Introduction to Industry 4.0 and Industrial Internet of Things

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Lecture – 14
Industry 4.0: Artificial Intelligence

In this lecture, we are going to go through some of the basic concepts of Artificial Intelligence in Industry 4.0. So, at present all of you must have heard about the hype of AI: Artificial Intelligence and its use in the industries and everywhere else, in fact, AI has become very attractive in the present times and it finds different applications in different domains industries inclusive. So, towards fulfilling the objectives of an Industry 4.0, it is envisaged that artificial intelligence will play a big role.

So, let us try to understand the basic concepts behind AI and how it can be used to improve the overall efficiency and address different challenging issues in the industrial sector. So, when we talk about artificial intelligence, what comes to our mind, it is some form of intelligence, we are talking about an artificial form of it. You must have heard about different things like a robot playing soccer, robo-soccer, robot playing soccer. Then you must have heard about the driverless cars, which has also become very popular in the last few years, the driverless cars.

These are all examples of use of AI techniques to solve different challenging problems, which otherwise are difficult to solve. But, it is not just robot playing soccer, it is not just the driverless cars where, AI has found application. AI finds the application in different domains in for credit card fraud detection AI could be used for designing a computer, which can play the game of chess. And, this is something that has happened since last few decades; a lot of people have taken a lot of interest in the applications of AI in games.

In the industries also for making the industrial processes much more efficient, to solve different problems, which manually was difficult to be solved AI and different other applications have found interest in the industries.

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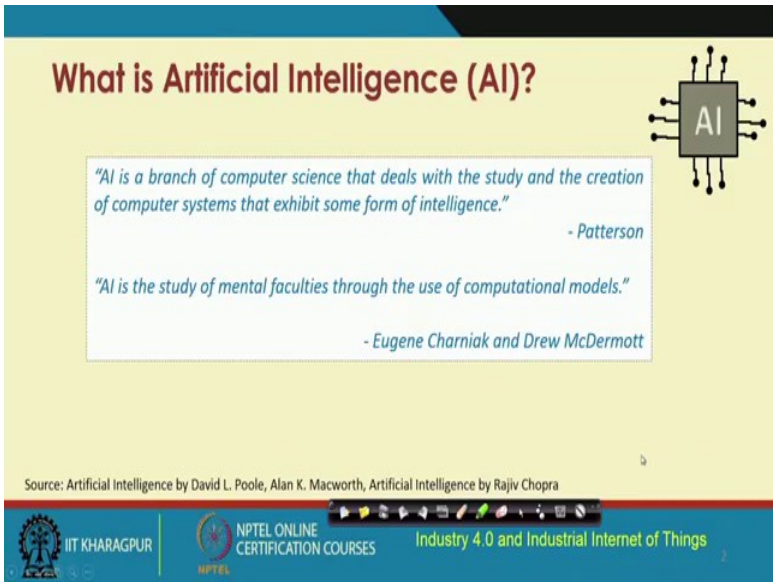

So, what is AI? Artificial Intelligence so, there are different viewpoints of what AI is. So, it is quite broadly scoped and there are multiple definitions to describe what artificial intelligence is, as per one of the definitions by Patterson; AI is a branch of computer science that deals with the study and the creation of computer systems that exhibit some form of intelligence. So, we are talking about computer systems exhibiting some form of intelligence which is very similar to the natural intelligence of human beings. So, striving to build systems which can try to intelligently think and behave like human beings is what one of the definitions of artificial intelligence says.

Another viewpoint as I told you that there are many different viewpoints of what AI is; another viewpoint is how we can use how we can use the different computational models to improve the mental faculties of humans is what again AI can do. So, that is another scope of AI. So, like this there are different viewpoints of what AI is. So, the lateral definition is basically proposed by Eugene Charniak and Drew McDermott.

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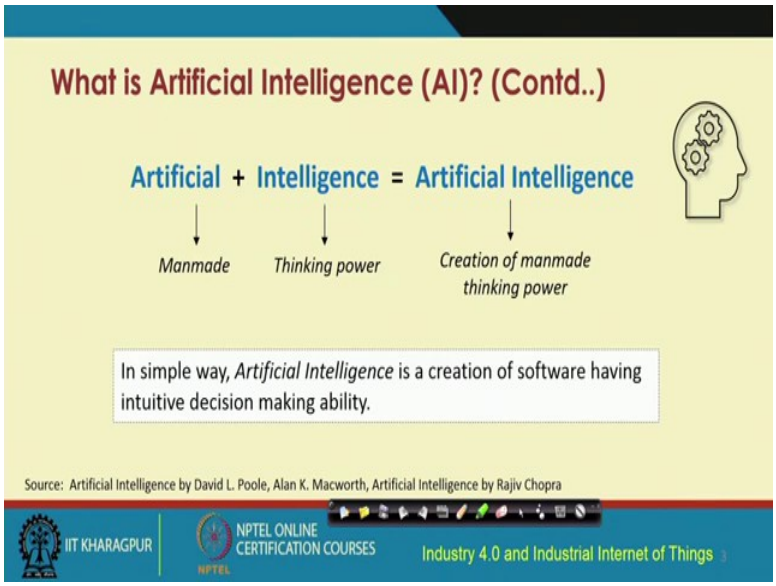

So, we are talking about artificial, which is manmade and integrating with the intelligence, which is basically the thinking power and together achieving a system, the development of the system an AI based system Artificial Intelligence system, which is a creation of man-made thinking power. So, in simplistic form AI is a creation of software, having intuitive decision making capability. So, remember one thing that AI systems are typically software-based, but in industrial sector or, many other domains they these AI-based software will have to work on some kind of hardware. So, you cannot, basically, leave hardware completely separated when you are talking about AI systems holistically.

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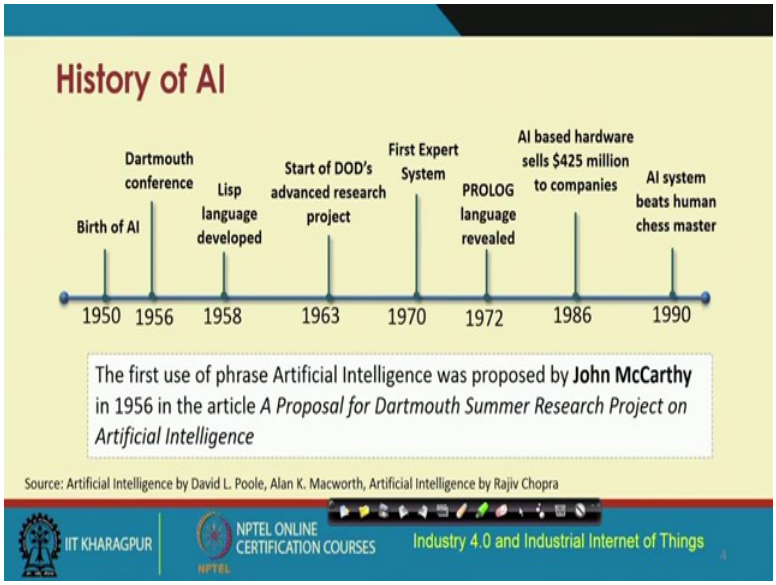

If you look at the origin of AI, AI in the recent times have found lot of popularity in our country and globally, but AI has been there since long starting from the 1950s AI has been in existence. Then in, earlier there used to be different theoretical research works on AI. There have been different languages that have been proposed for use with AI like Lisp, PROLOG. Then, in the 1970s the concept of expert systems came into being. Expert systems are basically the ones where based on certain pre-existing knowledge the systems are going to perform better in the future.

So, expert systems came into being, then in the 1990s, somewhere in the middle of 1990s, if you recall the Deep Blue became very popular. IBM came up with their computer, the Deep Blue, which is a AI based system, which can play chess. So, if you recall its history now, that Deep Blue, basically defeated one of the greatest chess players long time back. So, the computer, that was when an artificial system was able to supersede the brain of a human being and an expert brain, an expert chess player was defeated by Deep Blue in 1990s and that is when the applications of AI became popular in the domain of games and chess, particularly.

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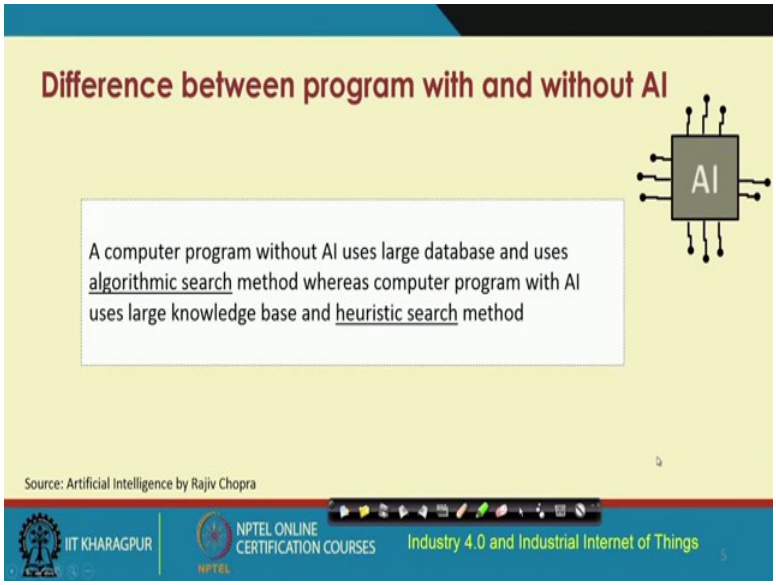

So, what is the difference between a program, which uses AI. So, a computer program without AI uses large databases and algorithmic search method, whereas, a computer program with AI uses large knowledge base and heuristic search method. So, it is algorithmic search versus heuristic-search method.

Algorithmic search basically follows certain well-defined procedures in order to come up with some optimized solution whereas, heuristic search as this name suggests; heuristic search is popular in AI. Because, many of these AI-based problems are not easy to solve. The search space is huge, many of the AI problems is huge. So, where you cannot come up with some efficient solution using the traditional methods of search like the algorithmic search methods.

So, heuristic search basically talks about heuristics or rules of thumb being used to come up with solutions which will be good enough to solve certain problems at a certain point of time. So, these are the heuristic search methods; heuristics search methods are quite popular search methods in the domain of AI. And, heuristic search methods have found lot of use in the applications of AI in games in different games chess inclusive.

So, actually what happens is why the AI is why the search method heuristic search methods are very popular in AI is, because think about computer games, things about chess the game of chess. So, sometimes the input space is so, broad and if you do not use you cannot use the traditional search methods. So, you have to use some heuristic methods to come up with certain solutions, which will perform superior at certain point of time under certain conditions. So, heuristic search methods are quite popular in AI and AI for games.

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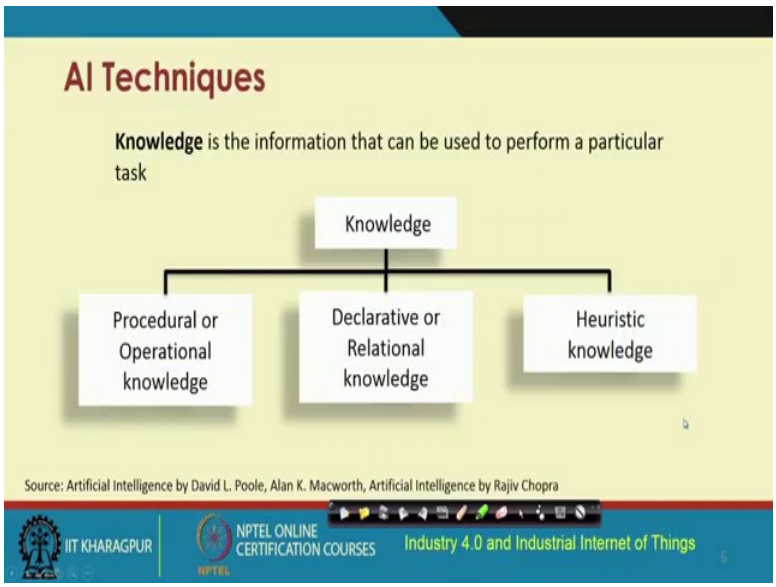

So, AI is heavily based on the concept of knowledge. So, we are talking about several pieces of data can lead to information and then information can build help in building knowledge. So, knowledge is that information that can be used to perform a particular task. So, there are different forms of knowledge particularly in the context of AI. There is procedural or, operational knowledge, which basically talks about the procedures that will have to be adopted in order to; the knowledge about certain procedures, that will have to be adopted in order to come up with a particular problem.

So for example, a quadratic expression or quadratic equation. So, the procedures that will have to be followed in order to solve it that is procedural knowledge, declarative or, relational knowledge, this is also known as descriptive knowledge. So, here basically we are talking about the knowledge, the description of a certain thing, an object an event or something alike the knowledge about it; storing such kind of knowledge is important. And, that kind of knowledge will be used whether it is procedural, declarative or, heuristic, that kind of knowledge is going to be used to make the next move or, to improve the processes in the industries. The way things are happening based on certain existing knowledge you can try to improve upon the processes in the future and so on.

So, that is where this concept of knowledge and AI comes in applicable in the context of industries and industrial processes. Heuristic knowledge is basically these different heuristics that will or the rules of thumb that will have to be used in order to address certain problems, certain challenges at different points of time that is heuristic knowledge.

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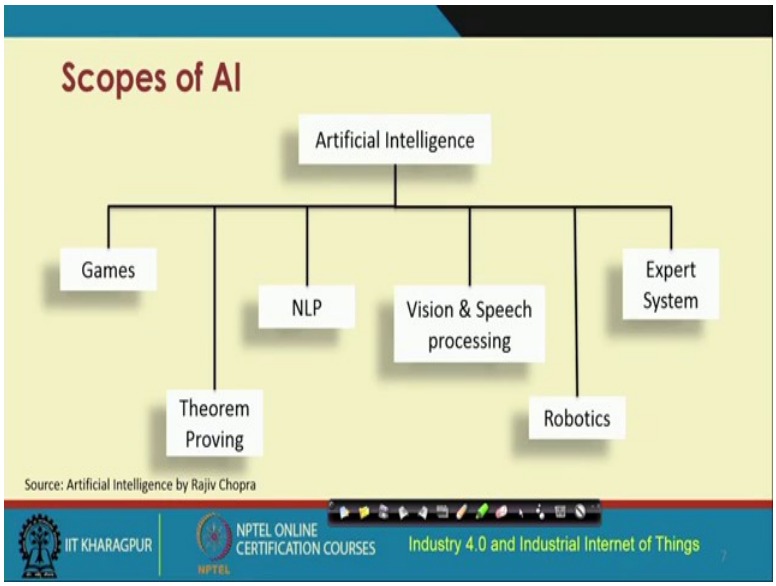

Now, let us talk about the scope of AI. Artificial Intelligence has found use in diverse fields. In games we have already talked about, in chess game, in soccer games, in different other games, AI has found applications. In theory improving, NLP is basically Natural Language Processing. So, AI in NLP means what that you are trying to come up with some rules, which can make the computer understand not the computers language, but the way the natural languages like English, French, with which humans are conversant to communicate with one another.

So, that is NLP, then AI has also found use in vision computer vision, speech processing. Computer vision is basically trying to enable a computer to see around, to see around, to feel what is around it and so on. Speech processing, on the other hand, is enabling a computer to understand, the way humans speak, what the humans are speaking. Not just the text, but the speech of the human beings can be understood typically in real-time or, may not be real-time as well. So, if you are speaking in English, the speech processing would help the computers to understand what the humans are talking about in their own language.

Then comes robotics AI in robotics, robot performing different actions, robot making different moves, in a particular terrain, performing different moves, taking different trajectories. So, the in AI in robotics is very important and in expert systems. Building expert systems, which are basically in knowledge intensive systems, based on the

knowledge base, that is resident in these systems, these systems can provide expert advice; expert advice to users about what should be done next or what should be done in the future.

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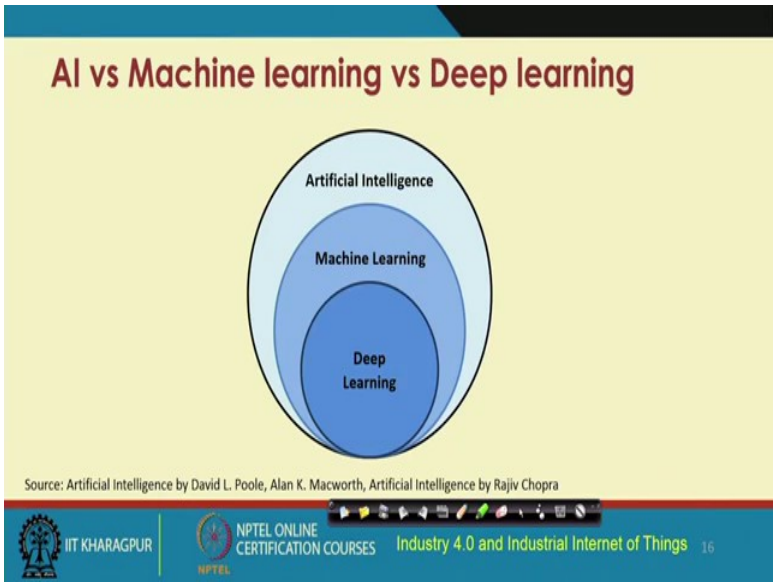

So, artificial intelligence is very important, it has become very popular. Artificial Intelligence, ML: Machine Learning, Deep Learning these things have become very popular in the recent years. So, Artificial Intelligence, ML, DL, these are linked to each other. All the people are talking about machine learning, deep learning, artificial intelligence, but there is a linkage and this is this figure in front of you shows what is the scope of each of these.

Machine learning or deep learning are basically branches of artificial intelligence, but then they are in artificial intelligence beyond learning there are different issues. Issues of search, classification, these that it sends means there are a lot of, lot of different issues are there beyond learning in AI. So, this is how these three recently popular technologies have become or what is what is what is there scope. So, that is what is defined.

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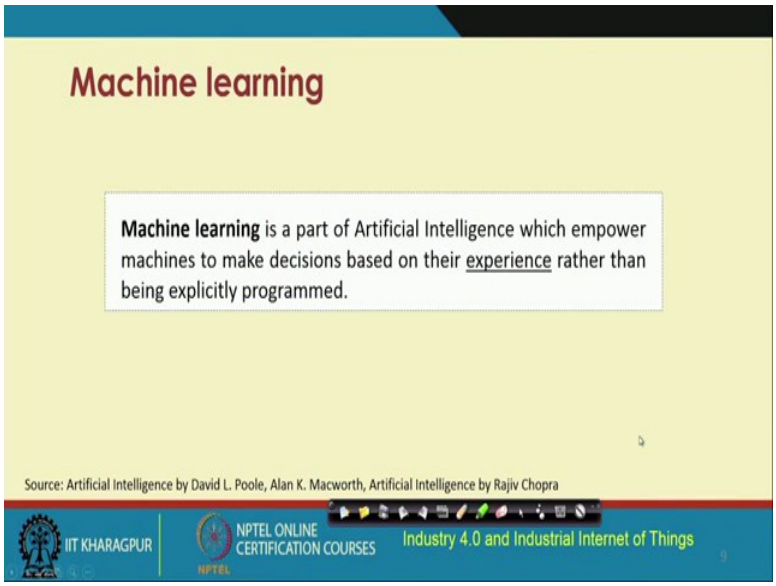

So, what is machine learning? So, machine learning is a part of AI which empowers the machines to make decisions based on their experience rather than being explicitly programmed. So, in the computer basic computer programming or fundamental computer courses in any B.Tech program or whatever; what the students are taught typically is to make to explicitly program certain steps, which the computer are going to take in order to solve a problem. In machine learning, we are talking about some kind of a software or a program, which based on the experience, previous experience, past experience will take actions, better actions in the future. So, with time better and better actions based on the past experience will be taken.

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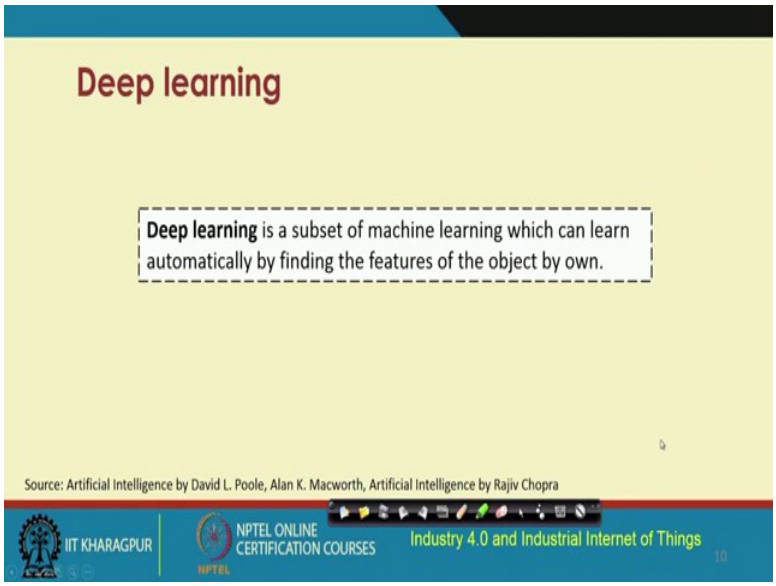

Deep learning, basically, is a subset of machine learning, which can learn automatically by finding the features of the object on its own. So, what is so, deep learning is basically where some deep computational structures are used to come up with some efficient algorithms, which can do certain things much more efficiently with grater greater accuracy; efficiency in terms of accuracy, typically. So, better accuracy in a better manner will be done things will be done by deep learning.

So, it is not like deep learning is the only solution, deep learning has its own application domains. There are other non-deep learning, the traditional machine learning schemes, which are also advantageous in certain contexts. It is not the deep learning is the solution in machine learning, it is not like that. So, you can use deep learning or non-deep learning methods to solve certain learning problems depending on the certain requirements that are there.

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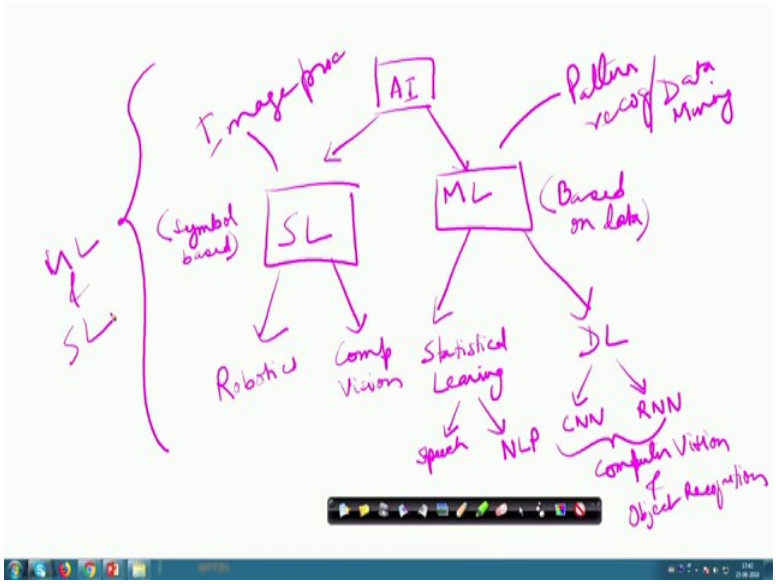

Now, let me talk about an interesting thing. So, we need to understand the, the difference between the different AI techniques. So, AI we have talked about machine learning, there is also something called Symbolic Learning. So whereas, machine learning is based on data; symbolic learning is symbol based.

So, applications of this thing good applications would be in pattern recognition, machine learning has lot of applications in pattern recognition, data mining, and here symbolic learning has lot of applications in for example, image processing, image processing. So, symbolic learning, basically, we are talking about applications in computer vision, then, robotics and this can be machine learning, can be of different types; we have already talked about deep learning.

But, it could be also the traditional statistical learning. So, statistical learning has applications in natural language processing, has applications in speech recognition. Deep learning can be of different types: convolutional neural network is one, a recurrent neural networks is another. Each of these can be used to address again different problems of computer, vision, and also object recognition.

So, this is basically the scope of artificial intelligence and the different forms of not the scope of artificial intelligence, entirely, but in the context of learning.

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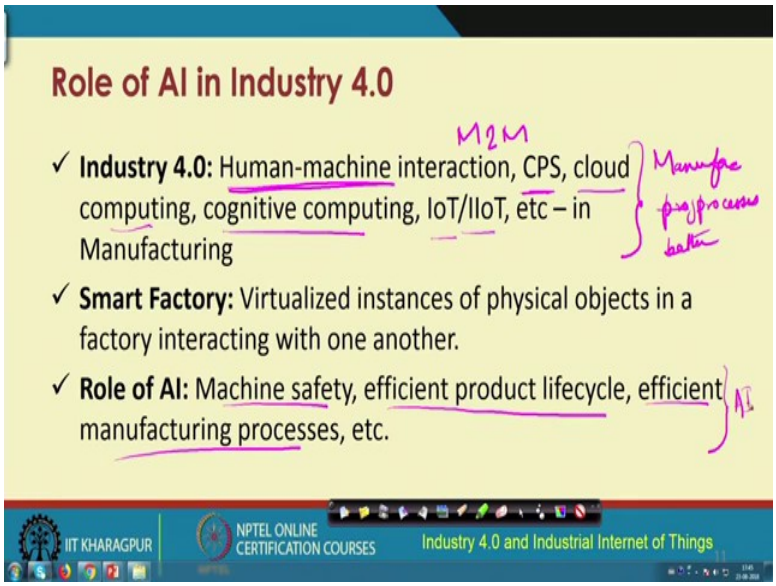

Let us now go back and talk about, we have understood more or less the scope of AI, the different applications of it, its importance in the context of industries and different other application domains like games, computer vision, robotics, but let us now try to understand in little bit further depth. So, that we will be able to realize that why AI is popular in building systems, which can help achieve the objectives of Industry 4.0.

So, in Industry 4.0 we have talked a lot in the previous lectures about Industry 4.0 and its scope, but what is Industry 4.0? In Industry 4.0 we are talking about few things, first of all human machine interaction. This is very critical, humans and machines interacting. We also in Industry 4.0, we are also talking about in certain cases machine to machine communication. One machine directly talking to another machine without any human intervention, machine to machine communication. Cyber physical systems we have talked a lot in a previous lecture also associated technologies such as cloud computing, cognitive computing, IoT or IIoT; all of these can help in making manufacturing processes better.

So, that is Industry 4.0. Now, smart factory smart factory is another one which is talked a lot in the context of Industry 4.0, smart factory. So, basically this smart factory what it does is these factory, machines in the factories, the physical objects that are there in the factory, which interact with one another. The virtual instances of them would be created and those virtual instances would be made to talk to one another. This physical world and

the virtual world, instantiation of the physical into the virtual space and making the physical objects and consequently the virtual ones talk to one another is what is done in the context of smart factories in Industry 4.0.

So; obviously, things like machine safety, efficient products lifecycle, efficient manufacturing processes, these could be achieved with the help of AI. And, these are required for making smart factories which in turn will help achieve in building Industry 4.0 compliant industries.

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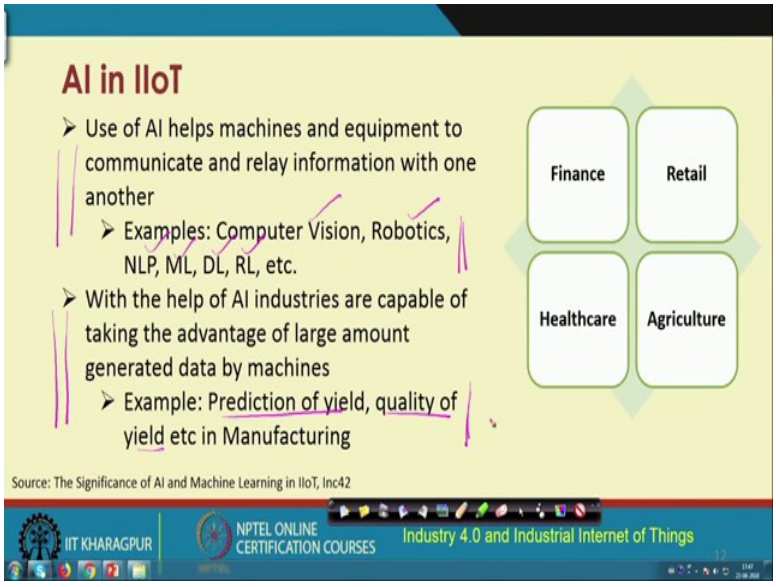

So, IIoT, IoT in general and Industrial IoT, these are the ones, which essentially will help achieve the objectives of Industry 4.0. AI can be used in along with IoT, along with IIoT and also to transform these systems into efficient systems; IoT and IIoT systems efficient using AI. So, basically, use of AI helps the machines and equipments to communicate and relay information with one another. And, this thing can be used in different industry sectors, finance, retail, healthcare, agriculture. And, you name it and it is possible to use AI in order to help these machines and these equipments communicate and relay information with one another much more efficiently.

For this specifically you could use computer vision, robotics, NLP, ML, DL, RL all of these things that we have talked about so far you could use them. So, with the help of AI in industries, in the industries are capable of taking the advantage of large amount of data that is generated by the machines to do something better. So, one aspect is to improve

upon the communication, automation, relay, etcetera, etcetera using AI. The other one is that once you have used IoT and IIoT, in the industries; what is happening is these sensors actuators, etcetera from these IoT devices are going to throw in lot of data.

So, that data we will have to be analyzed and one can take advantage of the past data. The experience that is generated from this previous historical data to make things much more efficient, to make processes efficient in the future. Examples would be for prediction of yield, quality of yield, prediction of the quality of yield, in manufacturing. So, these are different examples of use of AI. AI for improving the automation, communication, delay of information etcetera and for improving the prediction processes in terms of quantity of yield, quality of yield etcetera in the manufacturing industries.

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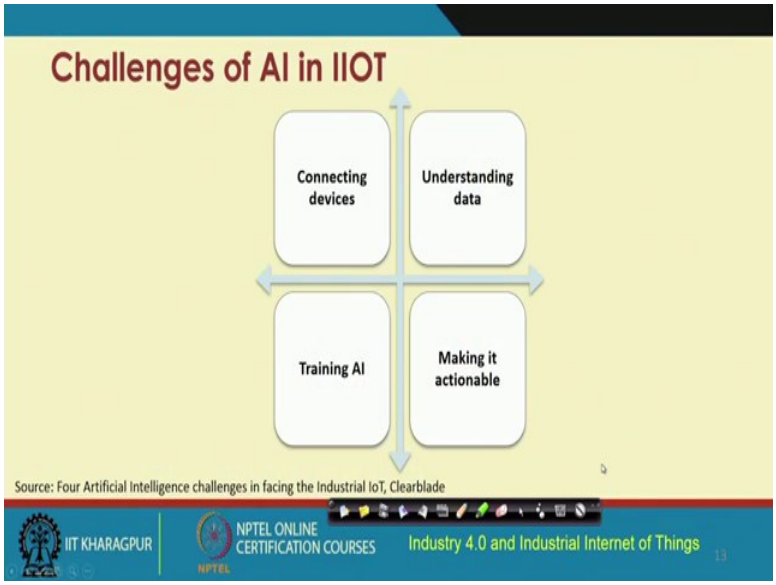

So, there are different challenges of AI in IIoT. Connecting different devices, understanding the data, training the data, making it accessible, making the machines or whatever actionable these are all different challenges of use of AI in IIoT. So, I do not need to explain each of these, but only thing that I would like to highlight is the training. Training is very important because, you are using past data, which you will be using to train the machines to do something better in the future that is one type of learning in fact, in AI that is one type of learning. So, there are different types of learning. This is one type of learning that using the training data set.

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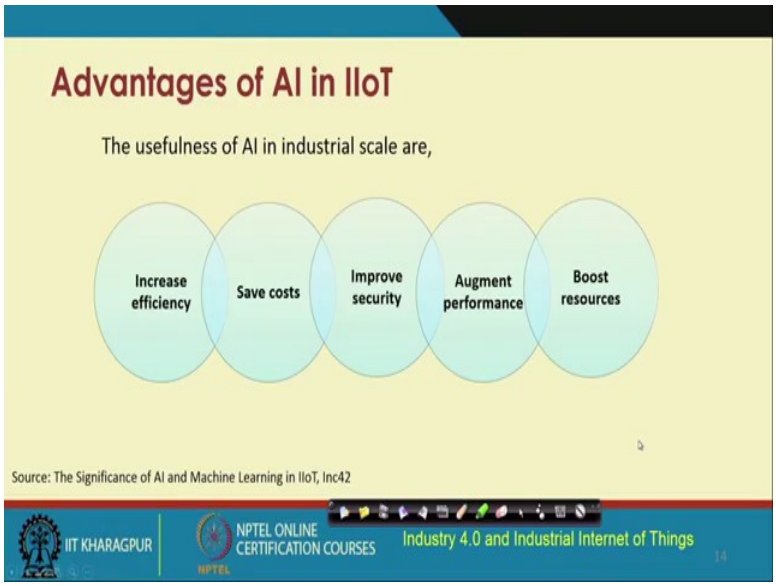

So, there are different advantages of AI in IIoT. The usefulness of AI in the industry scale are to increase the efficiency, save costs, improve security, augment performance and boost up resources in the industries; resources of all kind as I said in a previous context in a previous lecture before. So, boosting up all kinds of resources, all kinds of tangible, non-tangible human resources. So, all kinds of resources could be boosted up, with the help of use of AI in the industrial scale.

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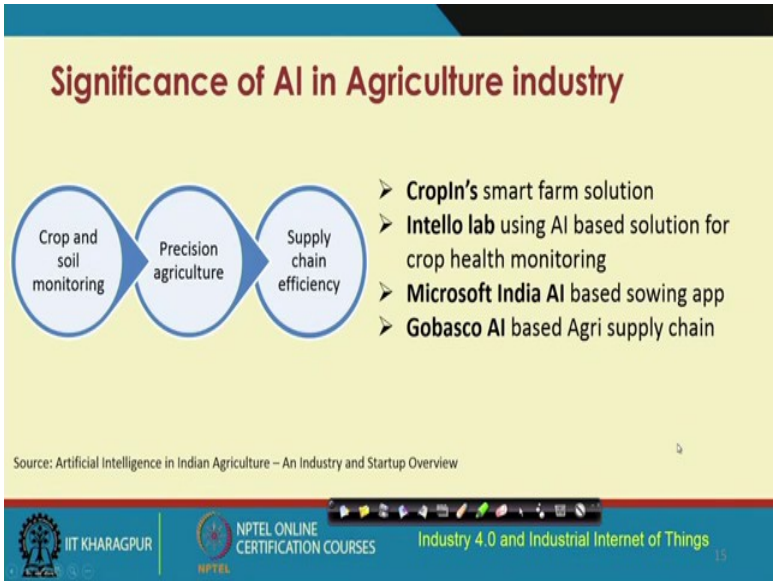

So, AI has found use in different industries. In the agriculture industry, AI could be used for crop and soil monitoring, for precision agriculture. Precision agriculture means like coming up with precise predictions about certain things, precise predictions about certain things. For example, when do you need in the agricultural field, when do you need precisely to irrigate the field, to put fertilizers in the field, and exactly the area, where the fertilizers will have to be applied.

What fertilizers exactly would be required, not that you put in any kind of fertilizer it will be. So, all these predictions, precisions, in agriculture could be achieved with the help of use of AI. Supply chain efficiency also can be improved in supply chain in the context of agriculture and food could also be made much more efficient with the help of AI.

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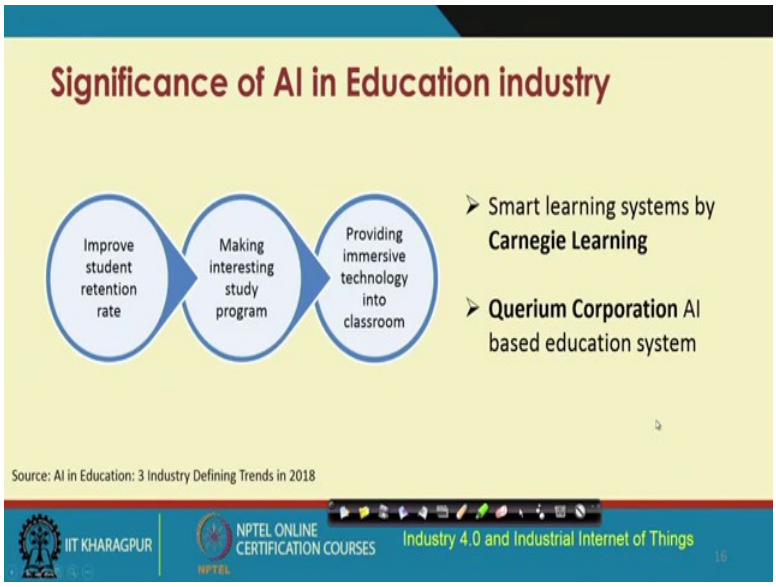

So, that is the AI in agriculture, AI could be used in education industry, to improve the student retention rate for making interesting study programs and for providing immersive technology into the classroom. So, already there are different existing systems which use AI in the education sector. So for example, the smart learning systems by Carnegie Learning, then Querium Corporation AI based education system. Like this, there are many different types of AI based systems in education sector that are available for use.

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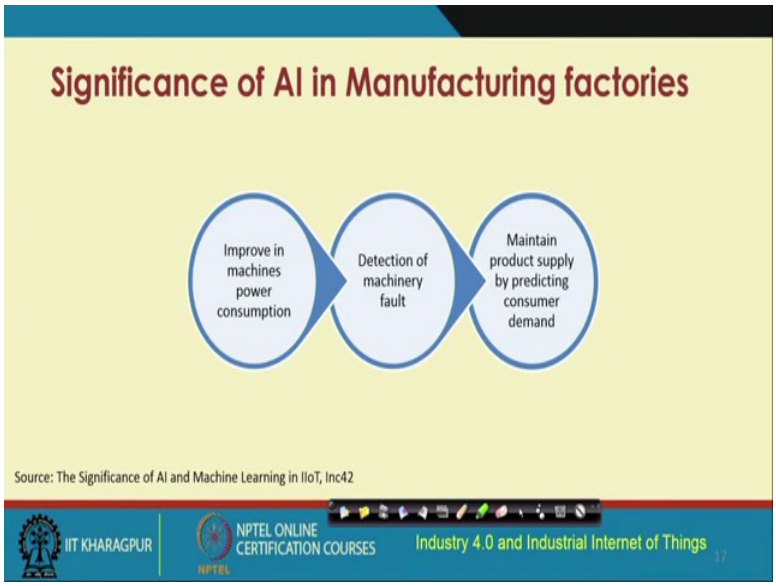

So, in the manufacturing factors sector, manufacturing industries AI could be used to improve machines power consumption, detection of machinery fault, maintaining product supply by predicting consumer demand. So, these are the different applications of AI in manufacturing.

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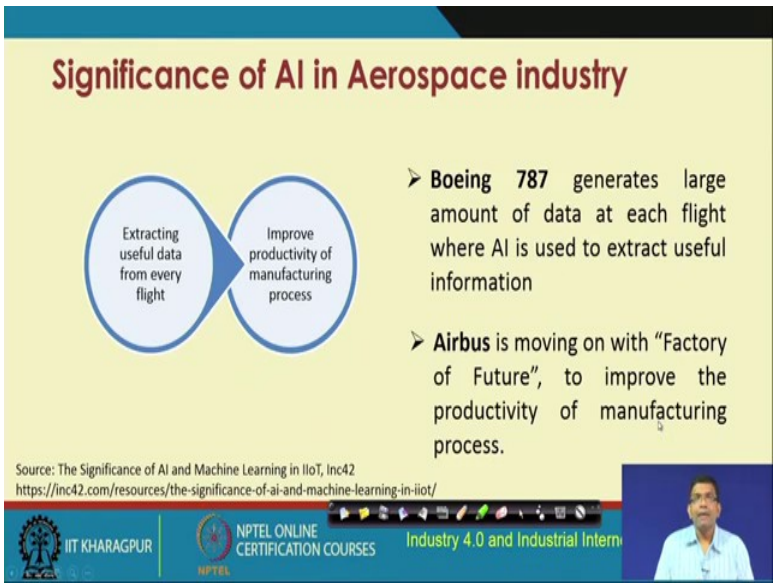

AI in the aerospace industry extracting useful data from every day of flight, improving productivity of manufacturing processes. All these top aircraft manufacturers like Boeing, Airbus, they use AI heavily in their processes.

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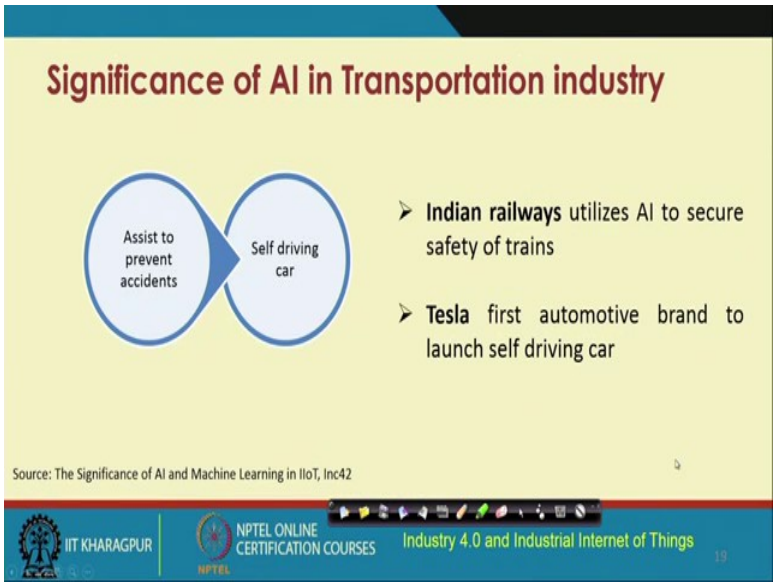

So, in the case of rail transportation or automotive transportation, etcetera AI is also used, self-driving car is something that I mentioned at the outset. Like this assisting drivers to prevent accidents these are all different applications; these are some of the different applications of use of AI in transportation industry.

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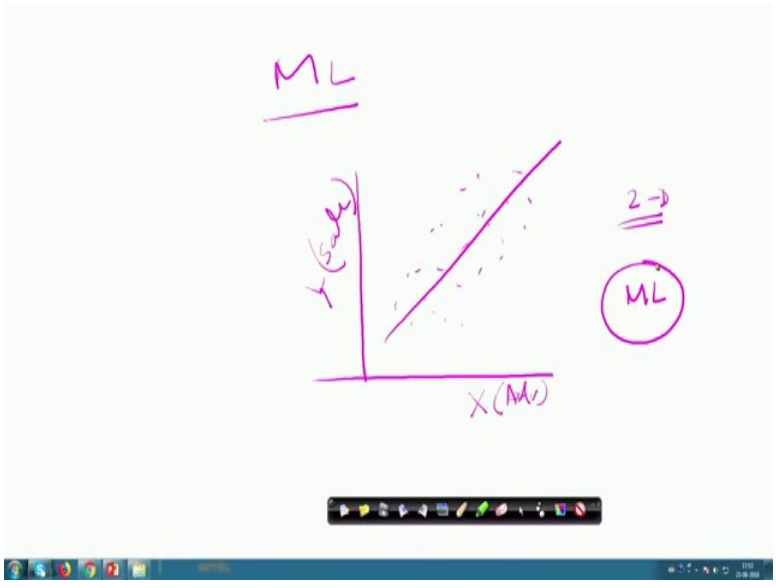

So, one last thing before we get into the references, one last thing that I would like to highlight about machine learning is that machine learning can help do something else as well. So, if you are talking about something X let us say some parameter advertisement

let us say and let us say that this is the sale, the Y-axis. So, you can have different data which could be plotted and then you can have some kind of a regression fitting or some correlation study etcetera. So, if you are talking about this kind of thing, the humans are very good in doing things because it is a 2-dimensional thing and we know different ways of curve fitting. So, handling correlation regression in 2-dimension.

Think about the same problem, if you are increasing the number of dimensions. So, if you are increasing the number of dimensions and doing something very similar using the human expertise and human eye, human intelligence, human brain, that is difficult. So, the computers can do it and in fact, more specifically machine learning can help you achieve these different types of correlation, curve fitting, in multiple spaces having multiple dimensions, at the same time. So, this is also another application of machine learning and how humans and machines can perform better than humans, in these contexts.

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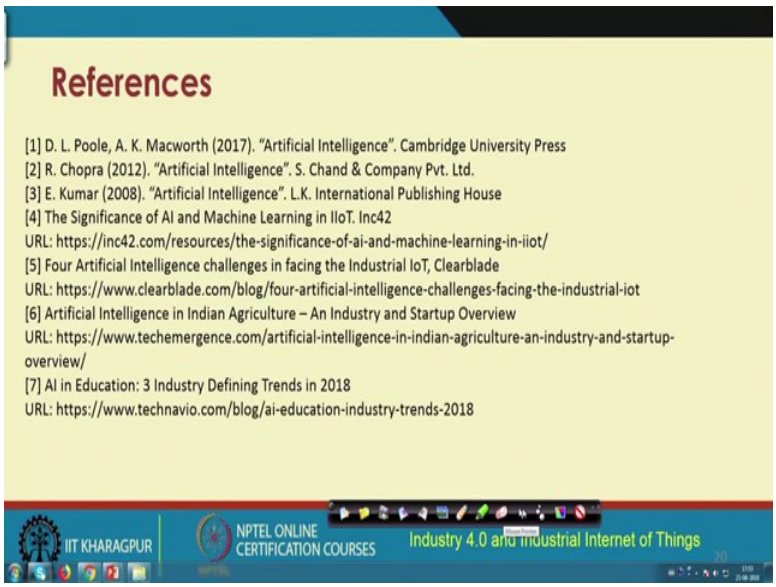

So, let us now, go back and look at these things. So, these are some of these references that are there. So, the references for AI, ML, DL, its huge these are some of the ones that, if you are interested to know little bit more, in depth, you could, but mind you that through this course you cannot become an expert of artificial intelligence. Artificial intelligence are semester long courses themselves and all you need to do in this course is just to get yourself exposed to the different concepts and which is what I have done. But,

then if you need to actually implement AI-based techniques to solve certain problems, you have to take separate semester long courses in AI, ML, DL. So, with this we come to an end.

Thank you.