Teaching AI for Control Engineers

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Course description and learning objectives

Academic year 2022 -2023 Fall term - Face to face

Master Students of the Control and Automation Ing. Department

Intelligent control is derived from conventional control, but is used to deal with complex processes that cannot be controlled by traditional methods.

It mainly has learning, adaptive and organizing function.

Objectives

- Learn the fundamentals behind intelligent control system design.
- Acquire skills in the latest technology trends and technical computing for modelling, design, and control with MATLAB/Simulink.
- Utilize computationally efficient tools to analyze practical considerations for both experimental and simulated systems.
- Engage in project-based learning to complete a specific project, and assess system performance.

Engineering-oriented analysis, Problem-solving, and Self-learning Skills

Course description

Intelligent Control Systems KOM5101	
1	Intro to intelligent control systems (knowledge-based vs data-driven systems)
2	Computational thinking tools
3	Dynamical systems modelling (Control System Toolbox could be used to transfer functions, state space models)
4	Intro to machine learning (including shallow neural nets) (Stats & Machine Learning Toolbox could be used)
5	Data-driven modeling -with machine learning (Stats & Machine Learning Toolbox could be used)
6	Data-driven modeling -with system Identification (SysID toolbox could be used)
7	Linear and nonlinear MPC (MPC Toolbox can be used)
8	Midterm Exam
9	Data-driven control techniques -Extremum seeking (Simulink Control Design could be used)
10	Data-driven control techniques -Model reference adaptive control (Simulink Control Design could be used)
11	Intro to deep learning (Deep Learning Toolbox could be used)
12	Reinforcement Learning (RL Toolbox could be used)
13	Students projects
14	Students projects
15	Final Exam

Data-driven modeling, data-driven methodologies and data-driven control

How MATLAB and Simulink were used in the course

- Oriented sections of about 3 hours per week with **theoretical work** in System Dynamics and Control, Matlab/Simulink examples.
- A presentation of the material with some **interactive live scripts** that guide our works and offer extra activities (ex. Lab Activities).
- Oriented lesson material that include videos, simulations and real-time experiments, **application-oriented!**

Engineering-oriented analysis, Problem-solving, and Self-learning Skills

How MATLAB and Simulink were used in the course

- Using a MATLAB or Simulink Course as an Assignments, **learning Onramp!**
- Engage in **project-based learning** to complete a specific project and assess system performance.
- All the students write a report and a make **presentation of their projects.**

Engineering-oriented analysis, Problem-solving, and Self-learning Skills

Reason for adoption MATLAB and Simulink

- Its high-level programming language and engineering development environment.
- It is optimized for easy prototyping with numeric computation, it includes engineering functions, add-on products, and toolboxes.
- It offers many options to analyse, visualize data, develop algorithms, and create mathematical models.
- Because of Simulink and Simsacape, as well as the multiple ready examples, academic support and the community behind.

Benefits / added value of using MATLAB and Simulink

Julia Mann née Hoerner · 1st

Managing Director at RWTH Center for AI

Experience: RWTH Center for Artificial Intelligence, MathWorks, and 4 more

Marco Rossi · 1st

Education Customer Success Engineer @MathWorks | PhD in...

Turin

2K followers

Melda Ulusoy · 1st

Senior Technical Marketing Manager at MathWorks

Boston, MA

Experience: MathWorks, Northeastern University, and 2 more

Academic support for INTELLIGENT CONTROL SYSTEMS

Benefits / added value of using MATLAB and Simulink

Control Design Onramp with Simulink

7 modules | 1 hour | Languages

Get started quickly with the basics of feedback control design in Simulink.

Machine Learning Onramp

6 modules | 2 hours | Languages

Learn the basics of practical machine learning methods for classification problems.

Deep Learning Onramp

5 modules | 2 hours | Languages

Get started quickly using deep learning methods to perform image recognition.

Reinforcement Learning Onramp

5 modules | 3 hours | Languages

Master the basics of creating intelligent controllers that learn from experience.

Benefits / added value of using MATLAB and Simulink

- 5G
- Artificial Intelligence
- Autonomous Vehicles
- Big Data
- Computer Vision
- Drones
- Industry 4.0
- Robotics
- Sustainability and Renewable Energy

MathWorks Excellence in Innovation Projects

Contribute to the progress of engineering and science by solving key industry challenges!

Inspiring projects based on industry trends. These projects help you learn about technology trends while becoming an important and valued contributor to the advancement of technical computing and Model-Based Design. Even more, you gain official recognition for your problem-solving skills from technology leaders at MathWorks.

https://github.com/mathworks/MathWorks-Excellence-in-Innovation

Benefits / added value of using MATLAB and Simulink

Internships of the Students

Benefits / added value of using MATLAB and Simulink

Fighter F-16 aircraft model
Swarm Coordination using Autopilot
Trajectory Planning and Obstacle Avoidance via Distributed Model Predictive Control

The successful application of Distributed Model Predictive Control (MPC) for tracking trajectories in a swarm of F-16 fixed-wing aircraft. It involves creating MPC-based trajectories for realistic fixed-wing aircraft, examining their movements in a swarm context, and ensuring obstacle avoidance.

Sadettin Balcan, Muhammed Çatı and Claudia F. Yaşar

Benefits / added value of using MATLAB and Simulink

MathWorks Minidrone Competition

Champions – First place!

MathWorks Minidrone Competition

Alper Makaraç and Enes Furkan Başlık

Results obtained and personal considerations

Results obtained and personal considerations

Certificates and toolboxes


BEST PROJECT

CERTIFICATE

Koray Muradoğlu

Participant Name

Coastline Prediction Using Existing Climate Change

Project

Intelligent Control System by Prof. Claudia Fernanda Yasar

Yildiz Teknik Universitesi

Dr.-Ing. Marco Rossi
MathWorks Academia Team

MathWorks

MPC with dual axis solar tracker using Matlab By Muntasser Mosleh

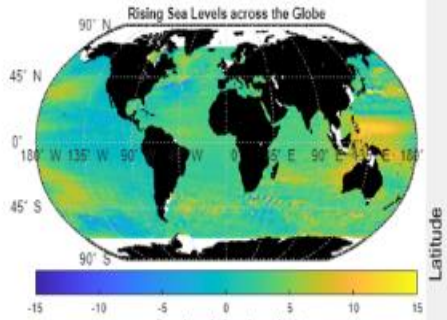
Coastline prediction using existing climate change By Berke Miraç And Koray Muradoğlu

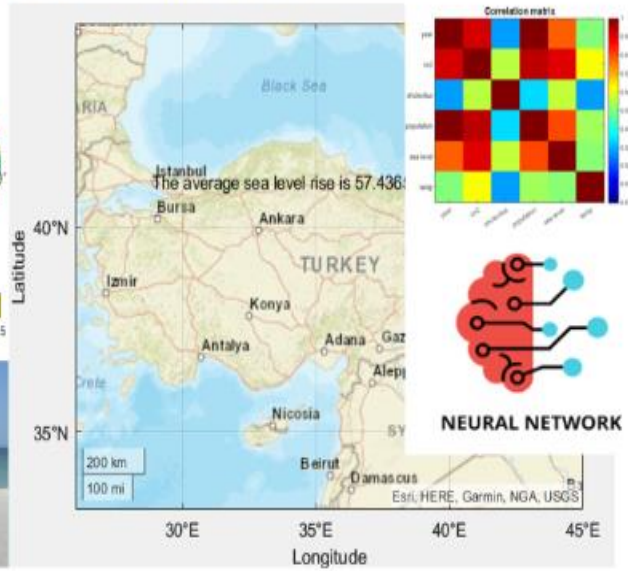
Inverted Pendulum Model Predictive Controller design By Ali Can Erdoğan

Results obtained and personal considerations

File Exchange

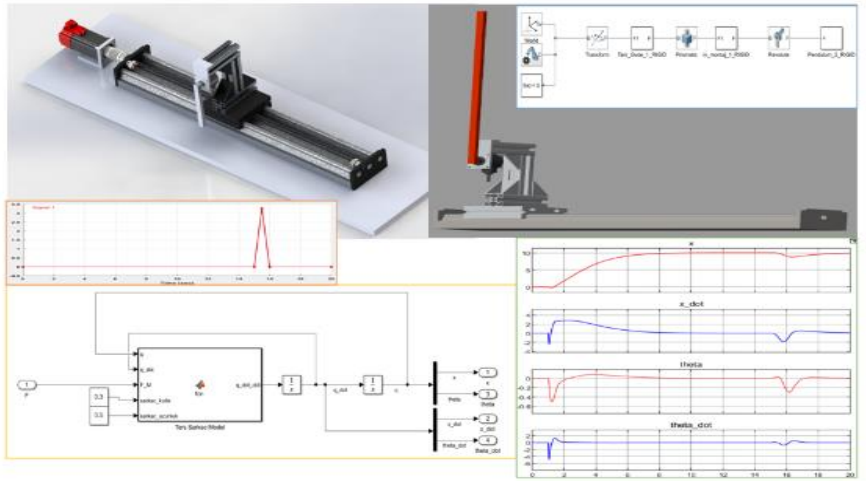
Coastline Prediction Using Climate Change Models



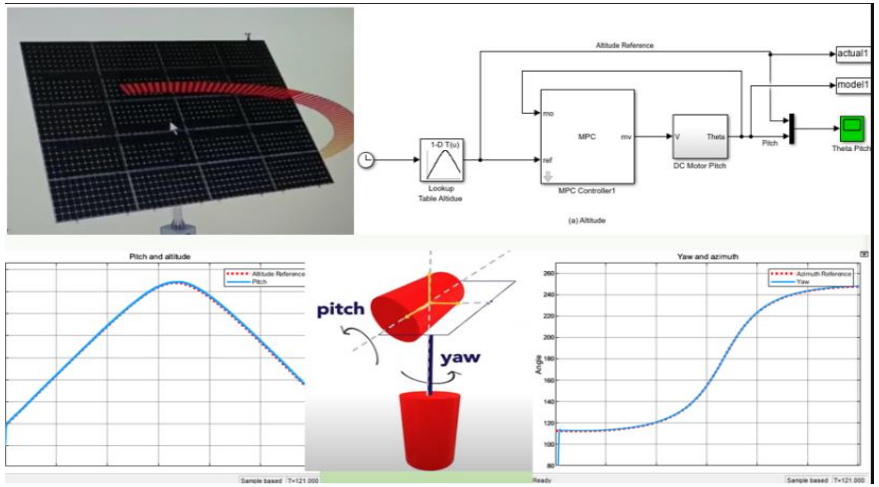


NEURAL NETWORK

INVERTED PENDULUM MODEL PREDICTIVE CONTROLLER DESIGN



MPC WITH DUAL AXIS SOLAR TRACKER USING MATLAB



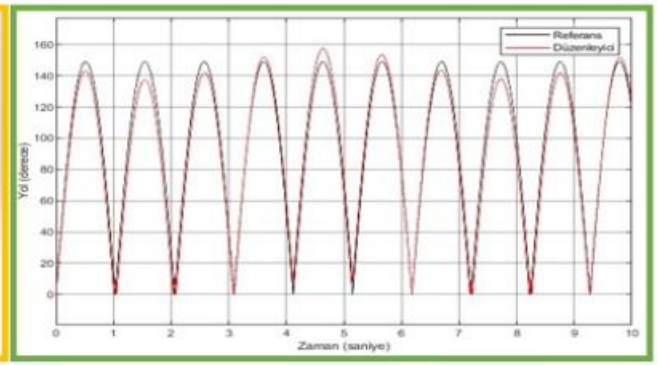
Results obtained and personal considerations

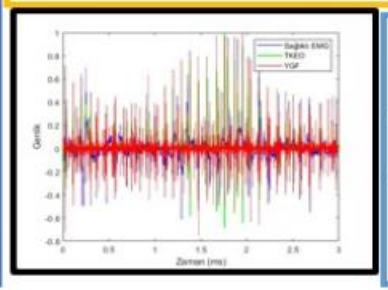
Papers

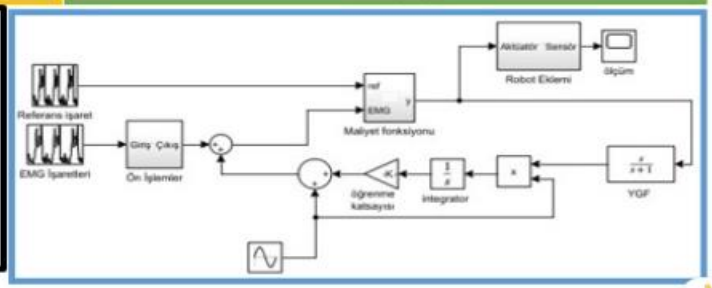
Happy to present the paper : Design of an Upper Limb Exoskeleton Controlled by Extremum Seeking Control Based EMG Signal Alteration. Ekstremum Arama Metodu Kullanılarak Düzeltilen EMG İşareti ile Kontrol Edilen Dış İskelet Robot Tasarımı

A big thanks goes to Berkem Vural

#TOK #IntelligentControlSystems #YTU #KOM #AutomationEngineering #StudentConference #MathWorks # **ExtremumSeeking**







Results obtained and personal considerations

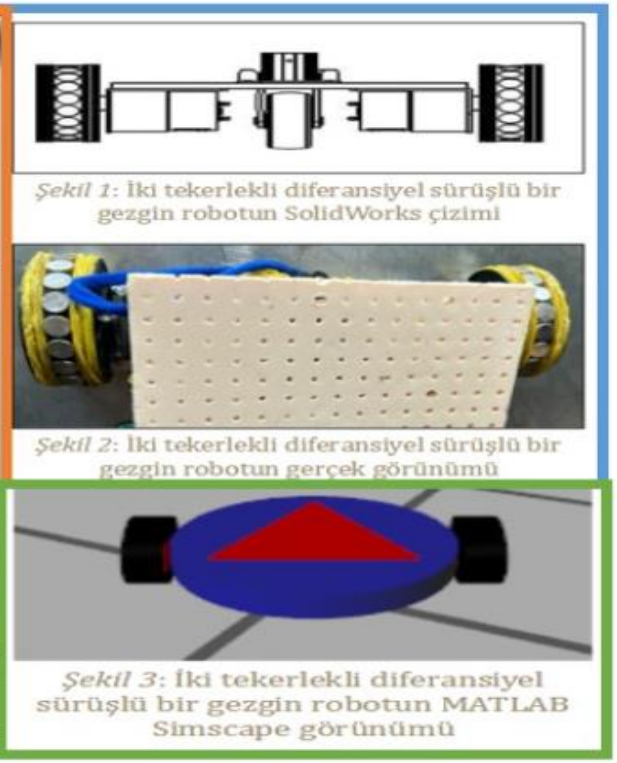
Papers

Happy to present the paper: Linear Model Predictive Speed Controller Design for a Two-Wheel Differential Drive Mobile Robot. İki Tekerlekli Diferansiyel Sürüşlü Bir Gezgin Robot için Doğrusal Model Öngörülü Hız Kontrolör Tasarımı

A big thanks goes to Hürcan Samet ÇAKIR and Buse TACAL UCUN

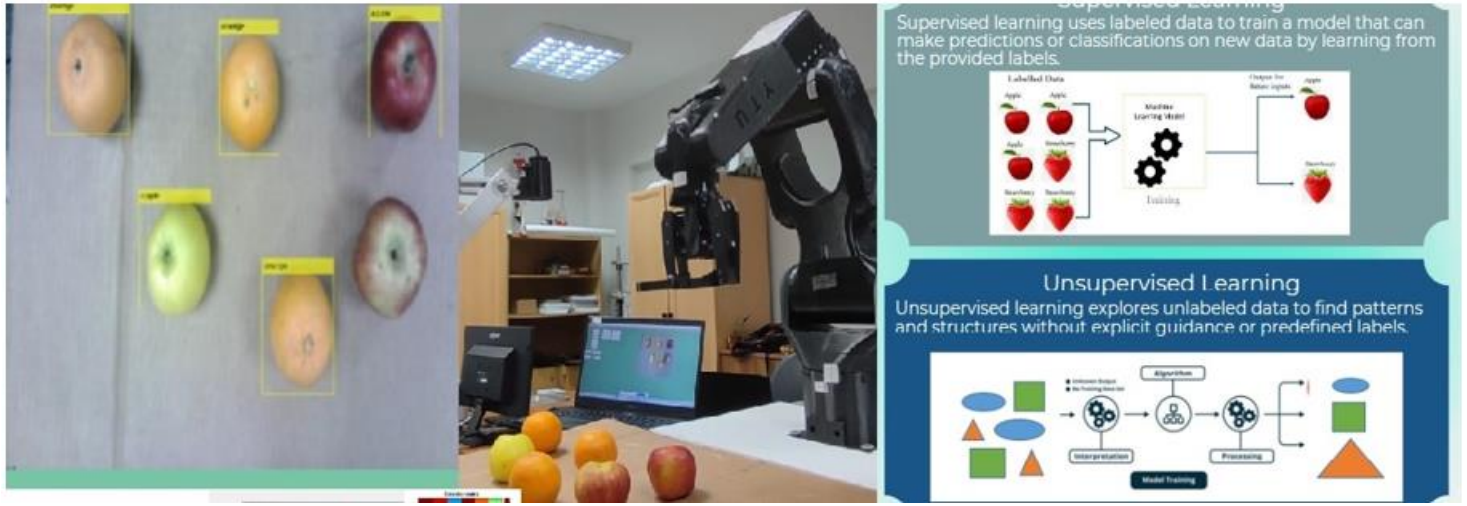
#TOK #IntelligentControlSystems #YTU #KOM #AutomationEngineering #StudentConference #MathWorks #MPC

https://lnkd.in/dcFRFunW



Results obtained and personal considerations

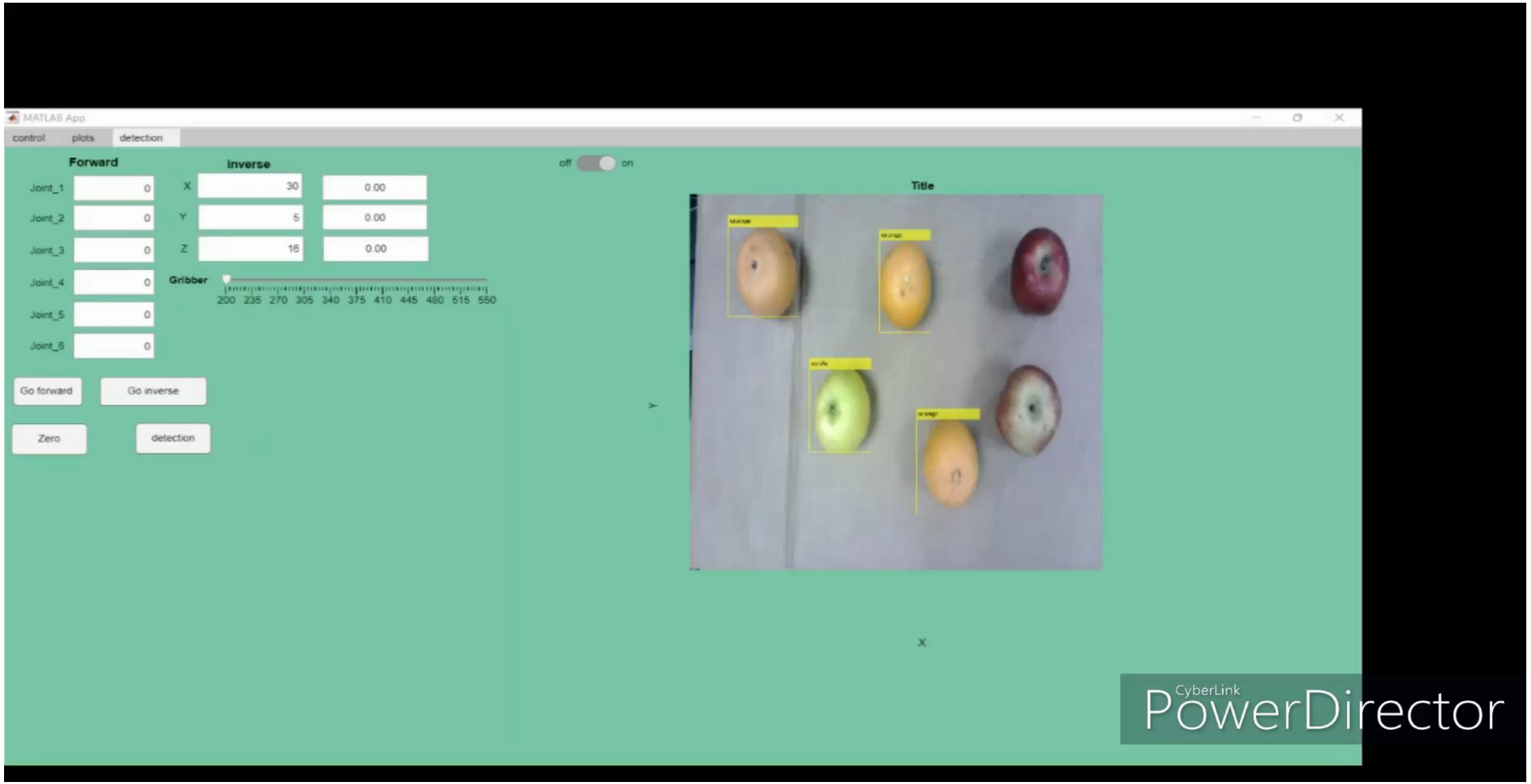
Papers in process…



Deep Learning Implementation In Robotics By Abderraouf Ziraoui, Ahmed Alhaj Jned, And Mohamed Khaled Gamal Ali Mohamed

An Optimized Deep Learning Approach for Forecasting Temperature By Çağatay Berke BOZLAK

Results obtained and personal considerations



Future plans

Introduction to Intelligent Control Systems enhanced with

Webinars + Material to Download
Online Trainings, MATLAB Apps, Tools beneficial for Online learning and Real-time Experiments

Thank you

Q&A – 5min

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