

**ECE 5397/6397: Intro to Robotics**

**In-Class Handout –Lecture 25: Inverse Velocity**

Overview:

forward kinematics (easy after learning rotations, geometry, DH)

Inverse kinematics (hard), multiple or no solutions

forward velocity kinematics , needed skew symmetric matrices

Example with single joint robot

Draw possible xy velocities

When can we find solutions to ?

What if ? Draw a 3-rotational link planar robot with

Where do we loose DOF (where are the singularities)?

Draw it. What are the instantaneous velocities?

How can we get ?

One way is

The norm is

Better way is

Because norm is

How did we get that? “**Right Pseudo Inverse of ”**

If if

Why “right” psuedo inverse?

Null space of J

To minimize joint velocity

Cool trick with singular value decomposition



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**Class Worksheet – Preparation for Lecture 26**

Using the definition of pseudo inverse,, the SVD of

and the fact that and are rotation matrices, prove that

definition

substitute

apply transpose operators

remove parenthesis

is rotation matrix:

Apply inverse

is rotation matrix:

is rotation matrix:

By definition

Suppose that is a solution to for .

1. Show that is also a solution to for any

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1. [grad students only] Show that gives the solution that minimizes the resulting joint velocities in

Let

By triangle inequality

Because , choosing minimizes

If a designer starts the study of the kinematics of a robot, it is essential to analyze the **manipulability** which is one of the most important **parameters of functionality** of a robotic manipulator; in fact, this term has a major impact on design since it facilitates the definition of kinematics performance indicators which allow optimizing the size of the robot.