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

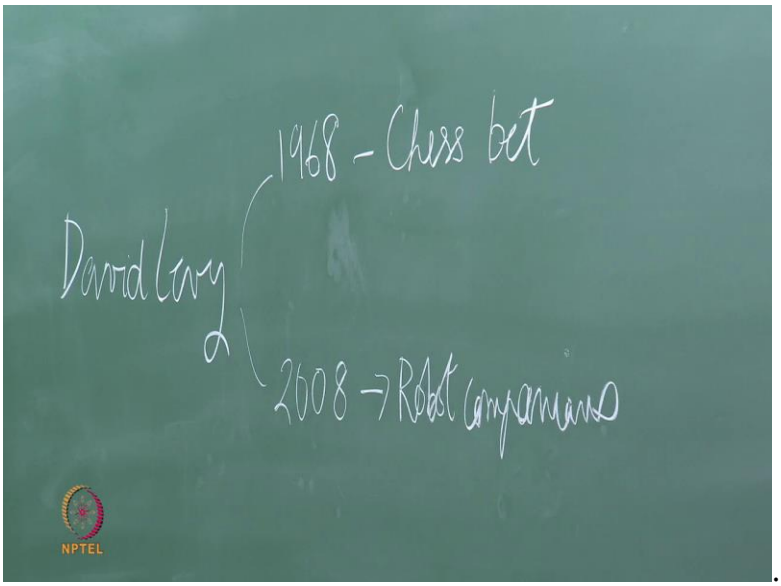
Module - 01
Lecture - 02
Introduction to AI

(Refer Slide Time: 00:14)

No one; you heard about this creature; kirobo is a small robot, 34 centimeter; it comes to about your knee or something; build by Japan, needless to say, it is Japanese based ahead of the rest of the world in robotics. And, this robot has been sent to space on Sunday that is how it came into news. If you are watching some news channel, well, but may be BBC or something else, the Japanese space agency has sent this robot into space.

It is a small robot which can recognize speech, understand what you are saying, talk back and recognize faces, and so on, exactly. And, the idea is that this robot will be a companion for a Japanese astronaut who is scheduled to go in November sometime; and, that is an interesting idea, robots as companions of people.

(Refer Slide Time: 01:36)



So, if you remember, we had talked about, I had mentioned about this chess grandmaster David Levy. In 1968 he had a chess bet we had talked about this in the last class. And, he had said that no program can beat him for the next 10 years which he luckily survived the bet. Because, now as we know, chess playing programs are much better, but in 2008 he is talking about robot companions.

So, he is come from one end of the pendulum in which he believe that chess, a program, a computer program could not do anything interesting, to the other end where he believes that robots can be companions to human beings. So, he wrote this book, it is called, it has published in 2008, and the title of the book is "Love and Sex with Robots".

And, the idea behind the book is something which many parts of the world now looking at; specially those parts of the world which have aging populations where they do not have enough young to take care of the old. But, of course, he is not talking of old here, but where robots could take care of people. So, robots can be companions and so on. So, that is the book he wrote in 2008. And, for example, what looks like a young lady, whereas in fact, it is a robot, the thing here.

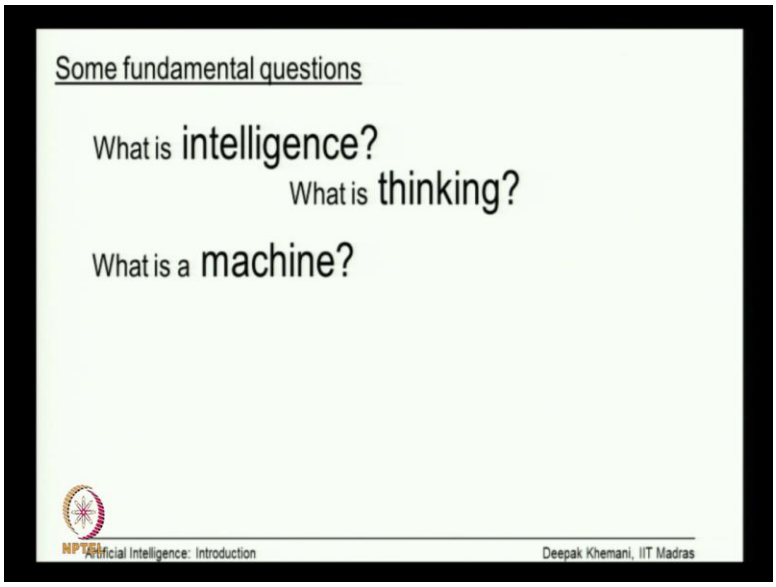
So, this idea of creating robots in the image of us has been around for a long time, and we will look at some of this history today; and, robotic companions could well be there in the future essentially. So, we saw in the last class; so, I just quickly go over this. These are the syllabus which will be available in some place and the text books. And, these are the 2 books that we will be following in the next couple of lectures – "AI: The Very

Idea" by Haugeland and "Machines Who Think" by Pamela McCorduck.

We saw some definitions of AI. So, therefore, 4 things here - one is that if they do machines are intelligent, if they do things which human beings are considered to be intelligent for; another definition is that AI is the enterprise of solving heart problems and finding polynomial time solutions. And, we must, of course, qualify that by saying that these are approximate solutions, so, or they are not necessarily optimal solutions.

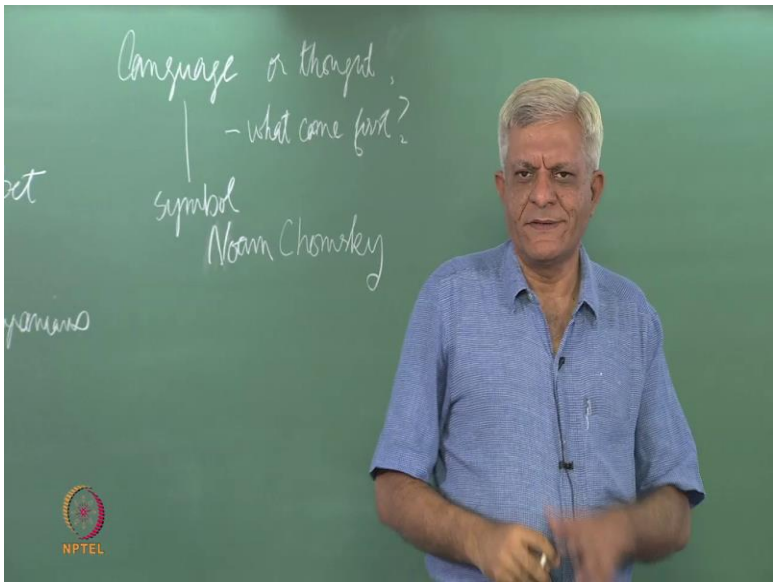
And then, the AI, the study of mental faculties by creating computation models that is the idea given by Sania Macdomote. But, the idea, but the definition that we like most is given by Haugeland. And, the definition says that AI is interested in the idea of machines with minds of their own essentially. And, this is the idea that you will pursue in the next couple of lectures.

(Refer Slide Time: 05:42)



We asked some fundamental questions in the last class - what is intelligence? What is thinking? And, we got several responses here; what we think is intelligent behavior? So, problem solving, reasoning, learning, perception and language; language was mentioned in the last class.

(Refer Slide Time: 06:30)



So, let me ask a question here. Language is something which is unique to human beings. And, many people believe that it is instrumental in intelligent behavior. But, the question that I want to ask is if you look at language and thought, what came first? So, he was thinking because of the language or was language was because of the thinking. In the sense, is that what ability to think dependent upon the scale of language that we have, or did language come because we are able to think?

So, let me see what people think here. And, again I will emphasize that there is no correct answer to this question; in the sense that it is like the chicken and egg problem. But, what do students think? And, I hope students from Monday will also join in, with their opinions. Can we think without language? Let me ask in this way. Or, is thinking closely tied to language? You are saying, no; we can think without language. So, can you, sort of, justify, or support your answer?

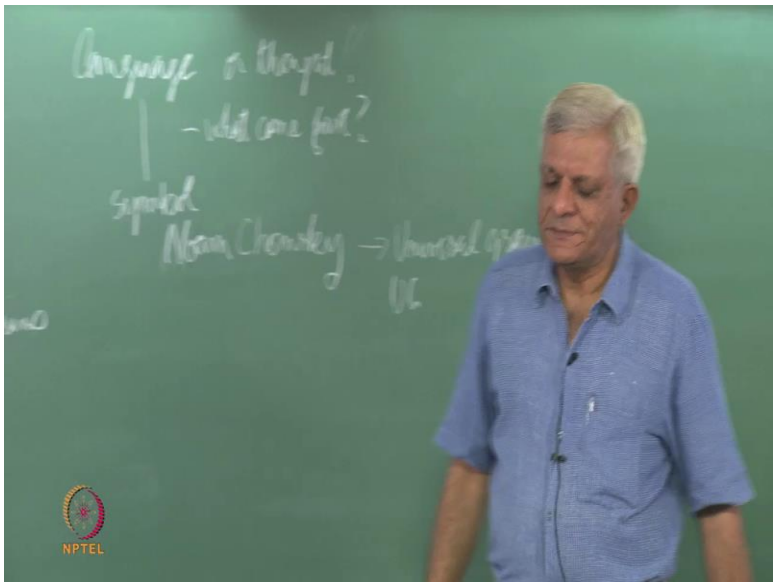
Student: Abstract thoughts we have; so, those are not language; those are not language dependent or something.

So, abstract thoughts are not language dependent; now that is a, some more debatable claim essentially. So, the question I am asking really is that our thoughts made up of language, or all our thoughts, good thoughts imply language; can we think without taking recourse to language. So, when you say language, we really mean symbol because language is just one kind of a symbol system essentially. Is it possible to think? Now you said graphics or visual images, yeah that is the thing which comes to mind, that if you

recall visual images then you are not really talking about words or things like that.

Interestingly, you have heard of Chomsky, right. Yeah. So, is there anyone who is not heard of Noom Chomsky? What is he doing nowadays? He visited India few years ago as well. So, he is actually become a political activist.

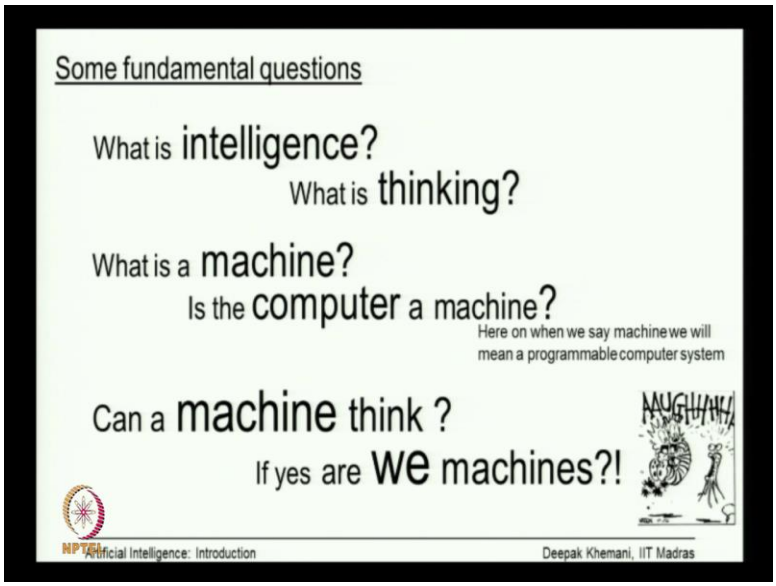
(Refer Slide Time: 09:38)



But, many years ago when he was active in linguistics he put forward the idea of universal grammar; so, UG, that it is called. And, he said that human beings are born with grammar in their heads, whatever that means in the heads, we will not explore that question, but essentially our brains come prewired with the faculty of linguistic ability which is, sort of, some kind of a grammar.

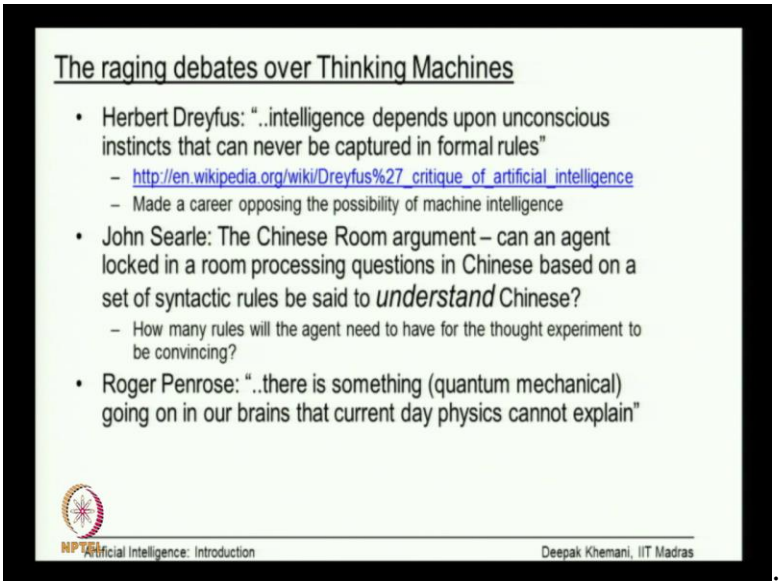
And, what he says is that depending upon which place, which society you grow up in, you tune that grammar to that particular language that exists in that society essentially. So, Chomsky, of course, so, he is saying that language came first; that we are born with the ability to use language, and may be that helped us, of course; he is not saying that, but may be that helped us in our ability to think essentially. But, anyway that is an open question; may be at later point I will come back to it.

(Refer Slide Time: 10:55)



So, we also ask some question as to, what is a machine? Is the computer a machine? And we said that, yes, we will assume that; whenever we talk of machines thinking we will be talking about computer programs running. And of course, we ask the question that, are we machines; that is something you can found over and some reactions to that.

(Refer Slide Time: 11:18)



So, historically there have been arguments against thinking. So, we had discussed 3 arguments by Dreyfus which says that there is something intuitionistic going on in our heads; something which is kind of intuition which we cannot define in terms of rules. So,

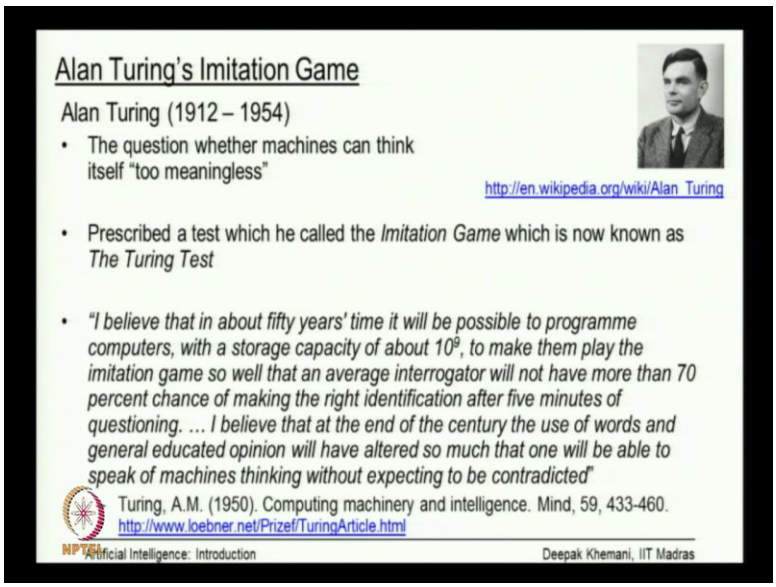
when Dreyfus was talking about all these people, we were talking about rules as a mechanism for reasoning. And, he said that there is certain kind of unconscious instincts that we have which cannot be captured in rules essentially.

John Searle, a philosopher, use the Chinese Room argument; and he says the argument was that just because he can manipulate symbols and convince somebody that you are doing something, like for example, children doing long division. Do they understand when, whether, what is really, what are they really doing. Or, when even younger children do addition; so, they add 2 numbers, where looking up a table, do a carryover, then add, and so on and so forth. You are doing simple manipulations. Are you understanding, what is behind that activity essentially?

All older students, should I say, when they are dealing with things like Fourier transforms and so on and so forth, are you doing it mechanically, or have you mugged up a formula of how to integrate something, or do you understand what is happening behind that decision. So, what Searle says is that symbol manipulation, the ability to manipulate symbols is not necessarily a guarantee that you are intelligent; maybe you are following some rules which somebody has taught you; this is how you add numbers and so on and so forth.

And, Penrose, the celebrated scientist says that there is something quantum mechanical going on in our brains essentially. So, there are other arguments based on emotion in intuition, consciousness, ethics, and so on which we will ignore.

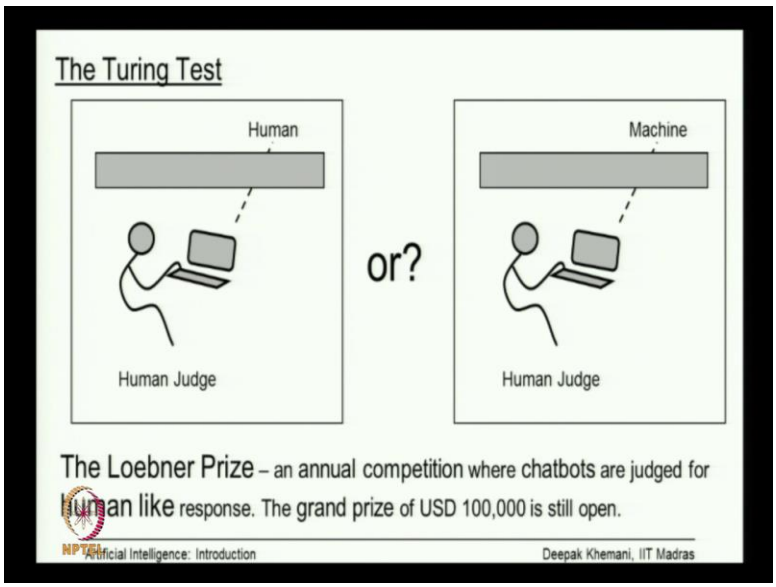
(Refer Slide Time: 13:44)



Then, Alan Turing, and he said that the question whether machines can think is meaningless. Let us not try an answer because first you have to answer what is thinking and only then you can say whether machines can think essentially or not essentially. He said that let me prescribe a test which is called as a imitation game, and which we now called that Turing test.

And, at that time when he prescribed it in this book that is mentioned in this slide here, in the paper that is mentioned here, 'Computing Machinery and Intelligence' appeared in 1950. It is available on the link that is given in the page. He believed that in 50 years on then which is in 2000, machines would be able to pass his so called Turing test essentially.

(Refer Slide Time: 14:03)



And, what is the test? This is where we stopped in the last class. The test is that there is a human judge sitting out there, interacting over some medium; it could be nowadays a mobile phone where you are chatting with someone; or, in those days it was a teletype which was connected to another room in which the other person who was responding; and what Turing said was that if that human judge can confidently discriminate whether the other side is man or a computer, then the computer has failed the test. But, if the computer can, most of the times convince the judge that the judge is talking to a human then the computer has passed the Turing test.

So, this is what is known as a Turing test of intelligence you might say, to test whether system is intelligent you will pass it through the Turing test and then decide whether it is

intelligent. You do not ask, what you mean by thinking, what is intelligence; and you know that do not go into fundamentals. And, as I said, there is a Loebner prize which is currently available; still now 100, 000 US dollars to anybody who can pass the test, so to speak essentially.

So, the question which I left the class with was, what you think of the Turing test as a test of intelligence? Do you have any views on this? Is it a good test? Is it a bad test? Do you agree that if a computer passes a test it will be considered to be intelligent, it qualify to be called intelligent? Any thoughts on this? While you are thinking, meanwhile let me address the mandy students.

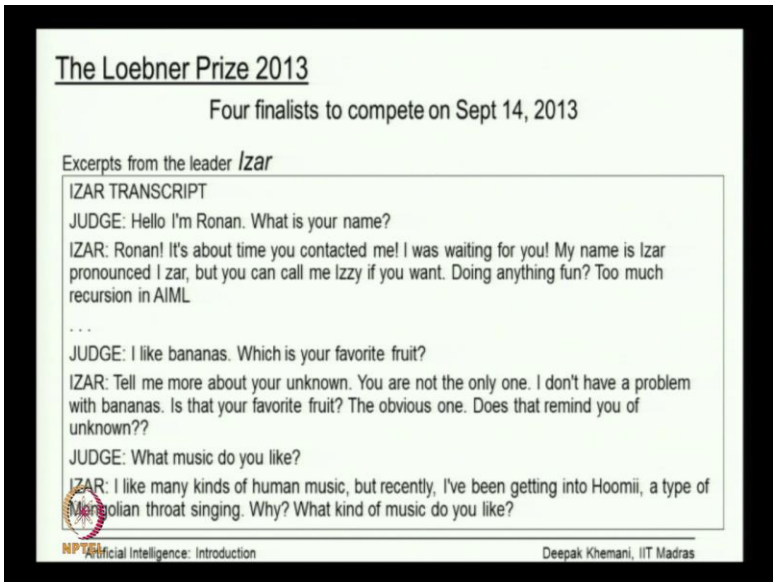
So, welcome again, and the basic idea of the first few lectures is that they are going to be a study of history and philosophy behind AI, what has happened in the last few 100 years which has led to the development of AI currently. And, after those 2 or 3 lectures we will have a qualitative shift, and we will spend most of the time using algorithms, using the syllabus which I will convey to you essentially. So, is it a good test or a bad test? Surely you can have some opinion. Yes.

Student: I mean you cannot judge the intelligence because like any performer can see the past media like through what type of question a grandmaster configuration and based on that data.

Yes, if that is, precisely what happens is Loebner prize is a context which takes place every year, and as I said this year it is going to, the final is going to take place on September 14. And, this one of the leading programs is called Izar and this is a pronunciation transcript from the earlier competition rounds. So, you have seen it and you can look at it again.

So, obviously, people who like such programs look at the history just like students who write exams they look at history of past questions, even such people essentially. So, that is all allowed; everything is allowed. Can you write a computer program which will cool the judge, if you want to use the term, to thinking that the judge is talking to a human being.

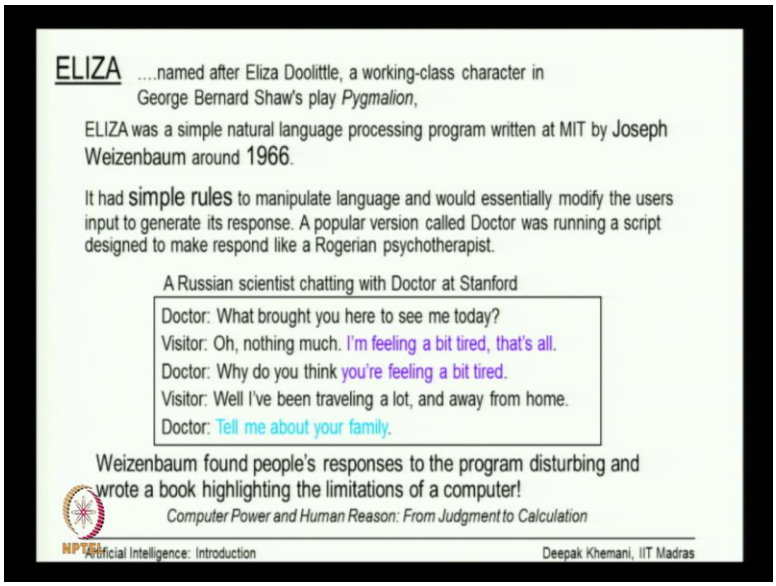
(Refer Slide Time: 17:57)



And, this was the conversation that we saw this izar had. And, he is making statements like I am getting into, when he is talking about music he is making statements about, the last couple of lines you will see, I have been getting into Hoomii, a type of Mongolian throat singing. What kind of music do you like? So, obviously, such a program will have to be equipped with general knowledge, atleast which everybody knows essentially. So, I mean no human would be, would not knowing it essentially. So, you have to have that kind of knowledge.

Of course, you also have to have some kind of a rhetorical skills and ways of getting around questions and things like that, all that is part of it. What if I were to give it to 12 digit numbers to multiply; say, what is the product of 2 billion 29 million whatever, some 12, 13 digit number I say, I give 2 12 digit numbers and ask it what is the product of that, and the computer, poor thing, being a computer gives me the answer before I even finish the question, almost finish the question. Would not I be able to say no, no, you are not a human being? So, I will again leave it you to think about this; is it a good test or bad test?

(Refer Slide Time: 19:28)



But, you have did mention Eliza, a program written 1966 when computer has just come into place by Weizenbaum. And, it is a program for simple manipulation of rules. If you take the input, do a little bit of twisting, turn it round of it and put it back to the user; and, to some people it is, one version of it called Doctor, sounded like a psychotherapist. And they would start talking to the program as if they were talking to a therapist.

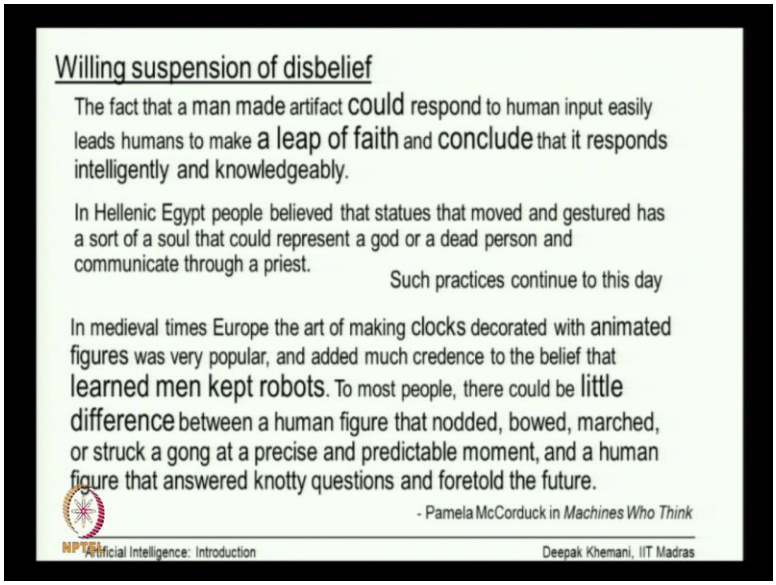
And, this was a Russian scientist who was visiting Stanford who actually went through this conversation, and we saw that in the last class. And, what you see in purple is the fact that how this program is manipulating your input into generating its own output essentially. So, something like I am feeling a bit tired, and it says why do you think you are feeling a bit tired, is standard; and, new questions like tell me about your family and so on.

Weizenbaum did not like the way people responded to Eliza. It is a very simple program. It is nothing deep sophisticated about it, but people used to interact with it as if they were interacting with somebody who understood the complexities of their problems and thinks like that essentially. So, he wrote this book "Computer Power and Human Reason: From Judgment to Calculation".

He wanted say, in essence, that AI is not possible; that you know computers can never be as deep thinkers as the therapist can be essentially. So, there is a difference between what can be, what appears to be, essentially. And, human beings have a tendency, we have, we are willing to suspend our disbelief essentially. They are willing to watch a James Bond

movie and believe that all that is happening is possible, and all kinds of things essentially.

(Refer Slide Time: 21:26)



So, the fact that the man made artifact could respond to human input easily leads humans to make a leap of faith and conclude that it responds intelligently and knowledgeably. Throughout centuries we have been doing that essentially. So, in olden times, in Egypt, people believed that statues which moved and gestured had a sort of a soul, and they could represent a god or a dead person and communicate through a priest essentially.

So, I said older times Egypt, but even today you can find in our country this sort of a thing happening. You have people who will eat tea leaves, or people who communicate with your ancestors, or people who go and get their fortunes foretold by a parrot who pulls a card out of a bunch of cards. So, we do it all the time. And. we believe, will not everybody, we mostly believe that this is possible essentially. Such practices continued to this day essentially.

And, in Europe, there was a great fascination for such moving figures, moving automita, or, you know, statues which could move around shake their heads and so on. So, Pamela McCorduck writes in a book “Machines Who Think” that in medieval times art of making clocks decorated and animated figures was very popular essentially. So, if you go to Germany, you can still find them. For example, in clock towers when it is 12 noon suddenly there is a lot of music and some statues come out and do something and go back in, that kind of stuff.

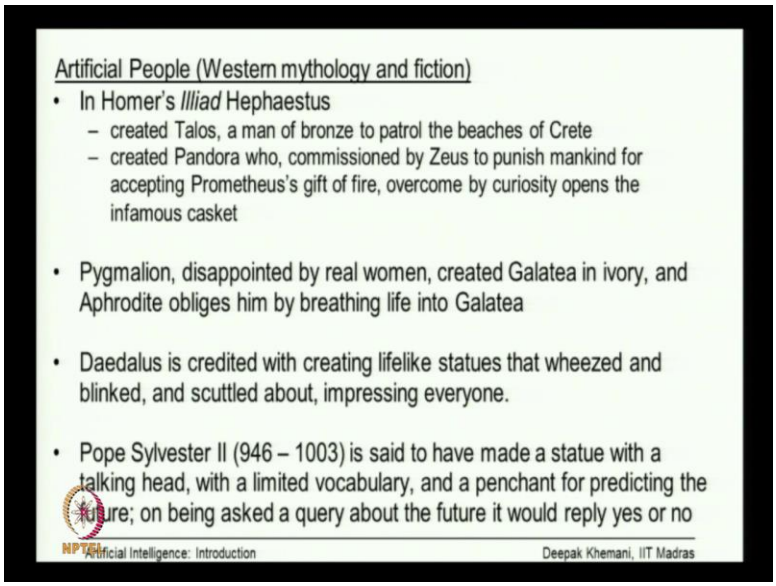
So, it was popular in medieval times that learned men kept robots essentially. By learned men, know, society was not very as galantive as it was now; they were the kings, and they were the peasants, and they were the learned men, they were the traders and the warriors. So, there are classes of people, in those learned men kept robots.

And, most interestingly to most people there could be little difference between a human figure that nodded, bowed, marched, or struck a gong at a precise and predictable moment which is entirely feasible. You can construct machinery which is accurate, and we know that such machinery exist, so between surf machinery and a human figure that answered naughty questions and foretold the future.

So, for us there is no difference. If you can construct a statue which can nod its head and we ask the question and it nods its head, we are willing to say that yes it understands what I am saying and it is telling my future, and you know that sort of a thing.

So, in the study of history that we are going to be doing, there going to be two strands - one is this mechanical side of talking statues, moving statues, and things like that; and other is going to be the philosophical side which is about what is the notion of the mind, how do the notion of the mind come. You know, I am, so those questions we will come to little bit later. Let us first address the mechanical side of things essentially.

(Refer Slide Time: 24:54)



So, all this is happening in Europe. We have this question of artificial people. In Homer's "Illiad" Hephaestus is supposed to have created this Talos, a man of bronze which would patrol the beaches of Crete. Hephaestus is also supposed to have created Pandora; you might have heard about Pandora who commissioned by Zeus, Zeus was a god, to punish mankind for accepting Prometheus's gift of fire. And, Pandora is supposed to take that casket, but she is so curious about it that she opens the casket essentially; you know, and let lose the evils into this world mostly.

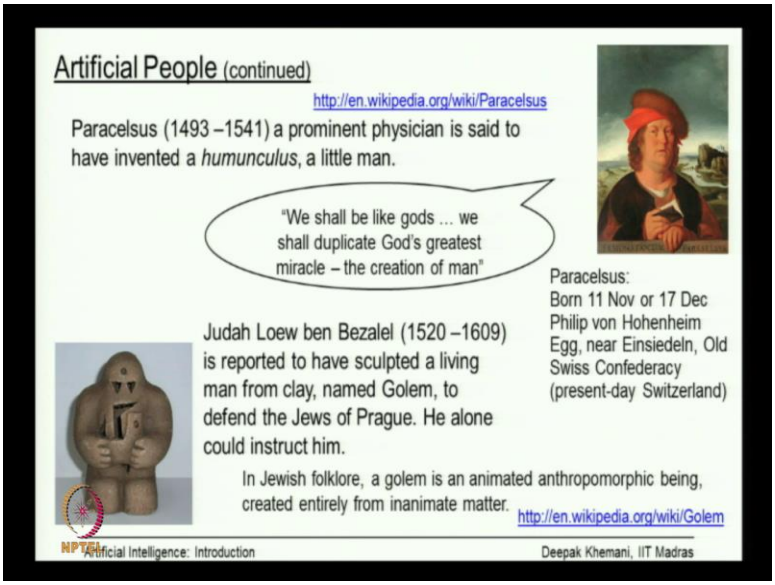
Pygmalion, remember this one act show of Pygmalion in which there was a character called Eliza which was a name of the program written by Weizenbaum. Pygmalion was also a mythical creature who was disappointed by real women and created Galatea in ivory, and Aphrodite who was another god. So, the Greeks also had many gods like we Indians have gods for doing different kinds of thing. Aphrodite obliges him by breathing life into Galatea and apparently, he fell in love with his own creation like in the play.

Then Daedalus, you must have heard about, more, well known for his artificial wings. He was, he wanted to fly, but he was also create, credited with creating lifelike statues that wheezed and blinked, and scuttled about, impressing everyone. So, this is the important thing. This statues which could seem to be autonomous; and, if you are autonomous you must be intelligent essentially. So, that is the leaf of face that we are making essentially.

Then, about a 1000 years ago, Pope Sylvester is said to have made a statue with a talking

head, with a limited vocabulary, and a penchant for predicting the future. So, that is why people are willing to believe that this talking head can tell your future; and on being asking a query, it would reply yes or no by shaking his head essentially, but all that is in myth, essentially. There is some more mythology.

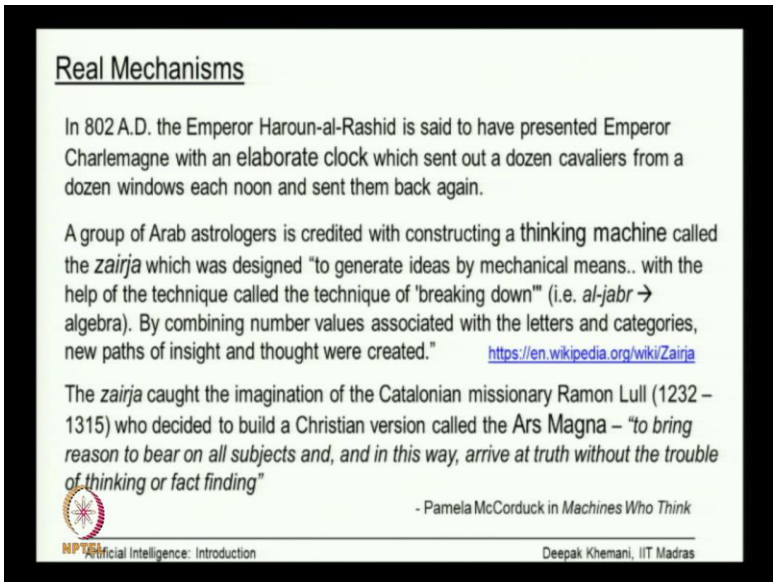
(Refer Slide Time: 27:18)



Paracelsus was a physician lived from 1493 to 1541 is supposed to have created a little man called humunculus essentially. And, he made this statement: "We shall be like gods ... we shall duplicate God's greatest miracle - the creation of man" essentially. Because in western thought we have been created in the image of god himself, and so, we can be like him and create creatures in our own image. So, he lived in Switzerland.

And, Judah Loew ben Bezalel is reported to have sculpted a human, a living man from clay, and he called him Golem, to defend the Jews of Prague. So, in Jewish folklore, a Golem is an animated anthropomorphic creature made out of an inanimate matter. So, that is a kind of a image, the kind of creature he supposed to have created essentially. All this material that is available in Wikipedia and I have given all the references from where I have taken the images.

(Refer Slide Time: 28:30)



So, let us talk about real mechanisms, or some of them are mythical of course. We cannot imagine man made of clay which could do all this sort of things. But, in parallel, real machinery was being created essentially. Some of these ideas came from the east by a Arabian countries.

And, in 802 Haroun-al-Rashid, you know, we heard his name in other context as well, is said to have presented Emperor Charlemagne with an elaborate clock which sent out dozens of cavaliers from a dozen windows each and back again. So, this is the kind of clockwork which if you go to Eurpoe you can still see now essentially in this, in the town, or the city center we have this sort of machinery still operating.

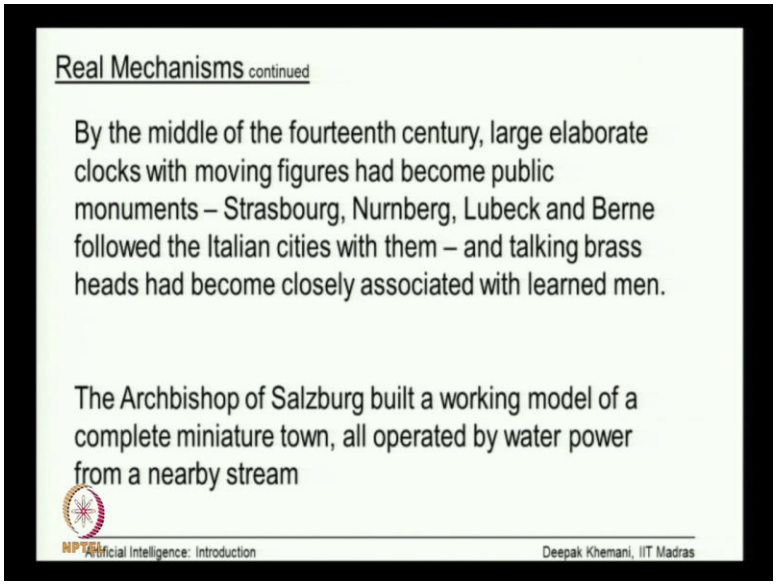
Then, a group of Arab astrologers is credited with constructing what they called as a thinking machine called the zairja which was designed. So, it was a collection of rotating disc, you know, with markings on them. And, if you rotate the disc according to some input information you would compute something.

But, their notion was to generate ideas by mechanical means with a help of a technique of breaking down called al-jabr which, as some of you know, is a route for the word algebra. And, by combining numbers values associated with letters and categories, new paths of insight and thought would be created essentially. So, this fascination of autonomous entities, autonomous machines which are thinking machines, goes back a long time essentially.

So, this zairja caught the imagination of a Spanish Catalonian missionary called Ramon Lull, and, who decided to design a Christian version of it which he calls as Ars Magna. And, he said the goal is to bring reason to bear on all subjects, and in this way, arrive at the truth without the trouble of thinking or fact finding. So, one thing, when you look at the quotations from these times you must remember that some of the meanings of the words are a little bit different from what they are know essentially.

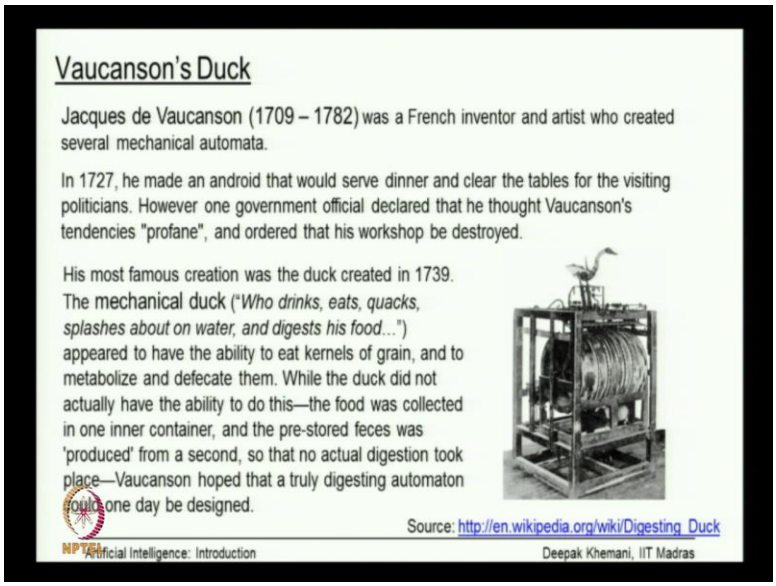
So, those of you who have read Shakespeare for example, would know that Shakespeare's English is a little bit different from our's English, and our English, and we need to understand things essentially. But, this notion of arriving at truth without the trouble of thinking or fact finding, of course, has been fulfilled now with programs like google and so on; just have typing something and you get answer obviously.

(Refer Slide Time: 31:22)



So, by the middle of the 14th century, large clocks and figures became popular in many areas of Germany and Italy. And, talking brass heads became closely associated with learned man again. The Archbishop of Salzburg built a working model of a complete miniature town, driven by water power essentially, operated by water power from a nearby stream.

(Refer Slide Time: 31:53)

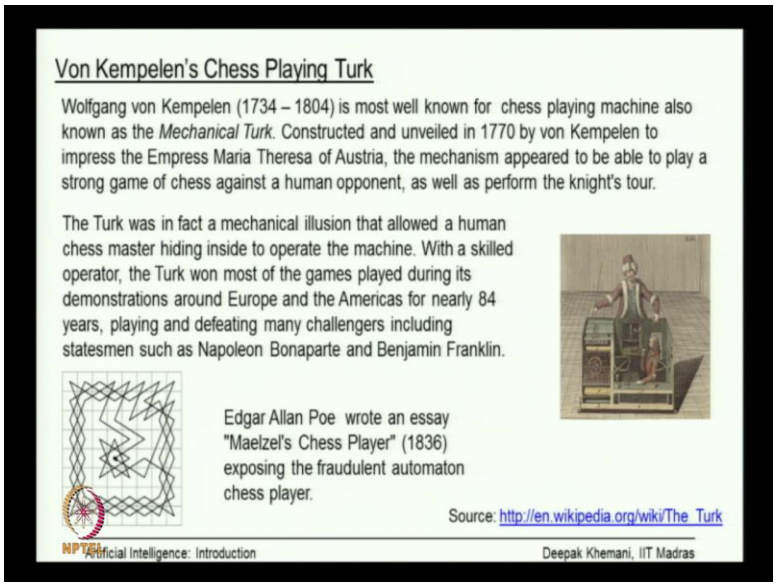


So, 1 or 2 more examples. Vaucanson's Duck, Vacanson, keep, note the years; this was, he made this thing in around 1730 or something like that, which is quite long time ago. He was a French inventor. So, one - he is credited with having made an android which could serve dinner and clear tables for the visiting politicians. However, one government official declared that he thought Vaucanson's tendencies as profane, and ordered his workshop to be destroyed essentially.

We will see later that this kind of political oversight has influenced europolian thought quite a bit political and religious source; for example, Copernicus and Galileo and all these people was sort of worried about putting forward their ideas, about what the world is really like. So, he created this, his most famous creation is this duck called the mechanical duck which could appear to be drinking, eating, quacking, splashing about in water, and digesting its food; became very famous, 1739.

And, there is a image of a replica of this duck which is lying in some museum somewhere. Though, of course, in real life, meaning in the actual duck that he created, it did not have digestive abilities. The food was actually collected in, the food that the duck was supposed to be eating was collected in one container, and the output was sort of pre-stored and sent out from another container. But, he was hopeful that a truly digesting automaton could one day be designed. So, this fascination with machinery is that you are trying to look at essentially.

(Refer Slide Time: 33:52)



Another very famous example is this chess playing Turk by Kempelen. Wolfgang Kempelen, 1734 -1804, he created chess playing machine known as a Mechanical Turk constructed in 1770 to impress the Empress Maria Theresa of Austria. And, the mechanism appeared to be able to play a strong game of chess against human opponents, as well as perform the knight's tour. So, you must be familiar with the knight's tour on the 64 board chess square, can you move a knight to cover all the squares exactly ones.

And, the figure on the bottom is knights to a apparently created by the Mechanical Turk, looks quite a aesthetic figure to make. Actually, you might have written a program to create a knight's tour of some point. Now, this was the automaton which Kempelen took all over Europe; he impressed Napoleon and other people, beating his general Hectaus.

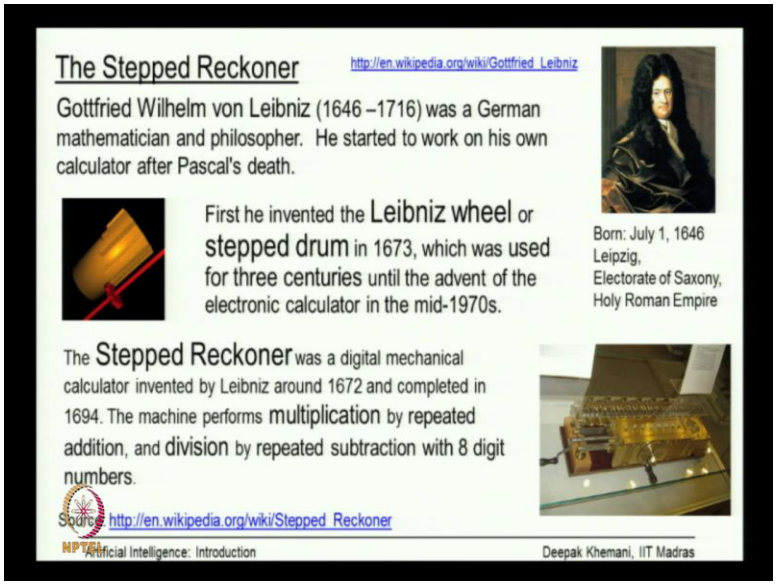
And, here is the picture of the automaton. You can see it; maybe I should make it a bit larger. If you look carefully, you can see that inside this box was a human chess player sitting this. So, it was a really a Hokes. Since, it was not discovered for a long time essentially. And it travelled for nearly 84 years, Europe and America, beating all kinds of luminaries at chess.

It seems, Edgar Allan Pope wrote an essay trying to expose that this chess play cannot be a real machine. So, let us move on to more useful things. Mechanical arithmetic; can we make machines which will do arithmetic for us? So, Pascal, of course, you are familiar with. As students of science in various places Pascal's name is appeared; not least as the programming language, name of a programming language.

So, he invented a mechanical calculator using something called Lanthonyer which we will not go into. And, he tried out 50 different prototypes before presenting his machine in 1645 with a public. It was called Pascalin or reflecting machines or Pascal's calculator. And, you could add and subtract 2 numbers; that was its limits of its mental abilities, and multiply and divide by repetition essentially.

There is a image of Pascaline from one of the museums. And, he received the rights to produce this machine and sell it in France, but it was not something which was commercially viable for him. So, as this article says, the cost and complexity of producing the Pascaline was too much for him; and the production ceased in a year. This is a real machine which could add, subtract, and multiply, 2 numbers. So, you can see, we are already looking at advent of calculating machines.

(Refer Slide Time: 37:16)



So, all these are famous names. You must have encountered them. For example, Leibniz we know as an inventor of the calculus. So, these are sort of multifaceted people with all kinds of things in those days. So, he was a German philosopher and a mathematician. He started to work on his own calculator after Pascal's death. So, he invented something which is called as a Leibniz wheel or a stepped drum which could do counting in some sense.

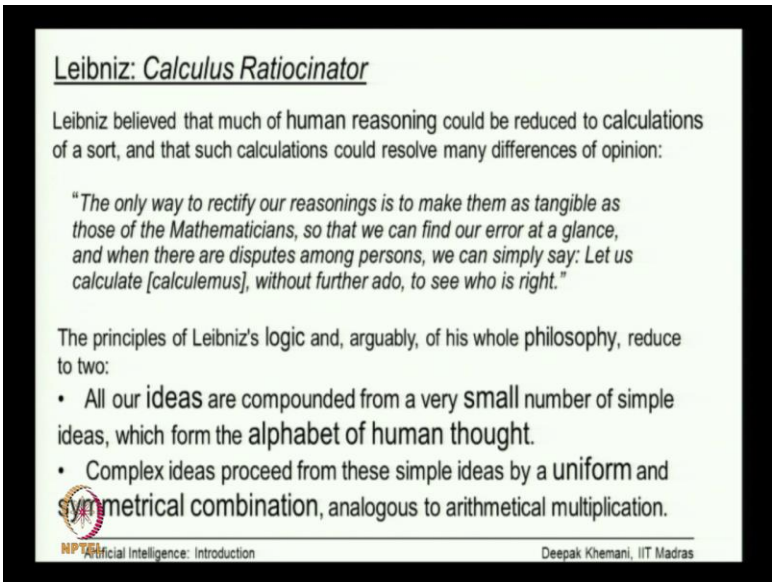
So, here is the image from the Wikipedia site. So, you can see there is a gear in the red color fixed to a rod. And, depending upon; and there is a step set of teeth in the orange cylinder. So, depending upon where the gear is it would be rotated some number of times

dependent upon howmany of those teeth is encountered essentially. So, when it was on the lower part it would count 0 or 1, if it was raised to the extreme right then it would be struck by let us say 9 or 10 teeth and it would count of 10. So, it is just a small counting device that he invented.

All these machines in those times were mechanical in nature. It is called as stepped drum. And, as you can see from this quote it was used for 3 centuries until the advent of the electronic calculator which came only much later in life, in fact, in the last century. And, he build this machine called the stepped reckoner. So, the stepped reckoner, the stepped name comes from the kind of drumit uses, the step drum.

It was a digital mechanical calculator invented by Leibniz around 1672 and completed in 1694. It could perform multiplication by repeated addition, and division by repeated subtraction. And, it could operate with 8 digit numbers. So, if you multiply 2, 8 digit numbers it would give you 16 digit answer. So, that was its precision; and image of the stepped reckoner from one of the museums essentially.

(Refer Slide Time: 39:35)



Leibniz, of course, was as I said, multifaceted person. He believed that much of human listening could be reduced to calculations of a sort. We are moving towards AI in some sense; that can we have machines automaton which think and it can do reasoning, and you know, including things like arithmetic. But, he is going behind arithmetic. He is saying that human visioning could be reduced to calculation of a sort and such calculations could resolve many differences of opinion essentially.

So, here is a quote from Leibniz. He says, "the only way to rectify our reasonings, and mind this language is not modern language, it is slightly old language, the only way to rectify our reasonings is to make them as tangible as those of the Mathematicians, so that we can find our error at a glance, and when there is a dispute among people, persons, we can simply say; Let us calculate without further ado, to see who is right".

The motivation behind devising logic is the same essentially. And, we will see that logic also evolved from similar background. But, this idea that arguments can be settled by calculation, so you do not have to fight or something like that, also goes back to those time. Of course, if we tell this to the UP government they would not believe it essentially. So, these are the general principles of his logic, and, in fact, his whole philosophy.

And, they are, that all our ideas are compounded from a very small number of simple ideas which form the alphabet of human thought essentially, very significant step is making essentially. He says that everything that we think about is essentially

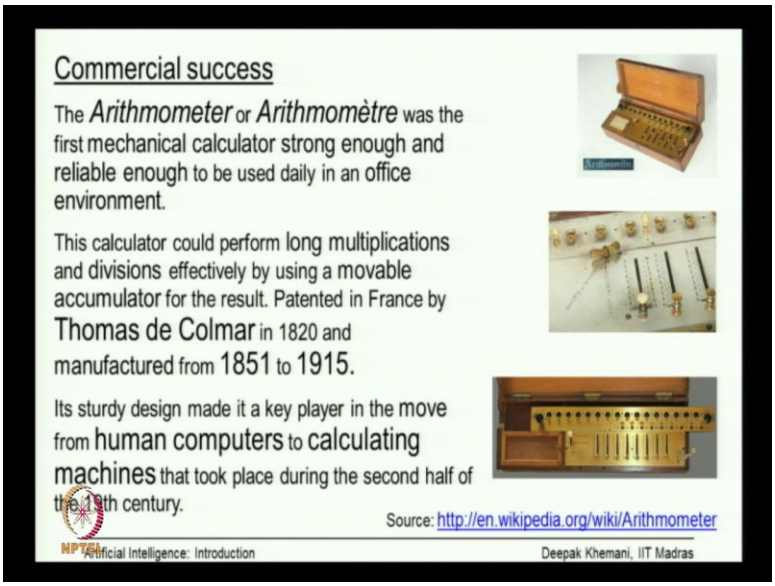
combinations of some small set of simple things. Remember, in those days, physics or science had still not discovered the notion of an atom. All those ideas came much later essentially.

And, Leibniz is talking about the fact that there are small number of simple ideas which combine and form complex ideas to form new ideas essentially. And, this is an idea which, sort of, carries forward to present that knowledge representation as well. They have been approaches to knowledge representation which says that we will work with small number primitive concepts and derive all other concepts from those concepts essentially. So, it is a very significant idea. So, the alphabet of human thought.

And secondly, complex ideas proceed from these simple ideas by a uniform and symmetrical combination, analogous to arithmetical multiplication. So, what you mean by uniform and symmetrical combination? Is that there is a well defined way of doing things essentially, well defined mechanical way of just like you have algorithms for adding or doing long division or multiplication, you have a algorithms for combining smaller ideas into more complex one.

So, there are two things he is saying - one is that everything, all ideas are made up of first finite set of simple ideas, and then there is a uniform way of combining ideas to form more complex ideas. Then remember this was in the 17th century.

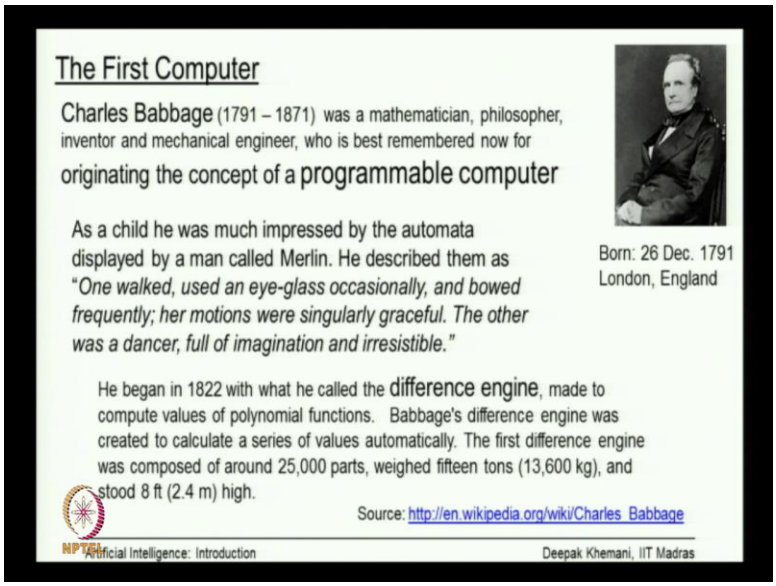
(Refer Slide Time: 43:25)



The first commercial success of a mechanical calculator was in 1820. Thomas de Colmar from France, he built this machine and it was strong and steady enough to extend daily use in the office environment essentially. So, if you look at the last paragraph, so these are some of the images which are of those real machines. And, as you can see the second paragraph they were manufactured from 1851 to 1915. So, not even 100 years ago you might have found people using such a machine to do arithmetic essentially.

The last idea says that its sturdy design made it a key player in the move from human computers to calculating machines that took place during the second half of the 19th century. So, I want to draw your attention to the phrase human computers. Before our computers, digital computers, or mechanical computers that we will see in the moment were invented, but the word computation was essentially applied to human beings. The human beings computed things and they were called computers essentially; and this is the term that you will see again later sometime.

(Refer Slide Time: 44:48)



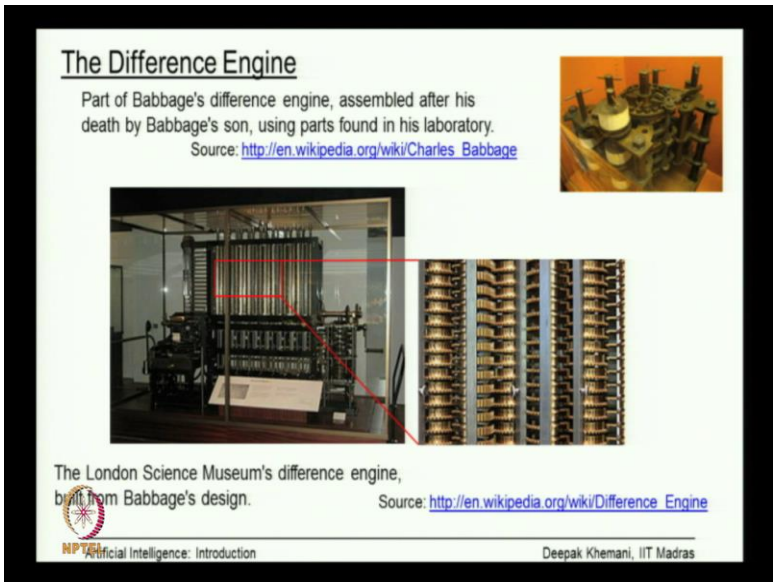
That brings us to the first computer, so, you all familiar with Charles Babbage I presume; 18th century; he was a mathematician, philosopher, inventor, mechanical engineer; best remembered for his idea of the programmable computer. All the machines that we have seen so far were not programmable; they could do arithmetic for example, and that was about it essentially.

Charles Babbage took this to the next step. So, he as a child was fascinated by the same automaton, the kind of talking heads, moving figures that we talked about. And he, this is a quote from what he said about some statues that he saw displayed by a man called Merlin.

And, he described them as saying, there is 2 feminine figures, he says, one walked, used an eye-glass occasionally, and bowed frequently; her motions were singularly graceful. And he says, the other was a dancer, full of imagination, I do not know how he got that, and irresistible essentially. So, this was the general fascination with talking, moving figures that, you know, was pushing all these ideas forward essentially.

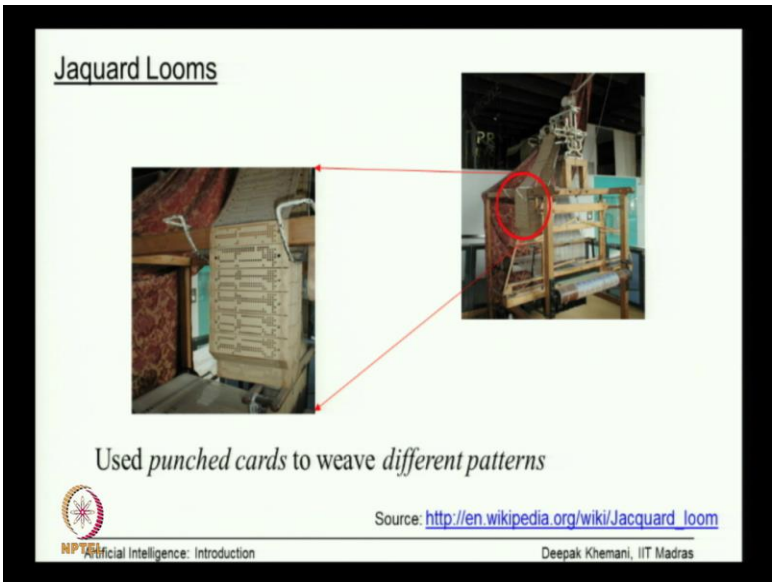
So, in 1822 he began a building what is called as a difference engine; you must have heard the term. It was designed to compute polynomial functions, more than addition and multiplication. The first engine was composed of 25,000 parts weighed about 13,600 kilo grams, and was 8 feet tall.

(Refer Slide Time: 46:29).



Here is an image of a difference engine. On the bottom we can see. On the bottom left you can see an image which is there in London science museum. And, on its right is a small enlargement of the gear system that it was using. And, on the top is a part of a difference engine assembled after his death by his son, using parts found in his lab essentially. That is a original Babbage engine, whereas what here is a recreation, modern recreation of the difference engine that you can see. So, these are working machines.

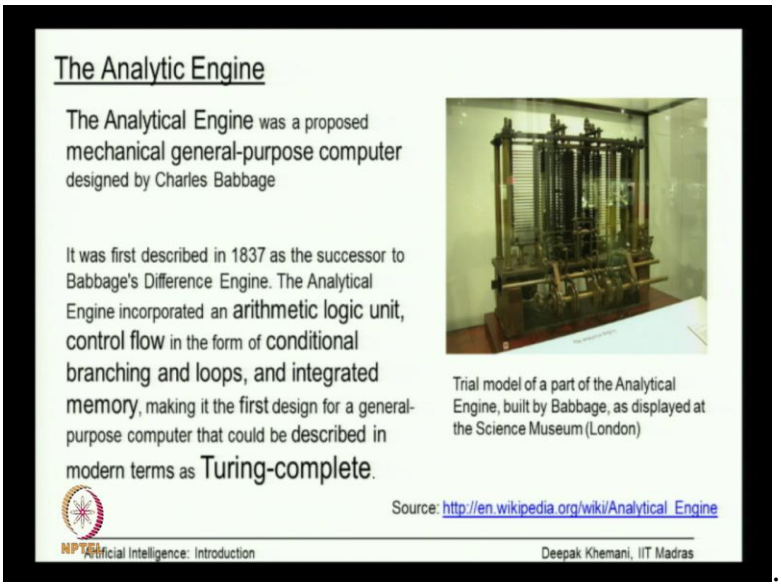
(Refer Slide Time: 47:09)



One place where Babbage got some ideas was from the so called Jaquard Looms essentially. So, why the computer are different machine from the rest of the machines, because it is programmable; and how was it programmable, because we have this idea of a stored program. We can plug in a program and learn that program, then we can plug in a different program and learn the different program. So, the stored program which can be input.

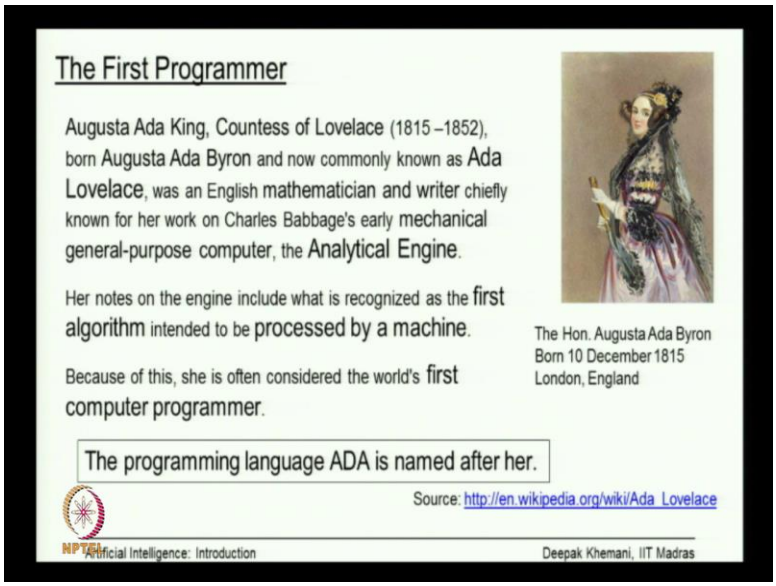
The idea came from this Jaquard Looms which was, which is the kind of punched cards that you see here on the left which is an enlargement of the figure on right which were used to create designs in fabric essentially. This looms were create to, used to create this pattern fabrics; and the pattern could be conclude by this punched cards. So, this idea of punched cards is what Babbage took from there.

(Refer Slide Time: 48:00)



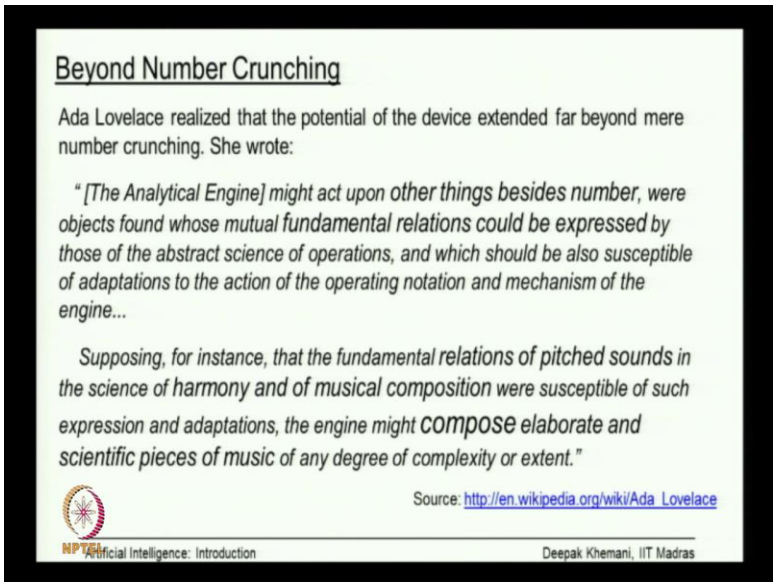
And he created what is known as the analytic engine. It was a proposed, he did not actually build it, mechanical general purpose computer designed by Charles Babbage, first describe in 1837. It had an arithmetical logic unit control flow, all modern terms in computer science in the form of conditional and branching loops and integrated memory. And, it was the first machine which in the modern sense could be said to be Turing-complete which means it is equivalent to a Turing machine.

(Refer Slide Time: 48:37)



The first programmer was his accomplice, a collaborator, Augusta Ada King. She was a daughter of Lord Byron who was a poet. She is now known as Ada Lovelace, was English mathematician and writer, chiefly known for the work that she did along with Babbage. So, her notes include what can be called as a first algorithm which is processed by a machine, and because of this she is often called as the first programmer. And, the programming language ADA that you might have heard about, promoted by the US department of defense, is named after her.

(Refer Slide Time: 49:30)

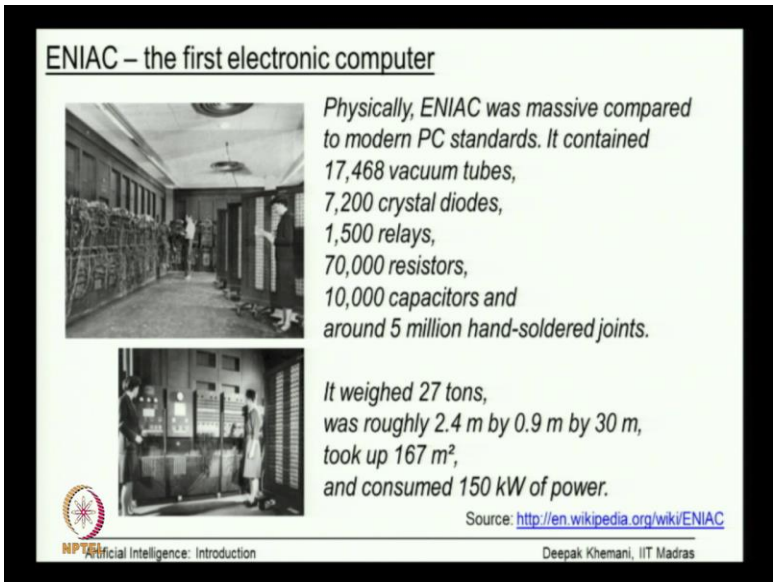


So, she went beyond number crunching. Again, like (49:20) she realized the potential of the device extended far more beyond number crunching. And, she wrote, and this is the quotation, that the analytical might act upon other things besides number, were objects found whose mutual fundamental relations could be expressed by those of the abstract science of operations, and so on.

And then in particular she talks about generating music. She says, that supposing that fundamental relations of pitched sounds and the science of harmony and musical composition were susceptible of such expressions, the engine might compose elaborate and scientific pieces of music of any degree of complexity essentially.

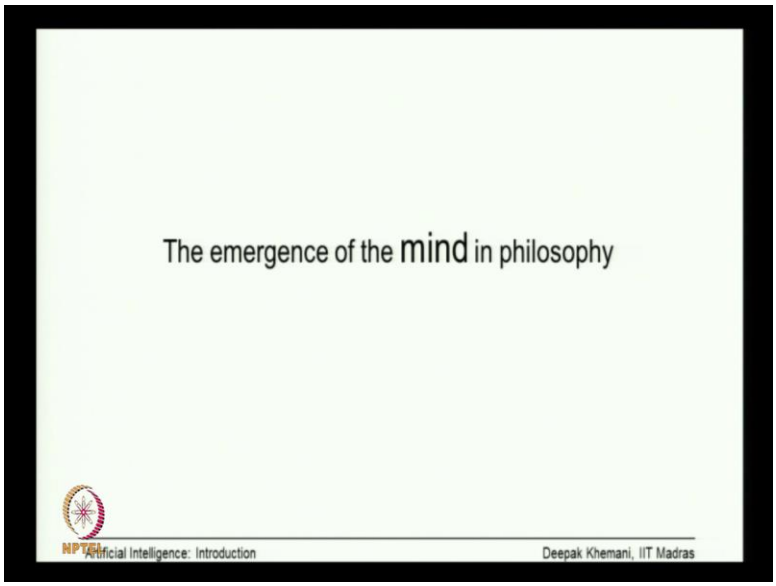
So, even then Babbage was just designing this analytical engine which is not even built, and she was imagining that such a machine would compose music essentially; because now days we know, it can be done.

(Refer Slide Time: 50:29)



And finally, in this study of mechanical history we look at this first electronic machine which was built called ENIAC. You must be familiar with it. And, you can just see the size of ENIAC – 17,000 vacuum tubes, 7, 200 crystal diodes, and so on and so forth. 27 tons, it occupied a full room essentially. It was not even as powerful as a small computer that you have on a smart phone nowadays. But, that was the first electronic machine essentially.

(Refer Slide Time: 51:00)



So, with that we come to the end of the first part which is the mechanical side of this thing. So, will take a small break and come back with the second question which is the motion of mind and philosophy; how do the motion of mind come back in philosophy. So, we will stop for a while and then we will start in about 3 or 4 minutes essentially.