

Artificial Intelligence: Search Methods for Problem Solving
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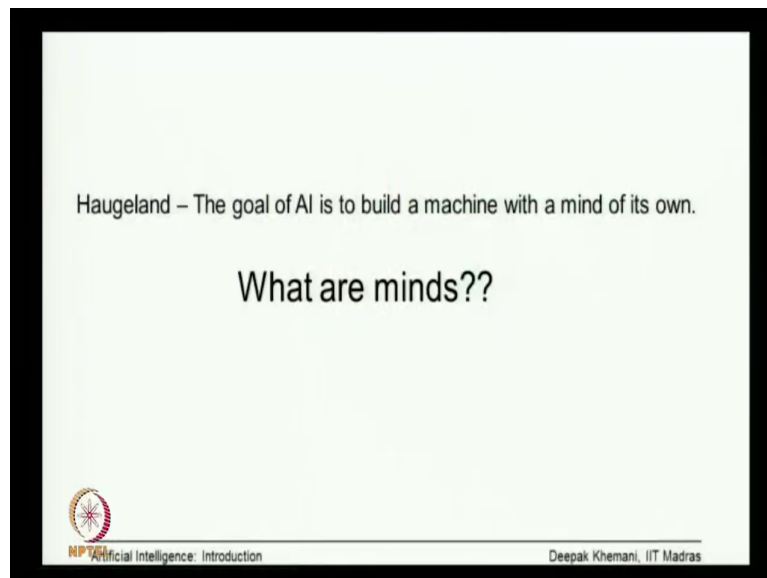
Lecture – 15
Introduction (2013)
The Worlds in our Minds

So, let us get back to this question you know the philosophical side of our introduction. So, what are minds essentially? So, if you remember the view from Aristotle, he said that our thoughts are reflection of what is out there. If I see an apple, it is or if I think of an apple it is because there is an apple out there, and I my thought is in the image of that apple that out there essentially.

The diametrically opposite view was given to us by Kant 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 chasm, 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 essentially. So, I have this concept of people I have concepts of you know boys, girls, man, women, all kinds of concept, trees, chairs, so that is how I think about the world, and it is out there. So, also I have concepts about you know clouds, and you see an image of something in the clouds, you see dog in the clouds or you know something else.

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What is out there really is the 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 and they realize that that what they are thinking about is not in direct correspondings 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 ok, so that is the question I am driving at today.

So, let us start with the basic question. And so what is reality? If course, we live in a world we are also part of this world, but what is an objective reality? If you wanted to create a model of the world, how would I do it, you know what is really out there? Any, 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 essentially.

Student: (Refer Time: 03:17).

But simpler things like people here is this young man sitting over there, is he real or? What is the young man, what is the human being?


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Reality

What is **really** out there?
What is the **objective** reality?

One thing is clear
Everything in the physical world is made up of a small number of **fundamental particles**
(even though we don't quite know yet what they are)
unless there is no matter at all (idealism)

The laws of physics that explain the behaviour of these particles are **sufficient** to explain the behaviour of ensembles of such particles

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Then let us take a science scientific imports point of view the physics point of view. Everything in the physical world is made up of a small number of fundamental particles. So, when I say a small number of fundamental particles, I mean that the number of different particles are small, it is not that the number of particles is small the different types is small essentially.

So, depending on what theory you are following, so the simplest one could follow the Bohr atom model for example, you know an atom is made up of protons and neutrons and electrons, and everything else in the world is made up of these three kind of things essentially.

So, physicist of course, have been struggling to figure out what the world is made up of, but let us take it for granted that it is some fundamental particle it could be something smaller than 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 you 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 physicist believe that you know we do not know what the.

So, there is a String theory, then there 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, but they behave according to these laws and therefore, everything can be explained according to these laws, so that is enough to understand the world in some sense.

So, we are talking about people, what is a person. So, human adult is made up of about 10^{27} atoms, I do not know whether you can visualize the number 10^{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^{27} atoms.

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Complexity


A human adult is made up of about 10^{27} atoms

These 10^{27} atoms continuously interact with zillions of surrounding atoms all the time

The air we breathe, the food we eat, the vibrations of air molecules we sense as *sound*, and impinged upon by trillions of photons (which have momentum but no mass).

Can we even hope to write down equations for these and solve them?
And what would we get if we did solve them?
A prediction of their location and movement?

Remember there are 10^{27} of them

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So, this young man sitting over there is just a collection of 10 raised to 27 atoms which for some reason decide to stick together, and that reason is given by the laws of physics you can be explained by the laws of physics. And of course, we make couch it in different terms, we may talk about biology or chemistry and so on, but deep down they obey this laws of physics is the fundamental particles obey essentially.

So, we had mentioned earlier that there are two views of the world one is the 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 by in the last slide I had said that if there are fundamental particles, because some people believe that it is all energy or something out there essentially, but that is 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 we 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 a question we are asking.

So, human being is about 10^{27} atoms. And these 10^{27} atoms are continuously interacting with zillions of other atoms out there, you know we breathe, we eat, we have sound waves impinging upon us which are also made up of particles oscillating particles and so on and so forth essentially.

So, if you try to talk about reality in these terms like a physicist, can we ever make sense of these world out there? And when I say it make sense of this world as a in I mean in the practical sense as an intelligent agent in some environment trying to do useful things essentially.

So, can we ever hope to write down the equations for them and solve them, even if you know the equations? And what would we get if we solve them essentially? You know the trajectories or their location how does that help us? You know that atom number 259 is moving in this direction was does not help.

So, we if we want to interact with the world, we need to have our own level of representation; and this is what I am going to be driving at today. The world that we interact with like Kant said is a world in our mind essentially.

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The World in our Minds

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 needed.

But we the thinking creatures create our own worlds in our minds. And it is only our own creation that is meaningful to us.

Idea embodied in movies: Matrix, Inception...

The Physical Symbol System Hypothesis says that the ability to operate at this epiphenomenon level is sufficient to build intelligent machines

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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 ensemble of 10 raised to 27 atoms behaving in some concentrated fashion. 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 called a dosa, so 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's physical symbol system hypothesis is that we can create symbol systems and manipulate those symbols that is enough for us to reason about the world in a intelligent fashion essentially.

So, Douglas Hofstadter who will I will talk about again in a moment has a different notion of a symbol which we will not perceive very much here he talks about how the mind creates symbol, how the brain creates these same symbols that we are talking about which stands 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 Hofstadter also talks about symbol processing in the human brain that the human brain creates symbols.

And what are these symbols? These are kind of concerted patterns of activity in thousands of neurons. So, we will not go into more detail, then that, but somehow neurons in act in concert with each other in a manner which we are inspecting ourselves think of a symbols that we are reasoning with symbols ok.

So, this kind of a 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 Neel.

Student: Neo.

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 energy out of him. So, which is a complicated sequence which we have to sort of watch the movie carefully to understand that when eventually that something is pulled out of his brain he really finds himself in some very

un New York 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 at it uses his idea that the world will even is it actually in our minds out there essentially, which is why of course, sometimes people can has hallucinate, they imagine something what is not out there, because their minds are sort of not in sync with again let me use the word reality out there. But there is this big chasm 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 fall the physical system hypothesis says that if you can create level of representation and reason at that level that should be enough for creating intelligence systems.

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Powers of Ten		A Film by Charles and Ray Eames (1977)	Source: Quarks to Quasars
100 yottameter	-10^{26} meters	The Visible Universe (about 10 billion light years across)	http://www.powersof10.com/film
1 yottameter	-10^{24} meters	a cluster of galaxies (about 100 million light years across)	http://www.wordwizz.com/pwrs10.htm
1 zettameter	-10^{21} meters	diameter of The Milky Way (about 100,000 light years across)	
100 petameters	-10^{17} meters	the nearest stars (about 10 light years away)	
10 terameters	-10^{13} meters	diameter of Solar system (11,826,600,000 km)	
1 terameter	-10^{12} meters	distance from Saturn to Sun (1,429,000,000 km)	
100 gigameters	-10^{11} meters	distance from Earth to Sun (149,600,000 km)	
100 megameters	-10^8 meters	the diameter of Jupiter (139,822 km)	
10 megameters	-10^7 meters	the diameter of Earth (12,756 km)	
1 megameter	-10^6 meters	the distance from Chennai to Pune (1190 km)	
100 kilometers	-10^5 meters	the distance from Mandi to Manali (110 km)	
10 kilometers	-10^4 meters	the diameter of a small town	
1 kilometer	-10^3 meters	longest span of the Golden Gate Bridge (1,280 m)	
100 meters	-10^2 meters	a sprint track, a meadow, a pond, a skyscraper	
10 meters	-10^1 meters	the width of a road, a small house, a tree	
1 meter	-10^0 meters	a typical door, a table, the height of a child	
10 centimeters	-10^{-1} meters	a sunbird, a typical mango, a cellphone	
1 millimeter	-10^{-2} meters	a mustard seed	
100 micrometers	-10^{-4} meters	pollen	
10 micrometers	-10^{-5} meters	a bacterium	
100 nanometers	-10^{-7} meters	a virus	
1 nanometer	-10^{-9} meters	the structure of DNA	
100 picometers	-10^{-10} meters	carbon's outer shell – 1 Angstrom unit	
1 picometer	-10^{-12} meters	the electron cloud – electromagnetism and gravity	
10 femtometers	-10^{-14} meters	the carbon nucleus	
1 femtometer	-10^{-15} meters	a proton	
10 attometers	-10^{-17} meters	quarks and gluons	

So, these are very dense slides that I have put in. We are not going to go through this slide. We will just to illustrate the levels of scale at which our concepts exist. Remember that in the end everything is made up of ensembles 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.

Now, the very nice movie I do not know how many of you have seen it called powers of 10 which is available on the web, and there is a link I have given here. Which essentially zooms 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 here 10 raised to 26 meters, and then zooms down back and goes to the bottom most level which is 10 raised to minus 17 meters and things like that. So, at different levels you see the world with a different perspective.

So, just some examples for example, mustard seed is about 1 millimeter thick, whereas the distance from Chennai to Pune is about 1000 or 1100 kilometers. So, in this powers of 10, you keep magnifying the image or reducing the image by powers of 10 every time, and then you sort of keep diving in deeper and so on and so forth. So, we can see at the top most level there are very things that we cannot I mean the our mind boggles. So, talk about something like 10 billion light years.

First of all you have to imagine what is a light year, remember what is a light year? It is a distance covered by light in 1 year, and we do not even think of light having speed I mean I just see you and I you raise your hand and I see it 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 you know it is so fast for all of us here that everything happens instantaneously. We are not we do not suffer from this effects of relativity and things like that.

But ten billion light years how much would light travel in 10 billion years, I mean we cannot even think of this kind of things essentially. All has the very extreme and 10 raised to minus 17 meters, where you have quarks and gluons and so on and so forth ok. So, the world as we think of nowadays exist at this very different scales of things that is 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 essentially.


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Our Perceptible Universe

1 kilometer	- 10^3 meters	- longest span of the Golden Gate Bridge (1,280 m)
100 meters	- 10^2 meters	- a sprint track, a meadow, a pond, a skyscraper
10 meters	- 10^1 meters	- the width of a road, a small house, a tree
1 meter	- 10^0 meters	- a typical door, a table, the height of a child
10 centimeters	- 10^{-1} meters	- a Sunbird, a typical mango, a cellphone
1 millimeter	- 10^{-3} meters	- a mustard seed
100 micrometers	- 10^{-4} meters	- pollen

↑ Scientific progress enables us to extend our concepts to different scales

↓ Scientific progress enables us to extend our concepts to different scales

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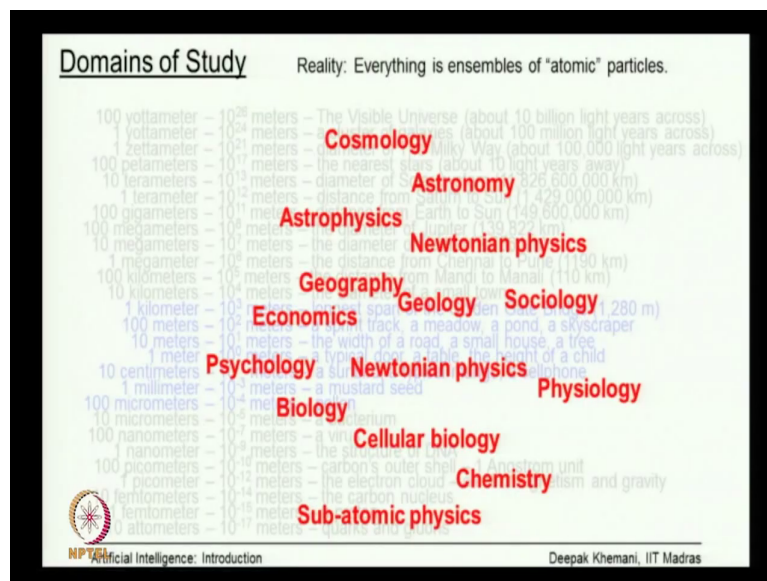
So, our perceptible universe is a small sub set of these scales essentially. So, the largest thing we can see is may be about kilometer across, so like the golden gate bridge in San Francisco or something like that. And the smallest thing is may be a mustard seed or may be some people can see pollen you know there is rays of light and you can see dust particles some of them may

be 0.1 millimeter across. So, we can perhaps think about level thinks at this level of scale essentially.

So, the human mind that is what 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 this 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. I mean at least we are not evolved to imagine that kind of a thing. And the to reason at different levels, we have created this different discipline. So, we become specialist in biology or geography or astrophysics or anything.

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But each discipline operates in its own level of scale. Social science is operate at some level, where you are talking about collections of human beings. Remember human being each human being is a collection of 10 raised to 27 particles. So, social science in some senses talking about collections of 10 raised to 27, collections of 10 raised to 27 particles. But we do not obviously think in terms of fundamental particles any longer, and we have these different disciplines essentially.

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Downward Causality

1 kilometer	- 10^3 meters	- longest span of the Golden Gate Bridge (1,280 m)
100 meters	- 10^2 meters	- a sprint track, a meadow, a pond, a skyscraper
10 meters	- 10^1 meters	- the width of a road, a small house, a tree
1 meter	- 10^0 meters	- a typical door, a table, the height of a child
10 centimeters	- 10^{-1} meters	- a sunbird, a typical mango, a cellphone
1 millimeter	- 10^{-3} meters	- a mustard seed
100 micrometers	- 10^{-4} meters	- pollen
100 nanometers	- 10^{-7} meters	- a bacterium
100 picometers	- 10^{-10} meters	- the size of DNA
100 femtometers	- 10^{-13} meters	- the size of a nucleon - 1 Angstrom unit
10 attometers	- 10^{-16} meters	- the electron cloud - electromagnetic and gravity
10 zeptometers	- 10^{-19} meters	- the carbon nucleus
10 yoctometers	- 10^{-22} meters	- a proton
10 xottometers	- 10^{-25} meters	- quarks and gluons

↓

We operate with concepts at our perceptible level. Our thoughts at this level cause the lower level activity that results in our actions

Douglas Hofstadter in "I am a Strange Loop"

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So, Hofstadter, so remember this mind body problem which Descartes was grappling with that if there is this world of some mind which is reasoning about the real physical world out there the body, how do the two things interact essentially?

Now, the physics we say we have laws of physics at the fundamental particle level and if you know that you know how the rest of the system is behaving essentially. But Hofstadter says

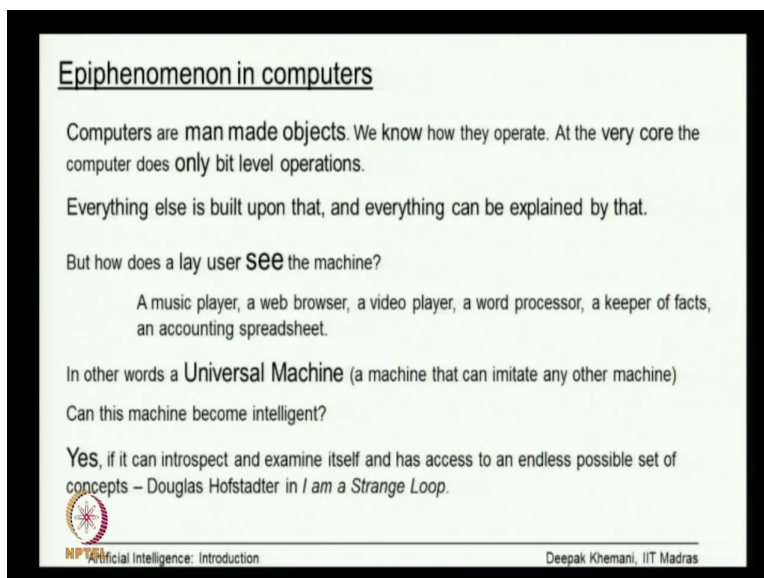
that we have to introduce a notion of what we call as downward causality which means the causality is from a higher level to a lower level.

Even though the laws of physics can explain going from particle level to on ensembles of 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 operate, which is happening with this 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 the 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 Kant even when he was talking about human categories was saying that space and causality are given to us that we accept we have to start working with those things essentially.

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Epiphenomenon in computers

Computers are man made objects. We know how they operate. At the very core the computer does **only** bit level operations.

Everything else is built upon that, and everything can be explained by that.


But how does a lay user **see** the machine?

A music player, a web browser, a video player, a word processor, a keeper of facts, an accounting spreadsheet.

In other words a **Universal Machine** (a machine that can imitate any other machine)

Can this machine become intelligent?

Yes, if it can introspect and examine itself and has access to an endless possible set of concepts – Douglas Hofstadter in *I am a Strange Loop*.

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So, this thing these things are called 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 surface of the inner surface of the balloon. And this cumulative activity or the epiphenomenon of pressure is felt 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 in saying, I want to have this cup of tea which is operating at a very higher level essentially. So, Kant a machine operate at the epiphenomena level like this, and that we feel is necessary for machines be intelligent.

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Epiphemona in Computers