Wheeled Mobile Robots
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Lecture – 01
Introduction to Mobile Robots and Manipulators

Welcome to the course on Wheeled Mobile Robot. So, this is actually like very broad course, but we are trying to restrict that mobile robot into a wheeled configuration. So, in that sense this course if you actually like a takeaway for 8 weeks so you would be able to understand basic concept to the end prototype this is the overall idea.

So, this particular course would be having at least you can see 8 weeks in that go you can see that the locomotion we will cover first then the sensing navigation and finally, we will start and end with the control. This is what the overall flow.

So, this is the first lecture on introduction to Mobile Robot and Manipulator. So, this is actually like very broad you can say spectrum mobile robots. So, in that we are actually trying to restrict to the wheeled mobile robots. So, I will be introducing what is mobile robot and what is wheeled mobile robot in this particular lecture.

So, before going to that particular aspect. So, let me actually like give a small note. So, this particular course intend to teach only for educational purpose. So, that is what this note or disclaimer all about.

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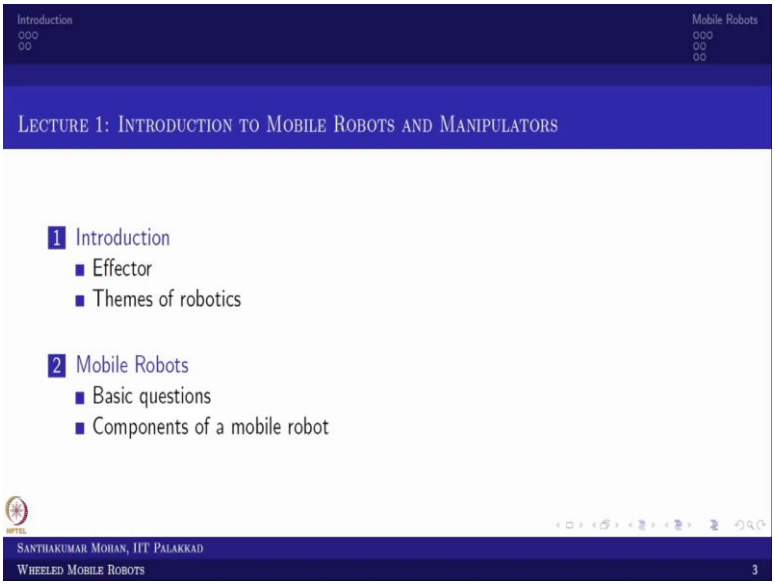

So, let us start the lecture 1, the lecture 1 would be having more you can say broad you can see it is a basic introduction. So, we will be talking about what is robot in the perspective of effect. So, which is nothing, but effector, then we will be talking about types of effector, then we will be seeing on the themes of robotics, then we will move to the original core which is mobile robot.

So, there also we will start with a basic question and then we will see what are the components will come into mobile robot. So, if we go this way. So, I as I already told. So, we will talk about the robot as a general term called effector.

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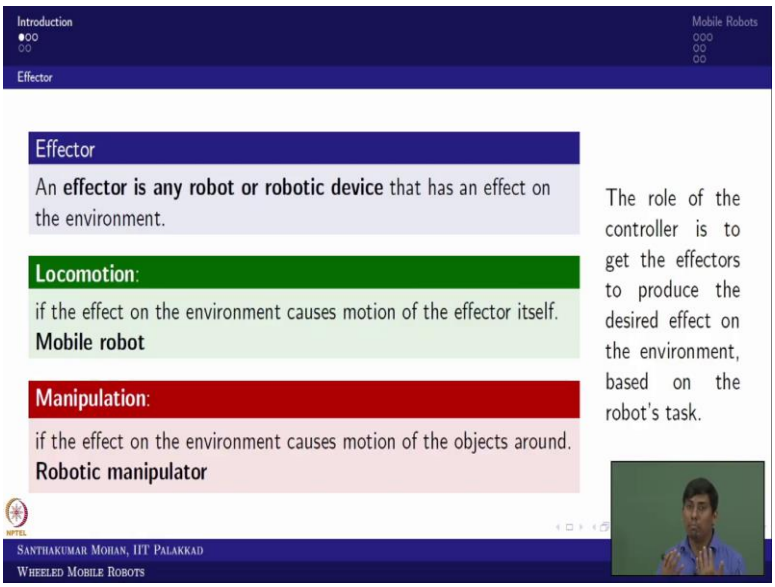

So, what is the effector? The effector is nothing, but you can say robot or robotic device that has a effect on the environment, this is what we are going to call as a effector. So, now, you can see that any robot whatever you talk in a real time these all actually like what we are brought bring into a effector.

So, now you can see that this effector can be broadly classified into two category. So, one is the based on the effect of the environment. Now you can see that the effect of the environment or effect on the environment causes motion of the effector itself. So, then what we call this particular motion called locomotion. So, now, whatever the locomotion happening that is what we call general broad way of we can say classify as a mobile robot.

So, this is what I am giving in this particular definition. You can see, the locomotion is actually like I am giving in another way of definition that is based on the effect of the environment. So, now, you can see if the effect on the environment causes motion of the effector itself this is what we simply call locomotion and the locomoting device what we call mobile robot now the contradict what would be coming.

So, the effect on the environment causes motion of the object around rather than the effector itself. So, this is what we call manipulation and I put the color red in the sense the manipulator what you call the manipulating device which is actually like very well saturated and matured field and the mobile robot what we are going to focus in this particular top or particular lecture and course that is why I put that in the green. So, now, you can see that this is the way we are actually like classifying and defining the robot.

So, now one thing can come in our mind. So, then what is the meaning of control, control also as a effector or not. So, in that sense what our perspective the controller or control is not a effector that is a aiding tool or you can say; you can say what generally it is actually like assisting device. So, that is what we are trying to say what exactly this does. So, the role of controller is to get the effector to produce the desired effect that is what the you can say important thing.

So, you are saying that the effect on the environment may cause the motion of the effector or cause the motion of the object around. So, now, this particular predefined way. So, how that motion or how that would be enable that enabling mechanism what we call controller. So, in that sense you can see that the controller is not part of effector that is what this whole slide talking about.

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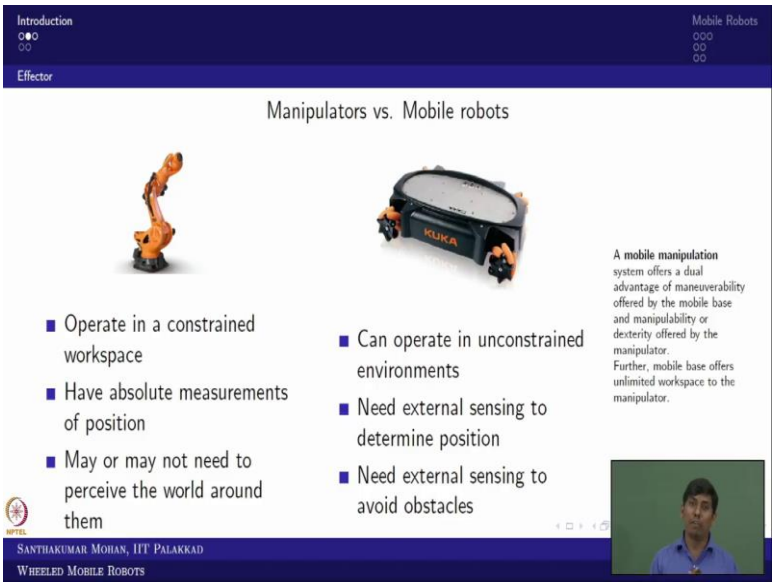

So, now we will move further. So, you have already classified the effector into two broad one is manipulator, the other one is mobile robot, we will talk more about you can say these in detail. So, what; that means, so the manipulator means it is manipulating the object around for example, I take my arm this arm is actually like manipulating the object around.

So, in that sense what one can see the effector which is nothing, but manipulator is actually like fixed in one end. So, it can be actually like have a multiple arm connected with a mobile base or it is actually like single arm which is actually like open space. So, the open one we call serial manipulator if it is actually connecting parallel chain with a mobile base that is what we call parallel manipulator.

For example, now I have 2 arm this is actually like individual serial manipulator, but now I combine this this is actually like giving me giving the parallel manipulator cares. So, now, that is not the you can say important in this particular slide, this particular slide says that this manipulator is actually like fixed.

So, because of the fixed what we can actually like see the operation would be happening in a constrained workspace. So, that is what more important whereas, the mobile robot is not constrained it is actually like can operate in a unconstrained and unstructured environment this is what the basic difference.

So, now based on this basic difference what are the things will come. So, now, it is actually like the manipulator is working on a constraint workspace in that sense the manipulator can be easily pre programmed and actually you can put a fence covered. So, then you can see that the interaction is actually like very much restricted.

So, in that sense what one can see the absolute measurement of the position or the robot is easily obtained whereas, in the case of mobile robot it is not happening. Why? Because the mobile robot is actually like moving on the unstructured environment and as well as you call the unconstrained environment. In that sense so the robot supposed to understand its own position and as well as it is supposed to understand the you can say environment around. So, in that sense you can see the manipulator does not required that.

So, in the sense may or may not need the perceive their work or the world around them whereas, in the case of mobile robot it required external sensing for you can say measure its own position and as well as the environment itself. So, this is the basic difference. So, now, you can see that.

So, one of the challenging thing is the mobile robot, but now one thing immediately come into our mind you see this is also like having a constrained and this is also having some constrain can I actually like have a combination of these two where both the pros can be combined.

So, this is one of the easiest idea which anyone can thought about it. So, this is what we are also going to call as a mobile manipulation in the sense you take this arm and put it on top of this mobile base what you will get. So, the base will give a locomotion and the arm will give the manipulation.

So, this is what we are actually like calling as a mobile manipulation which is actually like the system offer both advantage in the sense the dual advantage of having manipulability and as well as the maneuverability which is nothing, but what you call locomotion and what you call the manipulation.

So, in that sense some of the people they call the manipulation capability we simply or some of the general people call as a dexterity. So, that is what I put it in this particular slide. We will discuss more detail about what is maneuverability and dexterity in upcoming lectures, but right now you can actually like understand if you bring it to a mobile manipulation this would be giving a dual advantage.

Further what it gives, so you will get a unbounded workspace in the sense unlimited workspace for the manipulator because they are manipulating device on the top of the mobile base.

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So, this is what one of the simplest idea which is what you call a general category called mobile manipulator because this is on the mobile base the manipulator on the mobile base. This is the robotcians or you can say the field of mechanical sight these systems we called vehicle manipulator system ok.

So, this is not new to us because you would have seen several of us would have seen the construction side or road you can say laying side you would have seen there is a earthmovers we simply called the earthmovers usually have a backhoe.

So, which is nothing, but the mobile base where the wheeled locomotion would be attached with one of the you call the manipulator arm that is what we are going to call as a vehicle manipulator system. The understanding of vehicle manipulator system is very you can see little tricky. So, that we will be addressing in the end of this particular course ok.

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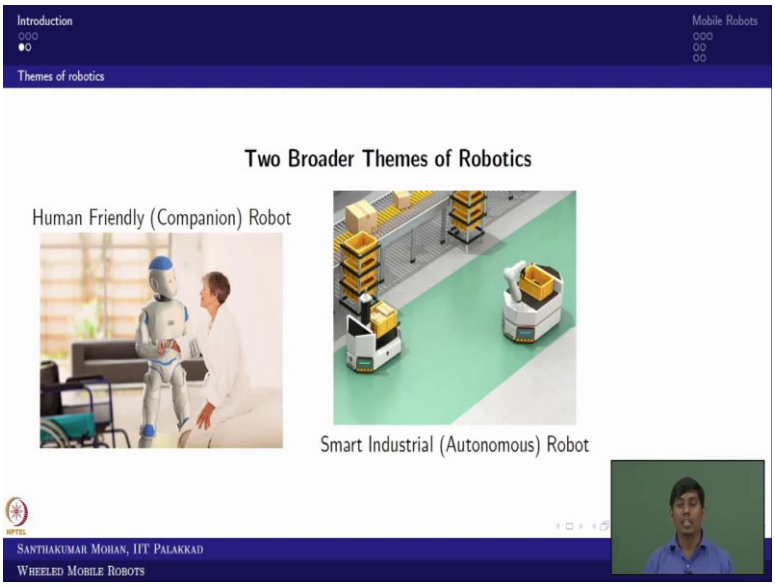

Let us go to the other side. What other side? You know like robotics is not a new field it started probably in mid of 70s and it started maturing in mid of 80s, but what one can see the theme of this robotics is not at all changed. So, what that mean?

So, the robotics theme is actually like still there are two broad theme one is to enhance the humanity in the sense increasing the human life and human style or lifestyle or assisting the human being, the other side is actually like increasing the efficiency or increasing the productivity of the machines.

So, now, in this broad category what one can easily find. So, one would be a supposed to be human friendly robot which would be human and robot interaction, the other side machine and machine interaction some cases it will come as see a human machine interaction. But one is actually like talking about cost and economic and as well as production and you call the resource utilization the other side is actually trying to see the value of the human.

So, now, in that case I will just give a very simple example before going to the slide in detail. So, for example, you take probably 10 or 20 years back where the kids would be grown in some kind of you can see even cities or village. So, the particular family will be having at least 4 5 adults and 3 4 kids and all the neighbors would be a relative of the same family, but now the scenario has changed right.

Even further the scenarios keep changing for example, the husband work in one of the in firm or employee employer, the other you can say spouse would be working in another employer and the kids would be staying even in some kind of residential campuses and they used to meet once in a month or once in a semester or once in a year.

So, these are actually like changing the lifestyle. So, further what one can see. So, even after 40 or 50 years. So, you can see like I am not saying that from now, the person who is having 40 or 50 years. So, they need definitely some kind of you can say company. So, that company usually like missing in the current perspective further you can see that we are all actually like brought into nuclear family the kids need actually like peer group attraction.

So, these all happened in the olden style would come with a pet animal, but most of the residential campus or you can say residential complexes they actually like restricted no pets allowed right. So, in that sense what one can see we can actually try to imitate the pet into a device. So, this is also another way of bringing the robot as a companion.

So, in that sense what one can see the two broader theme one we will be talking about you call human friendly the two like companion. So, the other side I just talk about this in a broad way the industrial sell earlier it was a fixed for example, I talked about a car industry this take probably like 20 cars in a day then it would be automated.

Now, even that scenario changed now you take a properly you can say Volkswagen classic or you take a BMW and all you can do a customization. So, now, this customization giving then the work cell what you are having it need not to be fixed, the work cell supposed to be flexible. So, now, in that sense what one expecting from the robotic side. So, the work cell supposed to be a smart cell.

So, what that smart in the sense it should be intelligent. So, these are the two aspect what bringing that overall robotician into two broad category; one is actually like human friendly robot, the other one would be industrial oriented robot. So, this would be actually like you call smart autonomous industrial robot, the other side is human friendly which is what I call companion.

So, now coming back to the slide you can see this particular picture would be actually like giving a small idea what is all about companion. So, the other side you can actually like see

that this is what the smart industrial robot what I mean to say you can see that this work cell is actually like no longer fixed for example, the pallet.

You can see it handling or you can say something like manipulation all actual like happening with the help of you can say mobile manipulators or mobile robot in the sense of work cell is need not to be fixed.

So, now, with this two broad theme one can immediately brought into a question before going to the course. So, what would be the question, sir when and where to use the robot? This is one of the biggest question right. So, because robots are actually growing faster, but you should know when and where to use.

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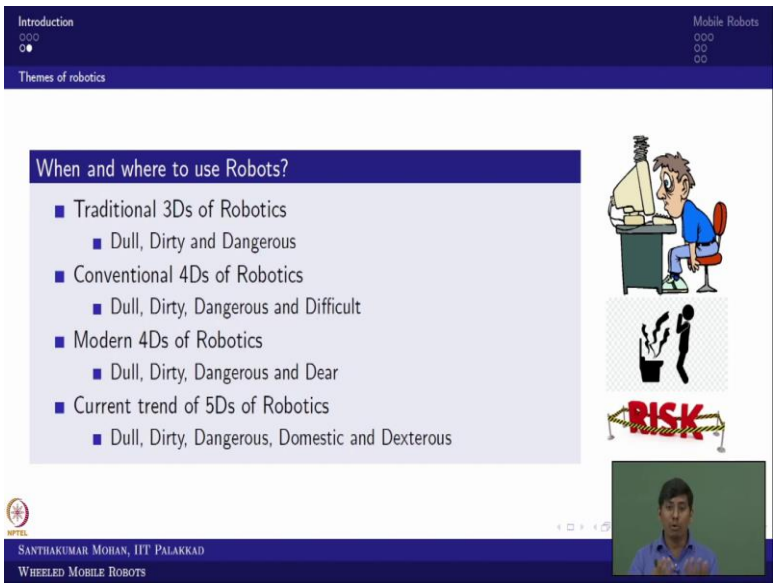

So, this is what we are addressing in this particular you can say slide. So, what that mean when the robot started evolving people brought some classes. So, what some classes? They asked there is some thumb rule we have to brought. So, that the robot can be employed in the industry.

So, what are the thumb rule they brought? They brought 3Ds. So, which is nothing, but we call traditional 3Ds. What that says? The environment is very dull or dirt or dangerous then we can employ the robots, it is actually like quite you can say convincing to everyone.

But what happened this is not convincing to the robot industry. What they say? No this dangerous dirty and dull you restrict our production may not be actually go up and as well as the industry also may not get that perspective. Then what they brought, they brought one

additional D what they call conventional 4Ds we brought the thumb rule added one more D which is nothing, but difficult.

So, what that mean? So, the difficult is actually like nothing, but the task can be obtained or can be achieved by the human operator, but it that is difficult. So, that we can employ the robot this is what the case. Still the industry people or you can say the developed countries were not convinced with this 4D, then they brought instead of difficult they brought one more D which is what we call dear.

So, what that mean? Dear means everyone immediately thought about it is close to us yes in one sense, but no in other sense. What no in the other sense, the industry is looking dear means whichever is giving economic benefit or profit benefit. So, if any system which is actually like making economic benefit that particular system called dear.

So, now, you can be cautious any industry or employer is calling you as a dear employee or dear person then you should be cautious. So, you are actually like profit oriented. So, you are actually like needed for making some profit that is what the whole idea.

So, then you can see that now the industrial robots are not the only which is actually like evolving lots of domestic and service robots have come in that sense of what this modern 4D is not restricted and if you are actual like applying to a domestic or you can say flexible layout these 4Ds are not sufficient, then what properly brought it the current trend.

So, they added one more D and they taken the dear out and they brought domestic which is in the sense you can apply into any you can say domestic application and other things other sense what we call the flexible, the flexible we brought into another D called dexterous. So, now, you can see that the right side as a core. So, what we call the 3 pictures what mentioned these are the 3 core Ds, but we added other Ds just for our benefit to brought the robot in these are the cases.

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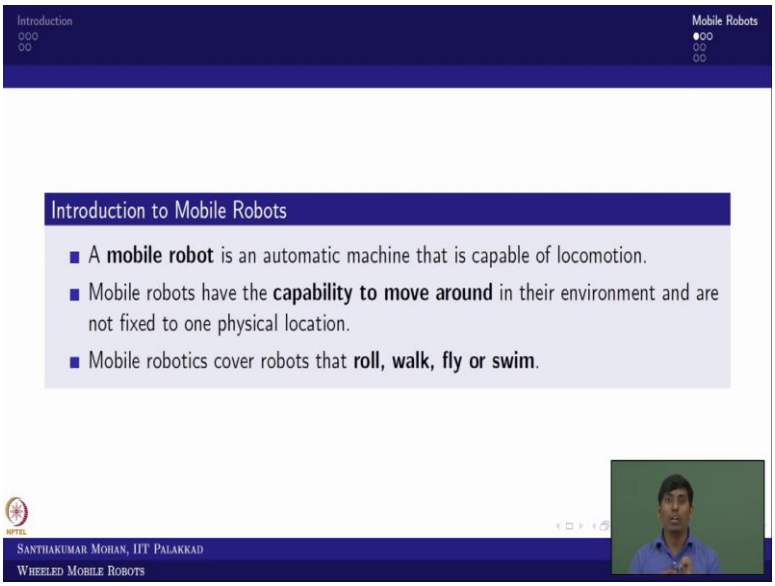

Now, you can get idea when and where to use robots right. So, now, we will move forward what we intend to teach in this particular course. So, this particular course is all about wheeled mobile robot. So, definitely you should know what is mobile robot. So, you know already locomotion. So, now, we brought into the way of locomotion the mobile robot is an automatic machine that is capable of you can say locomotion this is what the very simple one line definition.

So, further you can actually like add some other definition for example, you can say that the mobile robot means that have the capability to move around in their given environment that I have adding their given environment and are not fixed to any one physical location if anything is coming under this then what you call mobile robot.

So, then what then the robotics evolved because mobile robotics means it is a study of this particular science or you can say study of this particular area. So, then it covers all kind of mobile or mobility right.

The mobility can be like wheeled which is nothing, but roll or it can be a legged then that can be called as a walk or it can be fly or swim the swim can be underwater or on the surface of water. So, in that sense you can see that the mobile robotics very broad, I cannot actually like cover in only in 8 weeks. So, in the sense what we are restricting, we are restricting to the roll motion that is what we called wheeled ok.

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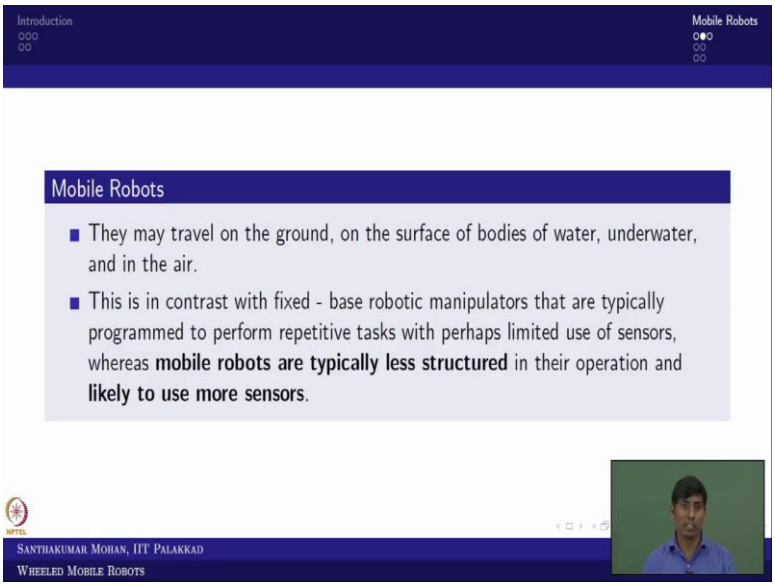

So, in that sense what one additional thing I am just recalling the same thing the mobile robots can actually travel on the ground on the surface of you can say bodies of water underwater or in the air or even you can say in the space. But right now what we are intend to hear talking about this is definitely a contrast between the fixed base manipulator how it is actually like different definitely you know already based on the definition further what the difference is the limit or you can say the use of sensor.

So, earlier the mobile manipulator what we discussed that is combination of these two, but what is the manipulator the manipulators is in the fixed. So, in the sense even a small encoder or the potentiometer of individual joint can give a accurate measurement, but in the case of mobile robot that is not possible.

So, you have to depend on several sensors in the sense of what one can see, you need to use more and more sensor and the system is actually like employed in you can say less structured in the sense unstructured or less structured environment. So, this is what the overall that is why we are focusing in this particular course more on this. So, in the sense we are going to talk about sensing perception navigation all in the overall go.

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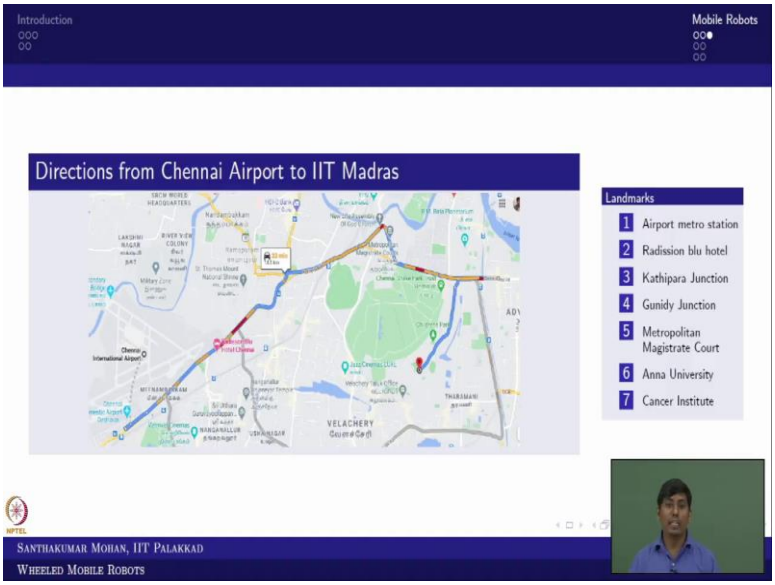

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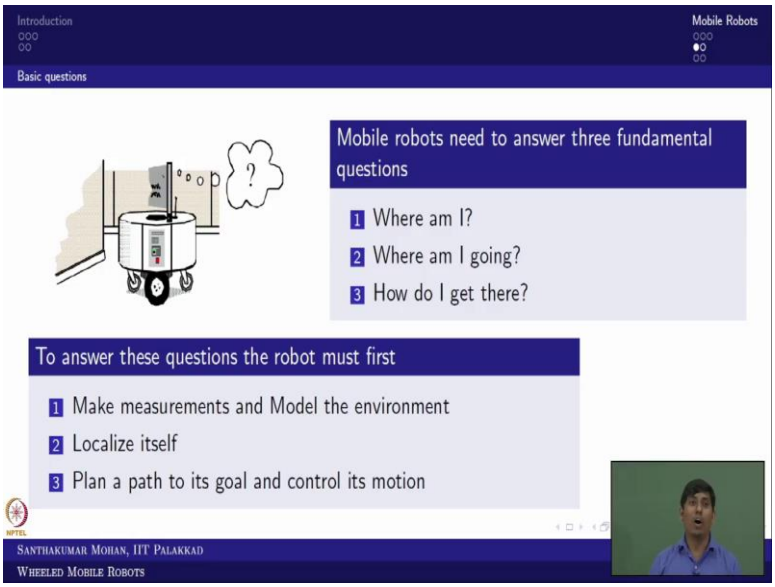

So, now, before actually like going to talk about this. So, I am just giving a mobile robot as a basic question. So, in order to understand this basic question, I am actually giving one simple example the previous slide is all about that. So, what that example? So, now, imagine I am actually like a Korean just imagine. So, I am a Korean I am actually like no only English for writing and reading I do not know how to speak.

But, somehow actually like one of the joined project with IIT Madras invited me to do some kind of you can say execution. So, for that the IIT Madras professors already said that. So, your guesthouse is booked and your travel arrangement all booked. So, you get down at the Chennai airport you would be seeing one placard call your name and you can actually like reach them

then they will take to the guesthouse. So, you do not worry; however, I am sharing the roadmap just for your understanding.

Then what I did, I just took this roadmap in a Google and then I am actually like checking on the you can say satellite image and I am seeing what are the nodes. So, the nodes actually giving several landmarks. So, I am actually seeing the landmarks you can say taking that landmarks on the road and I am taking into the Google picture and see what the landmark all about.

For example, if I take the metro station of the airport I see how look like and Kathipara you can say junction if I look how the bridge look like, all those things I am actually like visualized just for my own you can say benefit probably you imagine I am a conservative person I am trying to understand in that sense you can see there are several landmarks come. So, now the scenario is coming like this.

So, I took the flight I got down at Chennai airport safely I took my luggage and I am coming out of that you can say arrival gate. So, before looking that the driver some you can see 4 or 5 goondas actually like took me and put it in the car with a blindfold and they are actually taking out on the road fortunately in the same road what I supposed to do.

But later on they realize that I am not the person supposed to be taken out. So, they just throw on the middle of the road, when I actually like unfold. So, what I would see first I will localize right. So, now, I am actually like looking at the Kathipara junction where the flyover is looking like that.

So, then what I can immediately recognize this is a landmark which I have already recognized now I can see. So, if I go straight I can actually go to Gunidy and then I could take probably right turn and then I could go to cancer institute and then take the you can say immediate landmark which I suppose to go.

But what we are actually like seeing that the landmark is giving all the idea right. So, now, imagine the robot, robot is you can see right it is one of the mobile robot I put it. So, this robot does not know this right. So, what we need to give? So, we need to give all the information.

So, in the sense the robot will ask three basic questions, first basic question when you unfold what you are seeing is where I am right. So, that is what the first question with supposed to

know, the robot in the sense it is supposed to localize itself. So, it is supposed to localize and say I am here then that is fine.

Then I have to understand where am I am I going in the sense I need to see where what is the target of this particular robot. So, then I will see how to go there. So, in the sense the third question is how do I get there? So, now, in the sense you can see the process of these three questions.

So, you need to actually like do several thing. So, all the things I am putting as a three different answer one is definitely you have to make measurement, based on the making measurement what you can see, you can perceive the environment and as well as localize yourself right.

So, that is what we are actually like saying. So, you will model the environment localize yourself then you will actually like a plan, the execution path and then execute along with a motion right. So, these are the cases. So, now, you can actually get idea right. So, now, what in this particular slide is giving? So, whether am I actually like addressing these questions in my course or not, yes we are actually like addressing all the questions and on top of that we are addressing furthermore.

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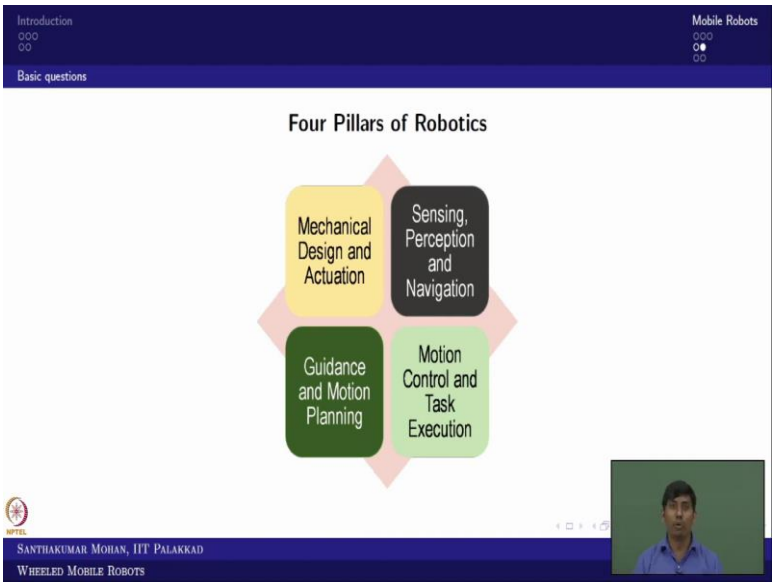

That is what we are actually like trying to see in the sense what one can see. So, the robots are actually like coming with the you can say mechanical system and as well as the you can see

electronic and computer based system. In the sense you have to see what are the pillars of the robots or what are the four, you can say founding or bounding and binding blocks.

So, in the sense what one can see I am just a giving a very simple example before going to this you imagine. So, you are actually like selected for a race car or you can say for a car race. So, now the race car has given. So, now, what that race car will give, the race car will give the mechanical system which you can take part into the race.

So, in that mechanical system you can see further things. So, there would be a driver line and you can see that there would be engine all those things like. So, now, you can see what that gives the mechanical aspect of the overall execution you got it.

Now further what you need to know since it is a race. So, you need to know like what would be the mission, what would be the roadmap. So, these all actually like what we are calling as a guidance. So, the overall mission would be given this is the layout you have to go this way and you have to stop here and you have to take something and go back on this lane. Just I am assuming this way.

So, now, what you can see you need to have some guidance where to go, how to go, further even in that guidance you need to have something like navigational aspect. What that mean? You have to perceive your environment for example, you have adjacent there is another car and you have actually like there is a block which is actually like unexpectedly put it on the road and there is a right sharp turn you need to understand all those things.

So, in the sense you have to sense perceive and as well as navigate accordingly. For example, you put in your navigational system you put a point to point location. What it will give? It will give the road right or the route, but that route is not sufficient. What you need additional, you need to have a guidance on top of that they are supposed to be one executor who is called the driver right.

So, in the sense what the four pillars on the robotics all about. So, the mechanical system along with the actuation that is one of the primary part which we simply call locomotion system this is what we are going to cover in the first a few weeks. So, later on we will be talking about the navigational which I am broadly localization and mapping.

So, these all will come into a second block this we would be covering fourth week onwards then we would be talking about motion planning and guidance and finally, we will be ending with motion control. So, now, you can see these are the four pillars right.

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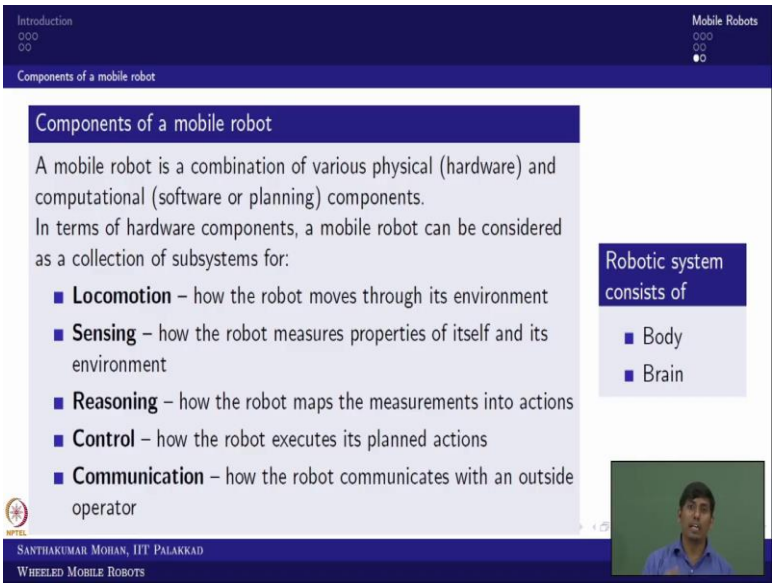

So, how these four pillars would be addressed. So, based on that you can actually see what are the components will come into a mobile robot. So; obviously, the mobile robot would be combination of both hardware and software, but here what we are interesting the components means the physical hardware.

So, what are the hardwares you will be expecting. So, definitely the locomotion system that is you supposed to know. So, in the sense how the robot moves through its environment that is what you call locomotion here.

So, then the sensing devices supposed to be there how the robot measure, the properties of itself or properties of the robot and the environment and then reasoning or perceiving system. So, based on the you call sensing the map will be generated and you would be actually like taking further action based on that. So, then what one can see. So, when the execution would come with a control.

So, how the robot execute it you can say planned actions. So, further what one can expect the communication right. So, the communication is actually like optional if it is autonomous system even then also you have to provide some kind of communication otherwise when you

launch when you take away these all required right in the sense what one can see the communication also like important in the sense of how the robot communicates with an outside operator.

But these are the you can say funding or you can say building blocks, but what we can actually like say that the robot system consists of two things one is the body, the other one is brain. So, now, we are focusing in the first few weeks about the body. So, later on we would be talking about the brain, in the brain we would be talking about navigation guidance and control ok.

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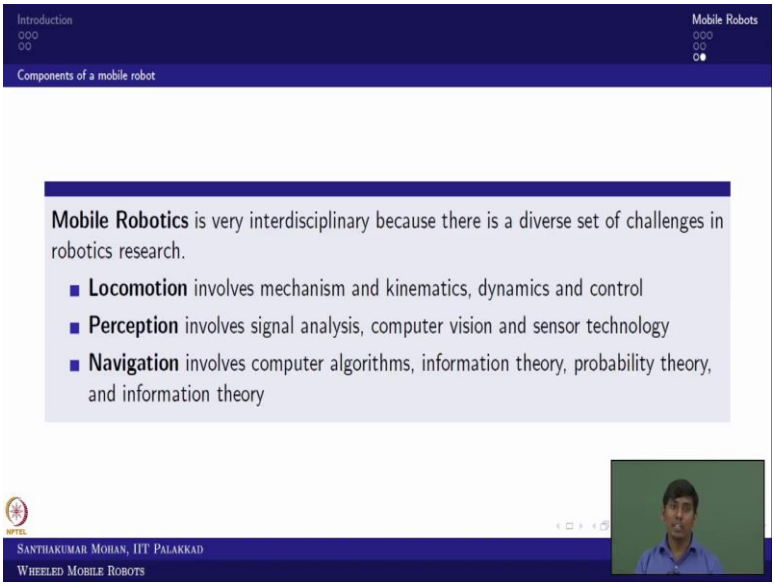

So, now, in that sense what mobile robotics in general what are the blocks would be covered in that particular course if you look at. So, one is actually the locomotion which is involved the mechanisms, kinematics, dynamics and motion control. The perception which we talk about sensing and you can say processing all those things signal processing.

And finally, you would be taking the navigation, since the guidance and control in robots we can actually squeeze it in the navigation that is why I put these three blocks. So, with that you can see this is the first lecture is ended. So, the next lecture what we are going to talk about is more about the locomotion. So, the types of locomotion in that we will be seeing what is wheeled locomotion and we would be focusing on the wheeled locomotion in the lecture 2.

I hope now you get a you can say clarity on what is mobile robot and how we are going further in the course. So, in the sense we would be talking first the locomotion then we would be

talking about the sensing and navigation finally, we would be talking about the motion control and intelligent aspects right. So, with that I am actually like closing see you in the next lecture.

Thank you bye.