Wheeled Mobile Robots
Prof. Santhakumar Mohan
Department of Mechanical Engineering
Indian Institute of Technology, Palakkad

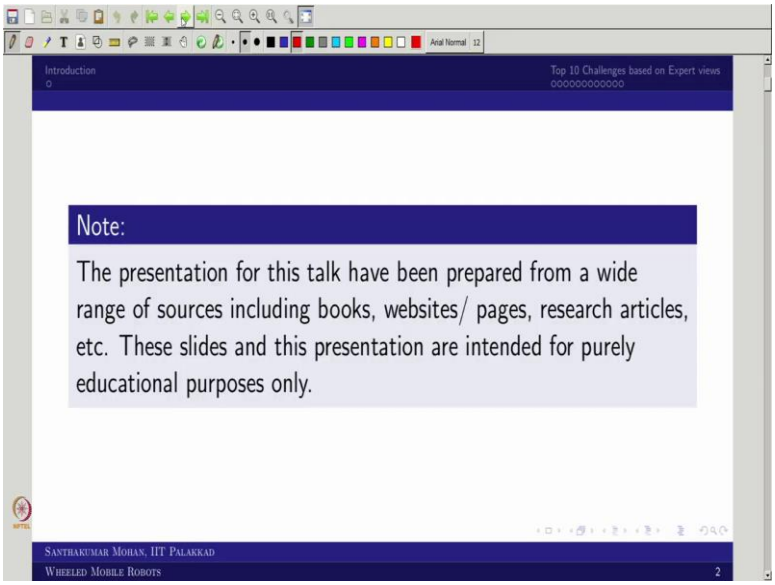
Lecture - 41
Modern Robotics and Challenges

Welcome back to Wheeled Mobile Robot. So for what we have seen actually like we have seen basic you can say system dynamics of wheeled mobile robot, then we have actually like gone up to what you call navigation, sensor, perception, even the motion planning and all.

So, this is the last week where we are actually like talking about the advance topics of you can say general robotics in specific what we thought about so what would be the modern robotics in connection with you can say the wheeled or you call general mobile robots. So, in that sense, this particular lecture we start from the modern robotics how it looks like and what are the challenges.

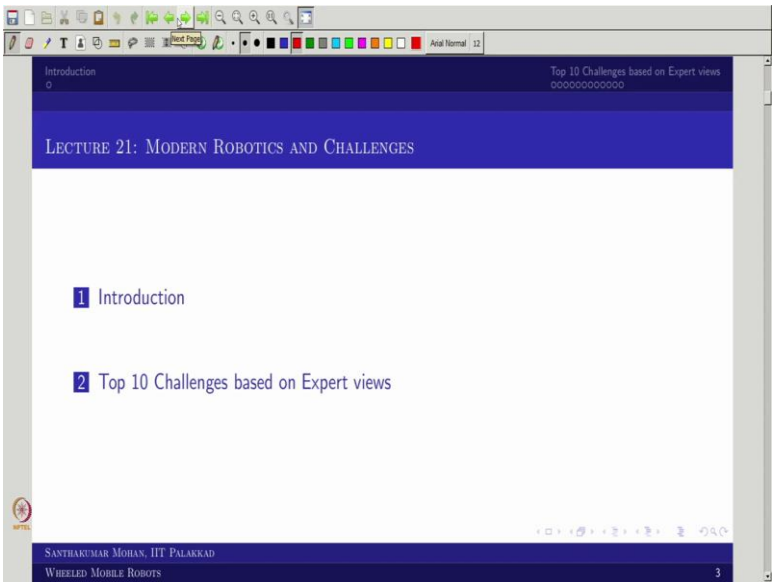
So that to like I would be taking one of the what you call standard text which was actually like published in 2018 that I am trying to recall and trying to address what are the top 10 challenges.

(Refer Slide Time: 01:04)



So, let us actually like move to the you can say slide. So, where we were actually like I already told this particular lecture would be consist of what you call some of the you can say previously published lecture article or you can say article. So, definitely I need to recall this disclaimer.

(Refer Slide Time: 01:17)



So, obviously, what we are trying to see what is modern robotics and in that what are the top 10 challenges based on the expert view. So, the experts here is actually like there are 32 top researcher all over world in the you can see filed of robotics. They have actually like a taken a review and then they put up these top 10 challenges. So, in that sense, you already know like what generally the robotics will be doing.

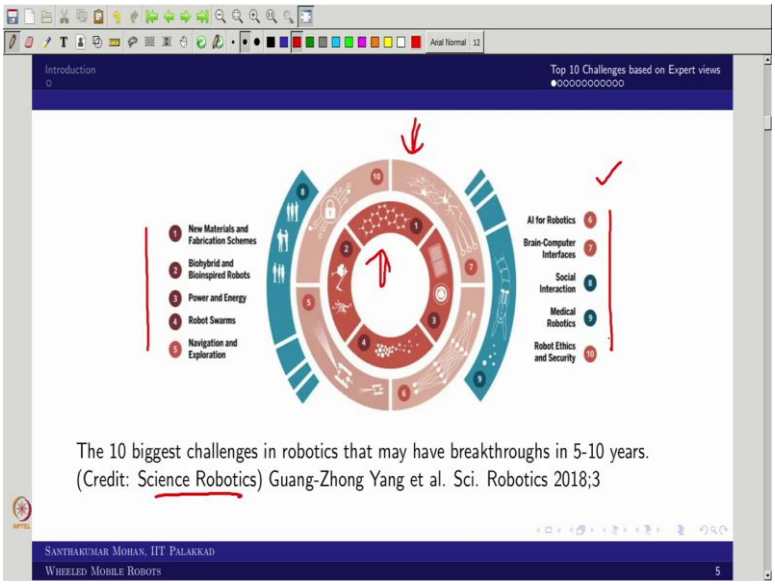
There are two theme right. One is actually like human oriented; the other one is actually like machine oriented. But here we will see like what the general challenges how that go across.

(Refer Slide Time: 01:51)

So, in that sense, you can actually like see the robotics is no longer exist in a industry shop floor. It definitely came out where it starts from entertainment to even the hazardous environment. So, the hazardous environment need not to be only space underwater, nuclear, even the war field you can consider as hazardous environment.

So, in that sense, what one can see like the robotics is actually like not possessed in the industry or the factory floor what used to be in earlier. So, now, it came out, then you can see like what are the challenges will come in this particular domain whether it is taken in you can see the industrial automation for the field industries, for example, harvesting or mine or you call oreing and all that and all how it goes, so that we can see.

(Refer Slide Time: 02:39)



So, in that sense, the 10 challenges what they have identify I am actually like trying to give here. So, you can see like this is the symbolic way of the top biggest challenges. So, or you can say 10 biggest challenges. I already said this is one of the research article which is published in Science Robotics you know Science is one of the popular you call journal.

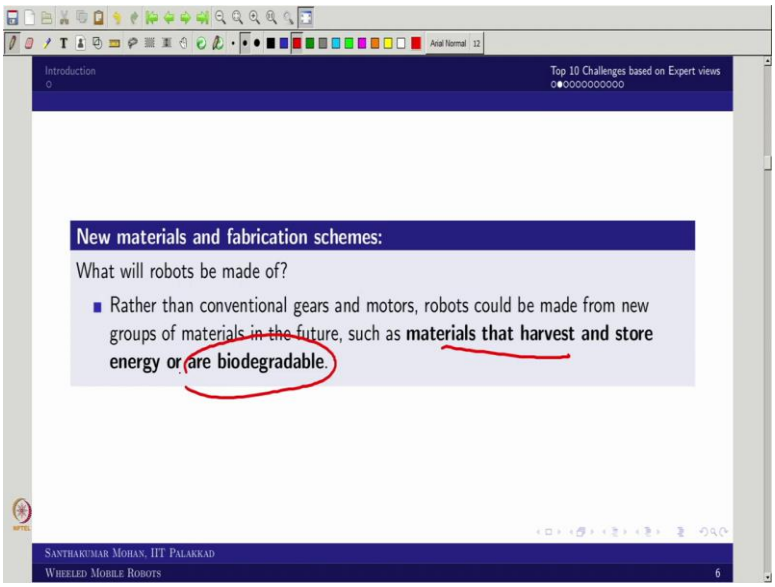
So, they have their one you can say robotic stream, so that is what Science Robotics; it launched in 2018. So, the inaugural edition, they clubbed as a group and then the group came with the top 10 biggest challenges. So, this is what we are actually like trying to address in this particular lecture.

You can see like the top 10 challenges they put it in something like as actually like pillar, and then actually like subcore and the core right. So, if you look at the core what are the things are actually given – the red color what it is marked? So, these are the core you can say topic which are actually like you can say one of the you can say important challenges towards what you call the Robotics.

So, after that, you can see that this is actually like alike topic and this is actually like the blue color is actually like completely out of topic, but altogether we are actually like putting a top 10 you can see challenges. In that sense, you can see that the inner most is actually like you can see the materials or you can say bio inspired or you call power and energy, or you can take it a robot swarm.

So, these are the core. So, let us see how these are actually coming into a picture. So, these all 10 challenges actually like asking some questions to us. So, that is what we are trying to address here.

(Refer Slide Time: 04:06)



So, for example, if you talk about the new material and fabrication scheme, the immediate question will come what will robot be made of? Usually what we assume that it is a rigid body and as well as it is a construction you can say materials right. In addition to that, the you can say the robot would be consists of several actuators and sensor.

So, the actuator usually consists of many you can say motors and gears right. Can we come up with a new material? Where, for example, you take our natural cell, for example, human cell. The cell is actually like even you actually like cut it, immediately what happens, the cell start generate right.

So, in that sense, can we think about that kind of material? The same material can be communicate can actually like sense can actually act for example, you take our skin. So, our skin is actually like can actually like do all three together right.

For example, you touch, the touching is actually like sensible, and the touch is actually like transmit to the brain and as well as the reaction also can come from the same you call skin or muscle, so that kind of actually like material can we thought about it.

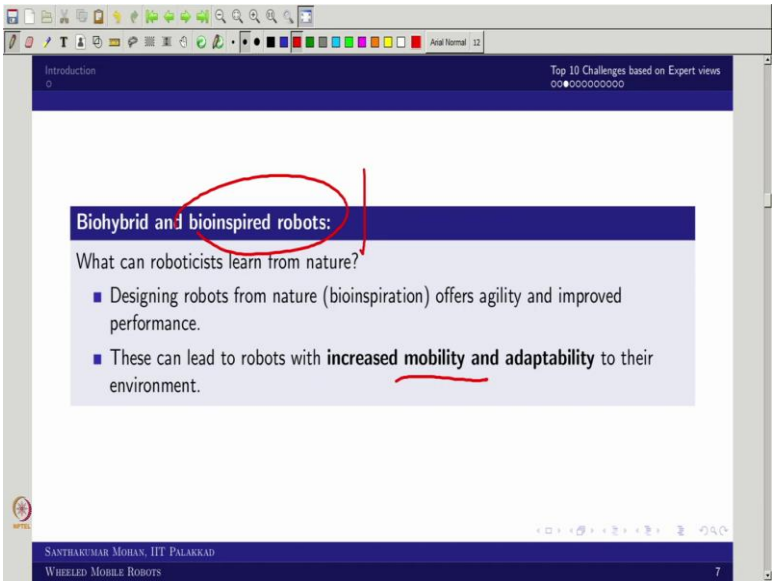
So, in that sense what we are thinking about rather than the conventional gears and motors, the robot could be made from new group of material in the future. So, now, you can see like although we are talking about you can say robotics, but what it is coming in the bigger picture the you can say the metallurgist and the materialists are coming right.

Further you can see that the fabrication. So, like what I said the cell is actually like cell fabricate or you can say self you can say evolve right. Can we do that kind of thing? Very simple example you know like the 3D printer that too metal 3D printers have come very very you can say dramatic way and that to drastic sense we are trying to imply right. In that sense, can we have a modern fabrication technique where we can actually like almost replicate to the nature, can we do it? So, that is a another topic.

But what you can actually see that this material that harvests and store energy that is what the important aspect which we are thinking about. And on top of that, the robot whatever it is made up of that supposed to be biodegradable. In fact, in this direction even few of the robotic researchers, they tried to imply some of the you call wooden you can say stuff can be made as a robot body.

In fact that was actually at work well, but it is not actually like scalable for all the sense right. So, in the sense what they were actually like thinking this is one of the key challenges that need to be addressed. So, in that sense, what we are actually like looking at? So, we are looking at one of the core which is actually like materials and the fabrication scheme.

(Refer Slide Time: 06:42)



So, let us move to the second one. So, what that I already said it is biohaybrid or bioinspired robot. Then what the question is giving to us is what can roboticists learn from nature? The nature is giving lots of actually like understanding. If you look at the aeroplane development, or you look at the train development, or you look at every aspect of what you call the artificial environment, these all somehow inspired from the nature right.

So, similar way can we actually like make the robotic system also more close to the what you call the nature in the sense bioinspired. For example, you take a aerial robot usually we go with a quad rotor or you will see multi router system which is easy, but the nature is not like that right. It is actually like flapping or you can see something like a rotor, but that rotor is not what we used to see.

So, then what we are thinking about can we actually like thinking about the bioinspired, if bioinspired is not completely done can we think about biohybrid, so that is what the question here putting up can roboticists learn from nature? So, obviously, there are several things. So, one is actually like we can think about the bioinspired. In the sense, what we are trying to see what the nature is giving the agility and you can say better performance.

Can we think about designing robot in that direction? So, this is one of the other challenge. So, what that gives? So, you know like for example, animal you take it. So,

animal is a although it is walking on four leg, but what you can see the same replica if we make it as a quaterpade or quaterpedal robot as a you can say dog robot and all that is not actually like economically efficient. Why? The actuator always consuming power.

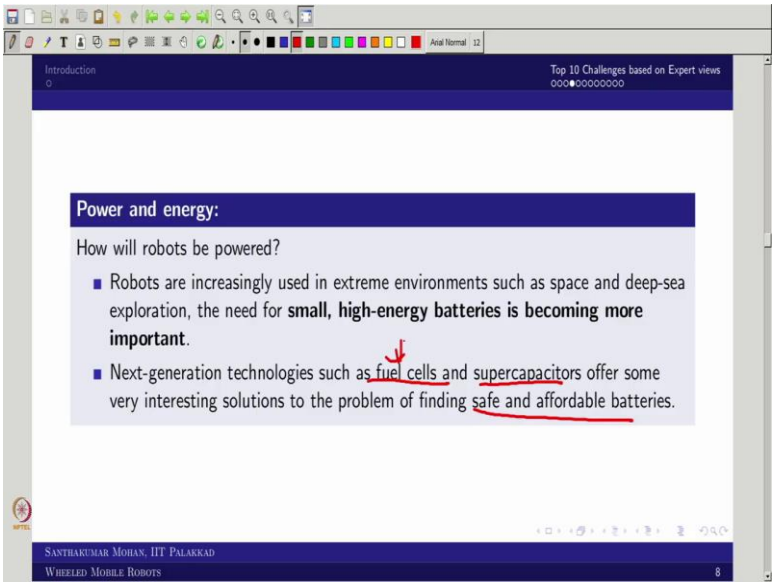
But you imagine the cow is actually standing with two leg that is not actually like feasible energy consumption based design right, so that is what the nature itself is giving like for example, now it is a bulky body.

So, you should have at least more number of contact points where the reaction could be actually like make it neutral right. So, in the sense what the nature is giving more you can say adaptability and as well as more you can say increased mobility within the available resource. So, that is what we have to see.

So, we have to see about the bioinspired robot. So, that is what one case. If the bioinspired is not possible at least you think about biohybrid. For example, you think about the fish robot or you think about underwater robot, you try to replica on the fish whether the fin is actually like a flexible fin or rigid fin, but at least you try to replicate.

So, then what you can see you can increase the what you can say the overall performance or the efficiency that is what we are trying to address in the second point what we mentioned biohybrid and bioinspired robot.

(Refer Slide Time: 09:21)



Then the what would be the third one? Third one is the important very very important in the current scenario because the energy is one of the you call critical factor. So, why that is so? Because the robots always actually like powered by electrical or hydraulic actuator, usually these actuators actually like eat energy. In the sense, for example, if I am taking a humanoid robot for probably 2 hours, I may required a huge battery backup or I need to charge at each and every time.

So, in that sense, what one can see, so the power and energy is one of the fact. So, what would be the immediate question will come how will robot be powered, whether we are powered like external source, or we are actually like keeping the powered with the battery or not? If it is a battery, then the battery supposed to be self sustainable batteries.

So, that is what we are actually like thinking about you see that robot increasingly used in extreme environment. What extreme environment? This extreme environment can be exploration or rescue task. So, then you can see that this is actually like dependent on you can say unmanned system. So, what that means?

So, it is not connected with the you can say some kind of power station. So, where the power would be laid with a cable, no, that is not possible. Then what we are actually like dependent on we are dependent on some power source which is inbuilt. So, immediately people can think about, can we use you can say solar panel or some other hybrid energy, or you can say non conventional? But that is not all the time feasible.

For example, now, I am keeping a solar panel on the mobile robot, so that would add a payload and as well as you have to actually like make some more thing. For example, now I assume that this particular robot designed for probably rescue operation, if I keep a solar panel, so something fall on the solar panel, it lost right. So, then what you need to think about?

You need to think about something else where you can think about a fuel cell or you can think about something like super conductor base kind of thing. So, in the sense what we are thinking about high-energy battery, battery is becoming more important in that case. You already know the lead acid batteries are not really used in the you can say called the modern case right. What modern case it is actually like lithium-iron or something else is actually like coming up right.

For example, you take your old mobile phone and the modern mobile phone, it is completely changed right so because of this high-energy batteries. So, similar way can be thought about that into robotics also? So, in that sense what we are actually like seeing it can we use the fuel cell as the sub or can we actually like think about some kind of super capacitor?

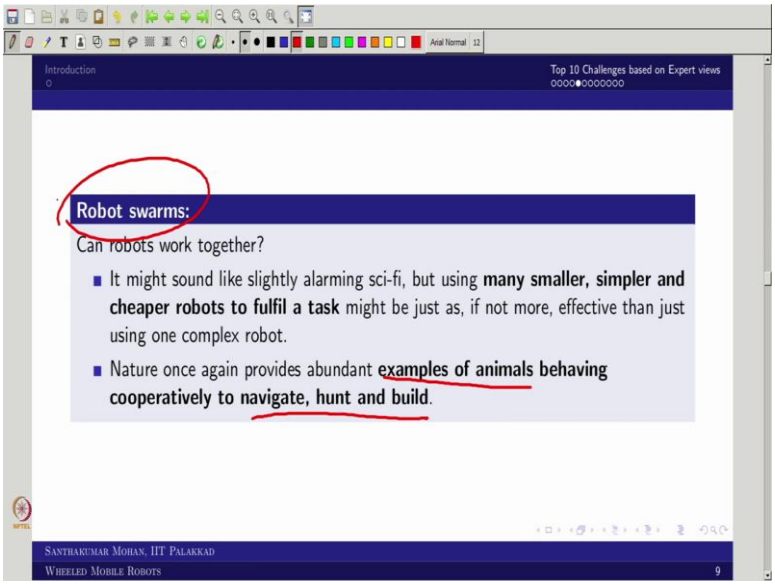
These are possible solutions which can actually like make the safe and affordable batteries. But the fuel cell you have to make it whether it is safe or not can we have it or not. So, you know already the cars also like change to hybrid or completely electrical car right.

But you imagine even if it is electrical car how that battery would be look like. So, and after a year or after 5 years what happened to those batteries? So, these batteries will come as e waste right. So, we do not have technology which will be make it as a scrap, so that is what you need to think about.

So, one of the bigger challenge which come from the robotics is actually like power and energy how we can actually like make it. So, as I already mentioned the material itself is actually like self-evolved and it is actually like energized based on what you call some other mode like how our bionic cells are actually like getting energy that kind of thing can be thought about it, or you can think about a plant.

So, like that can we actually like bring it. So, it is all actually like imagination. We are not able to do, but we are thinking in you can say very broad way.

(Refer Slide Time: 12:55)



So, then what would be the final core topic that would be a swarm, in the sense, can robots work together? Obviously, that is one of the case why is this is so? It is a very bigger question right. Why we need robots supposed to be work together? So, some of the task, for example, I am actually like lifting probably 200 kg weight imagine I am able to capable of lifting that.

But imagine the same 200 kg like 4 such people like me, so each of them are actually holding it actually like four corner, what would be the case? It would be very easy right. So, in the sense, the heavy payload can be distributed in among four equivalent parts right.

So, now, the equal part or heterogeneous in the sense the homogeneous in the sense almost everything is similar; if it is heterogeneous, is actually dissimilar. Still can we actually like make the group of robot what together for achieving certain task? So, this is one of the biggest question. So, this is what the current domain you might have seen several micro air vehicle would be lifting the construction break and make the construction right.

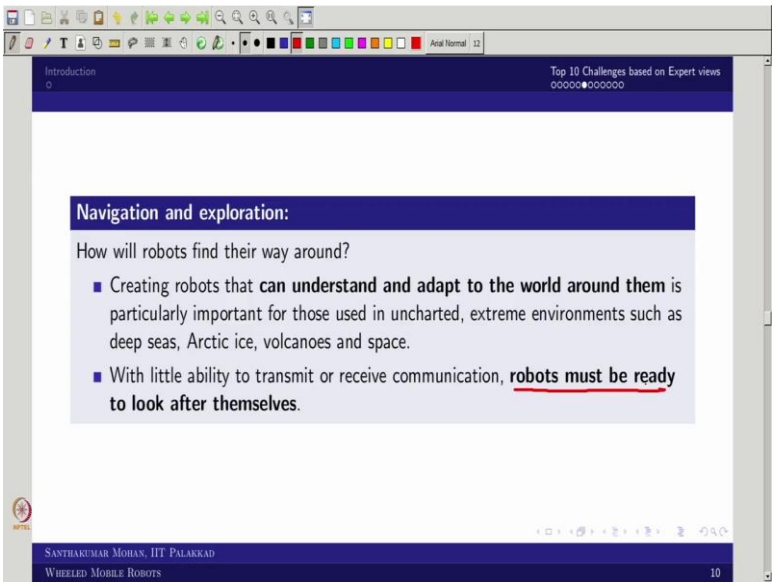
You would have seen that and all. Like that in some of the robot movies and all you would have seen that robots all actually grouped and make a formation and do certain task right. So, that kind of you can say idea what we are thinking about. Can robots work together?

So, if that is the case what one supposed to see, if we are actually like working together, what you can think about you can make a smaller robot in numbers in the sense more numbers, but what you can make that robots would be simpler and cheaper. Then what you can see for example, one bigger robot supposed to finish the task that bigger robot because of the biggest size the cost would be probably very high, instead of that I make it 10 small robot, but that would be less than that.

And in addition to that, it would be modular and multifunctional right. So, that is what we are actually like looking at. So, in that sense, you can see that the animals always like behaving cooperatively. For example, you take an ant ok. So, the ant would actually like grouply together and then lift even the heavier load. Can we do or can we replicate that? So, that is what we are actually like doing it.

So, can we actually like navigate that way or hand that way or we can build the system in that way? So, in the sense you can see this swarm robots or simply we called robot swarms is the one of the core important biggest challenges ok. So, these are the core challenges. Now, we will come to the outer. So, outer in the sense what we can see the pillar of this. So, I am not saying the supporting, so the outer core.

(Refer Slide Time: 15:21)



So, what would be that? So, one of the important aspect is actually like coming from the you call the computational side. What that mean? So, you know like the nowadays modern robots all are actually like moving across right, moving across in the sense it is

external environment based robot which is exploration or we can say rescue, some kind of task.

So, then what supposed to be required? So, you need to navigate and as well as explore whatever the case it is given to the robot. So, then what you have to see as the bigger question will come that how will robots find their way around? If you are actually like throwing a robot in a you can say unknown environment whether the robo can actually like do the task within its own, you can say permissible capability that is what the biggest question.

So, if that is the case, the robots supposed to be understand and adapt to the world around to them. So, that is one of the case. So, in that case, you can see that unchartered, extreme environment, for example, you take a deep sea, or you take a probably ice environment, or you take a nuclear power plant, or you take in a you can say rescue task where the volcano or some other disaster happen.

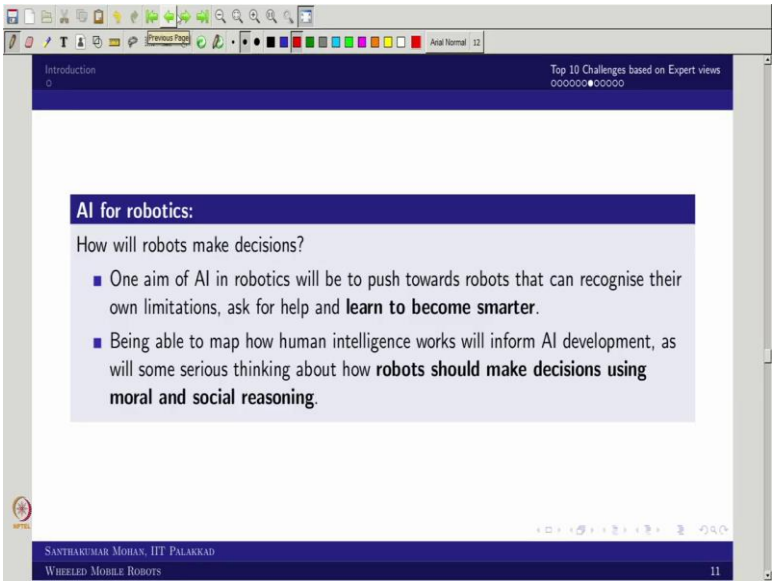
So, in that sense, can understand the robot or adapt the world around them? So, that is one of the biggest question right. So, then if it is able to address this, then you are actually like achieved this particular core or you can say sub core of this. So, then what additionally coming the robot must be ready to look after them self.

So, what that means? So, for example, I am actually like having something like thrown the robot to a external environment, suddenly there is a missing a communication. So, then how that robot will actually like perform? So, I am not talking complete autonomy, but still can it actually come back.

For example, you are taking a underwater vehicle and putting into the deep sea, suddenly some of the thruster failed. So, if you are not putting in a proper navigational scheme, what will happen? The robo will actually like sunk. But now you imagine something is failure, it is actually like throwing some kind of signal within that self within the robot itself, and it is actually launching the you call rescue mission.

For example, it is a drop some weight, immediately what happened, this is actually like now you can say positive buoyancy, then the vehicle will come up. So, that kind of aspect what you thought about it as a modern navigational scheme. So, that way you have to actually like see your what you call the navigation and exploration scheme.

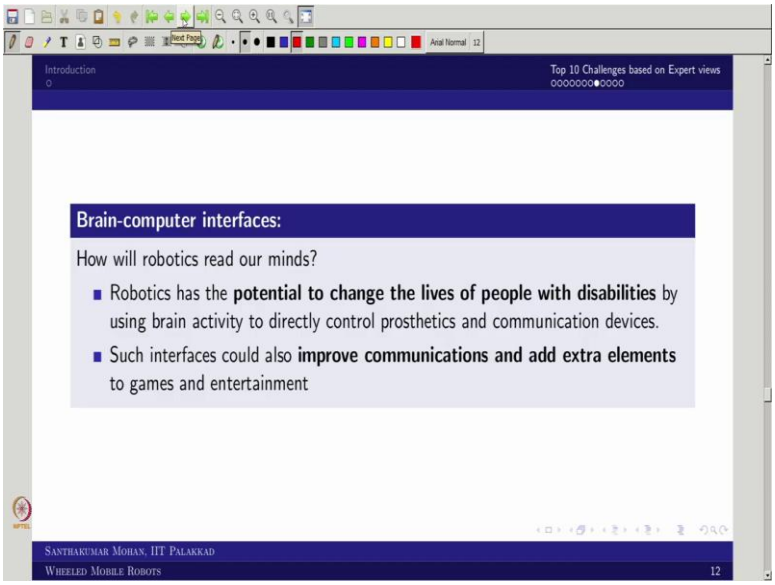
(Refer Slide Time: 17:52)



So, now you see that already we touch the navigation. Then what would be the next? So, can AI brought into robotics? So, definitely yes, already we started using it. But what the question here is how will robot make its own decisions, so or make their own decisions? So, that is a biggest question right.

So, now you know AI actually like one of the you can say critical factor. So, even people say that no no, AI you should not apply to robotics because that may actually like give self-evolving, then it may not actually like obey the you can say human operator or human commanders. Yes, of course, but you have to see that the AI should be very fruitful way how we can apply to a robotics that too modern robotics.

(Refer Slide Time: 18:31)



So, in that sense, what one can see here, so I have actually like answered that into two things. So, one is actually like potential to change the lives of people with disability this is one of the critical thing, sorry. So, yeah you can see that the AI for robotics is actually like what it is making, so it makes the learn to become smarter.

So, if I apply the AI to the robotics, what you can see that robot would be make smarter. So, what means of like what is the meaning of smarter? The smarter in the sense it is actually like getting little more intelligent, that intelligent should be actually like arrested in certain way.

So, that is what the critical fact, but that we will come in the last section. But right now we will see that AI will give the robot become smarter and smarter. So, if it is a robot making smarter, what it says, so it make its own decision and make social reasoning. So, what that means?

So, you can actually like make more and more knowledge. So, based on that, even if I am actually like moving around to the external environment, it will see what is happening, and then it will make its own you can say social reasoning for that particular task. For example, now the robot is actually like moving away, and it seeing that there is a baby is crying.

So, now the father or mother is coming and specifying with some actual like fake things they are telling. So, now, the robots should not think that ok, these people are telling something is false. Now, at it has to see that it is actually like some social reasoning, yeah it is trying to specify the kid that is why it is giving, so that kind of intelligent what need to be put it into the robot.

This is what we are looking as a one of the biggest challenge. Simple you can say following a line or following a point to point is actually like not big task for the AI. The AI should actually like make understand and give a moral and as well as social reasoning for each and every action which is happening around them, so that is what the case.

So, now, we will move to in the next one. So, what we call the brain computer interface, we simply call BCI. So, what that make? The biggest question is can the robot or you can say can the mission can read our mind? So, in the other sense how will robotics read our mind? For example, I am taking my mind, can the robot or the machine can read what I am thinking at?

So, if I am achieving that, so then I am achieving almost the one of the biggest challenge. For example, I am taking as a disabled person. So, for example, his arm is not actually like function. So, now, we are actually like put it one of the manipulator arm close to him which is fixed base, but instead of his arm this manipulator arm supposed to do. So, but what we can see he cannot actually do anything.

For example, he cannot actually like dictate so, but you can actually put it on your brain as a brain you can say computer interface. So, now, this interface is actually like understanding ok. Now, this man is saying that please pick the bottle ok. So, then feed some food something like he is thinking that is actually like the manipulator arm is doing then what you can see you have achieved the one of the greatest challenge right.

So, that is what we have put up here you can see that the robotics as the potential to change the lives of people with disability. So, in that sense, what it is actually like can directly or indirectly it can actually like give other side. For example, directly means, so for example, I am putting a prosthetic leg or arm.

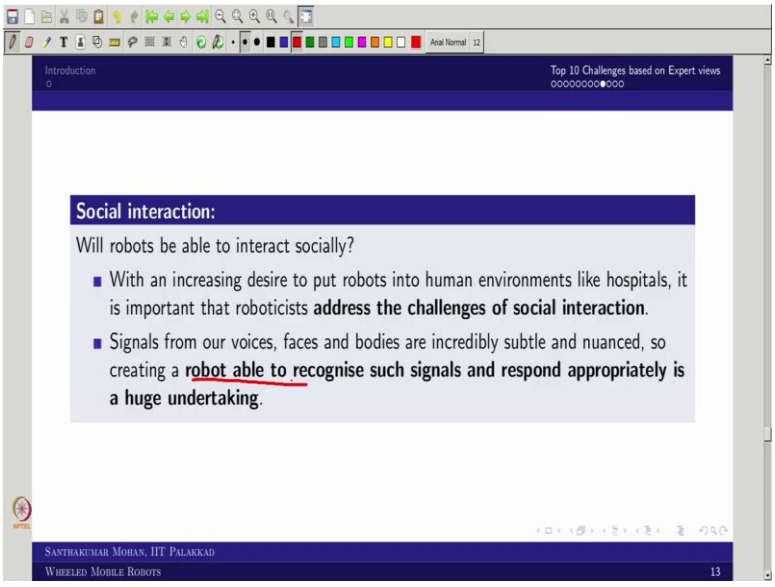
So, now, you imagine that is a artificial arm. So, this artificial arm supposed to give some kind of signal. So, now my brain is giving a signal through the nerve system right.

But if it is a artificial arm this would be connected with the wires and actuator. Can I use the brain control interface to do that? So, this wires will get the signal from the brain controlled interface, in the sense brain you can say computer interface will give some signal that signal will actuate the you call the you can say the arm. So, then you can see that it is directly controls the prosthetics right.

So, what would be the other way round? So, it can actually like improve the communication and add extra element. It need not to be games or entertainment even it can be you can see improve the communication for the one who does not have the proper communication. For example, somebody is orally not able to communicate ok, need not be actually like you can say deaf, blind or you can see; you can see other aspect, but this particular brained computer interface can give the improved communication.

But you imagine somebody who is actually like playing games and entertainment, so that also can actually like use it ok. So, that is what we are for example, somebody is doing a virtual reality game, so then virtual reality game can be adapt with this kind of brain computer interface right. So, these also can be adapted.

(Refer Slide Time: 23:13)



So, then what would be the you can say important aspect in the other side? So, one is actually like one of the critical thing is the interaction between what you call man and machine. So, this is one of the critical thing. So, then what we can actually put up a big

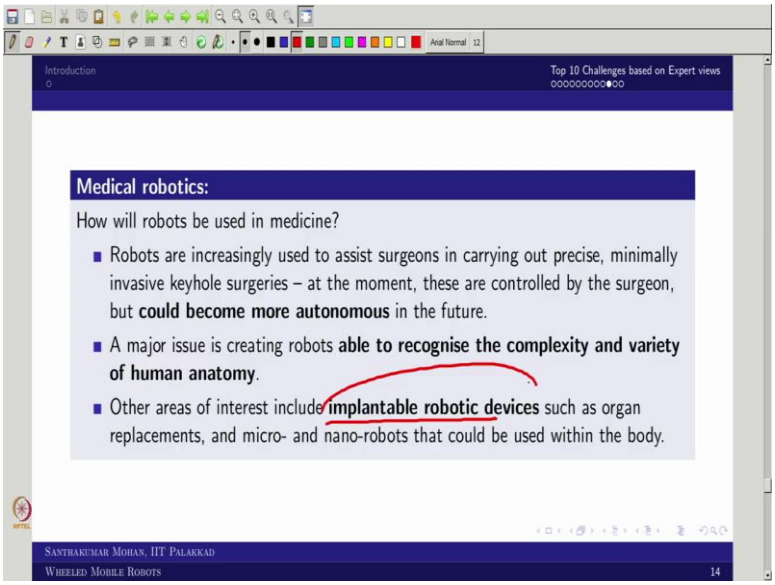
question. Well, the robots be able to interact socially, yes, so then what way? So, the man to man, and man to machine, and machine to machine interaction is different right.

So, then how that would be answered in you can say future. So, definitely the challenges of social interaction is still is a bigger challenge because the robot cannot address immediately what the human environment is saying, but somehow you can actually like feed more and more learning based algorithm, and then you can actually like train that. So, that is what we are actually like putting it.

So, in that sense, what we are actually like expecting the robot able to recognize such a signal which is actually like coming from the you can say human. For example, I am throwing some you can say probably I want actually like probably tease somebody. So, we make some noise right or probably we are actually like calling someone without even using the original voice, for example, I want to call a baby.

So, some you can say mimic we will do right. So, the robot also supposed to understand this and try to actually like get and respond to that. For example, now I want to call the robot instead of calling a robot come here, I am just showing that come, come. So, the robots supposed to understand that ok I am calling the robot to come to me, so that kind of actually like understanding is the biggest challenge right. So, if the robot able to do this, we are actually like achieving that aspect.

(Refer Slide Time: 24:48)



So, in that additional aspect what will come? So, one of the biggest aspect what you call medical robotics. So, why that is so? Because the medicine or you call the medical practiceness always actually like shortage. So, then can we actually like filled this. So, for that what we are putting a question, how will robots be used in medicine? So, then you can see that there are two way or three way we can do it.

So, one way is actually like we can actually like replicate the robots, replicate the doctors with the help of robot. Whether you can say away where the doctor will give a command and then the robot will do which we call actually like master and slave kind of thing. So, the other way is actually like it is not replacing, but it is assisting, for example, surgeon assistance this can be.

The other way round we can actually like improve the what you call health care. So, health care can be improved by adapting you can say theropetical robot that can be a you can see a simple emotional therapy or physical therapy, or it can be applied to some other aspect.

So, in that sense what we can actually like see. So, we can see that become more autonomous in the future. Already you know the robots are already deploy in the robot surgery right. So, for example, you can say da Vinci is one of the popular robot which was already put it in a surgical robot. But before that you can see the laparoscopy in eye.

So, earlier days laparoscopy may take a time. Now, you imagine the patients will go in a day, they will be back to their work. Even if you look at in the original time they may take only a half an hour of the processing and probably 2 hours for the you can say observation and you can say relieving task that is all.

So, earlier days you imagine if it is something like you are doing something in your eye, so people will be worried and they actually like take very very cautious decisions. They take at least three-four decisions, three-four observation, then finally, say yes I can do. But now it is not like that.

They just go for a like what you do in a dentist. So, they go to ophthalmologists, and the ophthalmologist will actually like a sense and then they put you can say some kind of a closeness and then they say that these are the process you do it. Then the laparoscopy machine will do the remaining process, so that is what you can actually like see it.

So, then what we are looking at even we are thinking about even the surgical robot can be more autonomous, even you take a sergeant assistant also can be more autonomous. Then what else would be there? So, the creating what we are actually like creating a robot that would be actually like creating very very complex things what in that way. The robot cannot understand the human autonomy directly.

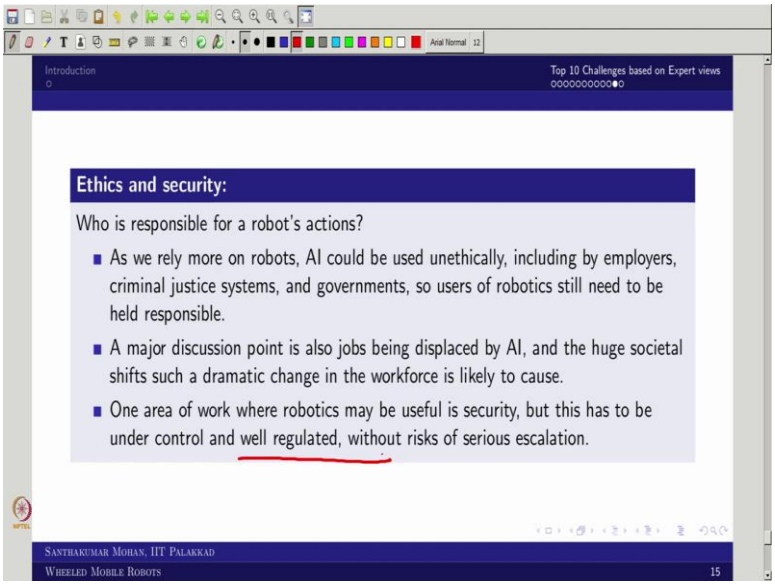
For example, I am saying that the robots supposed to make a hole in my abdomen, but it is supposed to send that were supposed to make a hole, so that the minimal inversely will happen. So, in that sense what you can see the complexity and as well as understand the variety or you can say variation in human autonomy is supposed to be understand.

For example, now I am taking a treatment or later on somebody else is getting treatment, their physical structure is different right. So, it is very very complex. The robot supposed to understand recognize that. So, that is what the biggest challenge. So, final what we can see that can we employ the implantable robotic device.

For example I have actually like problems with my lungs. Can I replace a robotic lung? Can I actually like communicate to that to the doctor whether I am functioning proper or not. If I am going even away, if my lung is actually I having some problem that would be communicated to the doctor that kind of devices where you can say trackable, you can say implantable robotic device, can we do it?

Similarly, for example, you want to actually kill the a cancer cells, can we do it with a micro and nano robots? So, that can be navigate. Right now what we are doing it we are actually like throwing it and navigate through some other mode, but the robot itself can actually like function. So, these are actually like biggest challenge.

(Refer Slide Time: 28:47)



Now, we will come back to the original case where the outer supports. So, what would be the support? So, one is actually like a ethics and security. What that mean? So, whatever the robot is doing it, who would be the responsible? So, the question I can put here who is responsible for a robot actions? For example, I am actually like taking a surgical robot imagine.

So, one of the patient is actually like doing the surgery with the robot. So, now, the surgery went wrong unknowingly or probably unfortunately it went wrong. So, now, who would be the responsible whether robot or the inventor or the fabricator or the installer or the organization who purchased this, or the practitioner who did, or the patient who accept it. So, there is nothing is clear right.

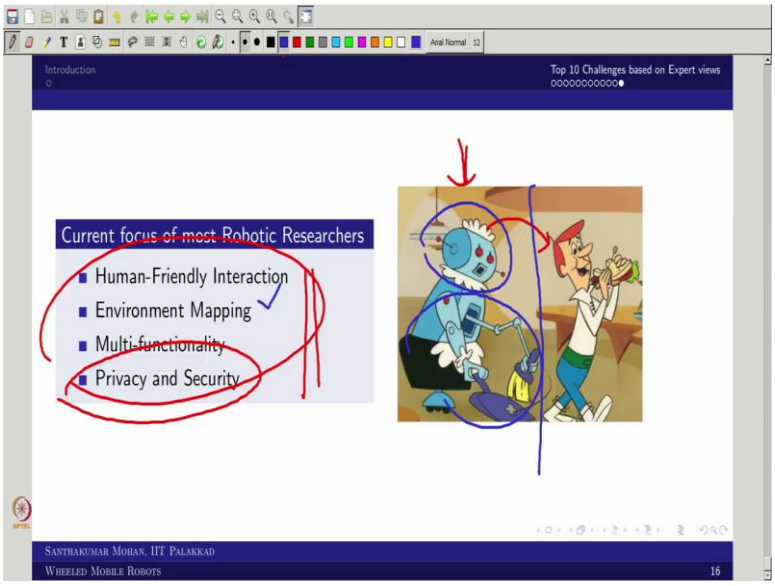
So, in that sense what you have to see you have to make the security and as well as ethical standard. So, the those things are actually like coming in a bigger picture. So, you see we are applying AI, but that should be actually like within the ethics limit. So, it should actually like follow all the aspect. So, this is very very important that is what I said robot should not self evolve right. So, these all the biggest challenge.

So, finally, what you can see the ethic side. So, the robot should not actually like displace the human job ok. Similarly, the manual job should not be displaced by the artificial intelligent. If you are doing that, so then you are actually like doing one of the

good thing. But what we are seeing the modern robotics means everything is actually like robot, then you have to see what the human will do.

So, these are actually like ethics. Further you have to see that the security aspect right whether everything is under control and well regulated without any risk that need to be always actually like consciously monitor. So, these are the you can say outer supporting thing.

(Refer Slide Time: 30:29)



What would be the final supporting thing? So, we are actually like we coming back. So, the final aspect, what the final aspect? So the current research what the robotics are actually like doing it. So, what the current focus? So, we are actually like focusing only four things so even including me. So, we are seeing that human friendly interaction. And we are actually like thinking about can we do the environmental mapping in some autonomous way.

And any robot what we make that should not be actually like single mono function, monopoly kind of thing, it should be multifunctional. So, that it can be done everything. And finally, what I said that privacy and security. So, these all need to be ensure whenever we are doing the robot actually like development and all.

So, this picture why I put it here, probably you may ask the question? So, why I put? This particular cartoon will give all the aspect what we are thinking about. Now, this

robo is actually like human friendly right. And what else you can actually like see that this is actually like multifunctional, and it is having several sensor, it is actually like mapping that.

Further it is actually like you can see it is not you can say intervene the private of this particular human. Although this human is actually like making a dirt, but this robot is not actually like stopping anything and further it is actually like maintaining some safe distance right. So, this is the way I put this particular picture here.

So, with that what we have seen in this particular lecture, we have seen what is the modern robotics top or you can say top 10 biggest challenge that was actually like we deliberated here. And we have given some kind of idea how it goes. So, definitely you might have actually like got some idea.

So, where you can say the humanities people to even the extreme metallurgist everybody is involved in robotics in the modern robotics. So, it is not only like electrical, mechanical, computer science people are involved, no, it is actually like across you can say domain; it need not be even engineering. So, that is what the whole idea of bringing this particular topic here.

So, now, you have actually like started the modern robotics. Now, we will see few of the modern you can say; you can say evolving robots or you can say what is upcoming robots, so those configurations we will see in a introduction level in upcoming lectures. Until then see you bye.