entirely what I mean by this sentence or if I say he went towards the bank again it is not clear what I mean.

Because the words bank and words terminal have more than 1 sense is more than 1 meaning essentially a terminal could be terminal in a lab a computer terminal. It could also mean a terminal in a airport essentially so we do not know what we are talking about. Likewise bank could mean a river bank or it could mean a financial institution this, only word which have different senses, but other things like verbs also have different sense. We saw an example time fly's like an arrow I think we had discuss it the beginning of the course is a sentence which for us seem some ambiguous. But if you what to look at it this passionately without the background context at we always carry in a our head it has more than 1 pass essentially. And we discussed may be 1 or 2 of them may be I would encourage you to look at them again. But for various reasons natural language is not attest yet a medium of knowledge representation though even eventually we hope that we will acquire our machines with enough language processing facility.

Capability is to talk us in our languages in English, Hindi, Tamil whatever and represent knowledge also in those language is essentially. Then we do not need to program in C plus plus python ogg in our any such thing you could simply talk to them in English that is way in the future we saw other mechanisms for representation. So, I am talking about representation here it could be an natural language, we a seen rules already essentially when we studied rule base systems we said that you know you could capture heuristic knowledge in the form of rules. And then use that in fact it turned out at rule base systems has become like a programming language in itself essentially. We also saw something similar to rules when we were talking about planning. The planning operators had the similar flavor about rules at there was a well defined language in which you could describe the preconditions. And then an action basically linked preconditions to post conditions essentially there was a well defined language.

So, we were moving towards move systematic base of representing things they could be other mechanism for representing things. We could be have tables for example, log tables I do not know how many of you have used log tables. But when I was a student that was the primary means of which you needed to carry to your exams know if you wanted to do some sophisticated computation you needed a log table and something called a slide rule. I do not know whether you have heard about it but these are representation of knowledge in some sense essentially then he tells you that for this number the logarithm is this for this number the logarithm is this and so on essentially. Then we have knowledge embedded in procedure at typically and imperative program contains a lot knowledge which is not explicit essentially. You may have written a program to create the, I to compute the Eigen values or Eigen vectors or to find routs of an equation.

All these programs contain knowledge which is your knowledge which has been put into the program. And hence for when the program runs basically it is executing your instructions knowledge is not explicit essentially. And I do not know whether we had discussed is sometime but the view that was performed by Kowalski Robert. Kowalski; he use to teach in imperial college London 1970s, he was the invent of 1 of the inventors of the programming language. The idea of logic program he said that a program is equal to logic plus control that the program compute a program has 2 components. 1 is what you might call as business logic or the domain logic or the problem solving strategy. And the other is control essentially what statements to execute in a program essentially and the view in an logic programming community is that control should be left to a system in our case and inference engine.

So, prolog will basically as you will see rather basically does depth first search over a representation, but we have seen a variation which is system which is the forward chaining system where you write rules and everything that you want to says express in the form of rules. So, we can associate logic with rules and control with an inference engine. So, we this we study the rate algorithm for representing representation of rules and then we saw the match resolve execute cycle which forward chaining the essentially. So, that is separating out the so the control is left to the inference engine you only provide the logic essentially. But very often in our imperative program C programs

specially whatever you do is embedded inside procedure that is another form knowledge representation when you talk about knowing how to swim or knowing how to ride a bicycle. It is almost impossible for you to articulate that knowledge how do you ride a bicycle you cannot explain, explain it so easily so it is sought of embedded into some procedure which you have learned over a period of time essentially.

So, we also carries us knowledge off course then there are things like neural networks which basically encode knowledge in form of weights. And we had already observed that these are sub symbolic they are representation they are explicit representations, but a symbol does not stand for something in a neural networks a symbol meaning. A weight basically everything in a neural networks is we called it in terms of weight essentially. A weight basically tells you what is a connection between 1 neuron and the, we will spend our time in the next in the remain the part of this course looking at logic as a mechanism for representation as well as vehicle for reasoning essentially. So, whenever we do representation what is the use? Representation if we cannot do something with it so along with representation you must have reasoning's essentially and logic provides a very nice vehicle for doing both essentially.

So, logic is associated with on the 1 hand with language and on the other hand with inference, inference procedure of the capability to doing essentially. So, before I get into logic I want to sought of try to create a outline of what are the different kind of logics at people talk about essentially. 1 thing common amongst all is that or the language of logic talks about sentences a thief race in logic is a sentence a basic entity in when you are talking about using logic as a language representation is sentence. So, essentially logics are devised to express instances in 1 form of the other. And what is the sentences some sentences something which in principle is true or false or can be true or false anything which in principle can be true or false is a sentence and logic. Various logics are device to represent various categories of sentences and then of course,, reason with them essentially.

So, what do you mean by something which can be true or false. If I say can you please lend me a book now that is not a sentence in the sense of sense of logic, because it is not something which is true or false is basically a request or imperative statement in saying.

Can you do something for me essentially or it could be question mark. So question marks are not sentences if I say what is your name, it is not something which is true or false. So, it not logically a sentence it cannot be assign a truth or false value or if I say please give me a glass of water, it is not a sentence it is a request or an imperative statement. Those things are not sentences anything which in principle can be assigned a truth or false value is a sentence if I say why it wins in chess or why it always wins in chess. And by this I mean when both sides play perfectly it is a sentence I do not know whether this sentences true or false, because as we discussed when we talking about playing the chess game tree so huge that we have no hope of solving it at least not in the very near future.

So, we can make such sentences whose value we cannot determine, but never thus they had they qualify a sentence if I say the moon is made of green cheese that is also sentence. But in this case you sought of fairly confidently say that it is a sentence which is false so sentences as those things which can be true or false essentially. Now, there are different kind of languages essentially so the simplest kind of language treats a sentence as 1 unit. So, if I say the earth is flat then that is 1 unit essentially and the simplest kind of logic or logic language which we called as propositional logic treats a sentence as a unit unbreak unbreakable indivisible unit you cannot look inside a sentence. You cannot say that this 1 is talking about something called the earth. And is talking about the property call being flat nothing of the sought it simply says this is some sentence and typically we use.

And you must we familiar with this something like a symbol to say p stands for this p stands for the earth is flat essentially or I can say Socrates is a man. This is a sentence in propositional logic I cannot look inside it I just it is something and there off course I would want to assign a truth value essentially. I can say all men are mortal this is also in propositional logic it just some sentence I can simply call it q and I can simply call this r or p 1 p 2 and so on and so far that the we cannot look inside sentences. So, a logic in which you cannot look inside the sentence or were a sentence is the atomic unit is called propositional logic. And then off course, we have logical connectives so we can say the earth is flat or Socrates is a man or the earth is flat implies that Socrates is a man you can do all these kind of things. You can combined sentences to form compound sentences we will see the syntax and I am sure you are familiar with it such logics are called

propositional logic essentially.

Now, these 2 statements are well known for anybody who have studied logic, because they together represents some of the oldest examples that people have been using in logic in fact from Greek times that is why we have the term Aristotle. Socrates and the logic and the reasoning part says that if you know this or if this is true. And if you know this and or in other words this is true we will use the term interchangeably then you can infer that Socrates is mortal. So, this is the reasoning party and this is what we mean by reasoning in logic is that if you know certain set of statements to true or you assume that to be true or that given to be true. Then you can infer that there are other statement which are true somebody tells with that Socrates is a man and somebody tells you that all men are mortal. Then what Aristotle should was that you should be able to infer that Socrates is mortal essentially.

And this particular form of reasoning or this particular loll is called a syllogism we will not go too much into history of logic here, because there is plenty to look at they, but we just keep in mind that this was there in Greek times as well essentially. In fact, reasoning is the motivation for which logics by maintained in the first place essentially. Because people wanted to say that we do not want to argue about truth value of statement essentially. If you know something is true and something else in true and something else is true we should be able to infer that something else is true essentially. So, in that sense logic is associated with the particular form of reasoning which is called deduction. And we will come to this again, but just to get started by deduction we mean making inferences which are necessarily true essentially. So, that if the premises or the given or the axioms are true then the conclusion man net must necessarily be true logic is concerned with forms of reasoning which take you from true statement to more true statements.

And they take you and it is a reliable robust mechanism if logic if a logic machine and we will talk about that says that this sentence is true. Then you should be able to believe it without any reason, but there are forms of reason that we often do which are not necessarily always true. So, in a experience for example, is always captured in patterns and conclusions. So, you see that clouds and you say it is likely to rain essentially now

off course that conclusion you can make, but it is not necessarily true. Because you do not know what is going to happen in a that is not a logical that is not something that you can did use essentially or to take a more topical example if I say this students signature is there on my sheet. Then he is present in the class know that is not a reliable conclusion to make essentially these are forms of reasoning which are not deductive essentially. And we do deduction we though other forms of reasoning all the kind we do for example, generalization the whole machine learning community is occupied with generalization you look at examples from that.

You generalize essentially you look at one leaf you look at another leaf you look at the third leaf. And then you a come to a conclusion that all leaves are green it is a form of inference which is not necessarily deduction essentially or you look at a crow. And you see that the crow can fly and you see that the sparrow and you can see that sparrow can fly. You see a parrot; parrot can fly and you come to a conclusion that all birds can fly this is a form of generalization is a form of learning you might say, but it is not infallible. For example, there are birds which cannot fly penguin is cannot fly so there are other forms of reasoning which we do all the time or look at the process of diagnosis. We saw recently an example of doing diagnosis by a process of consistency checking essentially..

But we can not necessarily say that we have concluded is the real fault, because in the real world in the real world a fault causes a symptom in the real world something has gone wrong. And therefore, we can see the symptoms of, it has it having gone wrong, but in diagnosis we move in this other direction. We look at a symptom and we jump to a conclusion or we way can inference that this is a fault essentially and these are not necessarily correct. So, if you go back to example that we looked of multiply as an adders we could have concluded that the 1 adder was wrong or you could have concluded that 1 multiple had gone wrong. Any of them could have been true in fact, we could have even said a combination of things could have gone wrong any of them could have been true and without further investigation we are not able to make a more definitive statement.

Medicine is full of this kind of reasoning you look at symptoms and you make inference has to what has happen to you; you have fever you have shivering in the evenings. And

you jump to a conclusion that you have malaria essentially now this is not deduction it is not necessarily true. We are interested in logic for deduction that statements that we derive or produce using this logic machinery should necessarily be true and logic is built around that motivation essentially. Now, in propositional logic I cannot take these 2 statements and I cannot device a mechanism for arriving a that conclusion, because it is not so straightforward to to make the connection for that. We will have to go to a higher logic or a more descriptive logic which is called as first order logic. And we will infects spend most of our time in first order logic; in first order logic we break up a sentence into parts.

We keep the word all separately; we keep the word men separately; we keep the word mortal separately and the connection between them separately. We break down the sentence and represented with consequent which we can then reason about essentially. So, essentially what will say is that men is men is a class of entities mortal is another class of entities and if anything happens to be a man then that was also be mortal. And there from that we will reason the, because Socrate is happens to be a man then Socrates is these reason, but to this to do this we need this machinery of first order logic which is little bit more expressive in nature. Now, this is a fact of logic is that the more expressive a language you device the more complex is the computational required to reason with that essentially so computational complexity increases with expressiveness.

So, some of you would have heard about good else incompleteness theorem and what that theorem says and may be will come back to that bit later. If we get time is that if languages are expressive enough then there are conclusions which the logical machinery cannot make in that sense it is incomplete essentially. So, we talk about completeness when we have talking about search there is a similar notion of completeness in logic is that given the fact that there true statement out. There is my machinery able to reach the true statement or not is the notion of completeness and what good else showed in 1931 that reach enough languages will never allowed completeness in. So, there is a trade of the more reached the language the more difficult it is do computation. And most of the computations that we do include including the program that we write C program will following to the category of first order logic essentially.

And it is characterized by having variables and being able to write lops with use variables and things like that essentially we will formalize that a little bit later but there are other kind of sentences we can talk about. So, we have seen 2 forms logic propositional logic first order logic there is also, mething of called second order logic which is what apply to we will see if we come to that, but what about sequence like this if I say Nisha is tall. Now, that is the statement in principle off course, I can give a truth value to this by saying that this is true this could I could say this is a true sentence or this is a false sentence. But the question arises as to when can I say that this sentence is true so logic will also we concern that semantics associate that when is this sentence true essentially. Now, the trouble with this kind of sentences is that if I want to device a rule with says if you have more than 6 feet. Then you are tall if you have less than 6 feet you are not tall then I have this problem that you know what is somebody's 5 feet 11 inches or 11 and half inches would is that person not tall.

And somebody who is just 6 feet is tall it leads to problems when you are trying to model real world domains. And reason with them that if you want to talk about properties like tall warm. Know cool what you really mean somebody say this room is to warm somebody else is feel is not to warm apart from the part the fact that there is subjective difference. There is also the notion of we do not really know what temperature does warm begin with. And what temperature it is known on the so do we say that if it is more than 30 degree centigrade it is warm or some. Or it is more than 35 degrees can have a crisp boundary that is the real question essentially. Can we divide things into warm not warm, tall not tall by drawing a crisp boundary and many people felt that that is not the case that that is not what you do should do. And one of them was lofty zeza zadeh you must have heard about in who device this thing call fuzzy logic so the where fuzzy logic is difference from what we is use here.

So, these 2 are what we call as classical logic and by classical logics we, but more less mean 2 valued logics sentence can take 1 of 2 value in our case we call them true and false. But that is only for our own convenience, but people have thought about multi valued logics somebody says may be you should have 3 values true false. And may be or something like that or true false and do not know maybe that is a third value people have try to device logics like that essentially what fuzzy logic. So in 2 valued logics a

sentences either true or it is false essentially. And that is as we will the semantic of sentence like this says that if you have a mortal you either belong to the set of things which are mortal. Or you do not belong to the set of things which are mortal if you belong to the set of which are mortal then you are mortal otherwise you are not mortal. So, that is a crisp set as we say as oppose to that what is Zadeh said was at why do you want to work with crisp set know you have a notion of a set membership or the characteristics function that you must have defined a some point why is it mapping only to 0 or 1 why cannot it map to 0.7 0.8 or something like that. And zadeh said that for example, if I want to define tallness and this is height then I should be able to define something like this.

Whereas, some point it becomes 1, but there are regions where you have different amount of commitment to this belonging to this set. So, set membership of fuzzy sets so fuzzy logic comes from fuzzy sets and classical logic comes from crisp sets that which either have membership is 0 1 here membership is a continuing between 0 to 1. So, you can if you have this height this is a membership to the set of tall people if you have this side this is a membership to the set of tall people and it varies essentially. There are other kind of logic which deal with uncertainty so for example, if I say tweedy is a bird can I infer that tweedy can a fly to make these kind of inferences. And we call these inferences defeasible inference meaning that the inference can be defeated that you may say yes tweety can fly, but somebody will give you some evidence to show that tweety cannot fly essentially. Somebody tells you tweety is a bird and you say tweety can fly and then somebody tell you the tweety is a penguin then you realize that penguins cannot fly..

Then you inference defeated essentially, but most of the time we do make inference which can be defeated. So, we go to the canteen and assume that I will get tea there or canteen will be open or my bicycle will have here all kinds of things. We believe in which can be defeated essentially so the ability to make defeasible inferences very important to us, because otherwise we would never be able to make inferences if I say if I use a statement that all students have bright. Then somebody comes and shows me 1 student in some corner of the country whose not bright then may statement becomes false essentially. Because when I say all students are bright it means that each and every students that each and every person whose the student must be bright. Now, if somebody

shows me 1 person not in Chennai off course, who is not bright. Then my statement goes is no longer to which means any in any inference that I would have use making that statement as a premise and know can no longer may, because the statement is no longer too.

So, if I say students in IIT go and take a jobs in gold man sacs where in bright or something like that the ability to make to ability to reason with statements in which you do not have complete belief of which there is uncertainty. And then reason with them is very important for us we use it all the time and we must develop mechanisms to that. And some of the things that off course we will not studied in this course a things like default logics and default reasoning essentially. Then we make other kind of statements which so we may want to make a statement this kind that may be let say we are sitting in this room. And we here some sounds and then we make an inference we make a statements that it is raining essentially. Off course do not know whether it is raining or not.

But we can make a statement that it is possibly raining what is a what you mean by truth values of sub sentences, how would you valuated truth value of such a sentence. If I say it is raining you can go out and look at outside window and say that the statement is true or statement is false. But what about statement like it is possibly raining essentially or if you say that may be he is sleeping in his room essentially. So, off course, you can in this particular case you can go and check with the person is sleeping in his room. And then you can have new statement which says he is sleeping in his room, but what can you say about the statement may be he is sleeping in his room is that the true statement or a false statement. Now, people have tried to device logics well I do not know what you mean when you say true statement so you have to be a bit careful essentially when you say it is a true statement.

Then what one should say is that there a possible world, so if you assuming that everything that you do not know you we have only a about the knowledge about the world essentially. Then if there is a possible world or a feasible world or a consistent world in which that statement were to be true then we can accept such a statement to be true essentially. So, it is a little bit not easy to discuss right now, but we have this that it

is possibly true or it is necessarily true. So, in fact there is a whole logic which is devised to talk about statements of necessity and possibility essentially. So, for example, you might say in that diagnosis that it is possible that he has malaria essentially and these logics which are called modal logics allow 1 to talk about statements like this essentially.

So, we have something called modal operators and there are in particular 2 operators, one is called diamond operator this is standard usage in modal logic community. And the other is called a box operator and if you write a statement in diamond p it basically means that p is some statement like this. For example, the earth is flat if I say diamond p it means is possible that the earth is flat essentially. So, I have a language for expressing this essentially and then they have mechanism of reasoning which such statement essentially. One particular kind of modal logics is temporal logics where the temporal off course deals with time and when you deal with time and you are talking about the future. Now, you know that not all the time we can make definitive statement. So, if the world is if the sky cloudy then you can say it will possible easy in essentially in the future. But temporal logics are even more tied to time you we can make statements like if you leave a block of ice on you table.

You can make a statement that it will eventually meat essentially that there will be sometime in the future when the block of ice will no longer be there and till meal essentially. So, we can reason about time essentially or time in change and things like that essentially so you can say that if you keep within proxy then eventually you will get a w grade essentially. Of course, not today now another kind of log temporal logics deal with statements like the following that John knows something so John knows that the earth is round. Now, look at this statement this sentence contains a sentence so that is the first thing you should observed that there is a sentence inside this the earth is round and well I had p here. So, let us call this P 1 now what I am saying in this sentence is that John knows p 1 essentially. So, such logics are called epistemic logics and I would basically represent this statement in a simple epistemic logic as saying that k j were k j is the modal operator which says the John knows something.

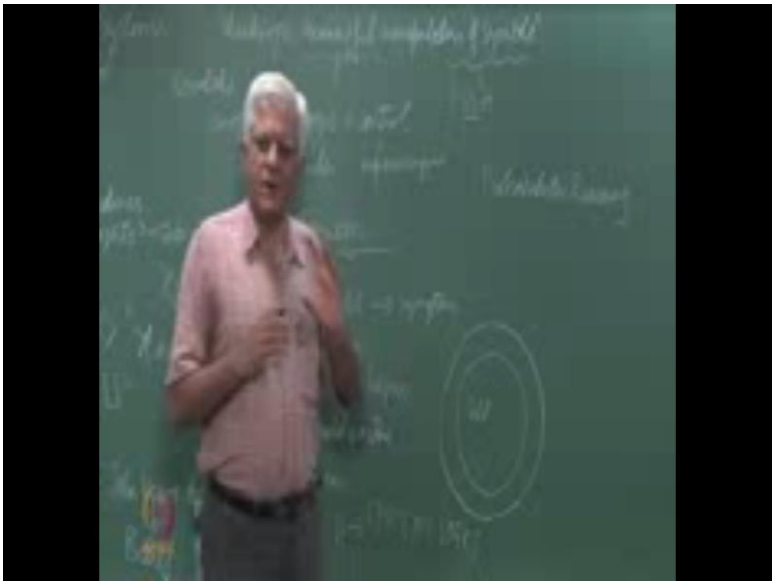
And then that sentence p 1 so when can now talk about someone knowing something's, but one can also talk about statements like this that this is another sentence in this

epistemic logics. And let say m stands for marry what this sentence is saying is that Mary knows that John knows that the earth is round. And off course, you can I have all kinds of thing you can say Mary knows that John does not know that peter has gone home or all kind of statement. So, you can combine logical operators which I am not seen so far, but we will see them in due course. So, what modal operators at modal logics are doing is that they are taking some standard logic and in our case is propositional logic that we are talking about then applying modal operators. So, these are modal operators which talk about necessity and possibilities possible that Mary loves John if I want to say then I could use a diamond operator essentially.

And or I could use a know this operator temporal logics use modal operators which talk about time epistemic logics use modal operators which augment a language by talking about what people know essentially. Now, almost similar to knows is the notion of belief so people have built logics which talk about belief essentially what is the difference between knowing and believing? Well, we would like to say that if you know something it is necessarily true if you believe something it may not necessarily be true. So, I can say peter believes at the earth is flat essentially that is the perfectly valid true statement, because that is what peter believes essentially. The earth may not be flat, but the statement is the true statement essentially so belief so knowledge and belief.

Off course, it is quite an interesting thing to work with specially when you are talking about multi agent scenario essentially. In fact, epistemic logics were created to handle multi agent situations if we have know many agents if you have networks of agents and they are doing certain things. Then how can we reason about it how can we show form example that given a certain protocol. A group people will always elect a leader or not elect a leader a would be unable to elect a leader. How can you prove such thing essentially this what people with epistemic logics have been associated with possibility and necessity is a mathematical foundation called rough sets. So, just like fuzzy sets form a basis for fuzzy logic and fuzzy sets are sets in which membership can vary to degrees rough sets are sets which have basically 2 boundaries essentially.

(Refer Slide Time: 47:22)



So, for example, if I say I am talking about the set of tall people then I could draw 1 boundary here. And another boundary here and the meaning of this is that anybody inside anything inside the any circle is definitely tall necessarily tall. And anything inside the outer circle, but outside the inner circle is possibly tall but not necessarily tall and anything outside both the circle is not tall essentially. So, rough set is a mechanism which has been device to deal with this kind of a uncertainty essentially now the last form of reasoning that it not so much like logic. But we have probabilistic reasoning so probabilistic reasoning is one way of handling uncertainty essentially. So, for example, when you are doing diagnosis for example, you might device a system with says if somebody has some symptoms. And somebody has yellow eyes then its lightly that the person has jaundice how do you express his lightly look us one thing is this possibility, but if you want to now talk about gathering evidence and increasing your belief in something.

So, you believe that that this is the really the case you may be you do one more test and you belief increases probabilistic reasoning is 1 mechanism for handling uncertain logic knowledge essentially. Now, you must distinguish between fuzzy logic which also is talking about numbers which are less than 1 and probabilistic reasoning which says my conclusion. I am 70 percent sure of my conclusion or something like that there is a

difference between this and fuzzy reasoning in fuzzy reasoning. It is a question of it is a linguistic problem really as what do you mean by the world tall? Word tall essentially, because it is not defined clearly whereas, in probabilistic reasoning if you say that the chances that he has jaundices 0.7 or the probability is 0.7. Then you are saying that this is way of talking about my lack of knowledge about the real situation. So, off course you know that you know when you throughout diceyou say the chance of it falling 1 or 2 is 1 by 3 is simply says that.

Because I cannot say what it what is going to fall I just use probability as mechanism for expressing my lack knowledge about what is what really is the cases essentially. If you had perfect knowledge about physics and all the information that is needed to do the calculations of what is really going to happen when you through a dice then between the moment when you through it. And the moment when it really falls you should be able to compute in principle whether it will fall with 1 or 2 or 3 or 4 or 5. But off course, we do not have that knowledge we do not have the computation ability. So, we say talk about probabilities it is likely that it that it will fall like this certain likely it will fall like this essentially if you get time we will look at a variation of probabilistic reasoning in the context of diagnosis and see that when you get multiple pieces of evidence. How do you combined those evidence to maintain a different amount of belief in all kind of things that will be towards a end if we get time.

In the next class, we will look at propositional logic more formally in fact, when we talk of logic we always use the term formal logic, because logic is concerned with form and not with content essentially. Logic is concerned with valid forms of reasoning and it does it is not concerned with what you are talking about. So, I can say that Socrates is a man and all men are mortal the syllogism allowed be to complete to conclude. Socrates is mortal if I say Ramesh is a student all students are bright then the same form of reasoning will allow me to infer that Ramesh is bright essentially. And why is that a form why is that a valid conclusion, because the form of reasoning that I am using which called as a syllogism he showed to be valid form of reasoning. So, we will look at valid forms of reason that we will use in propositional logic and try to show why they are valid also in the. So, will start off with the language and then we look at the mechanism for reasoning and this whole thing we will called as a machinery of logic. So, we will in the

next class try an build a small machinery for propositional logic essentially. And then the rest of the course will spend on first order logic essentially, because that is really interest more interesting essentially. So, I will stop here I think.