Artificial Intelligence
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Lecture - 5
Introduction Philosophy

So, let us get back to this question on the philosophical side of our introduction, so what are mines essentially. So, if you remember the view from Aristotle, it said that our thoughts are our reflection of what is out there. If I see an apple or if I think of an apple, it is because there is an apple out there and my thought is in the image of that apple that is out there. The diametrically opposite view was given to us by Canter much much later; he said that what is out there is the reflection of our thoughts that what we think is out there is what we think is out there.

Now you see there is a gap that you can never cross, because what you think is out there is only what you are thinking is out there, what is really out there. So, you see a person you know person sitting here. So, I think there is a person sitting here especially. So, I have this concept of people; I have concepts of you know boys, girls, men, women, all kind of concepts, trees, chairs. So, that is how I think about the world and it is out there. So, I also have concepts about clouds and you see an image of something in the clouds; you see a dog in the clouds or you know something else.

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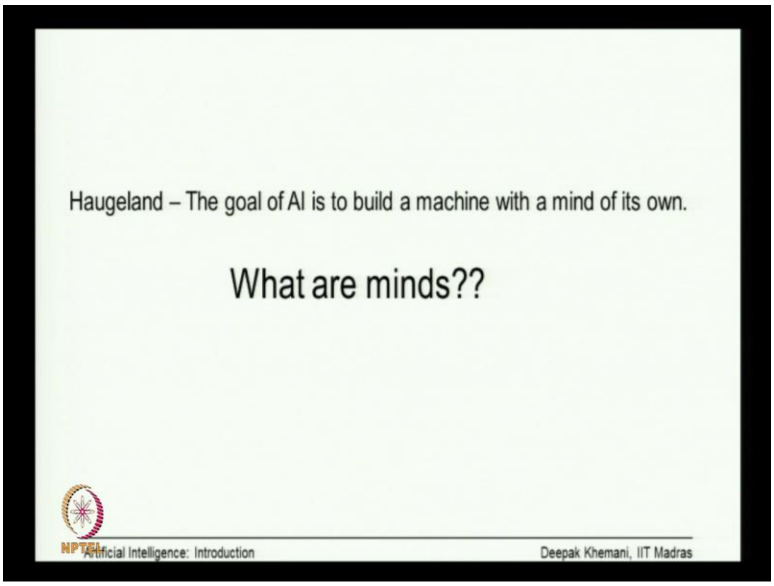

What is out there really is a question we want to start with and then we want to we have seen already that the notion of the mind has come about the people understood that there is something called the mind; gradually over a period of time when they realize that what they are thinking about is not in direct correspondence with what is out there. But now what we want to discuss is that it is a necessity that if you have to have an intelligent agent, we have to have a mind which can represent the world in a way that it can manage the representation effectively.

So, that is the question I am driving at today. So, let us start with the basic question as that what is reality; of course, we live in a world. We are also part of this world, but what is the objective reality? If you wanted to create a model of the world, how would I do it? No what is really out there, any suggestions? We are talking about reality. So, you are saying that reality is as we see a collection of situations which we can manipulate. No, but simpler things like people take this young man sitting over here; is he real or what is the young man; what is the human being?

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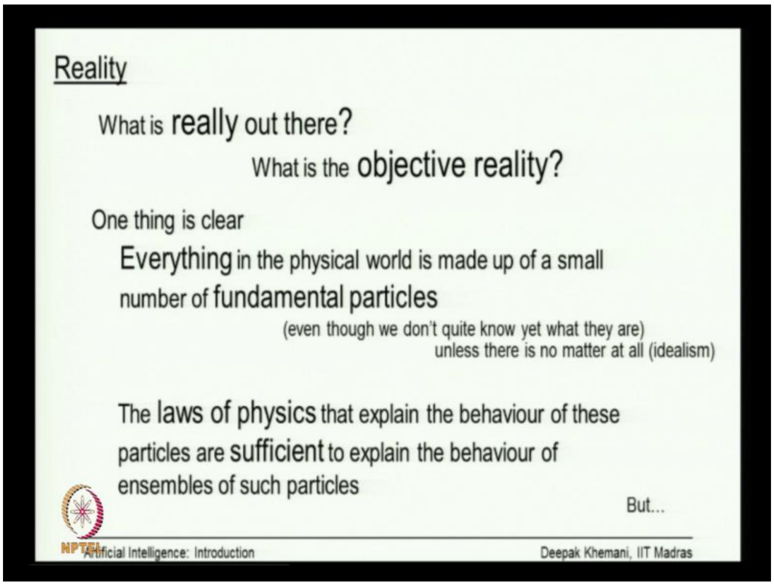

Okay, now let us take a scientific enforce point of view, the physics point of view; everything in the physical world is made up of a small number of fundamental particles. So, whereas a small number of fundamental particles I mean there is a number of different particles are small; it is not that the number of particles is small. The different type is small actually. So, depending on what theory you are following. So, the simplest one could follow the bore atom module, for example; you know an atom is made up of protons and neutrons and electrons and everything else in the world is made of these three kind of things essentially.

So, physics is, of course, I have been struggling to figure out what the world is made up of but let us take it for granted at it is some fundamental particle; it could be something smaller that proton and neutron, but everything is there, and these particles they obey some laws of physics. So, the laws of physics are sufficient to explain what is happening in the world out there. So, that is a first assumption that we will work with and it is not something that we can dispute because then you are saying the physics is wrong essentially. So, like Penrose was saying that the physics of the brain we do not understand, then you would be saying that we do not understand the physics of this world essentially.

So, the physics is believe that that you know we do not know what the. So, there is a sling theory, then they are neutrinos and gluons and that kind of stuff, but there is something out there. And they all behave according to the laws of physics which we are trying to discover; by the way they behave according to these laws, and, therefore, everything can be exchanged according to these laws. So, that is enough to understand the world in some sense. So, we are talking about people, what is the person. So, even adult, it is made up of about 10 raise to 27 atoms. I do not know whether you can visualize the number 10 raise to 27, but you should try; it is a huge number.

So, we can think of a person or person not in the social sense, but in the physical sense; a human body is made up of about 10 raise to 27 atoms. So, this young man sitting over there is just a collection of a 10 rise to 27 atoms which for some reason decide to stick together, and the reason is given by the laws of physics. It can be explained by the laws of physics, and of course, we may call it in different terms. We may talk about biology or chemistry and so on, but deep down they obey these laws of physical is fundamental particles obeyed essentially. So, we have mention earlier that there are two views of the world. One is materialist view which says that there is only matter and the other is the idealism view which says that there is no matter essentially.

So, which is why in the last line I had said that if there are fundamental particles; you know some people believe that it is all energy or something out there essentially, but that let us not get into that kind of a thing. So, we are trying to understand the world; we are trying to model the world; we are trying to why do you want to do that? Because an intelligent agent and we discussed this in the early lectures should be able to operate in a meaningful manner in the world. Do something useful for itself and achieve its goals and you know learn and that kind of stuff. So, it needs to represent the world out there, but what is the world out there is the question we are asking.

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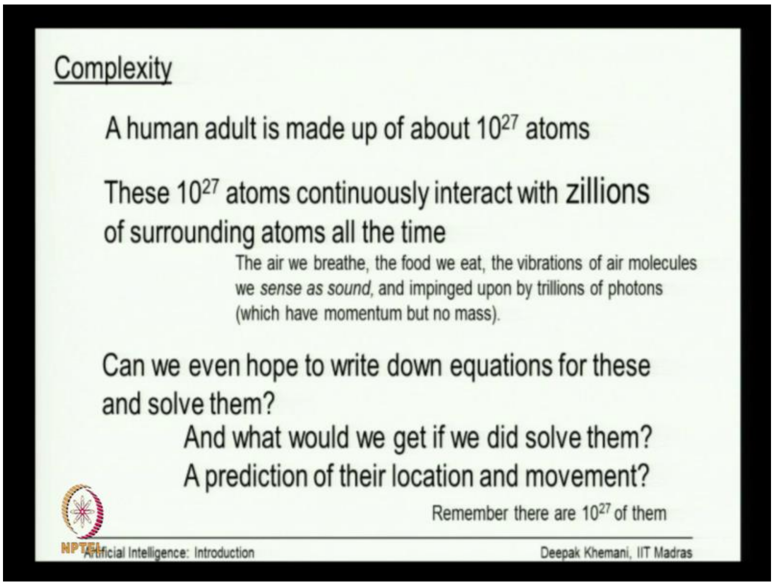

So, human beings is about 10 raise to 27 atoms, and these 10 raise to 27 atoms are continuously interacting with zillions of other atoms out there; you know we breathe, we eat, we have sound wave impinging upon us which are also made up of oscillating particles and so on and so forth essentially. So, if we try to talk about reality in these terms like a physicist, can we ever make sense of this world out there? And when I say it makes sense of this world as I mean in the practical sense as an intelligent agent in some environment trying to do useful things especially.

So, can we ever hope to write down the equations for them and solve them even if we know the equations and what would we get if we solve them especially. The trajectories of their location how does that help us? You know that atom number 259 is moving in this direction or something, does not help. So, if you want to interact with the world, we need to have our own level of presentation, and this is what I am going to be driving at today. The world that we interact with like handset, it is a world in our minds especially.

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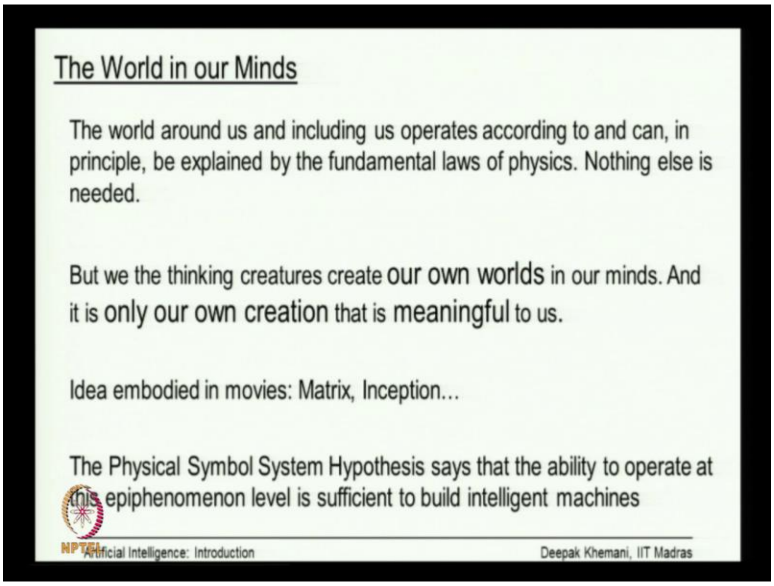

So, we have already said that the world around us and including us operates according to and can in principle be explained by the fundamental laws of physics; nothing else is really needed, but it is too big for us to work with, because the number of amount of information we would have to use would be too much essentially. What we do is that we create our own worlds in our minds, and it is only our creation that is meaningful to us essentially. So, coming back to the example of a person, I do not think of a person as an example of 10 raise to 27 atoms behaving in some concerted action.

I think of it as a single entity a person who is sitting on a single entity called a chair or eating a single entity which is I call a dosa some masala dosa; for example, I think of it as one thing essentially. Of course, it is not one thing; it is made up of so many things and so many processes and I do not want to get into that at all. So, we create levels of abstraction at which we represent things and reason at those levels of abstractions. So, we should also keep in mind Newell and Simon physical symbol system hypothesis is that we can create symbol systems and manipulate that symbol; that is enough for us to reason about the world in an intelligent fashion essentially.

So, Douglas Osheroff who I will talk about again in a moment has a different notion of a symbol which we will not peruse very much here. He talks about how the mind creates symbol, how the brain creates these same symbols that we are talking about. We stand for a person and so on and so forth. So, when I was talking about a symbol, I said something which was perceptible. So, for example, I write the name of a person; I can read it essentially or I can you know type it in a word processor and things like that, but Osheroff also talks about symbol processing in the human brain that the human brain leads symbols and what are the symbols? These are kind of concerted patterns of activity in thousands of neurons.

So, we will not go into more detail than that, but somehow neurons act in concert with each other in a manner which we are inspecting ourselves, think of a symbols that we are reasoning with symbols. So, this kind of an idea has been exploited in movies; of course, movies do not necessarily depict reality. So, again coming back to the matrix, so if those of you have seen matrix would remember that its main character called Neil Neo; in Neo's mind, Neo was a software engineer working in New York city, and that is how the movie begins, but in reality, whatever, that means, neo is in some cell in some human battery which the machines have constructed to extract the energy out of him.

So, which is the complicated sequence which we have to sought off watch the movie carefully to understand that when eventually that something is pulled out of his brain, he really finds himself in some very unknown like place you know inside some cell where he is just unit of a large battery or something like that. The important thing that I am trying to say is that it uses this idea that the world we live in is actually in our minds out there essentially which is why, of course, sometimes people can hallucinate. They imagine something what is not out there, because their minds are sought of not in sync with again let me use the word reality out there.

But there is a big case in that you know we do not know what is reality; we only know what we know essentially. Inception is another film in which you would not know whether you are dreaming or whether you are in some real world. And this is not the physical system hypothesis says that if you can create a level of representation and is it not that level that should be enough for creating intelligence systems.

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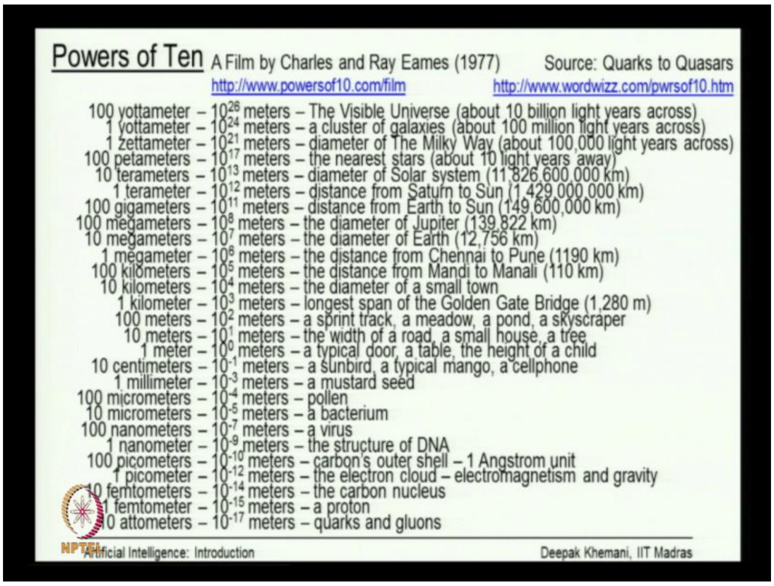

We have dense slides that I have put in; we are not going to go through this slide. It is just to illustrate the levels of scale at which our concepts exist. Remember that in the end everything is made up of examples of this fundamental particles, but then we talk of people, we will talk of football field, we talk of a planet. All these are at different levels of scale. There is a very nice movie; I do not know how many of you have seen it called, 'powers of ten' which is available on the web, and there is a link I have given here which essentially is rooms out of a level in which a couple is seen in a park and goes to the very top most level here which you can see a 10 rise to 26 meters and then zooms down back and goes to the bottom most level which is 10 raise to minus 17 meters and things like that.

So, at different levels you see the world with a different perspective. Suggest some examples, for example, mustard seed is about one millimeter thick whereas the distance from Chennai to Pune is about 1100 kilometers. So, in these powers of ten, you keep magnifying the image all reducing the image by powers of ten every time and then you sort of keep diving in deeper and so on and so forth. So, you can see at the top most level, there are very things that we cannot I mean our mind bowels to talk about something like ten billion light years.

First of all, you have to imagine what is a light year or remember what is a light year. It is a distance covered by light in one year and we do not even think of light having speed. I mean I just see you and you raise your hand and I see instantaneously; where is the question of speed? We do not even have a notion of speed; of course nowadays we have thanks to Einstein and all these people but light travels at a finite speed. And we do not realize it because we know it is so fast for all of us here that everything happens instantaneously.

We do not suffer from these effects of relativity and things like that. But ten billion light years, how much would the light travel in ten billion years? I mean we cannot even think of these kinds of things especially, alright, the very extreme end 10 raise to minus 17 meters where you have quacks and gluons and so on and so forth. So, the world as we think of nowadays exists at these very different scales of things; that are at one level. At another level, it is all just collections of fundamental particles which we have already agreed that we cannot deal with at that level; that is why we think of these different scales especially, okay.

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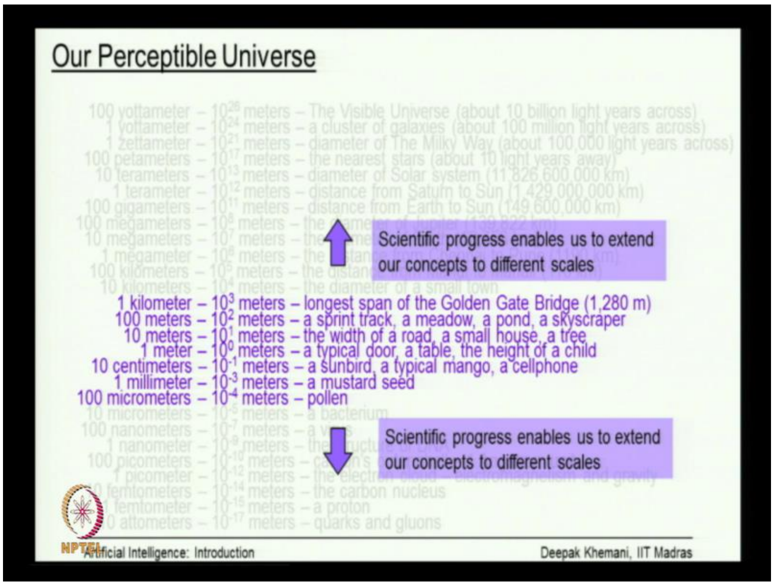

So, our perceptible universe is a small subset of the scales essentially. So, the largest thing we can see is may be about a kilometer across. So, like the golden gate bridge and San Fransisco or something like that, and the smallest thing is may be a mustard seed or may be some people can see pollen you know there is rays of light and you can see dust particles. Some of them may be 0.1 millimeter across. So, you can perhaps think about things at this level of scale essentially. So, the human mind as far I am trying to get at; the human mind has evolved to create concepts at these scales essentially.

So, we tend to think of objects at these scales; that is why we are comfortable with this. We are not even comfortable talking about how far the planet Jupiter is from here, because we cannot even imagine that kind of a thing. And at least we have not evolved to imagine that kind of a thing, and to reasons at different levels, we have created this different discipline. So, we become a specialist in biology or geography or aestrophysics or anything.

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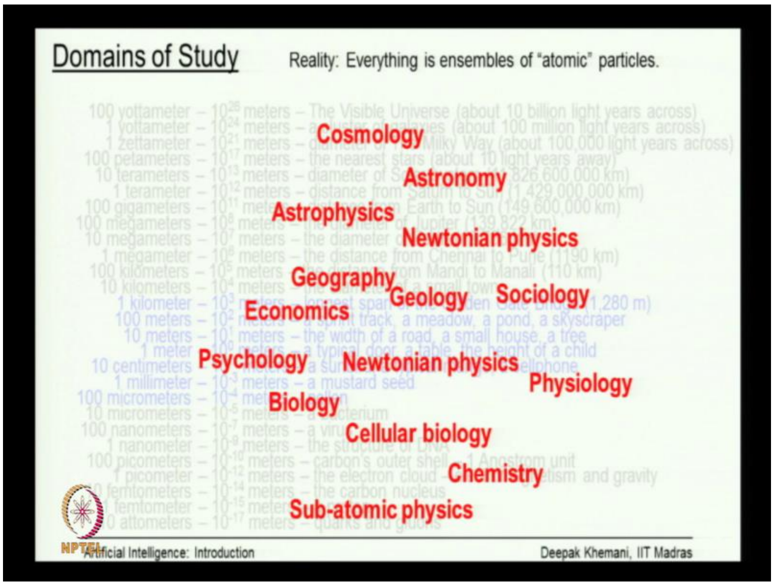

But each discipline operates in its own level of scale; social science is operated some level where we are talking about collections of human beings. Remember human being, each human being is collection of 10 raise to 27 particles. So, social science in some sense is talking about collections of 10 raise to 27 particles, but we do not, obviously, think in terms of fundamental particles any longer, and we have these different disciplines especially.

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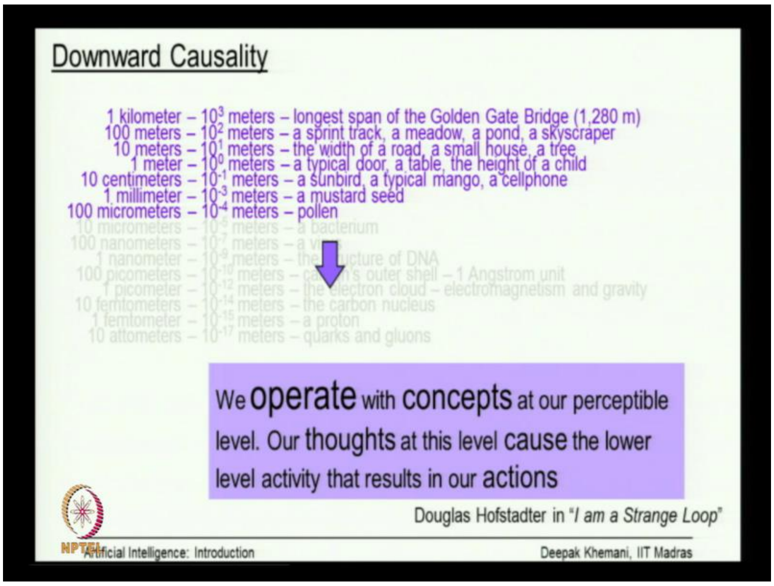

So, Hofstadter, so remember this mind-body problem which Decant was blipping with that if there is this world of the mind which is reasoning about the real physical world out there the body; how do the two things interact essentially? Nor the physics we say we have laws of physics of the fundamental particle level, and if you know that, you will know how the rest of the system is having essentially. But Hofstadter says that we have to introduce a notion of what he calls as downward causality which means the causality is from a higher level to a lower level.

Even though the laws of physics can explain going from particle level to ensemble particle level, he says that is not useful for us, we have to think about how. So, for example, if I want to drink a cup of tea, then I am thinking at a level about cup of tea and so on and so forth. And this level of thinking which is happening with its concepts at this level of abstraction is eventually driving at one level; you might say my muscles or my nerve cells or something at even lower level you might say the very fundamental particles which make up my hand, for example; in such a manner that my hand eventually reaches out for that cup of tea and pick it up and you know take a sip from it essentially.

So, the causality is from our level of reasoning to the lower level where things are actually happening. Now physics, of course, does not have a notion of causality; that is why Canter's even when he was talking about human categories, he was saying that is face and causality are given to us that we accept we have to start working with those things essentially.

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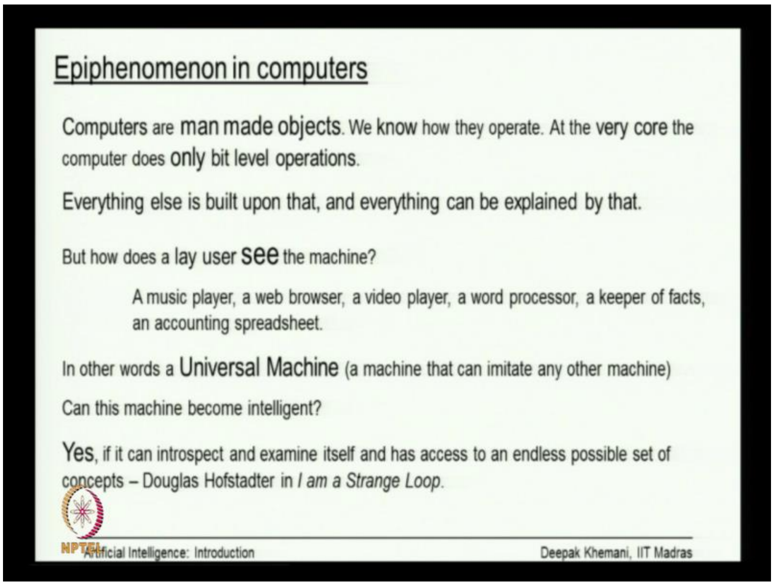

So, these things are calling epiphenomenon. So, things like pressure, for example, in a balloon, we talk of pressure, but what is really happening that lower level activities you know molecules of different kinds of molecules in air, nitrogen, hydrogen, carbon dioxide, everything; they are moving around randomly and you know impinging upon the inner surface of the balloon. And this cumulative activity or the epiphenomenon phenomenal of pressure is dealt essentially. Likewise, in our human brains, there are these billions of neurons which are firing away in some fashion.

We do not tend to think of our brain in that fashion. I tend to think of my brain and say, oh, I want to have this cup of tea which is operating at a very higher level essentially. So, can a machine operate at epiphenomenon level like this, and that we feel is necessary for machines to be intelligent. So, we have run through this. So, computers are manmade objects; we know how they operate. So, it is easy for us to explain; for example, if you type something in a word processor, in principle somebody can say that at the lowest level, these are the kind of micro level operations which were taking place. But we do not do that, of course; we as human beings tend to think of machines as doing higher level things.

So, how do we see a machine computer? As a music player or a web browser or a game or any of these many things that a machine can do; so the important thing is that many people have called starting with tuning is there is a universal machine. The computer just like us is a universal machine. So, if you want to call yourself as a universal machine and the universal machine is a machine which not only, of course, a simple machine can do only what it is designed to do, but a universal machine can imitate other machines and do what they were doing.

So, they are flexible in that nature. Scans as a machine be intelligent; Hofstadter, so I come back to Hofstadter. He says that if this machine can introspect and examine its own behavior, then it is possible for it to become intelligent essentially. So, he is going one more step from Newell and Simon. Simon and Newell they said that if you can create symbolic representations and create algorithm, you still work on this representation; that is sufficient and necessary to create intelligent behavior. Now we can see that that is at one level of.

So, there have been layers and layers that one has to talk about. In computers, we have bit level representation; they have machine code, assembly language, higher level languages, higher level data structures, representations, objects, all kinds of things and you keep going higher, likewise in the real world out there. So, Newell and Simon said that one level of representation which he calls as the symbol level is enough, but now Hofstadter is going one step further. He is saying that in addition to that, you need this capability to introspect essentially. So, if you read his book, it is quite an interesting book to read; I must change the loop.

He sought of goes through a long detailed argument of how Godel discovered this idea of self reference in Rusell and Whitehead Principia Mathematica, and this in spite of the fact that Rusell and Whitehead went out to formalize everything, and they wanted to keep away self referential structure. So, they had layered logical representation or typed logical representation where self reference would not be possible. The same type of an argument element could not be an argument to a sentence in that same language essentially, but Godel constructed this very elaborate; he gave us very elaborate mechanism of how to construct a sentence.

So, there is this two levels at which things are operating upon. One is this level of number theory which is principle of mathematics is all about, but there is also this level of encoding things into this number theory and then encoding sentences like I am lying or something like that essentially or this sentence is not true and things like that. So, Hofstadter is saying that if a machine can have this capacity to introspect and reason about its own actions which means also reason about other people's actions, then it can in principle be intelligent.

So, let us talk about intelligence agents for a moment; it is a very popular term nowadays. So, these are programs; we will talk of intelligence recent programs which are persistent which means like the operating systems, for example; if we leave a machine on that is exist all the times essentially. They are autonomous which means that nobody is saying that run this program, run this routine or call this subroutine or something like that; they are proactive. If the see an opportunity in the environment, they sense an environment; they will go after it essentially.

And they are goal directed which means that you know they have goals; of course, these goals may not be self generated; they could be given by the creator essentially. It is just like we have that secret agents and the governments are supposed to have who have all these properties they are persistent, autonomous and proactive, but they carry out the billing of the government essentially.

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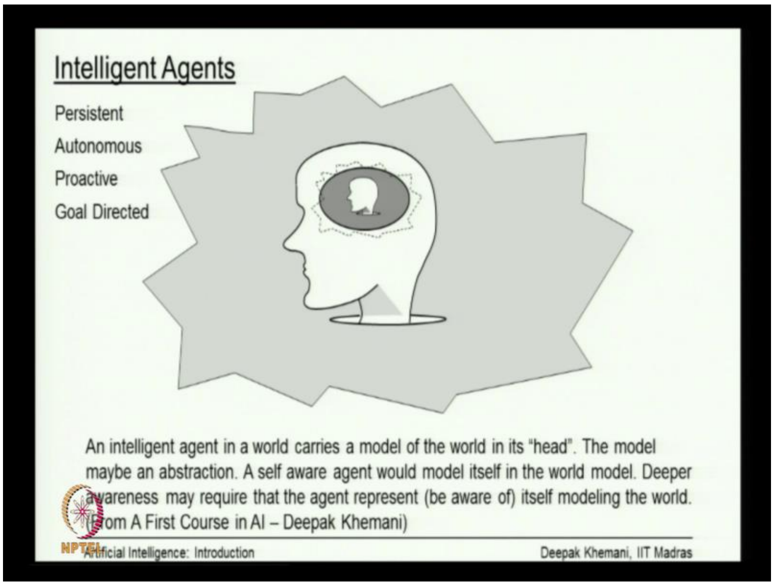

This is a rough diagram of what an intelligent agent should be like. So, that white figure at it is supposed to be the agent, and the thing inside that is what is in the head of the agent. And what is in the head of the agent is the module of the world out there, and the module of the world should contain itself which means it can introspect on itself. And, obviously, you might ask the question as to it that if the model of the agent has a world in which the agent is there, then in that agents head also I should create the model of the world. So, there is an infinite level of next thing which is possible in principle. So, they are these kinds of very curious loops which can form, okay.

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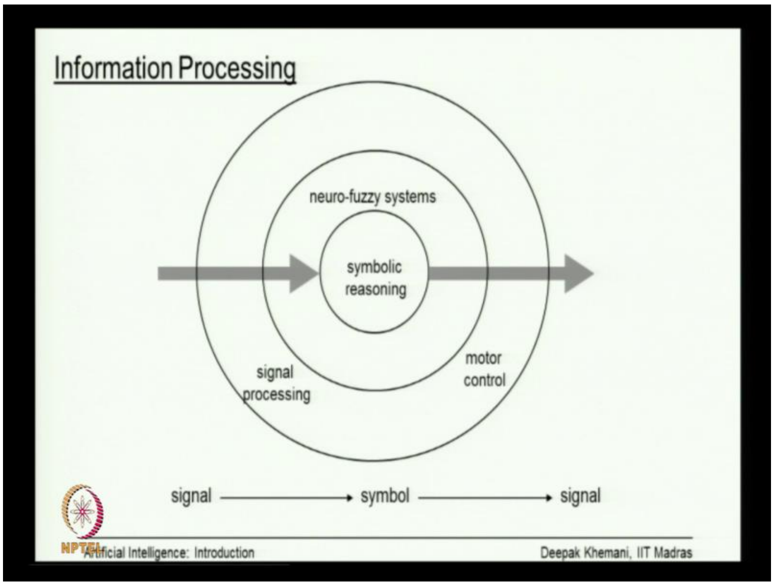

So, we are slowly coming towards moving away from history and coming to what we want to do. If you want to build an intelligent agent which interacts with the real world, then you have to have at least these layers of different kinds of reasoning. One is the outermost layer is what we can call a signal processing. It means you are receiving signals, sound waves, light waves or whatever from the world, and the innermost layer is symbolic reasoning which is what is classically AI is what all about that you can create symbol systems and reason with them.

And you may have and this is my interpretation of this whole thing that an intermediate layer of neuro-fuzzy systems which serve the purpose of converting signals into symbols essentially. So, for example, if I am speaking and what I am creating is a signal which is you know sound waves of a particular pattern, but your brain is converting these sound waves into linguistic entities essentially. So, you are recognizing words out of this sound wave; from these signals you are extracting symbols essentially.

So, if I say the word apple, it may be certain sound wave which is meaningless in itself just like neural activity in our head is meaningless in itself, but you can process it to understand at a higher level to stand for a symbol apple, and neural networks are particularly good at doing this kind of things. So, you must have heard about fact that character recognition if I were to draw the letter a on a hand written characters.

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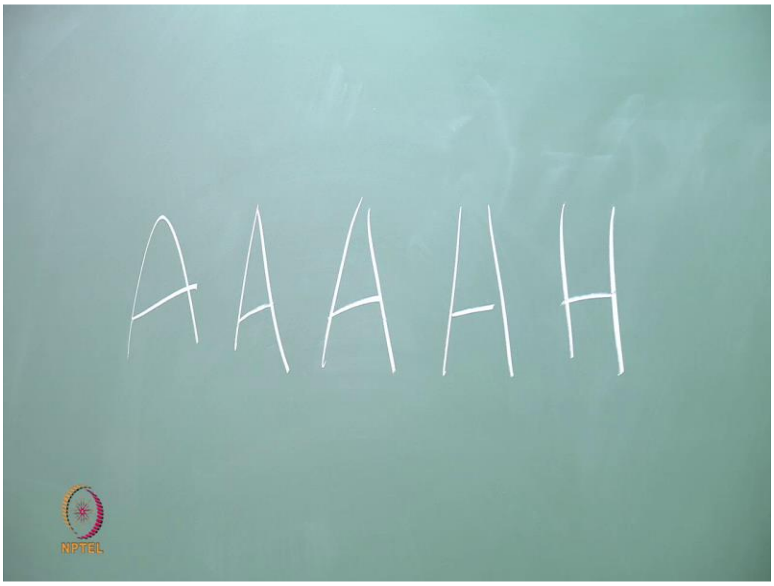

So, if I write A like this, if I write A like this, if I write A like this; we have no difficulty in recognizing that these are A and neural network is also very good at this sort of a thing. But at some point, you may start getting a doubt about whether I am writing an A or whether I am writing an H. And it is very difficult to describe rules to say that this sequence of segment forms A, this sequence of segments forms H and so on. Whether the learning system which will learn these characters in context of other letters around them will eventually learn to recognize the character A for example,

So, neural networks are very good at this sort of a thing, but if you want to do give an explanation of let us say the Pythagoras theorem, what is the Pythagoras theorem and how do we prove it. Then neural networks are not really very good at that kind of a thing; for that we need this symbol manipulation ability which everybody is from Simon Hostettler is saying it is necessary for intelligent behaviors essentially.

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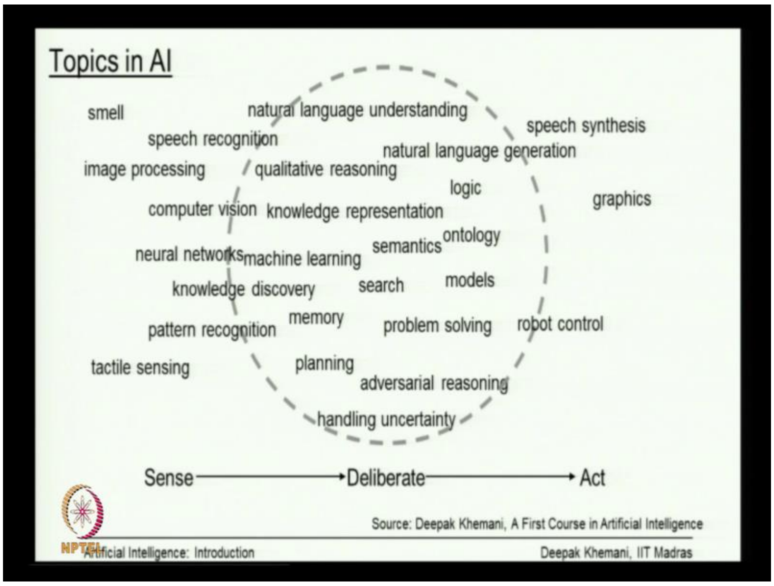

So, these are the topics that one can identify if you look at AI in general. This is not the topics of this course. If you look at the enterprise of AI, then we have all kinds of topics here, knowledge representations, semantics, anthology, models, search, memory, machine running, problem solving, planning, adversarial reasoning, qualitative reasoning, natural language understanding and all kinds of topics. So, on the left what I have drawn in this figure are the sensing kind of activities. Signal to symbol kind of activities, speech processing, image processing, video processing, computer vision, neural networks, pattern recognition, studs sensors and that kind of thing.

On the right hand side, it is the opposite from symbol to signal. So, you have motor control of. If you want to build robots, you have to eventually make the robot do what the robot is thinking about doing. If the robot is thinking about going from place A to place B, it must do something to make their physical movement possible. So, we need activators and things like that at that time essentially. So, these are the topics of AI. In the circle, basically this figure is taken from my book the circle roughly it is a kind of describe what is there in the book.

So, of course, we are doing this course on AI which we are doing here, but in our department, there are a whole lot of courses which cover these areas. And I just want to give you some idea of the kind of courses that we offer. The first four courses that will come are courses which I am personally involved with, but the rest of the courses you know mostly my colleagues are handling.

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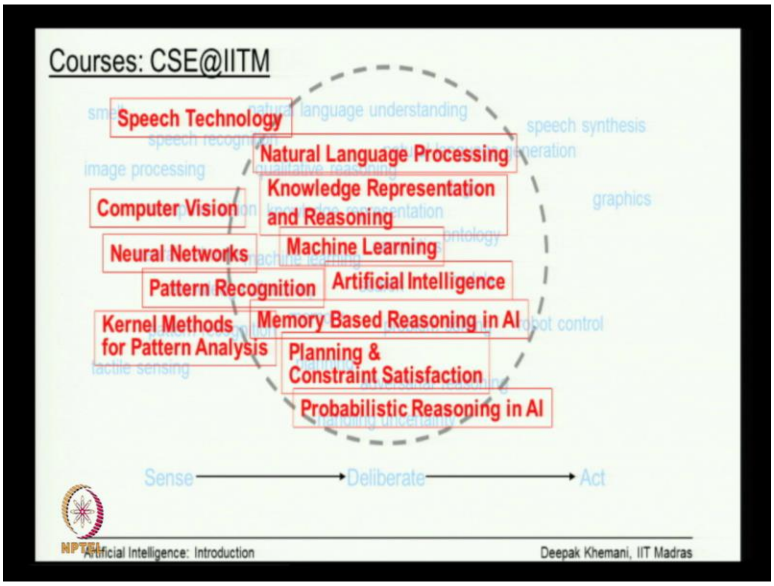

We will start with this course which is Ai which kind of covers some of this stuff inside this thing here, then planning and constraint satisfaction. These are names of courses. So, this will be offered next semester; for example, both these courses will be offered next semester knowledge representation reasoning as well. Then there are other courses which my colleagues teach machine learning which is being offered now. Pattern recognition is also being offered now I think. Natural language processing as well is being offered at this moment.

Probabilistic reasoning is not being offered at this moment; very often I think Dr. Ravindran offers it as a self study course. Then we have computer vision; I am not quite sure which semester, may be this semester it is being offered. Speech technology, Kernel methods, this is I think next semester, visual video processing, computer graphics. We do not have so much on the output side. So, you can see our department is not very strong in things like robotics. So, we do not really offer courses in that. Imagine mechanical department may be offering some courses. So, in terms of assignment, I might have mentioned this earlier; one assignment is going to be on game playing.

So, I will try to do game playing not in this order but a little bit earlier than this order; may be after heuristic search or something like that. So, that you can get going, and we will decide which game and we have to implement an algorithm for it. And your programs will play against each other that kind of stuff. And another assignment would be implementation of some of these algorithms.

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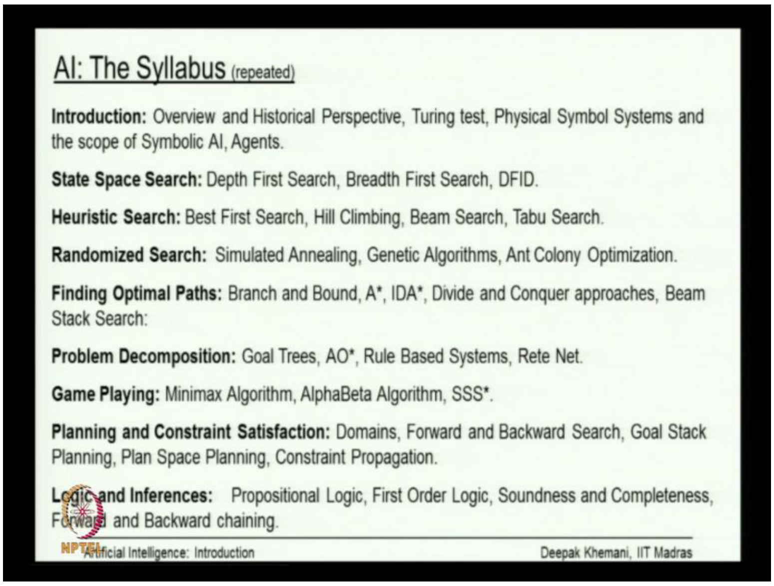

So, we will sort of assign some algorithm and you should implement in that way; we will go into the details as we go along course, okay.

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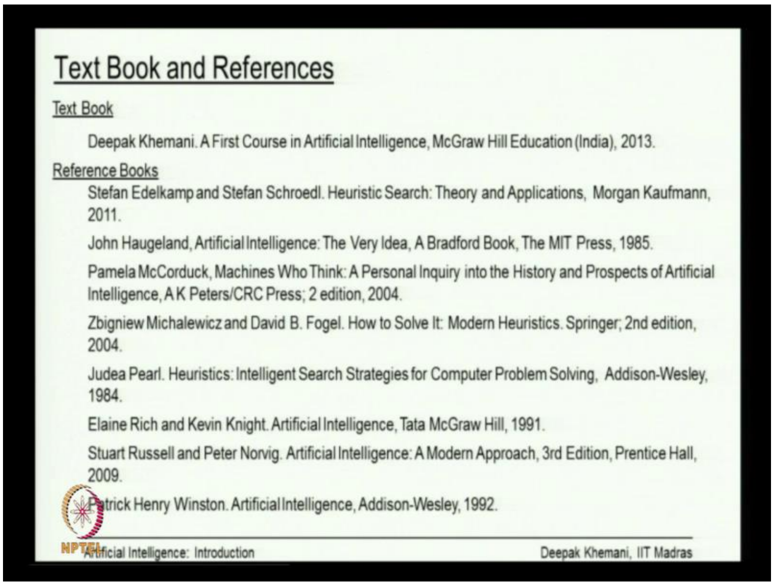

The text books as I said it is a text book which I have just written and everything that I am teaching is from there and vice versa in the sense what is there is what I teach. So, we will use that as a text book, and then there is a host of others reference books that I will point to as and when needed essentially. So, already from these reference books, we have in some sense finished with two of them which is Pamela McCorduck machines who think and John Haugeland AI the very idea artificial intelligence is the very idea, but some of the other books we will refer to as and when the time comes essentially.

So, we will stop here and next on Friday when we meet, we will have quality type shift and start devising algorithms for simple search that just we mentioned essentially.