The Future of Manufacturing Business: Role of Additive Manufacturing
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Lecture – 19
Machine Intelligence

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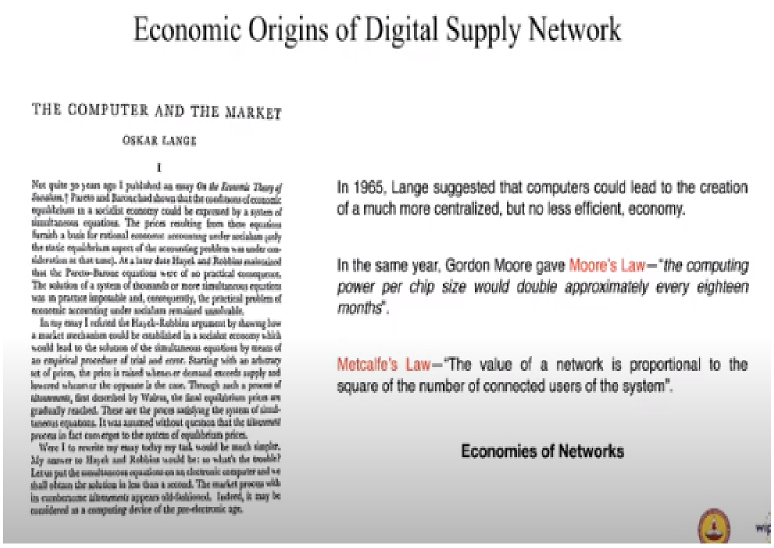

Welcome back for the next session. So were discussing about the economic origins of digital supply network and we talked about different laws, which comes along with different economies. I mentioned about the Huang's Law, but I have not discussed it. So, I request you, if you have time just have a look at it. I will continue with my discussion on the technology of the future.

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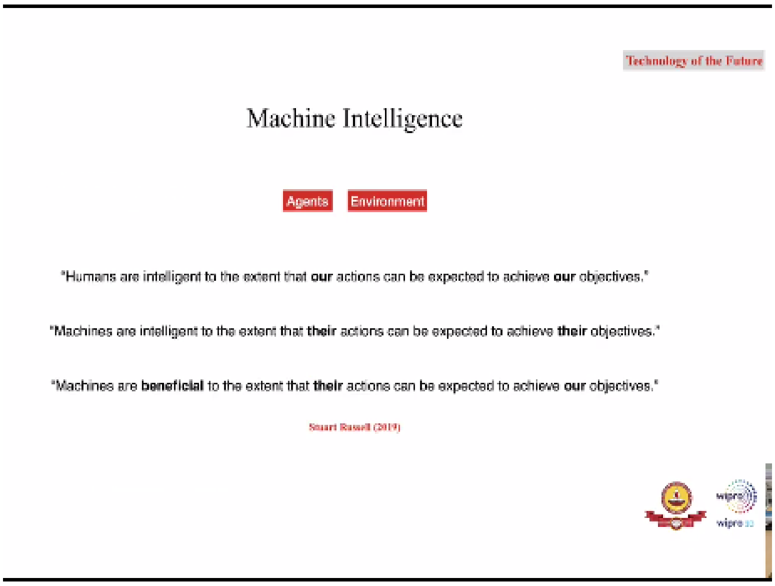

I just briefly talk about machine intelligence. So, just put a caveat up front this this is my version of what is machine intelligence and this suddenly cannot answer, maybe we are not going to discuss the algorithms, but we will try to get some idea about what does this machine intelligence all about. So, in fact, you can actually see different flavors of it.

So, it goes back to the work of Alan Turing, but the modern history of machine intelligence goes back to 1956 and if you recall, when we were talking about the complex supply chains, we mentioned that whether machine intelligence can help to reduce the complexity of those supply chains. So, this brings us to the setting where we have agents and we are looking for intelligent agents, and then there is an environment in which they have to decide something.

So, when we talk about agents, we as I mentioned that we assume that they are intelligent and the environment is a bit dynamic. We can call it variable and uncertain. Now given this dynamic and uncertain environment, agents would have some objectives to achieve.

You can think of a pretty simple example that the demand is fluctuating and I have to decide how much inventory to keep and my objective may be to maximize the profit or minimize the cost. So, humans are intelligent to the extent that our actions can be expected to achieve our objectives. Now when we extend this argument, so can I replace this agent with the machine.

So, instead of calling it intelligent agent, let me think whether I can actually call intelligent machine. Can the same thing be extended? So, machines are intelligent to the extent that their actions can be expected to achieve their objectives. Now machines if they achieve their objective, because I think this goes to very deeper insights like whether machines are conscious, whether machines actually can have that hedonic feeling.

So that normally we associate with humans. Machines are intelligent to the extent that their actions can be expected to achieve their objectives. From the perspective of machine intelligence, this objective is not correct. What is correct is, in fact, I have taken it from a recent book by Stuart Russell, which is Human Compatible. So, machines are beneficial to the extent that their actions can be expected to achieve our objectives.

So that is in fact defines what actually should be machine intelligence. So, even if you delegate some actions to the machines, they should be beneficial to the extent that they can achieve our objectives, but is it enough. Because human beings, even when I give you a typical inventory optimization example. Even if you recall the EOQ kind of simple formula, it has been observed in practice that the managers actually do not optimize.

So, they actually satisfy. They actually would have lot of biases when they actually make the decision. In fact, the whole area of so if you have heard about this book by an economist, Nobel laureate Daniel Kahneman,, Thinking Fast and Slow. This book talks about lot of biases and heuristics, which we use when we decide. So, whether this objective is good enough or whether we should do something else.

This brings us to the modern paradigm of machine intelligence. The machines are beneficial to the extent that their actions can be expected to achieve our optimal objectives. It is not just the objectives; it should achieve our optimal objectives. This gives the paradigm in which we want to look at machine intelligence. So this, so for time being, let me make it clear that this only gives maybe the epsilon part of how the machine intelligence should look like.

We are not going to discuss the algorithms. I will give you some used cases where people have used the machine intelligence to as part of the digital supply network. But I am just giving you the flavor of what actually should be machine intelligence. Machine learning could be a subset of machine intelligence, which may be data driven. But the whole objective may be much larger.

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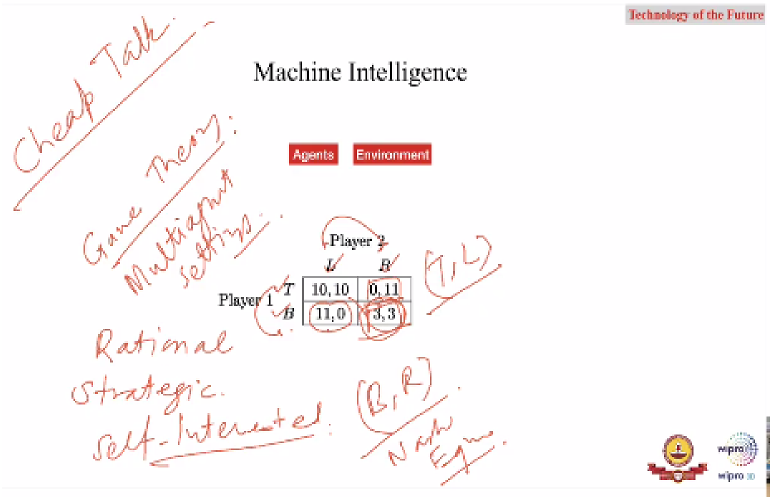

I will give you one setting which coming from Game Theory, and this would be interesting to see whether how to look at an agent and how to look at environments. So, let me start building this example and this will give you lot of insights about it and what actually happens. I will take some time for this. So, if you see this example, you can see that there are two players given; player 1 and player 2.

Now player 1 is descending in an environment in which the outcome is also controlled not just by player 1, it is actually controlled by player 2 also. So, you can actually see player 1 controls T or B. We can call it top or bottom and player 2 controls left or right. But the payoff, which is the first payoff is for player 1 and second payoff is player 2.

So, if assume player 1 chooses T and player 2 chooses the outcome is (10, 10). Player 1 gets 10 and player 2 gets 10 and same thing will happen if T, R. So, it becomes (0, 11). So you can actually see the whole payoff matrix is actually a function of joint action of both the players. Now we make lot of assumptions around it that both the players are assumed to be rational. They are strategic and self-interested.

When I say rational it means the players are intelligent enough to know what actually is the best action for them and they are intelligent to such an extent that they actually make out, so assume that this payoff matrix is known to both the players. But they cannot control the action of the other players, because both the players are assumed to be self-interested.

So, they are looking for larger payoff for themselves. They are also assumed to be as we mentioned that rational. It means that player 1 can infer what is the best choice for player 2 and player 2 can do the same thing. So, they are not intelligent enough to just know what is the best action for them, they are intelligent enough to infer what could be the best action for the other player and they are strategic.

It means that they want to move the outcome towards that in which they get a larger payoff. So now I hope you are getting. Player 1 and player 2 could be the agents in this case. The payoff matrix is the environment. But even if they have information about the environment, they cannot determine what is the best action for them.

They cannot control the outcome because the outcome is not just in control of player 1, it is also in control of player 2 and vice versa and let us make that assumption that both the players make the choice independent of each other and without communication. Player 1 is not communicating to player 2 that what I am choosing and vice versa. So, player 2 does not communicate to player 1 what player 2 is choosing.

Now given this setting what is the best choice for both the players. Now let us see how this whole thing actually works out. So, player 1 is not communicating to player 2 and player 2 is not communicating to player 1. So, what is what normally you infer? Will they actually converge on T, L or B, R? So, let us see that.

This gives you the idea about what I am saying in the previous one that how the machines should think about or you can say the machine should be rational to look what is the best objective for us. So, let us start building the case. Player 1 does not know what is the best choice of player 2. So, let us assume that player 1 assumes that player 2 is choosing L.

So, in that case I would respond by playing B and when he chooses R again, he chooses B and same argument you can actually see this guy will choose. If they cannot coordinate their actions and there is uncertainty about the choice of the other player the equilibrium or the optimal output is B, R which gives them a payoff of (3, 3). When there is a better outcome available, which is T, L which gives them a payoff of 10, 10. What does that mean? It means that even if there is a better payoff the self-interest leads to an outcome which is actually worse for both of them. Now the question here is if you want to machine make the choice, will you still prefer B, R or will you go to T, L and there is uncertainty about the choice of the players.

Now let me extend this argument if so I think when I talk about so this whole game theoretic part is in fact also called as multi agent setting and we are actually saying this because as we talked about the digital supply networks, you would actually see integration of so multiple firms multiple consumer and all these consumer and agents are assumed to be rational.

They are assumed to be self-interested and they are assumed to be strategic. what does that mean? It means that, you would actually need the modeling tool of game theory or multi agent settings to understand the dynamics which happens as part of the supply network. So in fact, this B, R is actually called as Nash equilibrium.

Nash equilibrium is in fact, John Nash paper was 1950 and very famous movie on the life of John Nash, A Beautiful Mind. So, if you have time just watch that movie sometime. What it actually is doing is we are converging on an outcome which is inferior to both the players. This is something which, so which gives you what is optimal.

So, in this case, if they could coordinate, there is an outcome which is T, L. If they are not coordinating, they are converging to B, R and this whole idea of self-interest or strategic or rational and Nash equilibrium, this is pervasive. I am pretty sure if you start thinking you can actually realize that in our day to day life, this is something which we observe most of the time.

Only thing which we can achieve, there is an outcome which is 10, 10. So whether the machines actually allow us to achieve our objectives or will they actually allow us to achieve our optimal objectives. So, the first the third line, if you see may converge on Nash. The fourth line will allow us to go to 10, 10. Now I extend this argument because the same argument we need to use in blockchains also.

Now let us assume that, if they communicate with each other that assume player 1 communicates to player 2 that I am going to play T and player 2 also communicates to player 1 that I am going to play T. Now when the game is played, so this is just a communication. They are not actually going to penalize if you deviate. What will happen? Both the players when the game is played, they try to cheat the other player.

This has been observed in lot of class experiments also. I have played lot of these experiments. So, player 1 assuming that the other player is going to play L, if I play B I get 11. He tries to go from T to B. But the same logic should be used by this player. So, both will actually converge to the same B, R even if there is a communication and that communication in game theory is called as cheap talk.

You would realize in the next discussion on blockchains, the main idea of blockchain is to actually avoid this cheap talk so the communication becomes credible and transparent. So, the logic is mainly game theoretic and the idea is to avoid this cheap talk. With this l will go to the blockchain part, which I will do in the next session. Thank you.