ROBOTICS

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Lecture No-4

Industrial Manipulators and its kinematics (Time start 1:15)

we talking on industrial Manipulators and kinematics of industrial manipulated this (Refer Slide Time 09:38)
today lecturer will be industrial manipulator and manipulators kinematics okay kinematics topics of lecturer will be we seen in industrial manipulators and i have shown you several clips in several photos of industrial manipulators and now we some geometry concept some other concept likewise space and all today

what will be look at now this manipulators essentially what will we call as serial change serial kinematics change okay there area also parallel change but a majority of manipulators industrial manipulator are serial change

so we are looking at serial change there compose the links and joints this manipulators compose the links and joints all arrange in series one likes connect to another links through the joints

you should accommodation in the relation motion between in the tool links is ok essentially the two type of joints the revalues which i am showing you i am draining here and the revalue this is the revalue pair okay

now this is nothing but a links the body if links internal access of a links what ever call it you can rotate is not possible to translate the up and down than how the structuring revaluate pair we called the revaluate revaluate joints and this symbols is R we have additionally Prismatic joints

you are all familiar with prismatic joints you have a table and you have to draw usually draw the to the table at a prismatic joints is am sitting one prismatic joints here so square rod a square hole body is prismatic notices only go up and down it can not rotate the in a rod with the respect to the body because the square is the go in to the square

now the engineer of this when you really built them there are several variation you know seem thus pistil and cylinder which is sincerely of prismatic joints though the both the you know object of the circular the internal the prismatic joints because rotation is not allowed there is the example of the prismatic joints here equal to here i have put a spring there in order to let it come back but it can not rotate

okay there are familiar with this now the reason why these the joints are use so other there are several others joint accommodate relative motion
the like cylindrical joints spherical joints the ball and jacket now the whole problem is those can power a revalue joints can be powered by a motor you can rotate the internal

task and the prismatic joint powered by a cylinder and what you called pistil so the symbol for the prismatic joints is capital B the symbol for the prismatic joints these are the symbol for you the standard R and P so

if you look at the industrial manipulators it is compose the plink which is the drawing joints together throw either nor are P i say one planar are manipulator i will start planar are one there is planar are manipulators and which a finger here with a end effectors

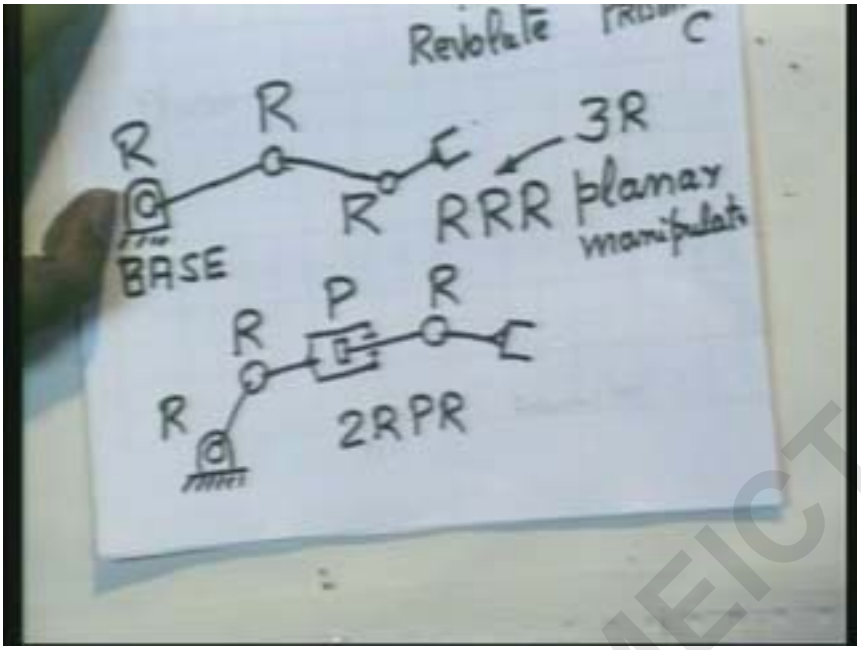
i have go to the revalue joints so this link rotate the respect with the base the base okay here is the revaluation joint this links and rotate with rotate wit h respect base because the revalue joints okay than where is the another revalue joint here the second revalue joint here the third revalue joint here okay and than the finger the end effectors the law polite

now we called RRR manipulators because we designation manipulators structure by the number of way type and type of joints so its R R R planer manipulators as you that word planar manipulators some time some people shorten this three R three R planar manipulators okay is it okay

now some time we should you say prismatic joint i say a planar manipulator here is the base link again one more links is connect and i got a pistil and cylinder here pistil pistil rod and than revolute pair and end effectors here okay

now notices i will give the notation here it to be R R this is P this R notices of the end effectors is not counted at all so what do this wheel there are two R followed by P you go from the base to the end effectors that how do write a notation not other way from the base end effectors this is the two R P P R manipulators planar are again two RPR these are there okay

the plane some body would most of you would recognized here re three degrees of freedom you see because of three revaluate pair right where he has four degrees of freedom because three revaluate pair one prismatic pair so that means here i have redundant degrees of freedom the planar three degrees of freedom are sufficient but extra degrees of freedom some flexible



okay i can use that i will say an example of one of the extra degree of freedom here is an object which several degreed of freedom i can notices (refer the slide time:09:46)

there is a manipulators which several degrees of look at the plane one R here okay this is one R than I whole ways than i has the second R than I whole this I have the third R i whole this fourth R four R these can be use if you want go inside as a tube like as fingering you know

you go inside a tube you can gal around of on object suppose i want gripper this object this fellow gal around the on object if we have more degrees of object like a snake it gal around some time manipulators are built intensely with more than with request of degrees of freedom in order to control in another source

okay here is one now what we call as the redundant okay more than what is decided in order to allow to you go throw top corner to get it now you have seen what a knows as the planar as industrial manipulators we have revalues prismatic phrase there re compose are these attached likes the form of the serial change let go to the next one this spatial one (refer the slide time: 21:07)

the spatial manipulators now notice one things spatial are manipulators as i have shown you here is one example of the planar are manipulators look at the axis there are parallel the least will pay play will switch are parallel to each other the axis are parallel the revaluate axis ever thing moves in a planar okay

so that is what is in a planar but than you go to spatial the axis are no longer are parallel there are perpendicular and parallel you can see here here is a example of spatial list one rotation like this the axis is perpendicular to the ground right the second notation is like this the axis of rotation is horizontal

so the first axis the second axis are perpendicular is each other the third axis is also in the same place because one of the plane but than you know ones in rotate it goes out of planar it will remind in this place and than you have if I omit first rotation

i will get a planar one so if omit this rotation rotation around this i remove this it is a planar is it one axis these are moves in and out prismatic and end effectors like okay right there move in parallel plane and In a spatial one I have the spatial robotic here for

i things i kept this much more clear are here you can see this one axis an second axis and third axis planar now i make it spacer i rotate it around the vertical axis vertical to play here as the plane okay so one axis second third this is spatial man the axis will revolute axis are perpendicular you to each other like vise i could this kais also rotating

i can have it see here these three links one two three move in a plane and whole things rotate around this is spatial manipulators i could have one axis here which is also rotating who is also perpendicular these parallel axis that also

i just shown you one two example of common likewise in a finger you see actually those all these moving all these you know digits we called them moving in a plane there also possibility of rotating this finger here you can see here this also spatial in the planar

i restricted operating in a plane by some means lacking this joints than more degrees of freedom joints but essential as it constructed it can also obscure you might asking how are you going to driving all the joint powered

i told you in case of finger mostly use in the cable and rob we have the series of table running throw and connect them small pulley you can drive this pulley okay i shown use of picture that is as for as the kinematics as let as look at chase i have got a spatial robotics

now there is the end effectors here okay and this one way axis we can see for as this is one axis there is another axis here these two axis as you ca see parallel as coming from end effectors as long s end effectors also pivoted to this the one axis rotation one rotation like this one rotation around this axis one rotation is around this axis there are three okay rotation like this followed by a rotation around this axis followed by a rotation around this axis than there is the fourth axis here than show you

you can sketch simultaneity here is the fourth axis so the axis is like this and again this arms rotation the manipulator then one more axis here that is rotation of this with respect this so this in R this another R this is third R fourth R so you have what is the five R spatial manipulation these are the designative five R five revolute pair okay

you could similarly have the base rotation of this around this axis i have on more here i am drawing one more is a prismatic joint than rotation around this axis is prismatic joints here let me complete the picture

you will get the real idea than the end effectors okay here is the end effect this can rotate around one axis here there is this prismatic joint which is giving one more axis than there is the rotation here of the whole things around there is one more so i had here R and R P and than R shown there is on more R is here so

i have if star from the base i have R R two R forwarded by P than again two R R two R P two R rotation around the vertical axis rotation around this axis this prismatic axis than rotation around one little axis here than rotation axis two R P two R manipulators use the five R manipulators and this is two R P two r

now i have shown only five degrees of freedom manipulators there will extra degrees of freedom one more rest joint using degree six degrees convention of drawing as show in the five degree of freedom because in space required unless holding on symmetric object

when you can omit particular rotation you need five degrees okay these are the kinematics change which are the use that serial change as a i told earlier you now notice how access perpendicular and parallel to each other the base here for example rotation is vertical and the other access are all horizontal so this

if i call this base rotation first axis the second axis is perpendicular to the first axis the third axis here is parallel to the second axis okay the fourth axis is also parallel to second and third axis there on the for the fifth axis again perpendicular to you know you have a series of axis

which are either parallel are perpendicular they should be at any angle you know is not necessary they should be perpendicular and parallel they should at any angle but consequent kinematics equation
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become complex that is why also you know some over other engineer prepare angle which a close to zero are ninety degrees and the kinematics in order to required to control this the become equation complex as you have the squat axis thinned axis

we called them squat mains axis with the not either parallel are perpendicular to each other than you have start problem in solving equation at all that one of the reason why but not exact reason because first built robotic seen that ever thing to move in plane with are parallel and perpendicular each other so that

how the went above is it these are the basic concept of the linkage which are use in now note note that I have take that drive linkage which transfer the motion i am one talking of he change which are you to construct is industrial manipulators

now let as go little cad and see what happens when you have there are many things one can observe with regard to things once you have the kinematics chains form each chains as advantage thrown advantage in disadvantage in will brief show you

we know the manipulator task is position and object and orientation way you like okay now several question arise for a give position how many orientation are there you want to position an object an you want to low (refer the slide time:32:27)

if want to position supposing i tell you ok here is an object pick it up this is the manipulators manipulator here now it case come to pick it up now which is more convenient pick up s it this way as i have in shown let as say let me take planar

manipulator now in order to pick this object the manipulators is sitting her the object is here there are various way pitting it up okay

now i could position object this way ask in pick it up some thing tell to that if the finger are going to close like this it may be better to pick the object the gripper oriented in the space but than and okay you i gri that is convenient the pick the object up gripper orientated yes what we decided all right fine

let i say the position manipulator like than this gripper should come and should touch it than what you decide right in the top floor the location of the this object to define by some reason where the machine so the manipulator finger must able to orient themselves any way in life that capability

we will have look at give a manipulators what are the orientation capability of manipulator let as see I will start us simple planar manipulator here is a planar are manipulator i am taking all revalue here is a private the base of the manipulator at A A B is one link B C is the other link and gripper is the okay the gripper is a it a what have drawn agree

so now let as go ahead as i will call C i will call the point you can see that i have orientation the gripper in particular fashion in order to able to whole this may be this object okay

some body terms this object like this so is that the same position that is gripper should able to whole the am i right how to you determine what are the this particular position given a position position given position is given how many orientations are there possible can anybody things affect how many orientation are possible at this way infinite what

some body say how to you determine that for that what i do it now you can see here for a given position am in the position is there remember that you want to orient to this way are you like orient this way this position let see what is happened so the position is fix some where here and you have like to you put a mark here okay you like orient in different ways okay if the big task i will take this position here now

i have this point i will like put pen to show that points okay now like to orientation way i could orientation this way i could orientation of this way how do you determine little bit of thought mechanical engineer should able to give the answer to this very simple kinematics

what do you to is put and imaginary revaluate pair here at the gripper the one more revaluate pair her now one revalue second revalue third revalue one more imaginary revalue what as it form it form four bar linkage you put a imaginary revalue pair he is the i am sorry you should not position

i will call it put an imaginary revaluate pair here now this forms is the four bar linkage now you are familiar with The those of mechanical engineer familiar with what is knows as the grashoff ‘s criteria the four bar linkage essentially quadrilateral okay i it is found

in most area of machine we an look up grahoff's criteria L pulse S and P pulse Q these are to two quantity which are i will live it to you find out what those are you know pourboire the essential quadrilateral there are four links one two three and four A B B C p and p A these are the four sides quadrilateral it obey law than you know what is the range we can find out

whether you can rotate pulley are accelerate output which links in accelerate and all determine and using trigonometry determine of ration of rotation also they use see our conventional close chains are useful here also to determine what are the all possible orientation

this is easier set and down in term in the case of this is easier down in the case of the planar but in case of spatial robotics slightly more complex because apart from moving one plane these links these also rotate so you know the rest also three joints

we have several orientation people are still trying figure out when you go to the manufacturers you have the work stations are you know on the place where you like to the robot work may be an automobile assemble and what aver you have the feel of the orientation required than you will ask the manufacture

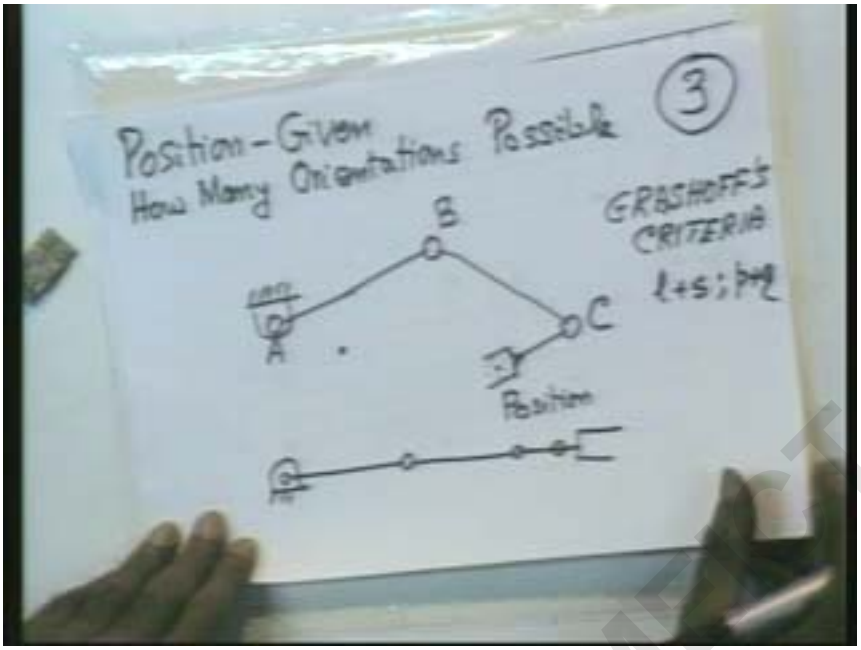
you have video robotics we will all the orientations at a particular position like this that the question you are going to ask how can you tell you what are all the possible orientations set of specific position (noise) now a notices if am i this position there are sudden number of the orientation

i can get if i move closer to this position suppose i come here a new position brought in here some where here than you suddenly a realize the number of orientation to get the different from what you have a the range of orientation not exactly number but the range of orientations you get will differ from position to position when a manipulator pulley stretch how many orientations are possible okay only one orientations is possible that is

why are one more joints i increase number go obscures at the pulley state position is still remind this at the pulley stretch position remind the same but i increase the possible orientations if i increase the number of joints go behind the three degrees of the freedom in a plane unfortunately that also call for okay

so the orientations what we have seen has the number of orientations which are possible in case in case of planar robot manipulators can be found by using well known criteria available in standard the range of orientations orientations is defends on the position of the object as you know object is closer to base

you get sudden amount of range are for away from the base some other ways i think goes to the edge of the work space you have only one orientations sprat only that is increasing the orientation with work space is to add some more degrees of freedom but than it all defense for control problem increase when you do that okay we have seen this



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now i would advice to look at the theory of seen look at the book and see the grashoff's criteria and such things really request do to have a good look at now we have seen that with in the work space there are several zone

where you know you get higher range of orientations several zone where you get a no a arrange it let as look at some more things what is work space of the X Y Z are cartesian main bodies we know that it is a queue
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some things like this the cartesian main bodies you give be cubical work space we are going to look at work space see i will taking of several small concept you know we are look at orientations now we are looking at workspaces now we saw that orientations differ from point to point in the workspace

we said we will have look at workspaces the Cartesian main bodies has a cube are short of the cube like object as the was space now if you had a rust is the workspaces going to increases if you add rust the workspace in going to the articulators arms as different type of workspaces am drawing in articulators arms here if you take main body okay

there is a axis here revaluate axis here another R here this is up to this main bodies up to this point because one R second R sorry up to this point the main bodies this is it end of that main body okay i have add one axis rest let me go up to this point before i look at rest there is i will find that the work space outer limit is some things circle it is and if i bold link this here this point come here i will call this A i will call this B i will call this C one if come here c two than i bold this and than obscures pick up here than i have another circle here

this is the workspaces of this planar whole for the main body unknown now whole of this rotate around rotate around this vertical axis so you get a complete workspaces as show you workspace one of the picture

i will be whole things is rotate if i add the rust the workspace is obviously explain beyond this one okay now with in this workspace because of the present of the rust i have a dexterous arms

you know there are two workspace one is the dexterous workspace and actual workspaces okay dexterous workspace is which you can vist rust orientations also now just like planar case defending an where you are in this workspaces in just arty to the available to the rust ability to oriental itself in more than one for a given position in range of angle differs as you go from point to point in this workspace okay

now the inerter of workspace this is the outer for the main bodies outer edge of the workspaces this is the inner edge when you you add the rest is will differ this will change remember that i am not add the rest

I just these will change determination of workspaces is very important thing because when you purchase a robotics like you know there were two worker kumar and Waldron look at this paper you have the kumar Waldron they gave the they came out the processor to determine the workspaces essential those mathematical model built in kinematics this idea is very simple

you know if tie thing end of the rust and pull the string in all three sixty directions in a planar as well as the over the spear all point on a spear to pull the string to that radialy out from the center okay you has pulling string in various direction the tie is things to the end effectors keep pulling the string in various directions

so this way that way and all the end effectors will go to some point behind which pull the string that is the edge of the one that what the they wrote the mathematically equation based on this particular concept okay those who are interested go throw kumar and Waldron paper because that is one give to how to now the workspace may not be complete circle unless

if you permit this joint rotate to three sixty degrees than the workspaces will obviously this the enclose by the complete circle but you know in reality robotics joints will not go beyond sudden angle may be two seventy degrees may be two eighty degrees may be as two ninety degrees

so the workspace will be some things will be turn some you know truncated from what you get circle there all the cut of now notices one things if this link length A B i call it L one and this main bodies i call it L two eleven equal to L two this point can touch the base of the right if L one equal to L two when i pool this this point c come in to coefficient

you get a huge workspaces compare this workspace of the primitives cartesian robotics the Cartesian robotics will mostly and out side this workspaces robotics some things here pillar if will be one the robot occupy more spaces for the give workspaces where are this fellow will be inside

if I take this equal equal visualize because i will complete rotation the whole workspaces is all over the robotics all around the robotics completely three sixty degrees rotate if i permit at each of the joints entire workspaces is around the robotics they just the small pillar and this rod so

if you look at the point view optimal workspace this is much better than here it will be essential out side first you take a prismatic joints i elected the simply like this suppose you know you take a prismatic joints on let say what is minimum length of the rod you can have

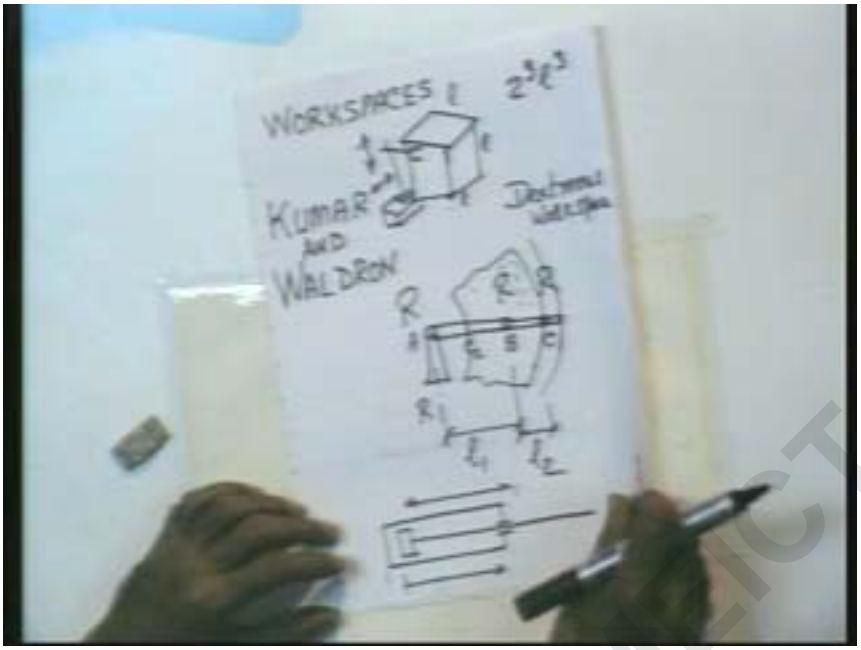
that will equal to the spoke of the cylinder like that is minimum like when this whole things come down here the rod will stick out what is the over all length whole system when the prismatic joints is that the outer end it is spice this scope that much space is required you are using this distance but robot will occupied some of pip this in the you got the point you want move to here to here

so the primitive joint it as whole things cylinder and system combination the system will have twice the length the so this portion is going to the out side the workspace you look at the the whole system will occupies L pulse L on the two L similarly two L two L two L

if it will take whole thing of the cube so it is two cube L in to eight L eight L cube whole space required by the system can you work out the similar to what is you volume verses the space occupied by the manipulators he okay for L by L by L work space of a cartesian manipulators cylinder pistil combination will occupies size of two L two L in to two L

so it is become two cube L cube that is eight L cube overall systems volume compare to the al cube divided by eight L cube is the radio work volume work space volume whole system ones can you come out some things like that for the articulators manipulators please do come out think up and do it may do some appropriate take L one equal L two just look at the main bodies the volume an than a completely rotation

you will ever things spiel down some short as two s you can find the volume much is than attempts at an excises to get a peal up of workspace nothing else okay



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now let as go to next position up as i told i am going to talk of as sever concept with in the work space and all this things now we are got the robotics you like this point is taken here some where okay the robotics is there you like this point let as look at what happens here supposing
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i am giving robotics and joint angles i have the planar i have the planar two access robotics if i give this angles this angle theta B we know the position of this or not a assume link in the A B and B p are given is ever easy for you to determine the position of point B one the two angle are given obscures the define a that is a cartesian coordinate system x than y once two angle are given you may the location this knows as direct kinematics direct kinematics is the leak length of manipulators are given the angle are given point the position of end effectors but is it a very difficulty task not at all is not at all the difficult likewise

if I have the two R the manipulators i have got two revalue pair two R manipulators i could have the three R manipulators how many angle you have to give you have to give three angle this another angle

i would know the where the end effectors is not only will i know the position put also the orientations of end effectors right orientations is I can have the angle is gamma gamma is a angle of orientation okay are you able to see that so this know as direct kinematics given the angle given the obscures

you know the manipulators so it link length give the joints angle point the end effectors than there is what is know as the inverse kinematics i have given the position of end effectors here in the same manipulators the point P is given and base of the manipulators location of base of the manipulators given the link length A B and BP are

given how do i position what are the angles again let remit repeat the position of the end effectors given there the base is given the link length are given AB and BP what are the angle this know as the inverse kinematics problem

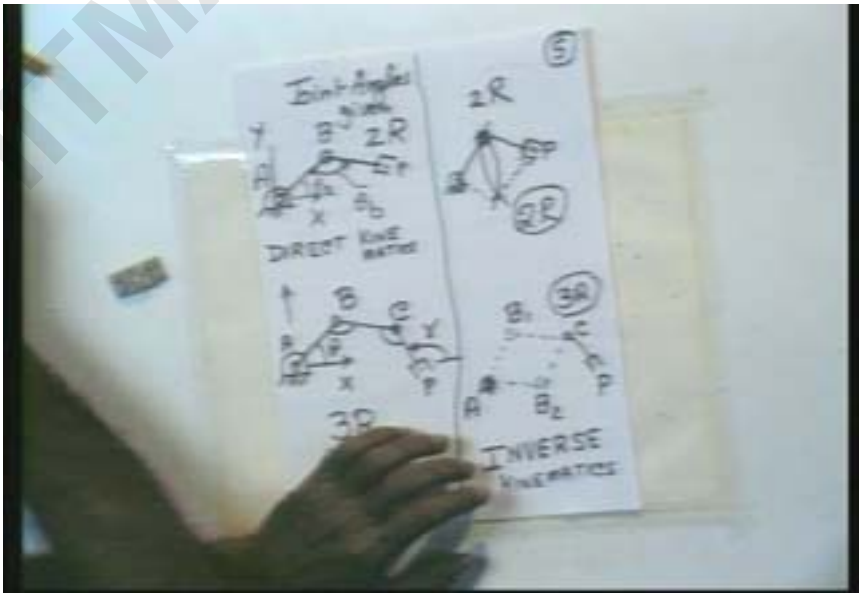
what are the angles is there the Unix solution are are the two solutions do determine the angle we can do one things we take the length BP on a compos try can not we take length AB on a compos okay this axis center stick another R this two R inter sector two points that are there are two solutions

you can approach this points either like this are right two solutions so the when you given the joints angle we can always fine the position straight forward easily but when you are given the position you will get the two set of now this cast of problem because twos one of the sets for what unique not a sevier problem never there is now this is for a planar let me go to three R manipulators this is two R manipulators

i have done it two R manipulators let me go to the three R manipulators there is three R manipulators in the case of the three R manipulators i have to give the position and orientations of end effectors give this I know this point i know where the base two things i know i will call this A I will call this B i will call this C and this is P now i will give the position and orientations of end effectors that means location of

so the angle required there are two joints again i follow the same procedure i can have one solutions B one another position B two here is one revalue pair other solution revalue pair okay so this is know as the inverse kinematics that me draw line between this is two R this is three r (noise) this are the okay now this okay for the plane three degrees of freedom

what about the six R six revaluate spatial manipulators obviously the same problem should be there also how many solutions are there here there area two solutions for inverse kinematics how many solution are there six R manipulators this what have you do no it have six is much more than that



this is some things would lot of kinematics working on because you have to select from a verity of so i live it find out how many are there in he next class discusses that the number of solutions in the case are six R manipulators you studied when you go to differ in to the inverse kinematics

we have a look at let me move on i will just given you let me summaries as give you data some things about workspace i given you some feel of have you told you some feel of the orientations possible on the various solution which are possible when will you give first angle and the find

where the you are ask where the end effectors second given where the end effectors find the joints angle this is what we have the seen proper so this are some of the small simple concept which once you glow as a preliminary as you go along you know you will find that you are going in to spatial kinematics one tens get last is you not very cleary about the particular to which is let move get the last item which i want to the discusses today what is know as resolution

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accuracies and repeatable the three points discusses this is the last point set of points i will resolution what angle does the stepper motor go convention stepper motor you are know that i convention stepper motor goes to “on point eight degrees”

when a stepper point (some noise) let not worry about the other drive the electronic switching view the “ point nine degrees “ temporary let assume that assume doesn’t exit so that means what is the resolution of the stepper motor “ one point eight degrees “ anything less than “one point eight” degrees command it two may not be able do

now you connect to stepper motor to a screw and than drive a nut forward and back the repeat associated with this screw and nut than move forward and backward so
What is there is may be obviously a minimum distance which a nut and go any things below that it will not able to handle the defend an the fid stepper motor and “one point eight “degrees

so that is resolutions of the system for all familiar with just repeating for to all for a perhaps know okay now you know servo drive how shall we determine the resolution what can be called the resolutions stepper is very clear (m noise) you give it the stepper “one point nine“in a servo drive where there is a feed back either the potential meter are an encoder

what shall we denote at the resolution the number of the lines encoder contain suppose the encoder as the three sixty degrees is a circular you know rotary encoder three sixty line is at than you say that resolution is one degree okay

now one you have put the short of the system and encoder three sixty lines as that the servo motor can take one degrees increment more you can tell it okay go by one

degrees if you say go by “point five” degrees it may not be able do okay the motor as a resolutions than you have connected screw moving some things

so the nut resolutions of that you can work out but in addition the resolution also affected by many things likes backless the you know play in he system it also affect the you can not escape okay so

you have stepper move resolutions is “one point eight “degrees id you have the encoder the resolution defense on the number of lines on the encoder how many lines are there encoder three thousand sixty lines means (noise) “point one” degrees (noise) like that goes on fortunately

now a day encoder with how several thousand lines are available there are café there are more resolutions you want for a robotics the more expensive okay now what about the part that a potential meter the potential meter is give what as the signal analog signal the analog signals is converted in to the digital signals throw electronic so

let as say ten volt potential meter let means zero to ten volt equal to three sixty degrees that is what is one turn zero to ten volt equal to three sixty degrees but a converting electronics is eight bit so how much how much to what extend divided in to ten volt using this eight bit when you read of eight bit two two power eight equal to correct two fifty six ten volt by two fifty six is the resolution is teams of voltage three sixty by two fifty six is the resolution in terms of the rotations

so three sixty by two fifty six equal to resolutions i can also say that ten volt by two fifty six so now in addition to the there is the play there i there so the entity resolution speak on he now if you have the manipulators a planner are two R i will take because for as the follow now these two fifty six point in case of the encoder

we call them adjustable point are these are the adjust can go to that why we are called adjust full point so suppose i have got a manipulators equip with stepper are this encoder in so obviously

you can not go allow over the place continues way you and i think you adjust only a finite set up points large number points defiantly this fellow defiantly using a part you can you can go throw two fifty six in three sixty degrees three sixty by two fifty six it can adjust similarly here you will have several set of points in work space of manipulators as the increase this counts obscures I make it more an more persistence you will get more are less continue okay

so you have seen what is resolution you know that that the resolution remind the uniform in the work space for a cartesian manipulators if I have a Cartesian manipulators given by two stepper motor will I get uniform resolution in the work space what about the two R manipulators will it uniform because some things tell to when you rotate here (noise) by “one point eight” this by another by “ one point eight “ here this post her one particular resolution if you go else where

if i want this one right the resolution the distance between two points adjustable point at the here in the task in the work space so keep on things defending on he position in addition you have the other problem like

you know backlash so many other the second concepts is one of the accurse what is accurse if you are told the robotics is a commanded to the robotics go throw four centimeter at goes to only " three points nine" at will do Resolutions that not worry

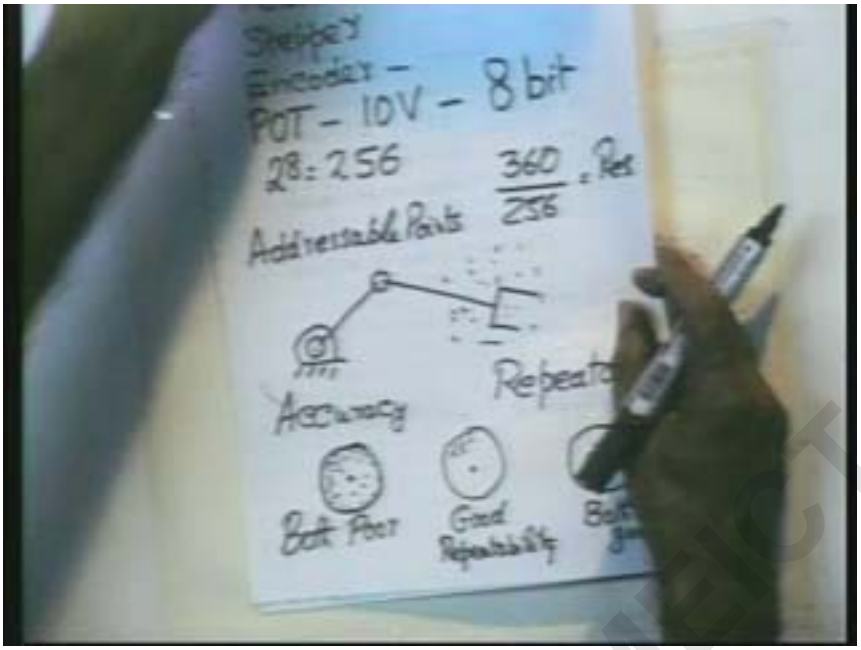
if very large resolutions keep on you goes only three points nine that means is not accurate robotics is not going to the commanded okay robotics thirteen call repeatability you note down addressable points okay we have what is know as repeatability

let me that supposes this is the you want reach the center of the circle and you contact several trails with a robotics and you find it always reaching some point randomly here follow you want to reach you are ask go to the center of the circles both accurse as well as this one repeatability are pole which think al over the suppose

it is always going here exit path than repeatability is good it is suppose it go to this point but it always going here repeatability is good but accurse is if you want both to be good the point must be cursed around we cursed around both good than both are boor here and here good repeatability

so i will draw a circle before you want read when I look at accuracy repeatability both are poor The robotics will go all over the play away from the center points one part twice may be it good it is good in repeatability but boor accurse

it will always reach some points for away from the target points for never less all cluster there is repeat and both are good the accurse repeatability are good these are some of the concepts so have in a next class we will continue this more concept before we look at



characteristics of what you called is the servo derive and eclectic motor thank you very much