Conclusion
Computer Vision and Machine Learning
Control Design
The System
Introduction

Two-Wheeled Inverted Pendulum

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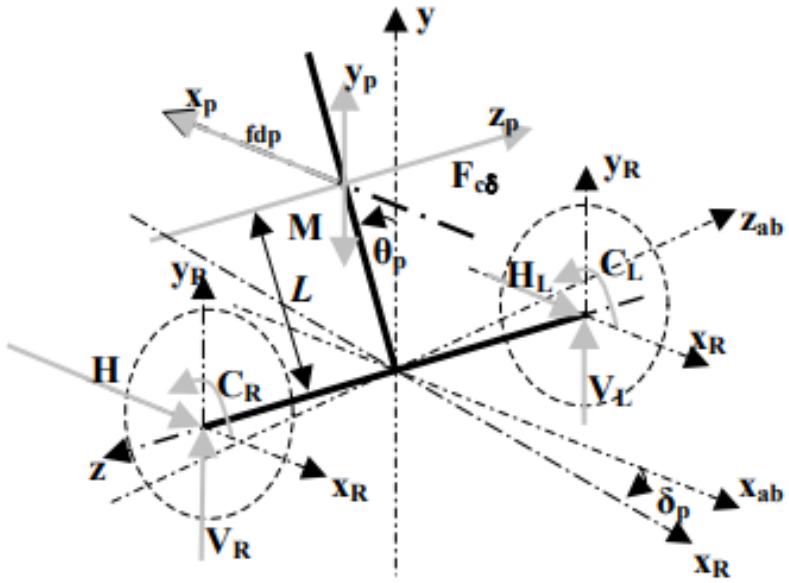
"Presented" to Prof. Hassan Shreim

What is a Two-Wheeled Inverted Pendulum?

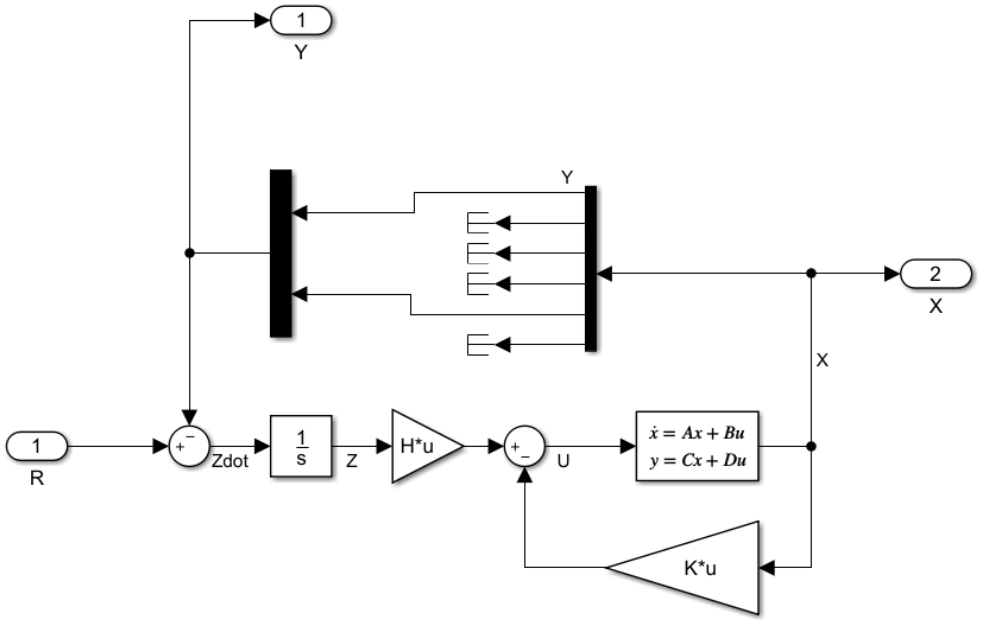


$$\begin{bmatrix} \dot{x} \\ \ddot{x} \\ \dot{\theta}_p \\ \ddot{\theta}_p \\ \dot{\delta} \\ \ddot{\delta} \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & \dfrac{\left(\frac{\lambda_4\Delta_1}{Z_3} - \lambda_1\right)}{Z_6} & \dfrac{\left(\frac{\lambda_4\Delta_4}{Z_3}\right)}{Z_6} & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & \dfrac{\left(\Delta_1 - \frac{\Delta_5\lambda_1}{Z_4}\right)}{Z_5} & \dfrac{\Delta_4}{Z_5} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} x \\ \dot{x} \\ \theta_p \\ \dot{\theta}_p \\ \delta \\ \dot{\delta} \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ \dfrac{\left(\lambda_3 - \frac{\lambda_4\Delta_3}{Z_3}\right)}{Z_6} & \dfrac{\left(\lambda_2 - \frac{\lambda_4\Delta_2}{Z_3}\right)}{Z_6} \\ 0 & 0 \\ \dfrac{\left(\frac{\Delta_5\lambda_3}{Z_4} - \Delta_3\right)}{Z_5} & \dfrac{\left(\frac{\Delta_5\lambda_2}{Z_4} - \Delta_2\right)}{Z_5} \\ 0 & 0 \\ -\Delta_6 & \Delta_6 \end{bmatrix} \begin{bmatrix} V_{aR} \\ V_{aL} \end{bmatrix}$$

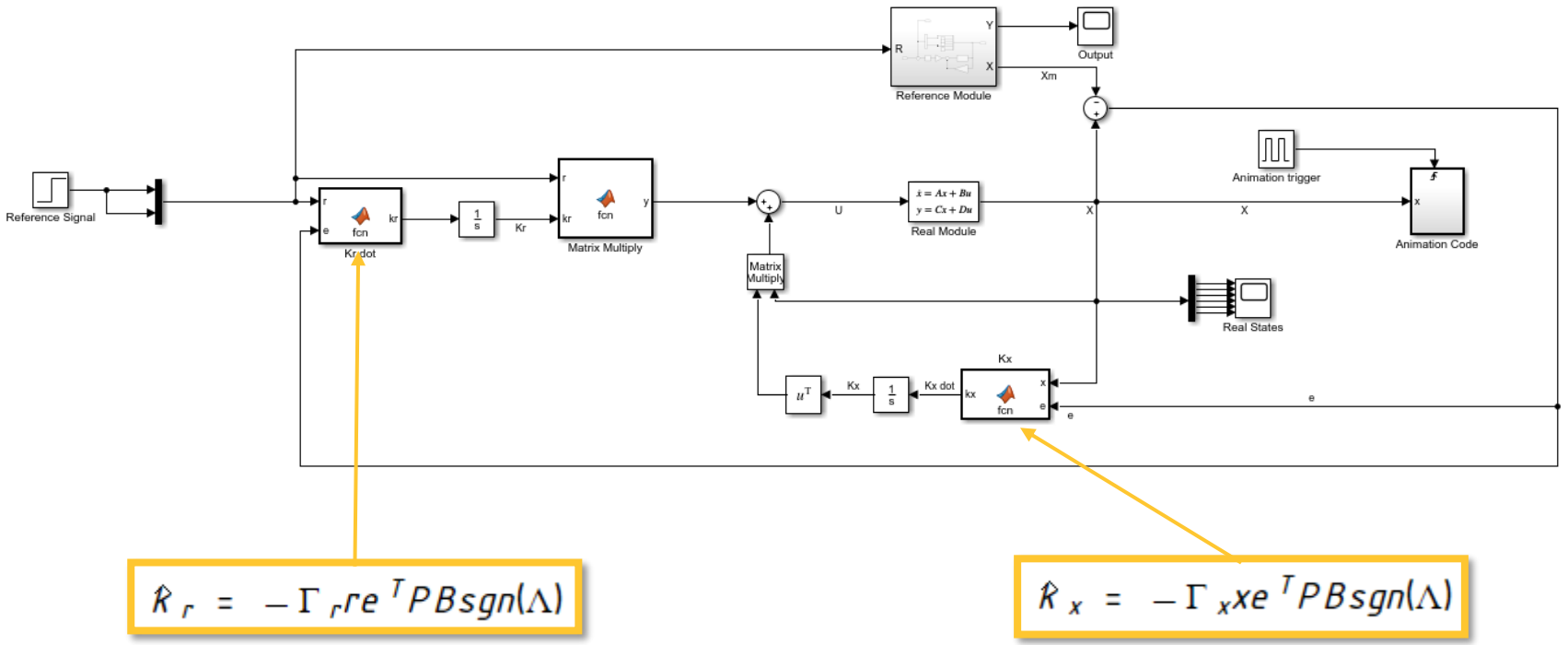
What is MRAC?

- MRAC is a controller that uses a model reference to depict the perfect the perfect behavior of the system.
- Gains are continuously estimated on runtime

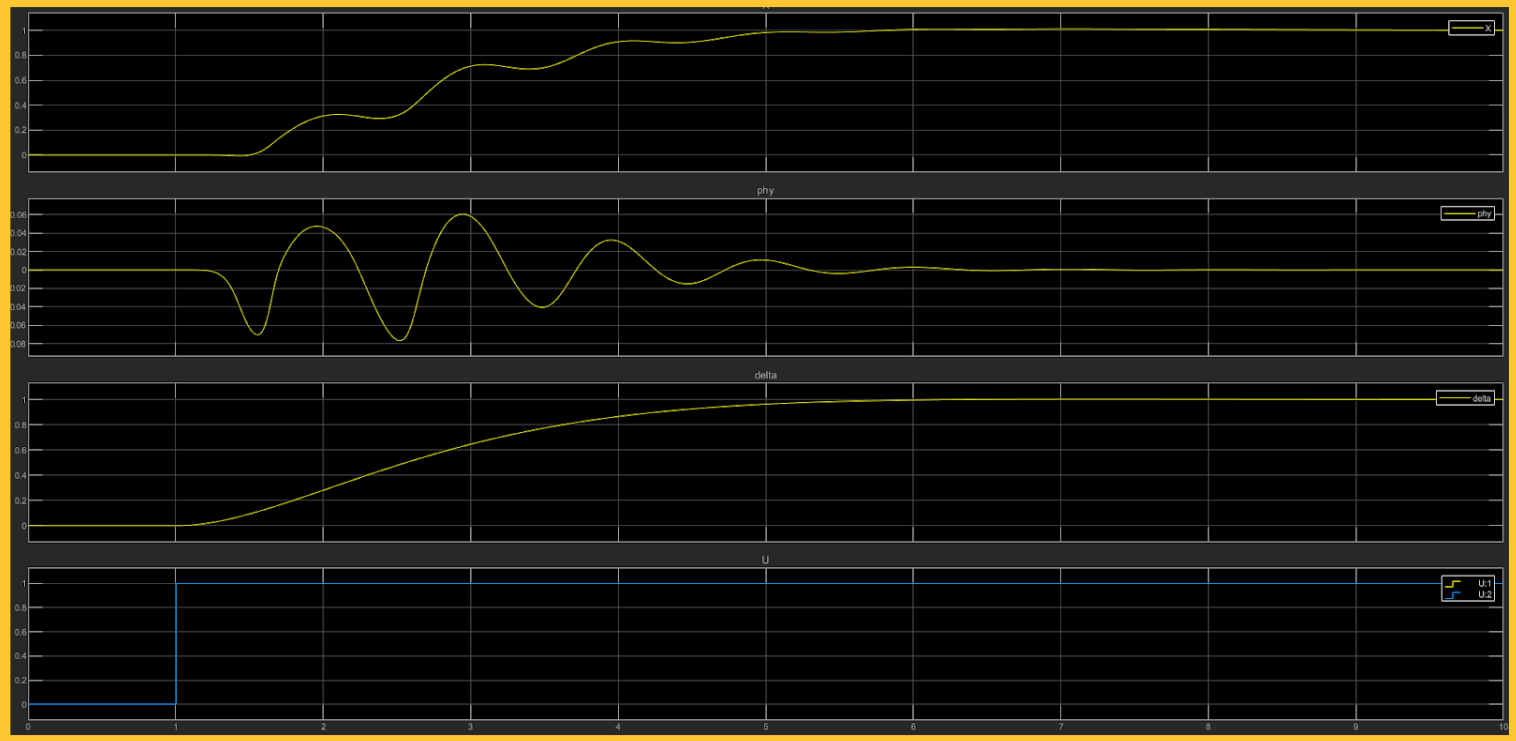
Model Reference



Adaptive Control Implementation



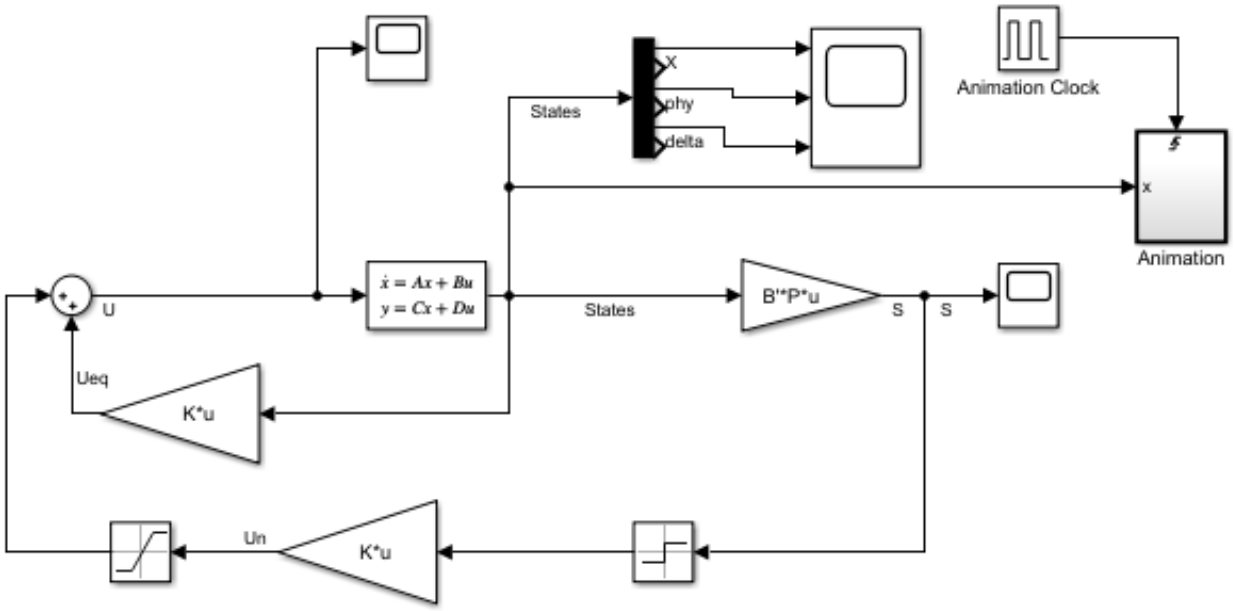
Results



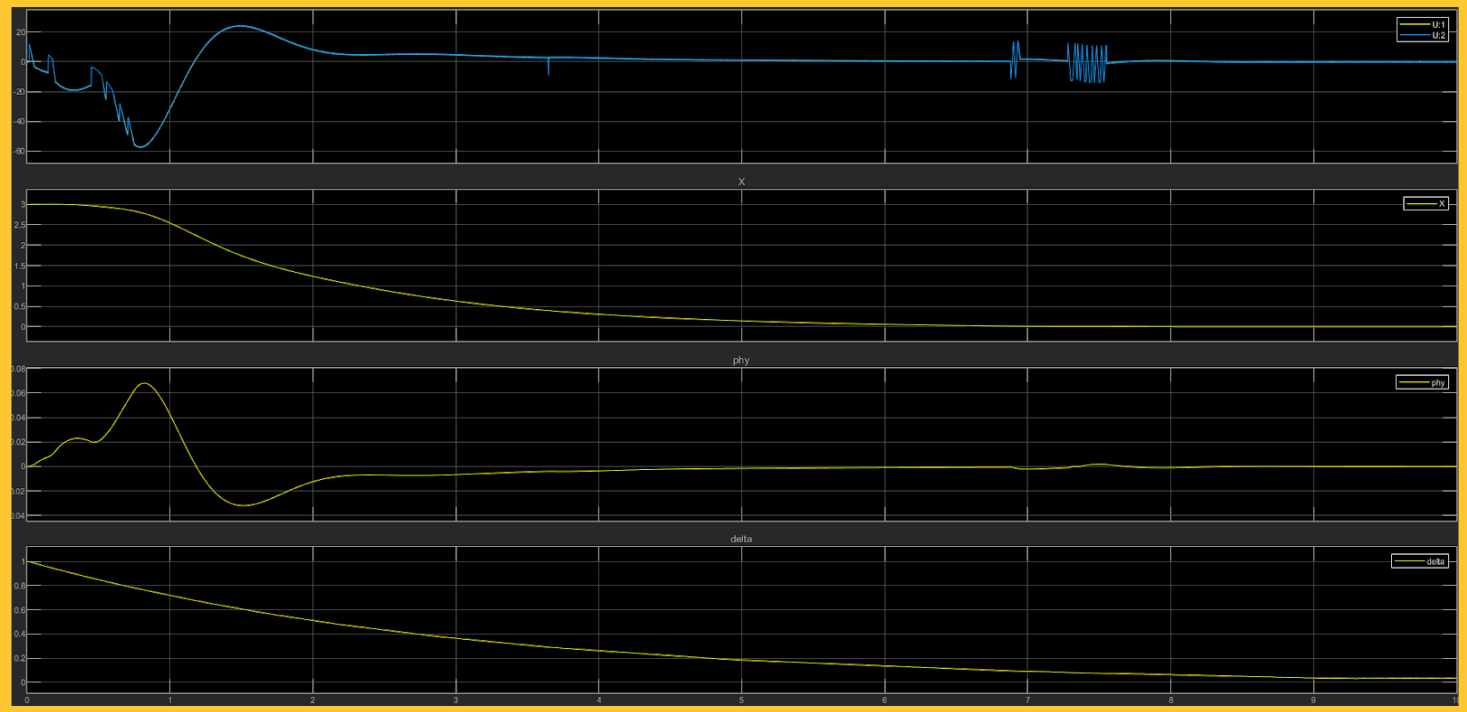
What is a Sliding Mode Controller

- SMC is a controller used to control system having unknown nonlinearities
- The system follows a chosen switching function

Sliding Mode Implementation



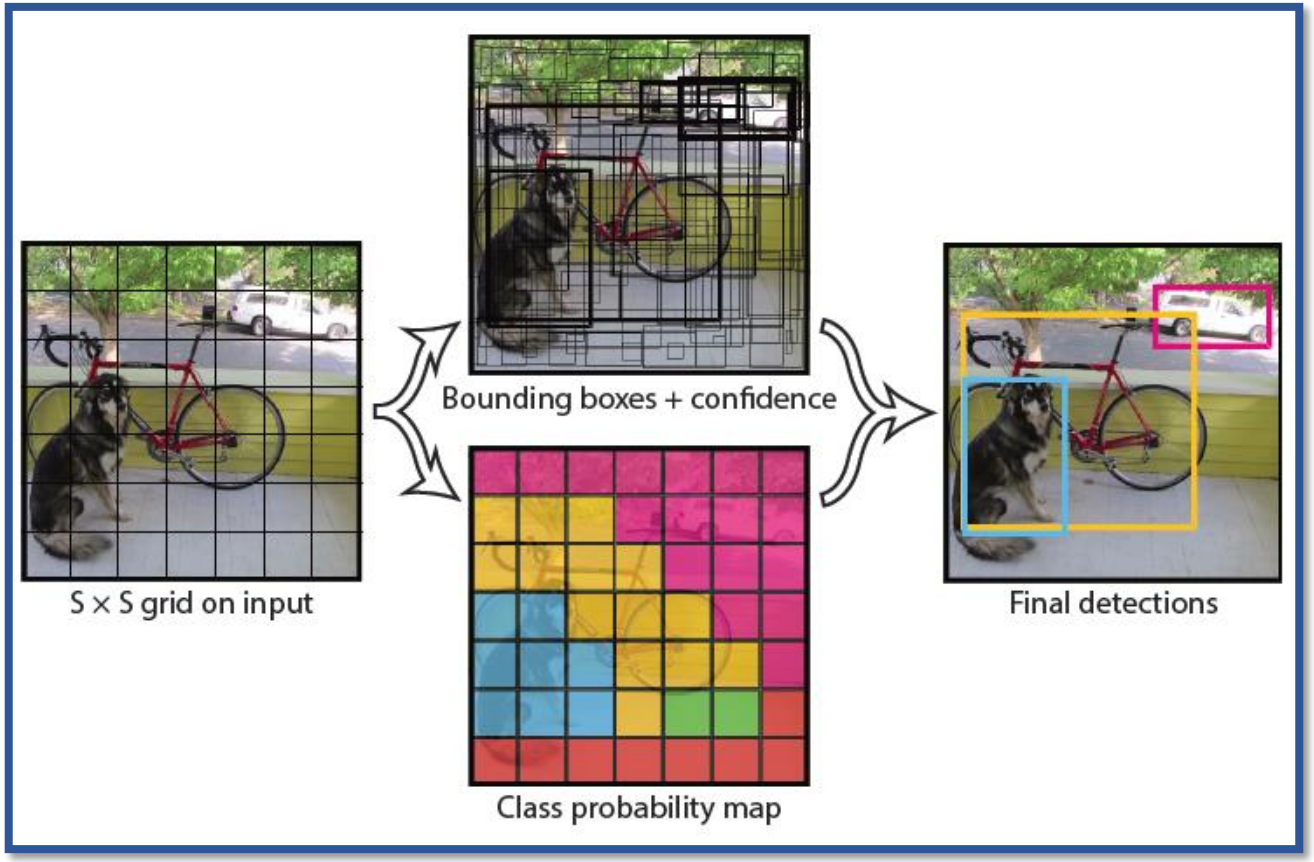
Results



Definition

- YOLO is a CNN that is applied one time on the image to detect objects and their size
- YOLO is faster than RNN and fast RNN

YOLO


Bounding boxes + confidence
S × S grid on input
Class probability map
Final detections

Choosing a Deep Learning Framework

- It is the framework built by the developer of YOLO and made specifically for YOLO
- Fast, can work with GPU or CPU
- Only works with Linux

Data Set

- Open Images Dataset is a good source for getting datasets

Implementation

- We will focus on the detection and results upon running the YOLO v3 based on the pre-trained weights of YOLO on the COCO dataset that is composed of 80 classes.
- After an image is taken, we import it into the pretrained YOLO network. The output of this network is an image that shows the bounding boxes around the detected object with its most probable class.
- The network also outputs the estimated distance of the obstacles which are going to be used as a reference to the control system.

Conclusion

- The system was studied
- MRAC and SMC were implemented
- YOLO algorithm was used to drive the system autonomously