Lecture 05: Experiment 02: Control of Tracked Mobile Manipulator

 I  welcome you all to second experiment of this NPTEL course on Experimental Robotics. The title of this experiment is Control of Tracked Mobile Manipulator.  Now, these are the concepts which I am going to discuss here.  I will give a brief introduction to the concept of tracked mobile manipulator.  That means, I am just going to define what do you mean by a tracked mobile manipulator and this is one combined robot, and why do you need this combined robot that I am going to discuss.  Then, I will concentrate on design and development of one tracked mobile manipulator.

 Now, this particular robot has been designed and developed based on some specifications. So, I am just going to concentrate on the specifications decided for this robot.  We are going to carry out some real experiment with the help of this tracked mobile manipulator.  So, the aims and objectives of this experiment will be discussed in detail.

 Then, the real experiments we are going to carry out and these experiments will consist of a few tasks.  So, all such tasks will be carried out one after another.  After that, some inferences will be drawn based on the experiments, which we are going to carry out here. Some precautions are to be taken while carrying out these experiments.  Those precautions will be discussed in details and references will be given.

 Now, introduction to the tracked mobile manipulator.  So, this tracked mobile manipulator is a combined robot.  That means, we are going to put one serial manipulator, which is a robot with fixed base, on one moving vehicle that is nothing but a tracked vehicle.  Now, let us try to understand the reason behind going for this type of combined robotic  system. Now, the serial manipulator is actually a mechanical hand that is nothing, but a human hand copied in an artificial way, in a mechanical way, in the form of a particular robot.

 Now, let me try to take one example.  Now, supposing that my hand consists of a few links and two links are joined by a joint.  Say, we have got one joint here, another joint here, another joint here and we have got the  end-effector or the fingers.  We have got at each of the fingers, we have got a few joints.  Now, if I just take one task that what is the volume of space that the tip of my end-effector, that is the finger.

 So, it can follow, it can cover say.  Now, let me take the example.  So, I can put my hand like this, I can put my hand like this, I can also put my hand  like this, I can also put my hand like this.  Now, whenever I am moving my hand like this or I am moving my hand like this, if I concentrate  on the tip of this particular manipulator that is the finger, this particular finger is going to move within a volume of space.  So, that particular volume of space is known as the workspace.

 So, we can find out the workspace of this particular manipulator.  So, by definition, workspace is the volume of space of the end-effector which can be  reached with different

configuration of each of the joint angles that is what we mean by the workspace of a manipulator. And here, this particular manipulator is put at the top of one tracked vehicle and we know that a tracked vehicle is a mobile robot which we generally prefer when the terrain is neither very smooth or not very rough and if it is in between. So, if the terrain is neither smooth nor very rough, we generally go for a tracked vehicle. So, the tracked vehicle can move on that type of surface.

Now, this particular tracked vehicle has got some mobility. So, the tracked vehicle is having mobility and the serial manipulator is having workspace. Now, what I need is to solve some real-world problem, I need both mobility as well as workspace. And if you want to get both the mobility as well as this large workspace, there is no way out, but you will have to go for this type of combined robotic system, that is the tracked mobile manipulator. That is why, see, we generally try to design and develop the tracked mobile manipulator, so that we can get both mobility and workspace and in one word, we can get one extended workspace.

So, this tracked mobile manipulator has got a few applications, real-world applications. For example, say in mining and exploration, we can use the tracked mobile manipulator. Then comes your for defense and security purposes, we can take the help of this type of tracked mobile manipulator. For remote inspection, we can also use this type of tracked mobile manipulator and for agriculture purposes, we can also use the tracked mobile manipulator. Now, there are some other applications also.

Now, here in this particular experiment, we are going to concentrate on how to use this tracked mobile manipulator in agriculture. Now, before I discuss that how to use it, let me take one very simple example. Now, let me try to see the way one farmer solves his problem. So, generally in the morning, the farmer goes to the field for the purpose of inspection. So, the farmer is going to use his own eyes, own camera just to collect information of the field, carries out some analysis in his head, take some decision.

Now, let me consider a few decisions taken by the farmer. For example, while inspecting the field, the farmer will take a few decisions like whether watering has to be done on the plant or not, whether the plant leaves are suffering from any disease or not and if it is suffering from a disease, appropriate pesticide is to be spread and these pesticides are not very suitable for health, human health. So, there is these are health hazard pesticides. Then comes your, whether the quality of the fruits or the vegetables has reached that maturity level or not and if it reaches the maturity level, then how to pick these particular fruits and when to pick and so on. So, these are some of the decisions taken by the farmer and then, he uses his workers or the subordinates to carry out all such tasks one after another.

Now, here this particular farmer, the task of a farmer will be replaced by a robot and that particular robot is nothing, but a tracked mobile manipulator where a serial manipulator will be mounted on a tracked vehicle. Now, here, I am just going to discuss how to carry out

this particular task.  Let me concentrate on the task like your disease detection and spraying of appropriate  pesticides.  So, as I told the farmer collects information of the plant with the help of his eyes that  is camera.  So, this particular robot similarly is going to collect information of the plant and plant  leaves with the help of the camera mounted on it.

So, with the help of the camera, it will collect information of the plant leaves and that particular  information that is the picture will be sent to the computer for the purpose of analysis  just to identify whether the plant leaves are suffering from any disease.  If it suffers from a particular disease, then what type of disease and once it is decided  that the plant leaves are suffering from a particular disease.  So, the most appropriate pesticide will be selected and that will be sprayed automatically  by this particular robot to the plant leaves. So, this is one task.  So, these experiments, we are going to show you.

Now, there could be some other applications also, as I told.  For example, say while taking the picture with the help of a camera, this robot can  take also the picture of the soils and depending on the quality of the soil, whether it is a  dry soil or a soft soil, the robot is going to take the decision whether watering has  to be done or not.  Then comes your the quality of the fruits whether it has reached the maturity levels  or not.  If it reaches the maturity level, then there must be some arrangement for picking the fruits.  So, with a little bit of modification, the same robot, the same tracked mobile manipulator  will be able to do the fruit speaking also.

So, by doing all such tasks, the robot is going to help the farmer to enhance productivity,  to increase the efficiency and sustainability in agricultural operations.  So, by doing that, the farmer is going to gain a lot in terms of the productivity and  most importantly, the farmer will be able to protect himself or his workers from the  health hazards due to the pesticides. Now, this particular robot will see how it does the operations like disease detection  with the help of vision analysis and how it can select the most appropriate pesticide  and do the spraying automatically.  So, with this technology provides automation and intelligence to support the farmers and consequently, the productivity is going to increase.  So, with this little bit of introduction to the tracked mobile manipulator and its possible  application.

So, now, I am just going to concentrate on the various components of this particular  the tracked mobile manipulator.  Now, here you can see say we have got a tracked vehicle, you can see that we have got the  driver wheel here and this is the driven wheel and over these two wheels, we have got this  particular the belt sort of thing and this is going to constitute the tracked part that  is the tracked vehicle part.  So, I can show you this part other side is on the other side.  So, this is the way we try to design and develop.  So, this particular the tracked vehicle and the vehicle is going to move in this particular  direction say and as I told this vehicle will be able to tackle the little bit of ups  and downs and disturbances on this particular the field.

So, this tracked vehicle will be able to negotiate the rough terrain, which is generally

available in the agricultural field and a serial manipulator. So, this is actually the serial manipulator you can see. So, this is the base of the serial manipulator, this is the end-effector of the serial manipulator and this serial manipulator is having 5 degrees of freedom. So, we are going to use here one 5 degrees of freedom serial manipulator. So, look wise actually this is nothing, but a mechanical hand and here there are 5 joints all 5 joints are the rotary joints.

We are going to discuss we have got 2 types of rotary joints here the revolute joint and the twisting joint that I will be discussing after sometime or let us spend some time on this. Now, we have already discussed that in robots, we generally use 2 types of joints. So, the robotic joints could be of 2 types: the linear joint and there could be the rotary joint. So, this linear joint as I discussed there could be of 2 types. So, the linear joint could be of the prismatic joint.

Now, this prismatic joint and we can have the sliding joint. The difference between the prismatic joint and sliding joint I have already discussed. The prismatic joint will have either square or the rectangular cross section for the sliding member. On the other hand, for the sliding joint, the sliding member will have circular cross section. Now, the rotary joint we have got 2 types as I have already discussed, we have got the revolute joint and we have got the twisting joint.

And revolute joint is that particular rotary joint where the axis of the output link will make 90 degrees with your axis of rotation. And if the axis of rotation coincides with the axis of the output link that type of rotary joint is known as the twisting joint. Now, here you will see that we have got a few twisting joint and a few revolute joint which I am going to discuss after sometime. And at the tip of the manipulator, we are going to put one camera. So, the vision system or the camera will be put here and we have got the gripper for this particular manipulator.

So, this gripper can be closed and open. So, there will be linear movement between these two fingers or the jaws of the gripper. Then comes your this particular robot has got a battery pack. So, this is the battery pack inside which we have got the necessary battery which is going to provide the required energy, so that we can move it. Then there must be a spraying nozzle or the spraying system.

You can see that we have got these white tanks. There are 3 white tanks. So, these white tanks are going to carry 3 different pesticides. So, depending on the disease, the type of the disease, a particular pesticide will be selected for the spraying purpose. And we have got the spraying system and you can see that we have got this connection and here we have got the nozzle.

So, with the help of this particular nozzle, we can actually spray this particular pesticide to the plant leaves. Then, comes your we have got some wireless control. Now this particular

equipment, this is nothing but the remote controller for this robot and this remote controller, its different knobs, switches I will be discussing in details. Now, with the help of this your the Zigbee wireless module, so this particular module, so the remote controller will be connected to this particular the robot, ok. So, with the help of this remote controller, we can control the movement of this whole robot that tracked mobile manipulator will be controlled with the help of this your the remote controller that is denoted by number 9.

Then there could be another wireless communication, so that the image collected with the help of this particular camera that has to be wirelessly transported to one computer, where we are going to carry out the analysis. So, there we take the help of this particular the serial number 10, this is this particular thing that is wireless outdoor CPE, customer premises equipment. So, with the help of this, we can, in fact, collect the information of this collected image wirelessly to the computer. In computer, we carry out analysis, image analysis, we do classification, we take the decision, where the plant leaves are suffering from disease A, B and C and that particular information is passed to the spraying system and so that automatically the spraying system can spray the most appropriate pesticide to the plant leaves. So, these are the various components of this particular the combined robot that is your tracked mobile manipulator.

Now, let us try to concentrate on the specification of this particular the robot. Now, here once again from this schematic view, so you can see that this tracked mobile manipulator. So, this is the tracked vehicle part, this is the battery pack and here you can see the joints the different joints of the serial manipulator. So, the first joint which I am going to use here is nothing, but a twisting joint. So, the first joint is the twisting joint, then there will be a revolute joint, then comes another revolute joint here, then here there will be another twisting joint here and there will be a revolute joint here.

So, there will be another revolute joint here that is your J5 and we have got a linear joint at the end. So, this is actually not a joint, but we can generate this particular the linear movement say. Now, so here we have got J1 is the twisting joint whose range is your 300 degrees. So, it can be rotated 0 to 300 degrees, then comes your J2. So, this particular revolute joint the range is 0 to 65 degrees, then J3 another revolute joint the range is 0 to 65, then comes your J4 is a twisting joint and the range is your 0 to 180 and then comes your J5 is a revolute joint and it has got in fact, the range is 0 to 180 and here we can have the linear movement between the two jaws or the fingers.

Now, the voltage is 22.5 volt to 25.2 volt and its capacity is 30000 milliampere hour and the vehicle speed the linear speed that is your 0.2 meter per second. Now, this serial manipulator has got the payload capacity of about say 1.5 to 2 kg and the load carrying capacity of this particular the tracked vehicle is around 50 kg and the total weight of the serial manipulator it could be around 10 to 12 kg and we have got these wireless modules and others.

So, these are some of the specifications. Now, using this specification, we are going to show a few configurations. For example, say when the arm is extended that means, it is going to show the maximum reach of the tip of the manipulator. So, this shows actually the maximum reach of the tip of the manipulator and whenever it is squeezed. So, when the arm is retracted, this is showing the minimum expansion or the movement of this particular tracked mobile manipulator and as this tracked mobile manipulator is going to work on the real agricultural field.

So, there must be some ground clearance. So, this shows actually the ground clearance we are keeping in this particular the design. So, this shows actually some of the configurations of this tracked mobile manipulator. Now, this particular the schematic view shows the remote controller, the different components, the buttons of the remote controller. Now, there will be power switch for the remote controller. So, you can see that this power and the lights will be on off, power arm and disarm this is actually the indication, this is the power indication and this vehicle will be able to move in the forward direction, backward direction with the help of this particular push buttons.

Similarly, there will be another push button here. So, I can control the movement towards the left or towards the right and the arms configuration will be controlled with the help of a few other push buttons. Now, with the help of this particular push button, I can move joint 1 either clockwise or anticlockwise. You can see that clockwise movement of joint 1, anticlockwise movement of joint 1. Similarly, the joint 2 it is a revolute joint, I can move in the upward or the downward direction. Then comes with the help of this particular the button, we can move joint 3 either in the upward direction or downward direction.

The joint 4, joint 4 is actually one twisting joint. So, we can move clockwise or anticlockwise. Then comes your joint 5 like up or down, we can move and this is once again a revolute joint and the gripper open and close. So, we can control the movement of the gripper. The gripper will be either in open condition or close condition with the help of this particular the button. And we have got three tanks for the pesticide and those tanks could be controlled like the spraying system for the tank 1, tank 2 and tank 3, we can control from here.

And so, these are actually the push button and of course, we have got this LCD screen, where we can see the movement which is in action. So, this is the way actually we can use this particular control panel, the remote controller just to control the different movements of this particular the robot. Now, these aims and objectives as I told that in this particular experiment, we are going to show a few tasks. The first task is actually related to the navigation of tracked mobile manipulator on the rough terrain and control of manipulator joint. So, here actually what we are planning to do, we are going to control.

So, this particular tracked mobile manipulator in the forward direction, in the backward direction, this particular robot will be able to take the left turn or the right turn depending

on the requirement, it will be able to negotiate a little bit of roughness if it is there on the field, ok. And this is how to control that particular the tracked mobile manipulator. But now, I am just going to tell you in this particular experiment, we are also going to show you how to move or how to generate the movement at the different joints of the manipulator. That means, your the tracked mobile manipulator will have some desired movement and this particular manipulator joints will have desired movement and consequently this particular robot will be able to perform some specific task. Now, this particular task based on which we are going to show you the experiment is the disease detection and the spraying of pesticides.

So, the second aim is your image analysis of the disease plant leaves and their classification. So, one camera will be mounted at the end effector and with the help of camera, we are going to collect information of the leaves that means, your the picture the images and that particular collected picture or the images will be passed to the computer wirelessly for the purpose of analysis. So, in the CPU or the computer, the necessary analysis will be carried out and classifications will be done and if it is suffering from any disease. So, whether it is suffering from disease A or B or C that type of classification will be done and based on this particular decision taken. So, if it is suffering from disease any one of the three pesticide strand will have to put it on and if it is not suffering from any such disease.

So, there will be no such action of spray painting or your spraying of pesticide. The third objective is your disease based pesticide selection and spraying. As I told there are three tanks carrying three different pesticides and depending on the requirement. So, decision will be taken whether pesticide A or B or C will be sprayed and accordingly the spraying system is going to spray either pesticide A or B or C. So, these are the aims and objectives of this particular experiment that is experiment number 2 of this course.

So, whatever I discuss I am just going to put it here that these are the real experiments which we are going to do and here you will see that three tasks we are going to perform. So, the task 1 the navigation of the track mobile manipulator in the forward backward direction and its turning motion that is the first task which we are going to show you through real experiments. Then task 2 the control of different joints of serial manipulator. So, with the help of this remote controller we will try to control the different joints of the serial manipulator depending on the requirement. Then task 3 is your disease detection of the plant leaves through camera captured images and we will carry out analysis and classification.

So, that we are going to take the decision which one out of the three pesticides is to be sprayed. I am sorry, there are four tasks here. So, task 4 is actually the spraying of the appropriate pesticides. So, these are the four tasks which we are going to perform with the help of this particular tracked mobile manipulator.

Let me repeat once again.  Task 1 is the navigation of the tracked vehicle in the forward backward directions and there  could be turning motion also.  Task 2 is control of the different joints of the serial manipulator.  Task 3 is your information collection with the help of camera, then image analysis, then  your through classification we are going to find out whether it is going to suffer from  say disease A, B or C. Accordingly, the pesticides will be selected and the spraying of the pesticide  is the fourth task.  So, all such four tasks we are going to show through the real experiments and to carry  out the real experiments, these are the steps to be followed.

We can, we are going to show you that we will have to put the tracked vehicle in on condition,  the control unit is to be put in on condition and we will have to control the direction  of movement of the vehicle as I told forward backward or turning, then we will have to  control the serial manipulators joint angles, there are five joints.  So, those angles are to be, in fact, controlled.  We will have to capture the images of the plant leaves, carry out analysis image analysis,  we will have to identify the disease, the plant leaves' disease through classification,  then we will have to activate the spraying tank to do the spraying of the pesticide.  So, all such your steps we will have to follow while carrying out so, this particular the  experiments.  Thank you. .