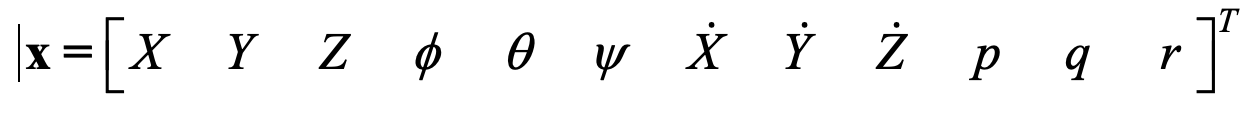
**PID gains from ISE optimization**

1. **STATE SPACE MATRICES:**

A picture containing logo

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A picture containing background pattern

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A picture containing text

Description automatically generated

Y = C**x** + D**v**

Text

Description automatically generated with low confidence

1. ***Tune PID controller (without LQR)***

Block diagram of system:

Diagram

Description automatically generated

Referring to the above figure,

Text

Description automatically generated

In the above equation, are parameters to find and G(s) will be obtained from ss2tf(A, B,C,D).

Plant transfer functions (G(s)) from MATLAB ss2tf function:

**Attempt 1: PID controller**

Final system transfer function will be a function of .

**For z position**

For step input,

Now, we find ISE defined as:

Text

Description automatically generated

The error signal TF is of the form,



We require J3,



Where, , , , .

Hence, .

For our case,

This gives,

**To minimize this, we can set Kp =0 and any value for Ti and Td will work. NO!**

Once, we obtain J3, we can use the following conditions to obtain PID parameters individually for x, y, z positions and psi angular displacement,

Text

Description automatically generated with medium confidence

Taking partial derivative w.r.t the 3 parameters and using the above conditions we get,

For, *, , ,.*

**Attempt 2: PD controller**

**Since we do not need integral action we can assume a PD controller,**

Final system transfer function will be a function of .

For z position,

Now, we find ISE defined as:

Text

Description automatically generated

The error signal TF is of the form,



the Integral, for the second order system (n=2) with numerator c(s) and denominator d(s), may be transformed from an “integral table” to the form:

,

Where, , , .

Hence, .

For our case,

This gives,

Setting partial derivatives to 0 means can be anything and must be as big as possible. (TRUE BUT NOT useful!)

Verify sufficient conditions,

**PID controller for X position**

For x position,

Where *a* is a constant

For step input,

Now, we find ISE defined as:

Text

Description automatically generated

The error signal TF is of the form,



We require J5,



Where, , , , , , .

For our case,

This gives,

**Since we cancelled Ti from the denominator it cannot be 0?**



Set Kp =0,

Ti should be as big as possible?!

**Using on the Derivative (Td) feedback, the closed loop A matrix is:**

Ac=A-B\*[ 0 0 0 0 0 0 Td1 0 0 0 0 0;

0 0 0 0 0 0 0 Td2 0 0 0 0;

0 0 0 0 0 0 0 0 Td3 0 0 0;

0 0 0 0 0 0 0 0 0 0 0 Td4];

Use Ac in the LQR synthesis;

edot = A\*e + Bv

e = xd - x

u\_pd = kp \* e + kd \* edot

u\_all = kp \* e + kd \* edot

edot = A\*e + B( v – u\_pd )

edot = A\*e - B\*u\_pd + Bv

edot = Ac\*e + Bv

where Ac = A – B\*PD

PD = [ Kp 0 0 0 0 0 Td 0 0 0 0 0;

0 Kp 0 0 0 0 0 Td 0 0 0 0;

0 0 Kp 0 0 0 0 0 Td 0 0 0;

0 0 0 0 0 Kp 0 0 0 0 0 Td];