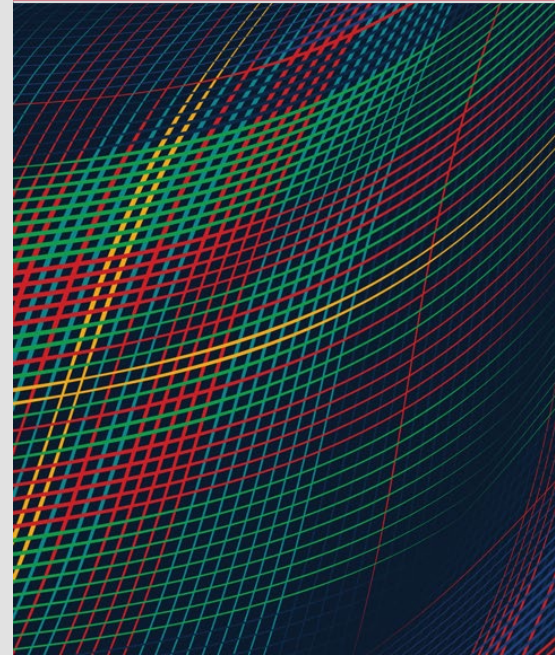


Accelerating Insertion of Capability using GenAI based Control Synthesis from Image

SEPTEMBER 17, 2024

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**Carnegie
Mellon
University**
Software
Engineering
Institute



This material is based upon work funded and supported by the Department of Defense under Contract No. FA8702-15-D-0002 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center.

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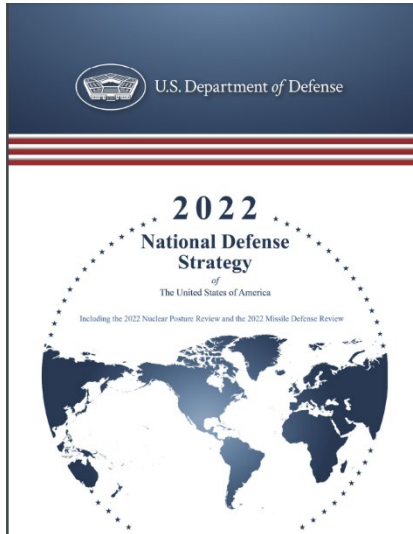
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DM24-0874

The need for speed (of software development of aircraft)



The Department will instead reward rapid experimentation, acquisition, and fielding.



How do we combine the need for safety with the need for speed?



How do we combine the need for safety with the need for speed?

In this talk, we will ignore this

In this talk, we focus on this.

DoD systems interact with their physical environment



Control is important



```
while (1) {  
    s = read_sensor();  
    a = perform_computation(s);  
    actuate_command(a);  
}
```




```
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    s = read_sensor();  
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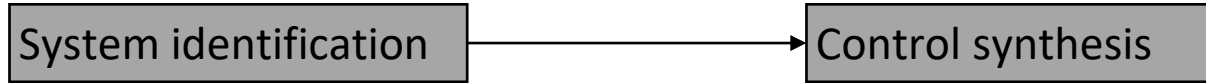
← We need to generate source code for this.

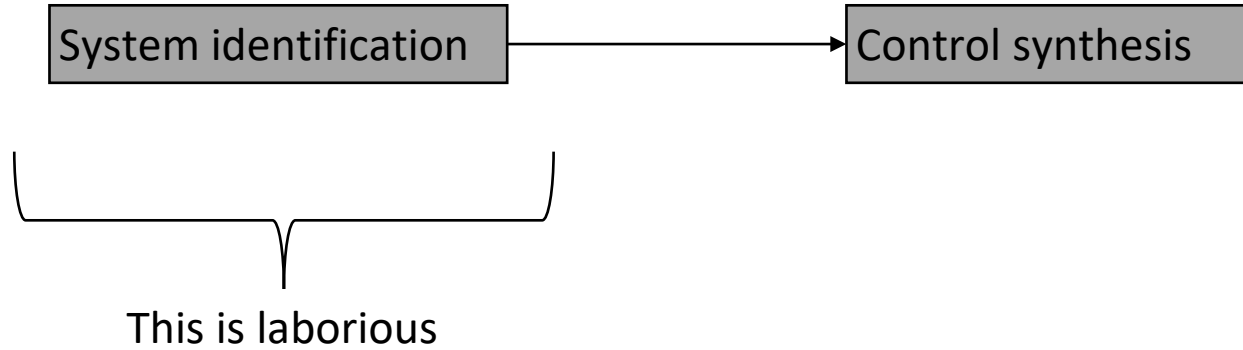


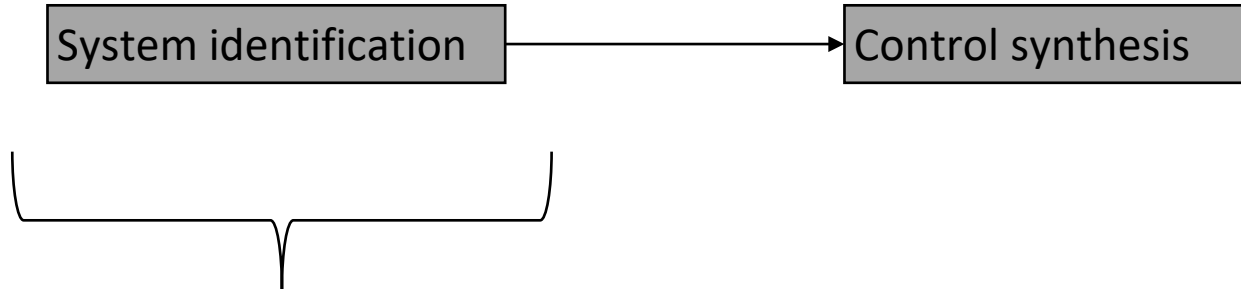
```
while (1) {  
    s = read_sensor();  
    a = perform_computation(s);  
    actuate_command(a);  
}
```

The source code generated depends on a model of the physical environment (plant)

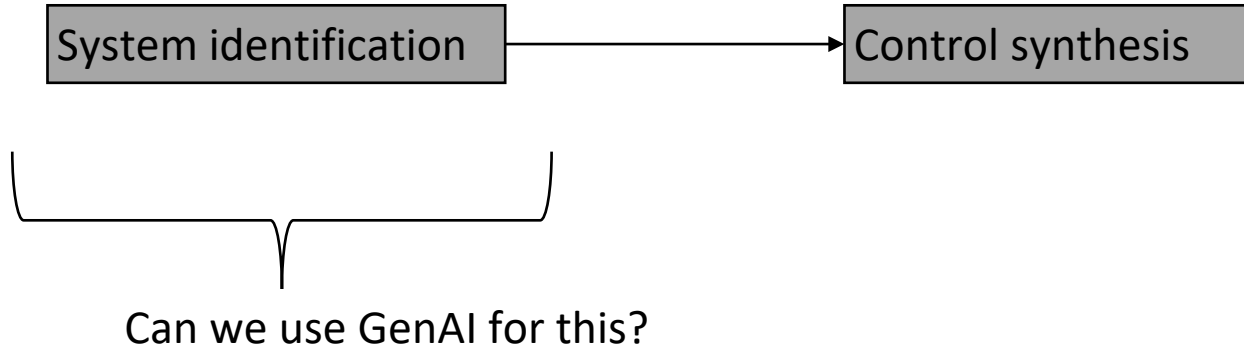


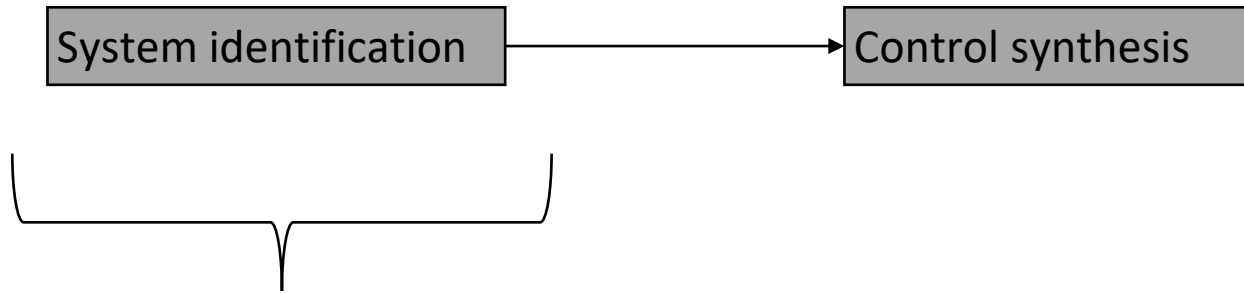






Can we reduce human labor for this?

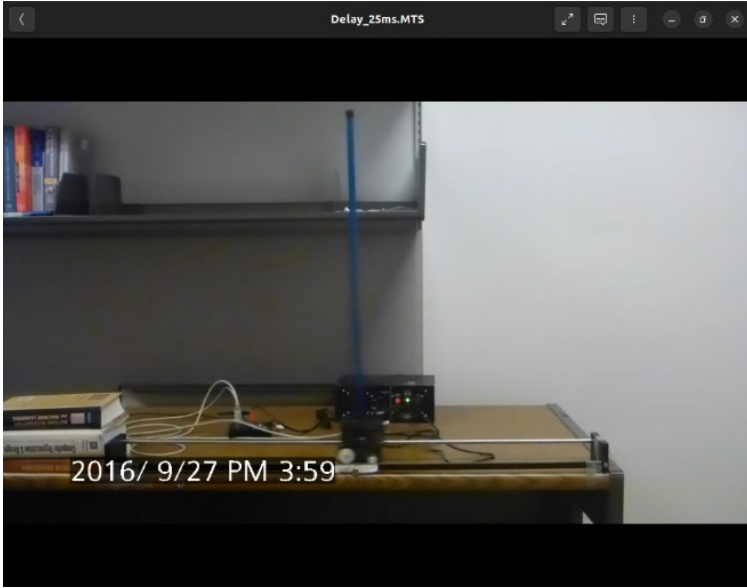




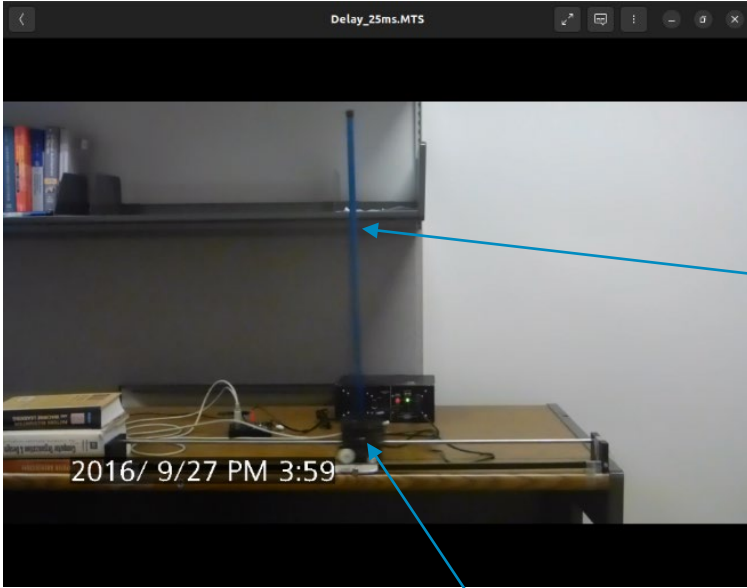
In this paper, we show how to use
GenAI for this.

and synthesize this.

Case study: Inverted pendulum



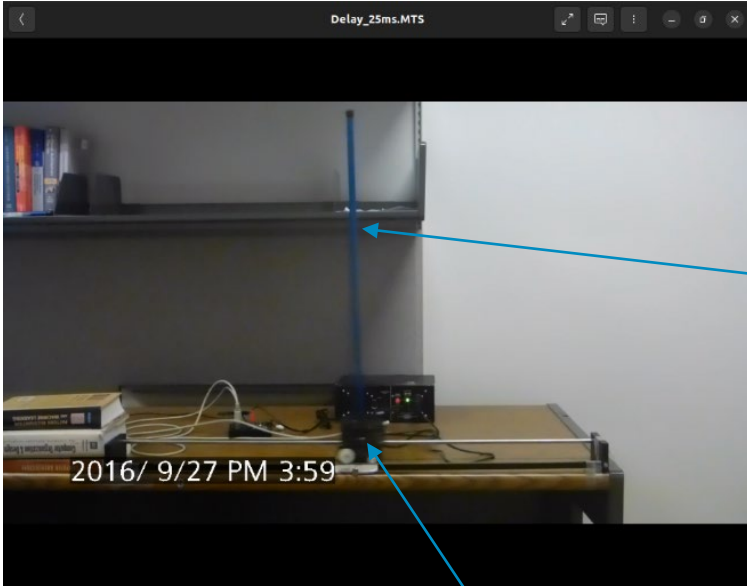
Case study: Inverted pendulum



Rod

Cart

Case study: Inverted pendulum



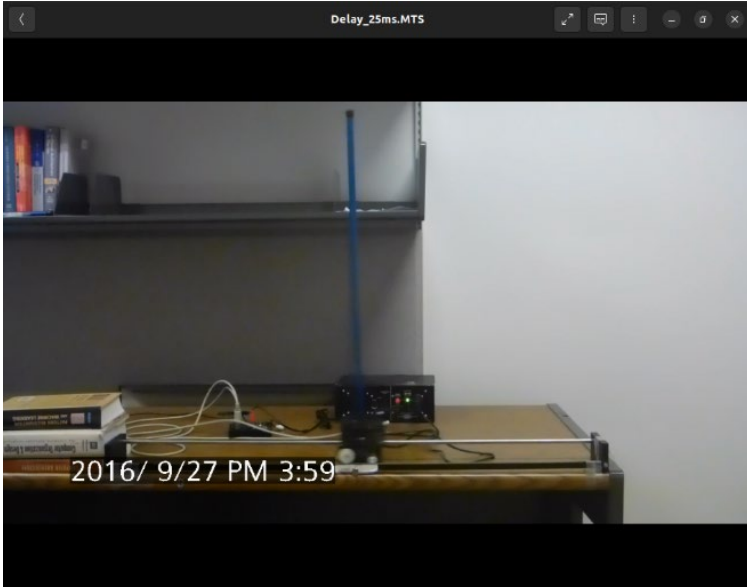
Rod

Cart

Goals of controller:

Move cart so that rod stands up

Generate source code of controller
from image.

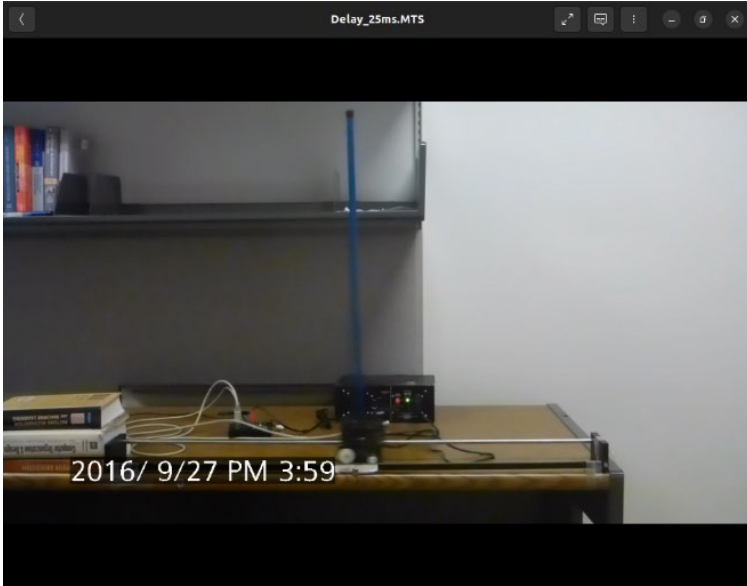


Prompt to GenAI

Gen AI system

controller

Prompt to GenAI

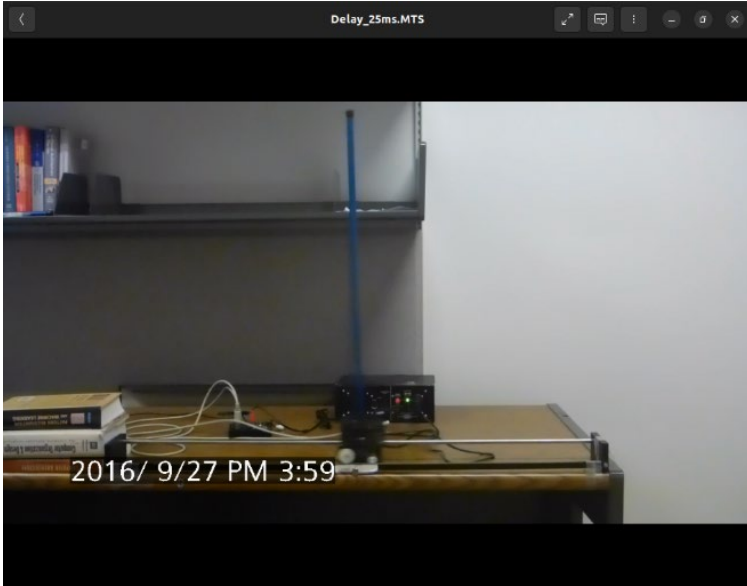


This image shows an inverted pendulum. Please give me the differential equations for this particular inverted pendulum. Based on the image, please estimate the parameters that describe mass m and M and also estimate l , the center of mass of the pendulum. Be aware that l is not the length of the pendulum. In fact l is half of the length of the pendulum. After that, please express the dynamics of the system as a linear time-invariant system (LTI). Then, use LQR controller synthesis to get a controller. You should solve it with concrete values; that is, give me the K matrix.

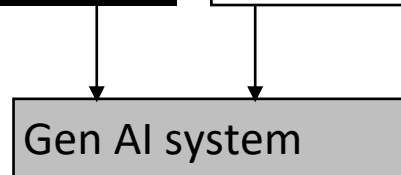
Gen AI system

controller

Prompt to GenAI



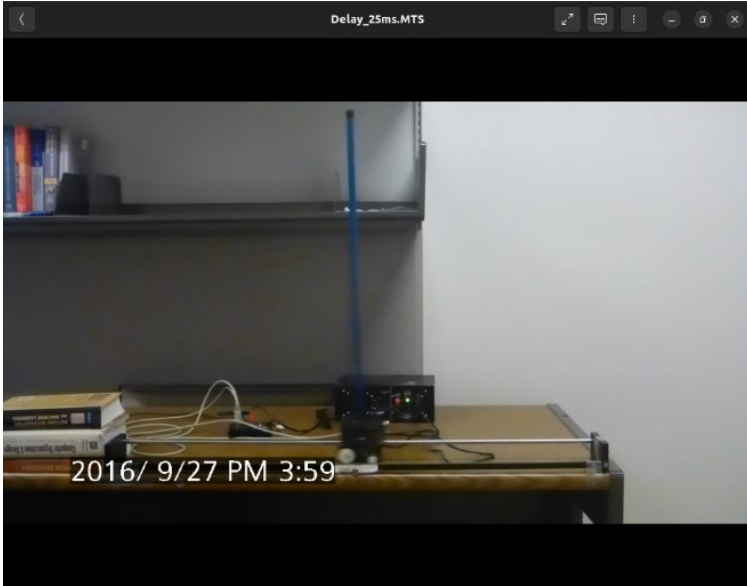
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Advantages:

- No need for humans do to physics modeling
- No need for humans to read manuals/data sheets

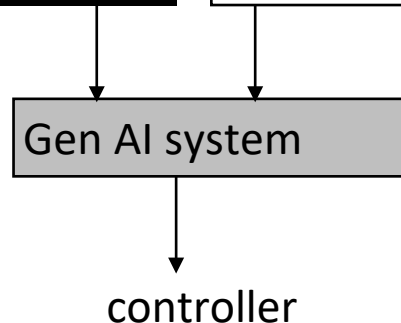
Prompt to GenAI



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Open questions:

- How well does this controller perform?
- Is this safe?



Advantages:

- No need for humans do to physics modeling
- No need for humans to read manuals/data sheets



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