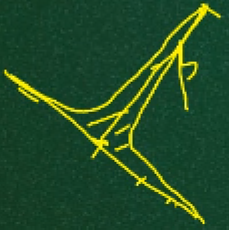
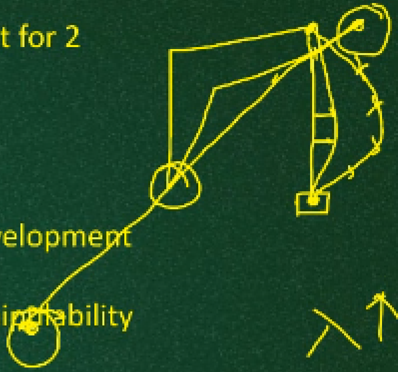
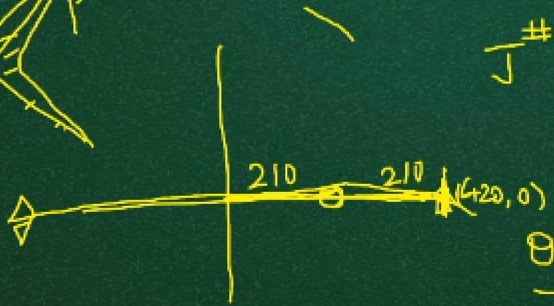
PERSONAL USE ONLY

1) presentation by all on ik code solver development for 2 axis planar case
2) 2) discussion on the following
   1) A) velocity ik
   2) B) Acceleration ik
   3) C) Jacobian generating vectors and code development to generate Jacobian from DH parameter
   4) D) matrix norm for Jacobian matrix and manipulability derivation for velocity and torque vectors







$\lambda \uparrow$

10, 20, 30

$$J^{\#} = J^T (J J^T)^{-1}$$

DLSIK ✓

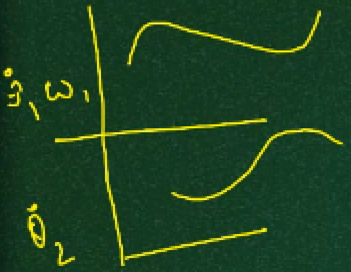
$$\boxed{J^{+} = J^T (J J^T + \lambda^2 I)^{-1}}$$

$\theta_i^1 = 5^\circ . \theta_i^2 = 0 - 5^\circ$

$\lambda =$

$-419, 01$

Manipulability



Velocity

$e = f(\theta)$

$\theta = f^{-1}(e)$

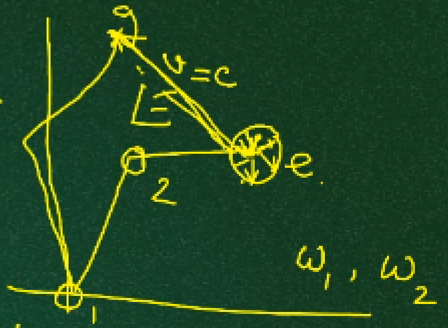
$\omega \; \frac{d\theta}{dt} = J^{-1} \frac{de}{dt} \; v$

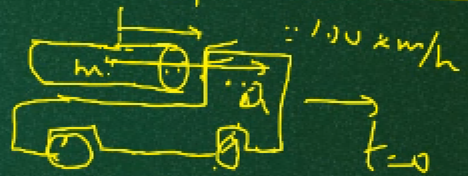
$$\boxed{\omega = J^{-1} v}$$

$x, \dot{x}, \ddot{x}$

$\theta, \dot{\theta}, \ddot{\theta}$

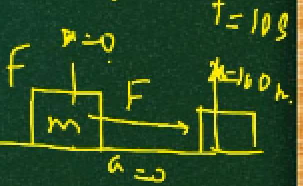
$\dot{\theta} = c$



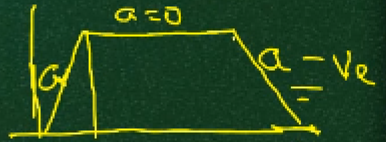


βE.

$\boxed{a}$



$F = ma$

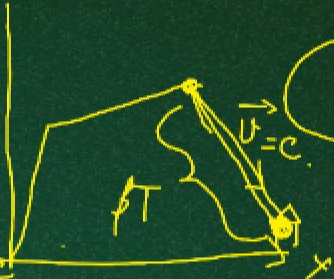


$\boxed{\dot{\theta} = J^{-1} \dot{q}}$ c.

$\boxed{\beta\omega} \rightarrow$ instantaneous

$\omega \rightarrow$

$v = 10\ mm/s\ y$

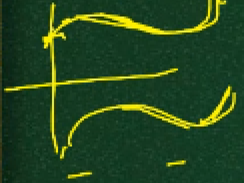


$\Delta\theta = J^{-1}\boxed{\Delta e} \rightarrow \beta E$

$\omega = J^{-1}\boxed{v}$

$v = c$

βv



Real time Komph..

$\theta_{i+1} = \theta_i + \boxed{\omega \times \Delta t}$

$\Delta\theta$

$\boxed{\beta T}$

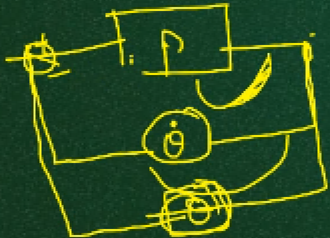
$\vec{E} = \vec{g} - \vec{e}$

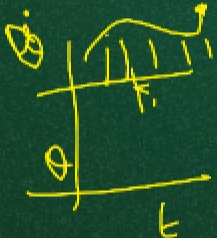
t T ?

$v = \dfrac{E}{t}$

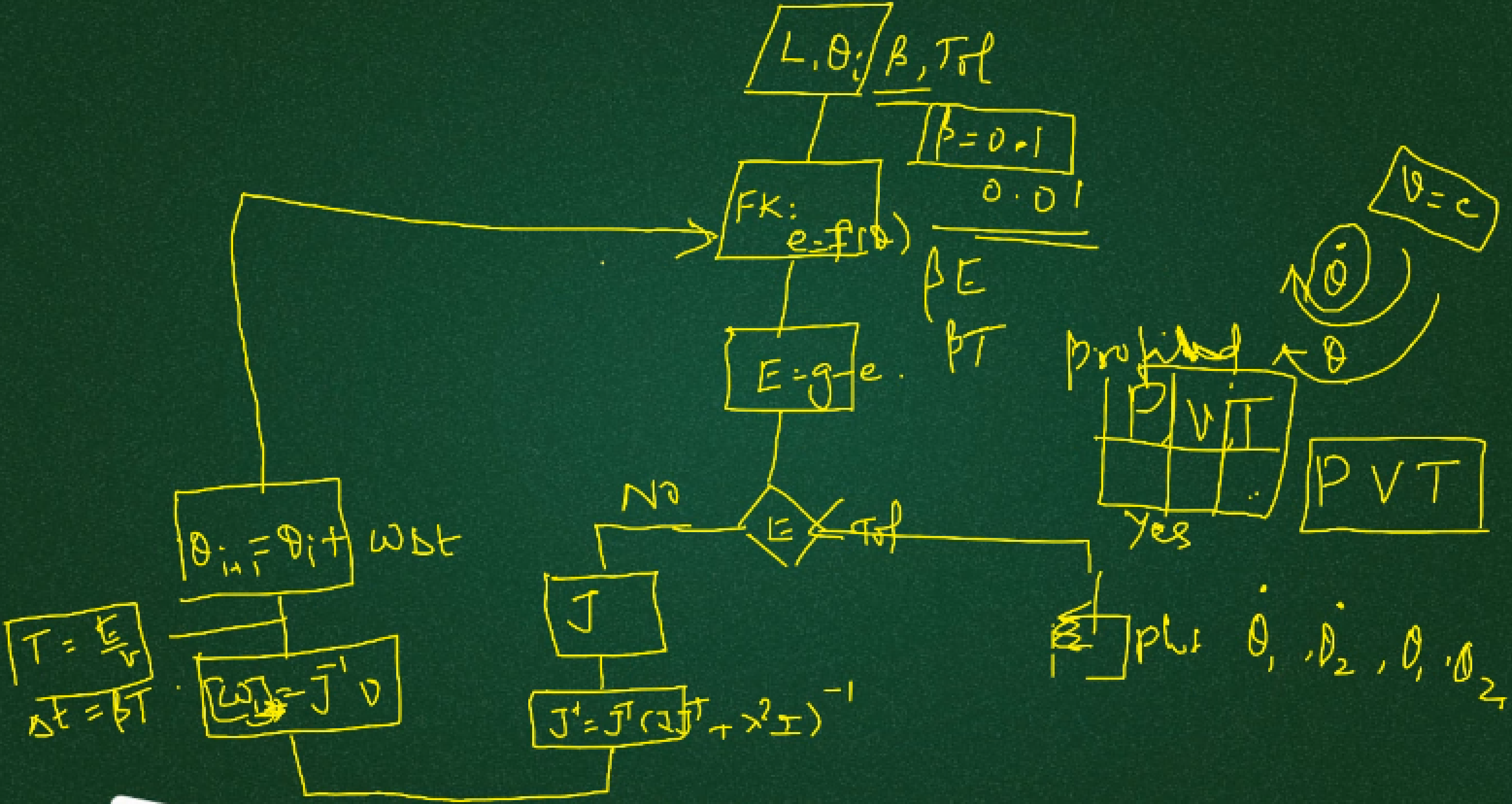
$\boxed{T = \left(\dfrac{E}{v}\right)}$

1 sec - x units





Man. th

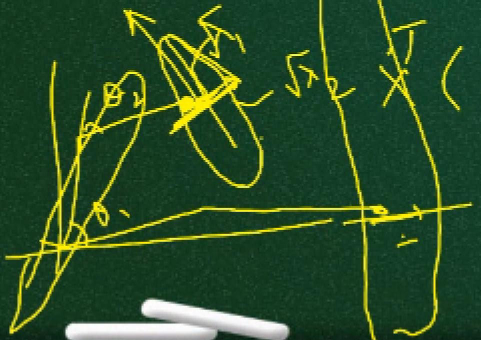

L, θi, β, Tol
β = 0.1
0.01
FK:
e = f(θ)
βE
βT
E = g - e
No
E < Tol
Yes
J
J' = J^T (JJ^T + λ^2 I)^-1
θi+1 = θi + ω Δt
T = E/v
Δt = βT
ω = J^-1 v
profiled
P V T
PVT
θ = c
plot θ1, θ2, θ1, θ2

$$\lambda^{\frac{1}{2}} = \sqrt{JJ^T}$$

$$\mathrm{Eig}(JJ^T)^{-1}$$

λ_1, λ_2

v_1, v_2



manipulability

$$\dot\theta^T \dot\theta = 1$$

$$\left[(J^\#)\dot x\right]^T \left[J^\# \dot x\right] = 1$$

$$\dot x^T (J^\#)^T J^\# \dot x = 1$$

$$\dot x^T \left(J^T (JJ^T)^{-1}\right)^T J^T (JJ^T)^{-1} \dot x = 1$$

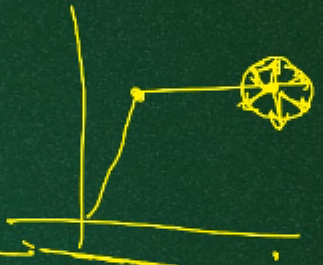
$$\boxed{\dot x^T (JJ^T)^{-1} \dot x = 1}$$

DH → J

$$\cancel{\dot\theta = J^T(JJ^T)}$$

$$\dot X = J^\# \dot\theta$$

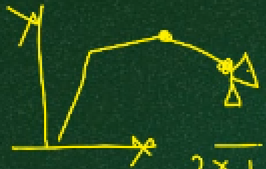
$$\dot\theta = (J^\#)\dot x$$



$$\dot\theta = J^\# \dot x$$

$$J^\# = J^T (JJ^T)^{-1}$$

Principal



manipulability

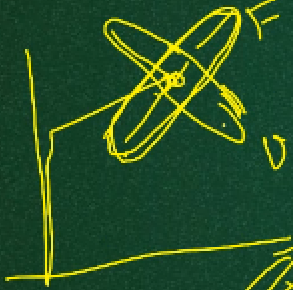
Force $\quad \tau^T \tau = 1$

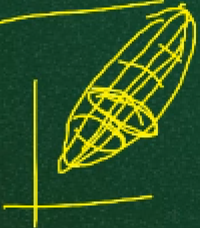
$F^{2\times 1}$

$J^{2\times 3}$

$\boxed{\tau = J^T F}$

$F^T x$

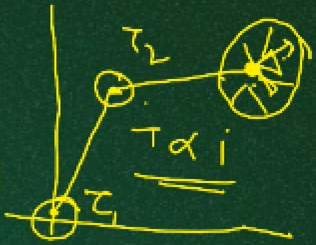




$$\boxed{F^T (J J^T) F = 1}$$

$$\boxed{\dot{x}^T (J J^T)^{-1} \dot{x} = 1}$$

eig(JJ^T) , eig$(JJ^T)^{-1}$



$\tau \propto i$

$F =$

$v \to \dot{\theta}, \omega$

$x \to \theta,$

$F \to \tau$

$F = (J^T)^{-1} \tau$

First order

$\omega = \dot{J}$

$\frac{d^n y}{dx^n} + \ldots\ldots$

$\frac{dx}{dx} = f(x)$

$v = J\omega$

$\frac{dv}{dt} = \frac{d}{dt}(J\omega)$

$y_{i+1} = y_i + \Delta h \cdot$

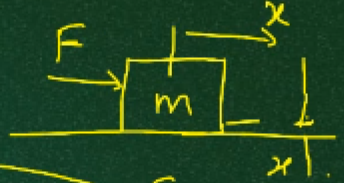
$a = J\frac{d\omega}{dt} + \omega\left(\frac{dJ}{dt}\right)$

Scipy.integrate

$a = J\alpha + \omega\left(\frac{dJ}{dt}\right)$

R.K

Runge Kutta method



$F = ma$

$\theta\ [\varepsilon]$

Reza & Jazar

1 Applied Robotics

2 2 order Diff eqn

Euler → Numerical method

First order

$$\frac{d^n y}{dx^n} + \ldots\ldots$$

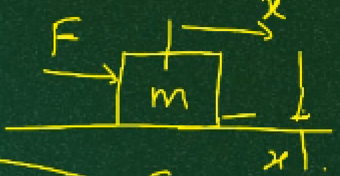
$\cancel{\omega = J}$

$$\frac{dy}{dx} = f(x,y)$$

$$v = J\omega$$

$$\frac{dv}{dt} = \frac{d}{dt}(J\omega)$$

$$y_{n+1} = y_n + \Delta h$$



$$F = ma$$

$$a = J\frac{d\omega}{dt} + \omega\left(\frac{dJ}{dt}\right)$$

Reza & Jazar

$$a = J\alpha + \omega\left(\frac{dJ}{dt}\right)$$

Scipy.integrate

1. Applied Robotics
2. 2 order Diff eqn

R.K

Runge kutta method

Euler → Numerical method