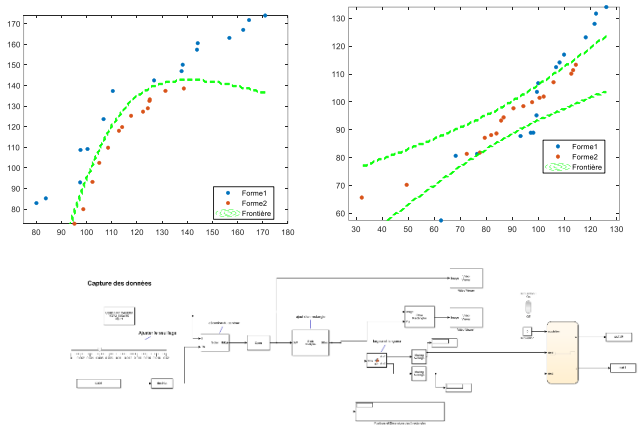
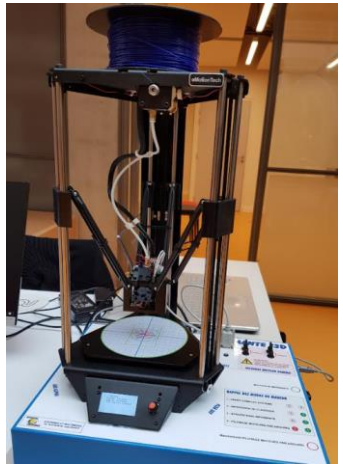
L’Intelligence Artificielle avec MATLAB/Simulink





ICSTEng
international conference on sciences & technology for engineering / an event
UPSTI

Ascension Vizinho-Coutry, avizinho@mathworks.com

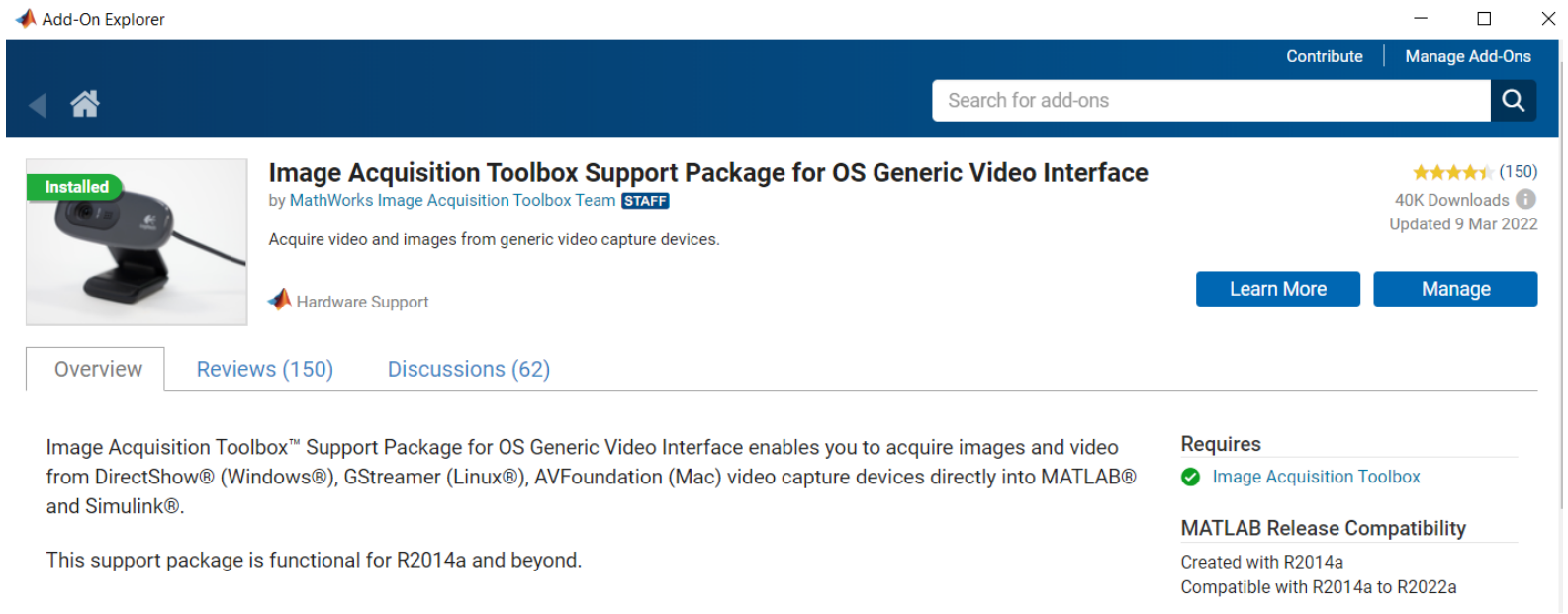
MathWorks®
Accelerating the pace of engineering and science

DIDASTEL PROVENCE

Required products and add-ons for the workshop

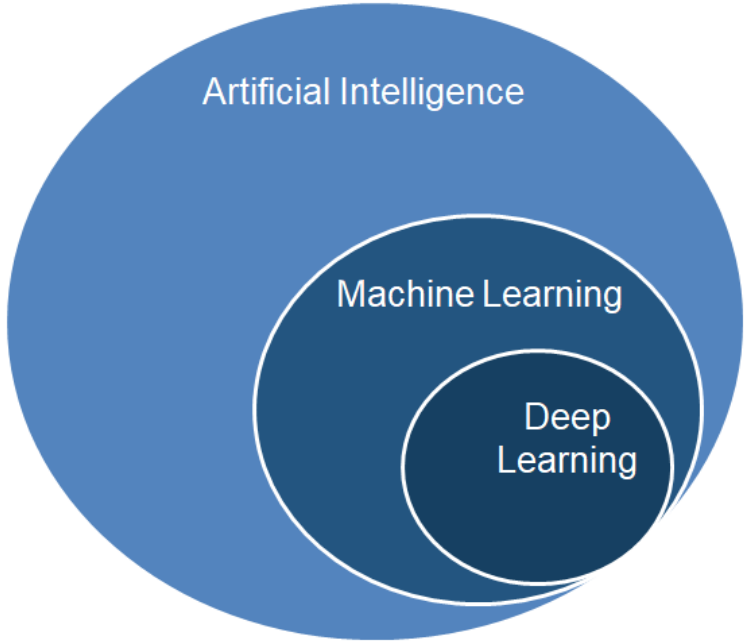
- MATLAB, Simulink, Stateflow
- Instrument & Control
- Image Acquisition, Image, Computer Vision
- Statistics & Machine Learning
- Signal Processing, DSP System

+



Artificial Intelligence

Ability to learn from data without being explicitly programmed



Automotive

Off-highway vehicles

Aeronautics

Retail

Finance

Healthcare

Internet

Industrial Automation

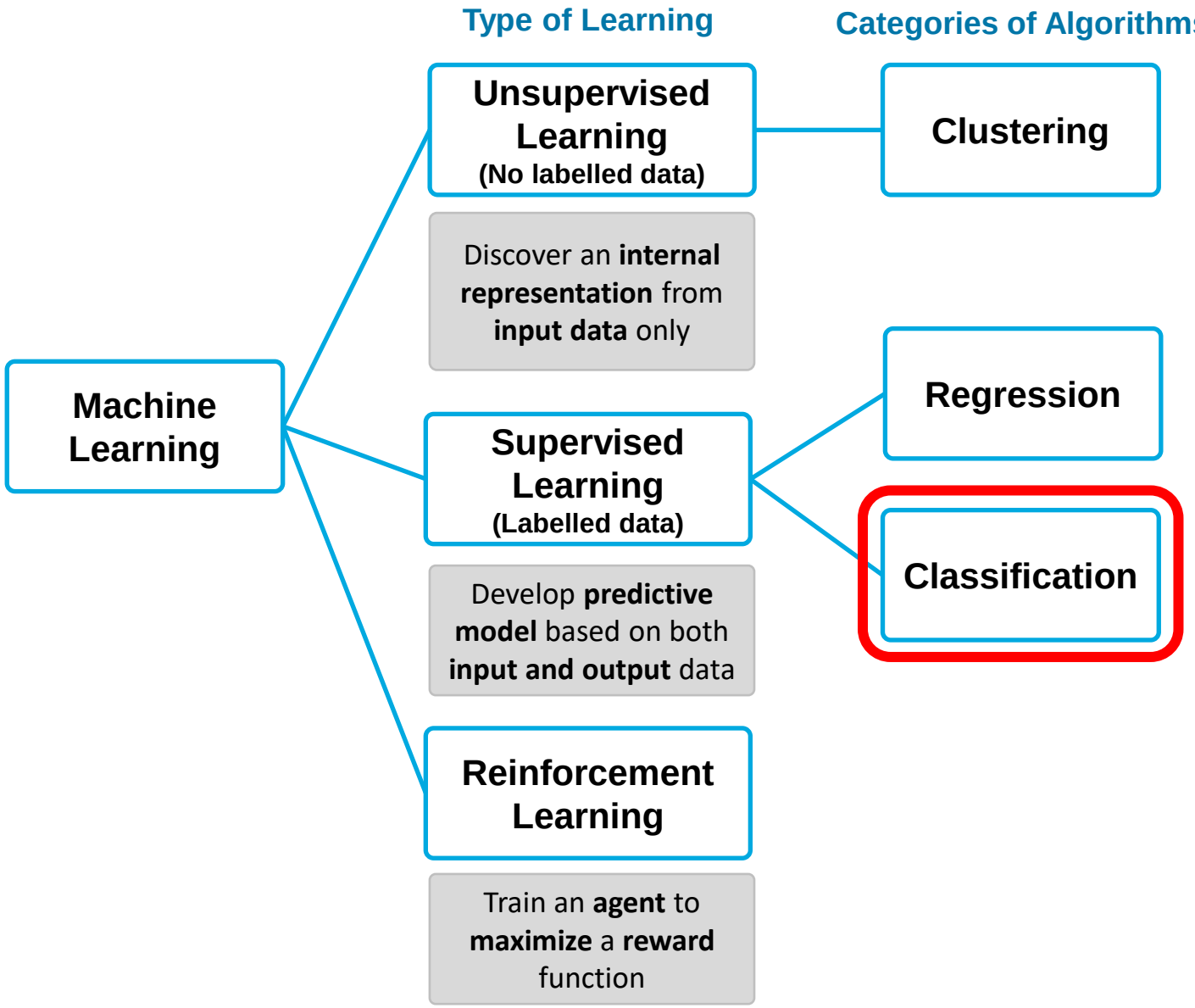
Oil & Gas

Medical Devices

Clean Energy

https://eduscol.education.fr/sti/ressources_techniques/introduction-lapprentissage-automatique-machine-learning-philippe-hautcoeur

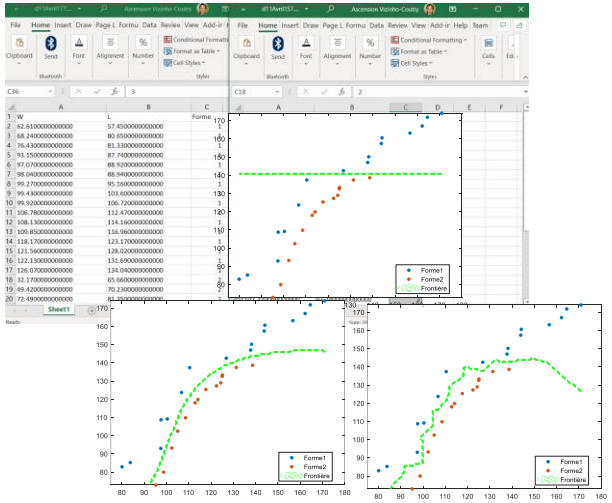
Types of Machine Learning / Simple Demo Case

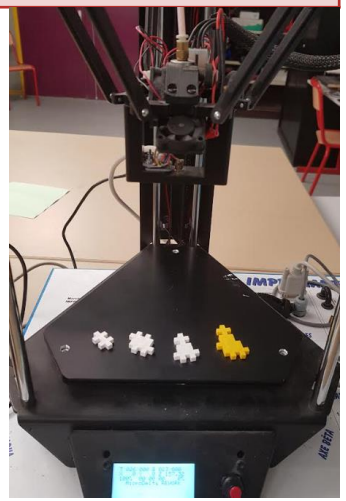


Objective:

Train different classifiers to classify 2 objects from the mini-camera and embed the model in Simulink

Inputs	Grayscale images acquired from the mini-camera
Outputs	Object types *(1 or 2)*





Data Analytics Workflow

Access and Explore Data

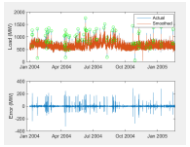
- **Files**

- **Databases**

- **Sensors**

Preprocess Data

- **Working with Messy Data**



- **Data Reduction/ Transformation**

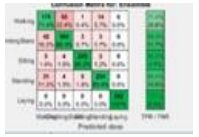
- **Feature Extraction**

Develop Predictive Models

- **Model Creation e.g. Machine Learning**

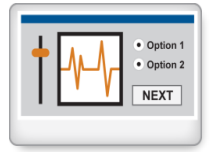
- **Parameter Optimization**

- **Model Validation**



Integrate Analytics with Systems

- **Desktop Apps**



- **Enterprise Scale Systems**

MATLAB Excel .NET .exe C/C++ Java .dll

- **Embedded Devices and Hardware**

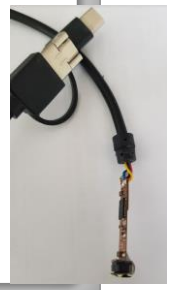
Smoothie and mini-camera

Access and Explore Data

Files

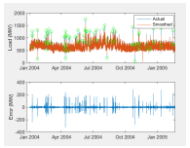
Databases

Sensors



Preprocess Data

Working with Messy Data



Data Reduction/ Transformation

Feature Extraction

Develop Predictive Models

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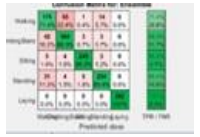
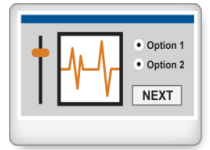
Parameter Optimization

Model Validation



Integrate Analytics with Systems

Desktop Apps

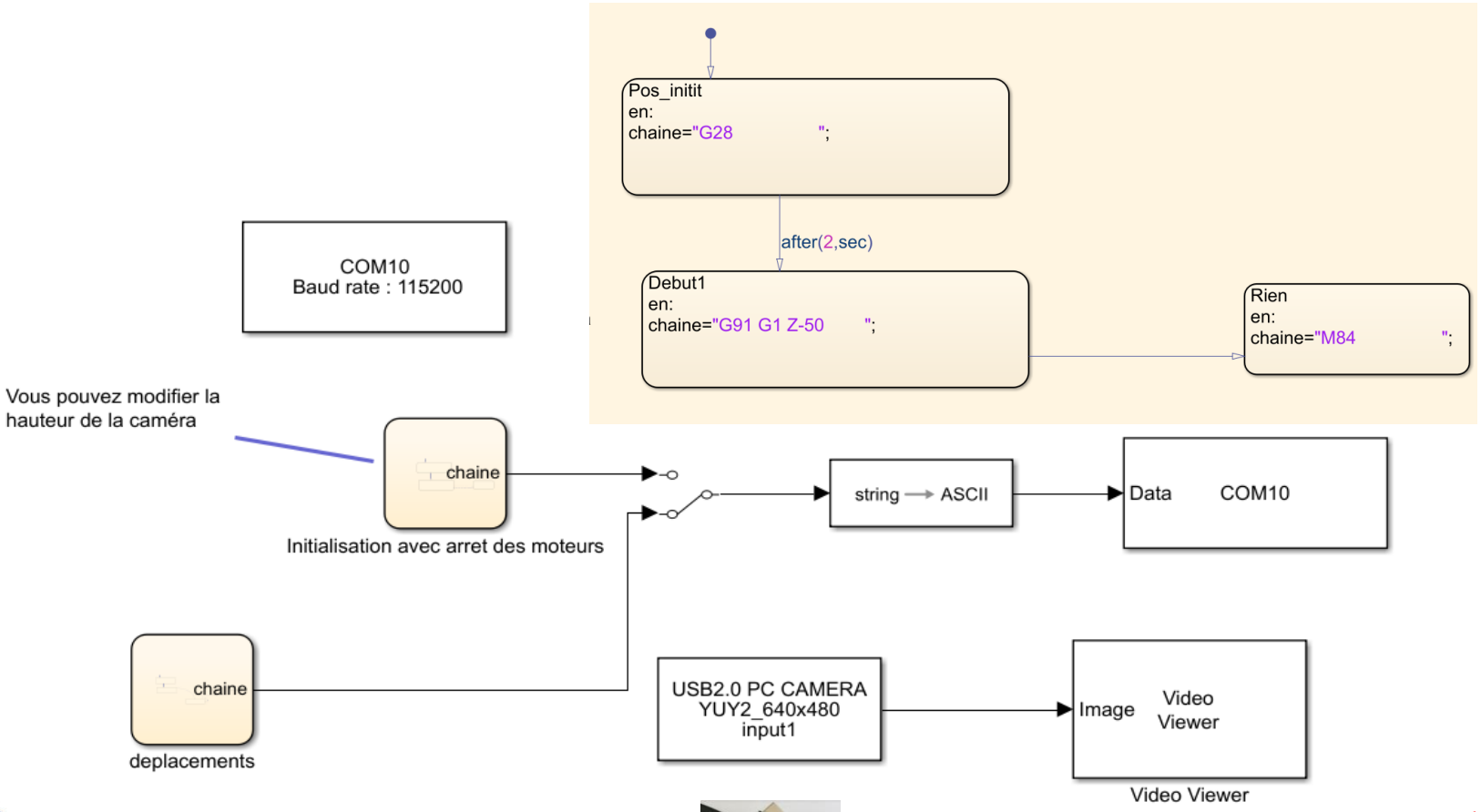


Enterprise Scale Systems

MATLAB Excel .NET C/C++ .exe Java .dll

Embedded Devices and Hardware

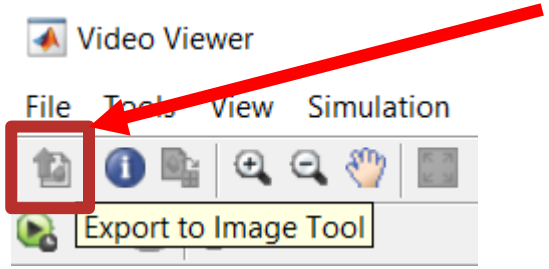
Smoothie and mini-camera



G-code commands:
G28: initiate motors and position of the camera
M84: stop motors
G91 G1 Z-50: move of 157.32mm in Z axis

X and Y mesures in mm:
Use Image Tool

Connexion_smoothie_captures.slx



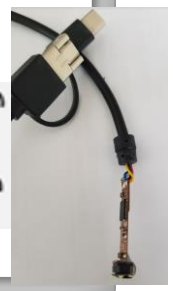
Feature extraction

Access and Explore Data

Files

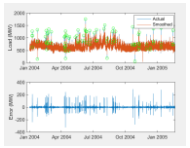
Databases

Sensors



Preprocess Data

Working with Messy Data



Data Reduction/ Transformation

Feature Extraction

Develop Predictive Models

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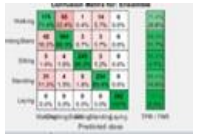
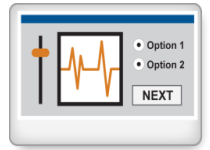


Integrate Analytics with Systems

Desktop Apps



Enterprise Scale Systems

MATLAB Excel .NET C/C++ .exe Java .dll

Embedded Devices and Hardware

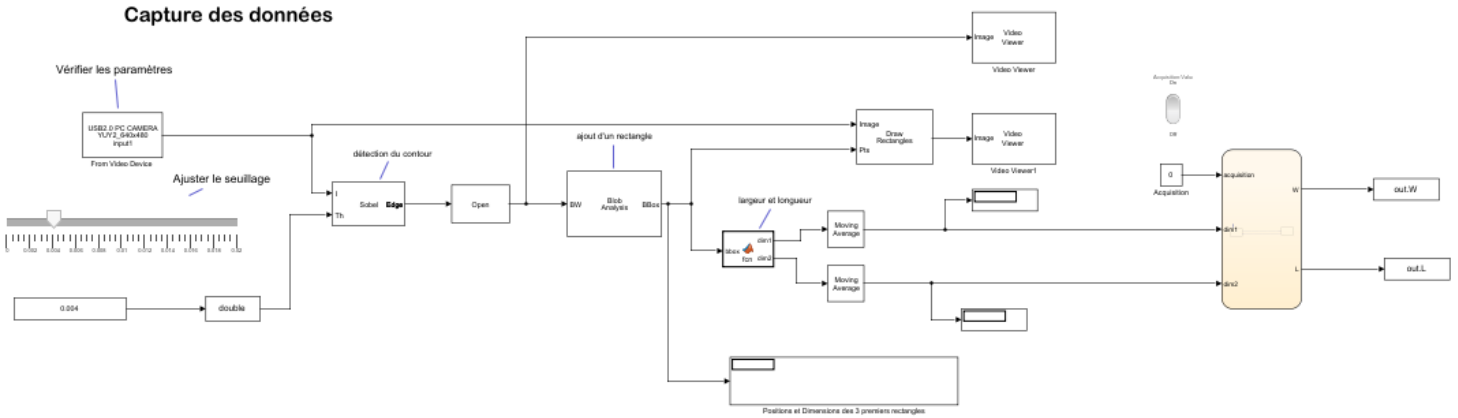
Feature extraction

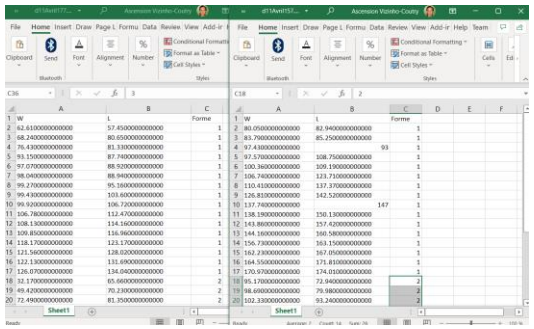
1- Sobel1.slx or Sobel11.slx

We use a **Sobel detection** with multiple choices for extracting the features.
The mesures are exported in the MATLAB workspace, variable « out ».
A Stateflow chart was added to stop or start the acquisition in order to move the object on the plate and avoid outliers.

2- Excel file creation:

Exécute the MATLAB script clean_data.m to eliminate redundant data.
Copy the numerical vaules in an excel spreadsheet containing 3 colomns (ex: Width, Length, Label)

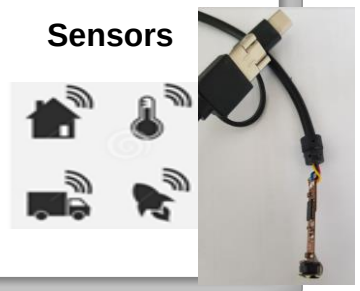




Machine Learning: Classification

Access and Explore Data

- Files
- Databases
- Sensors



Preprocess Data

- Working with Messy Data
- Data Reduction/ Transformation
- Feature Extraction

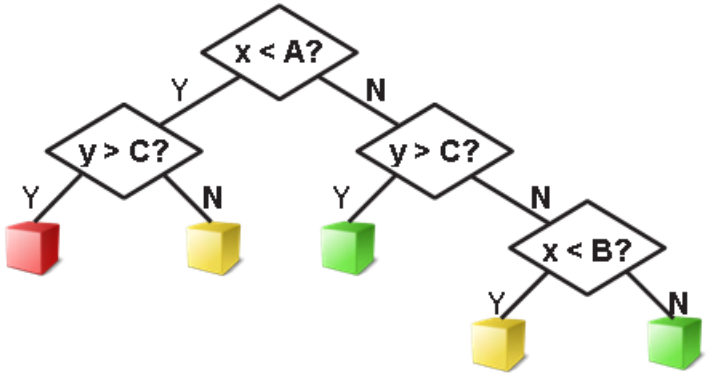
Develop Predictive Models

- Model Creation e.g. Machine Learning
- Parameter Optimization
- Model Validation

Integrate Analytics with Systems

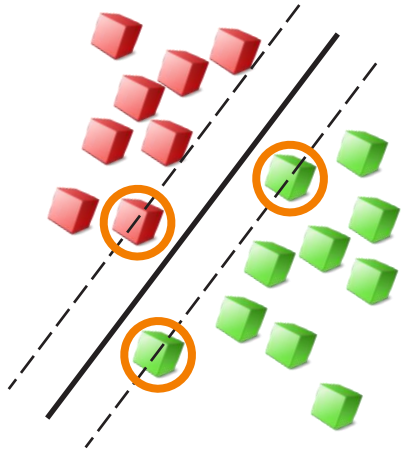
- Desktop Apps
- Enterprise Scale Systems
- Embedded Devices and Hardware

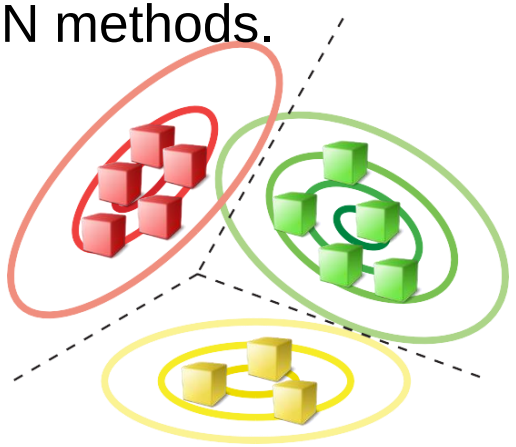
Machine Learning: Classification



Study of Fine Tree, SVM and KNN methods

1- Import the data from the existing Excel Spreadsheets.
2- Use of the Classification Learner App to compare Fine Tree, SVM and KNN methods.





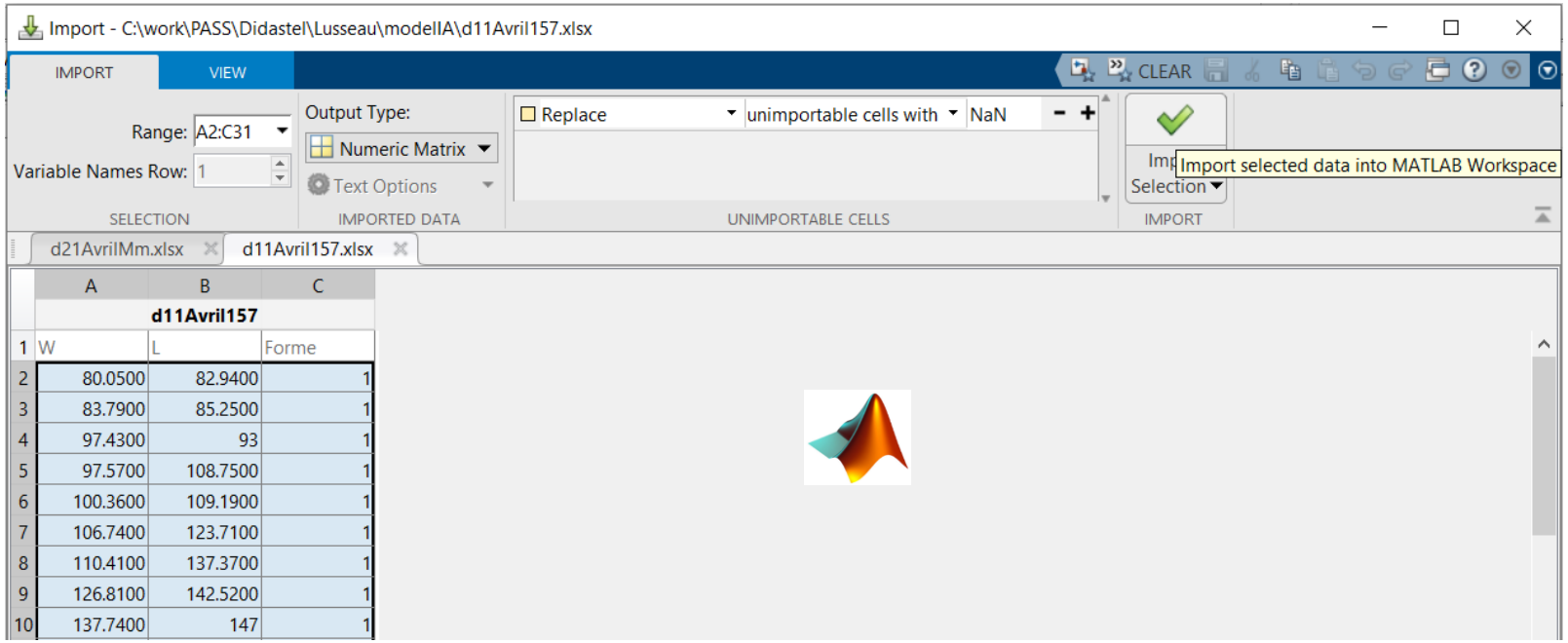
Classification: import the data

Import the data

1- Click twice on the Excel file d11Avril157.slx (the height of the camera was fixed at 157.32 mm.

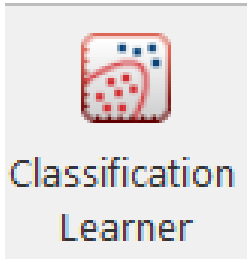
2- For the Output Type, select Numeric Matrix.

3- Click on the import selection button. It creates a new matrix d11Avril157 in the MATLAB Workspace.

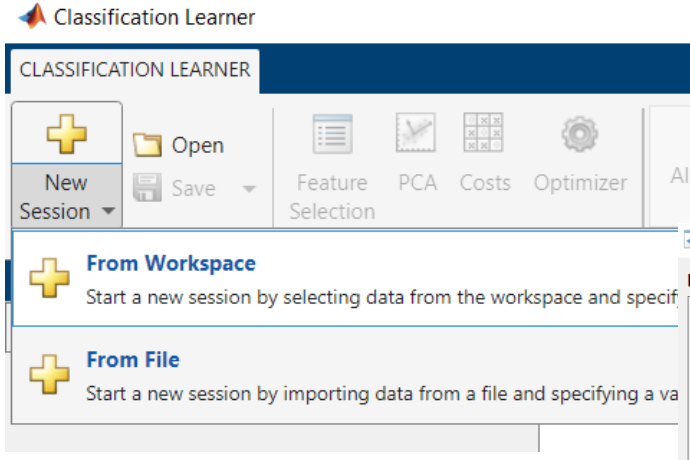


Classification Learner

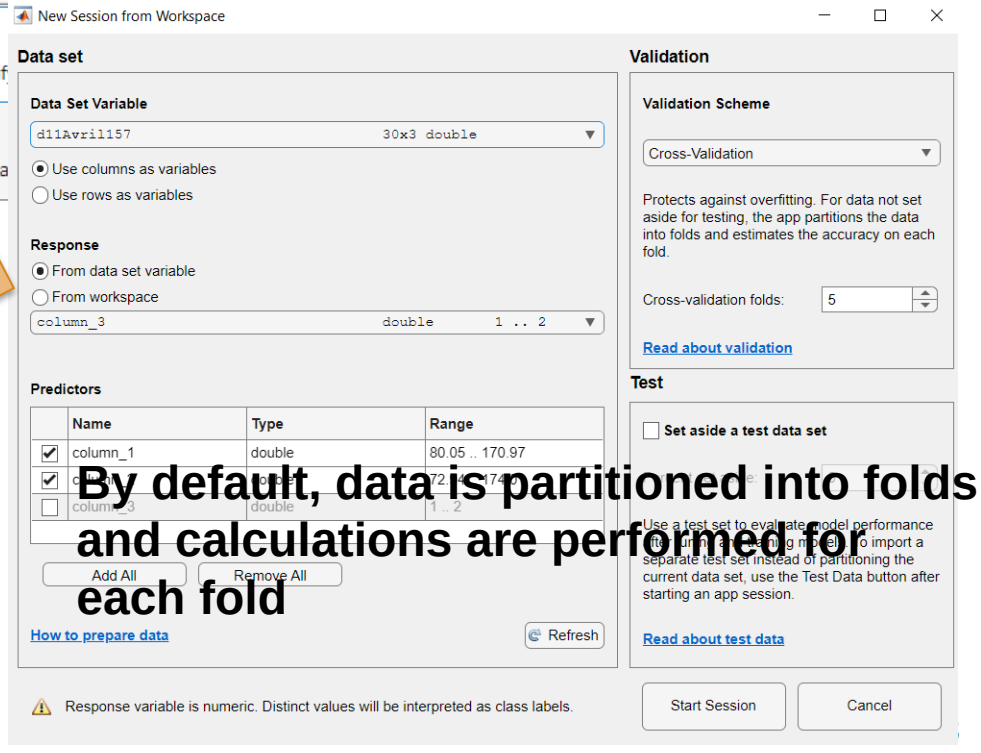
1. Choose Classification Learner from APP gallery



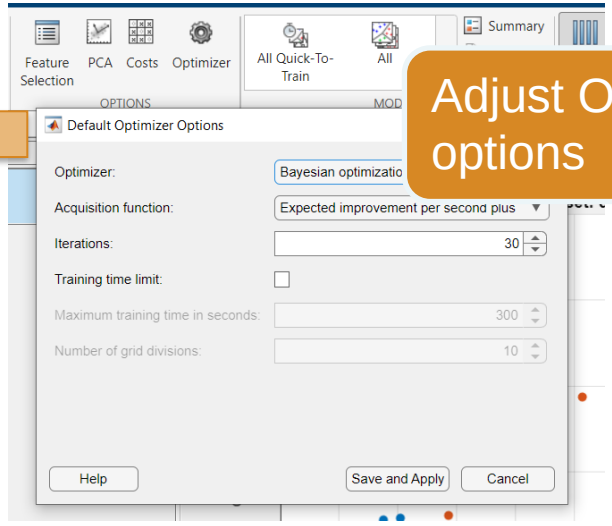
2. Select a New session From Workspace



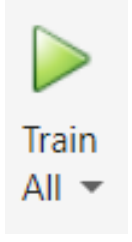
3. Data set preparation and start session



Adjust Optimizer options



Click on Train button

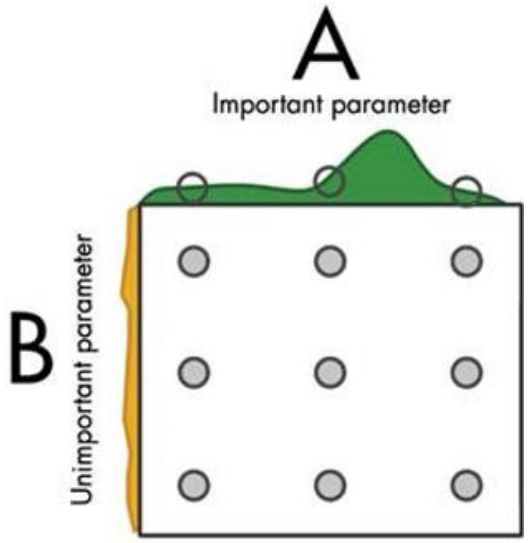


By default, data is partitioned into folds and calculations are performed for each fold

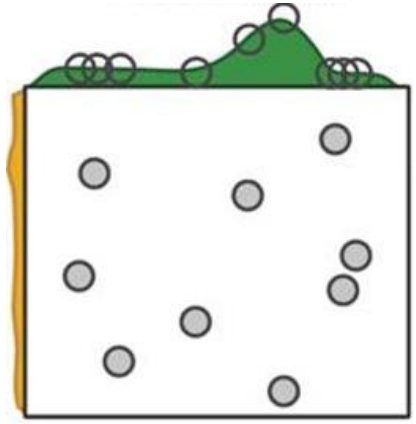
Hyperparameter Tuning

Why? – Model "knobs" (hyperparameters) need to be set properly for optimal performance

Standard:
Grid Search

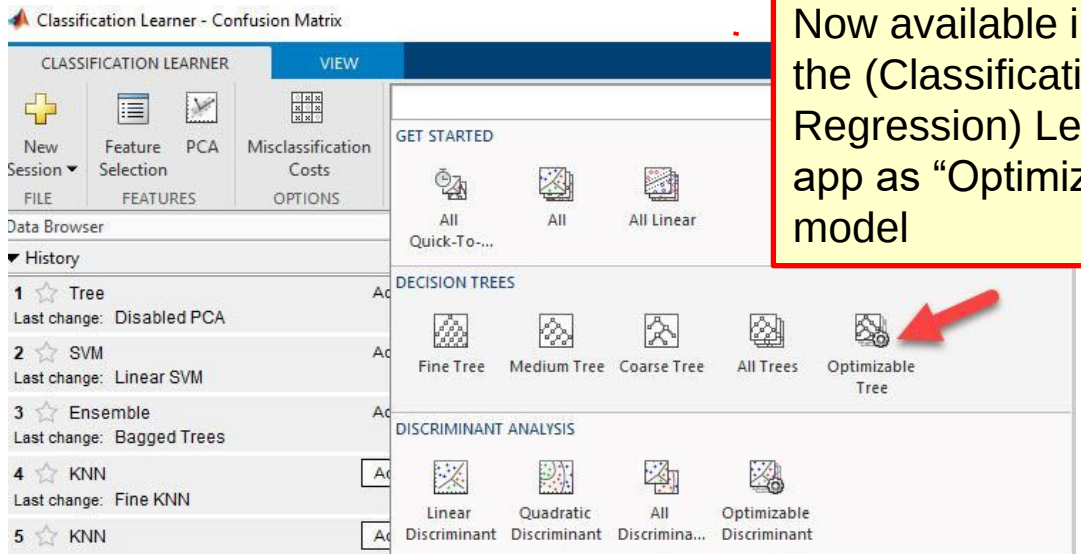


Better:
Random Search



Best: Bayesian Optimization

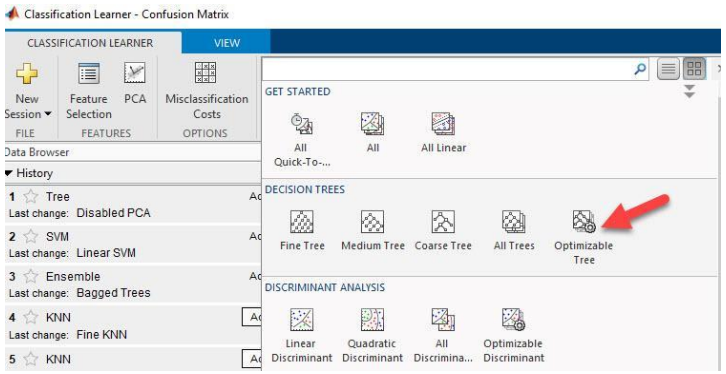
- Bayesian model indicates impact of change
- Model picks "good" point to try next
- Much more efficient!
- Scale to multi-cores (using PCT) for larger datasets



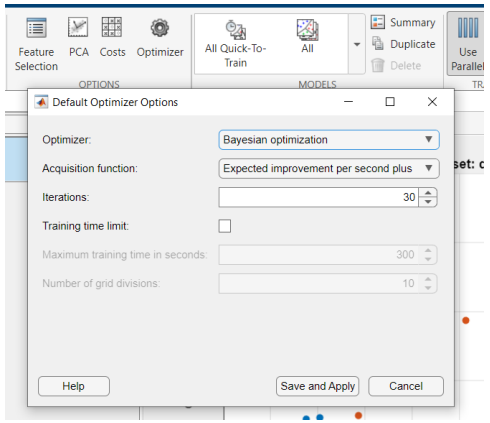
Now available inside the (Classification/ Regression) Learner app as "Optimizable" model

Hyperparameter Tuning Workflow inside Learner Apps

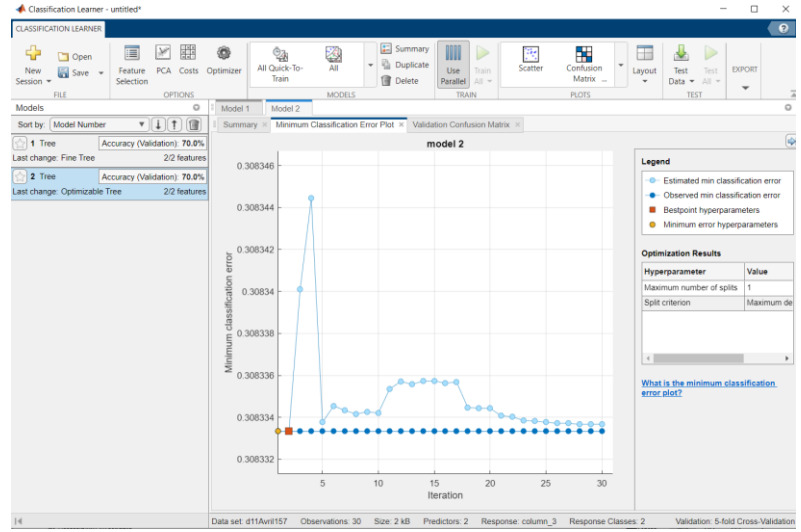
1. Choose “Optimizable” model from gallery



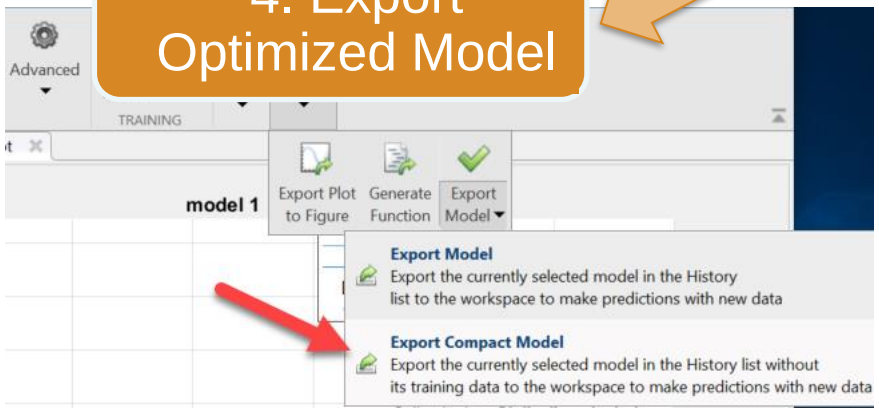
2. Adjust Optimizer Options (control runtime!)



3. “Train”: Bayesian Optimization iterates

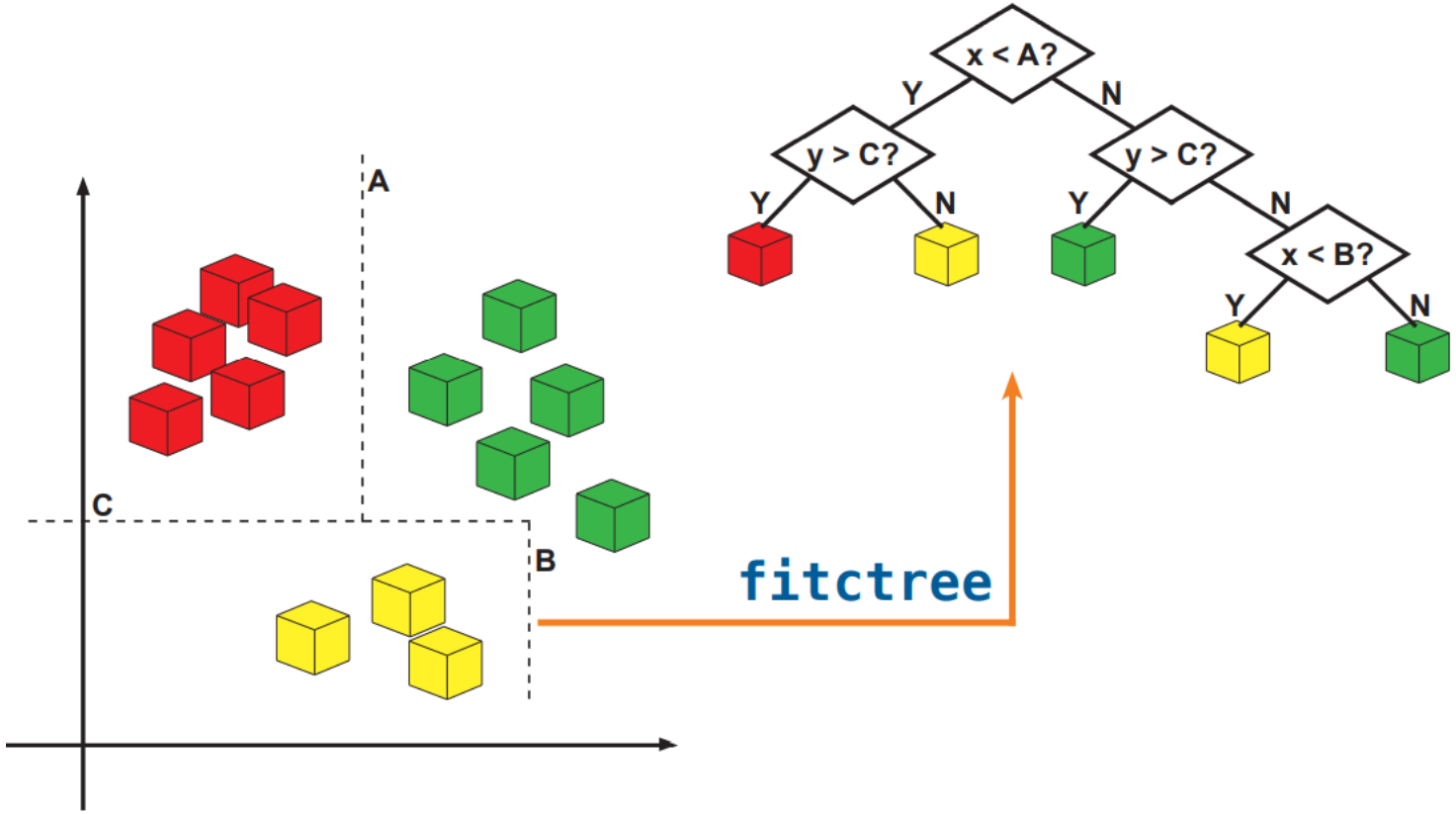


4. Export Optimized Model



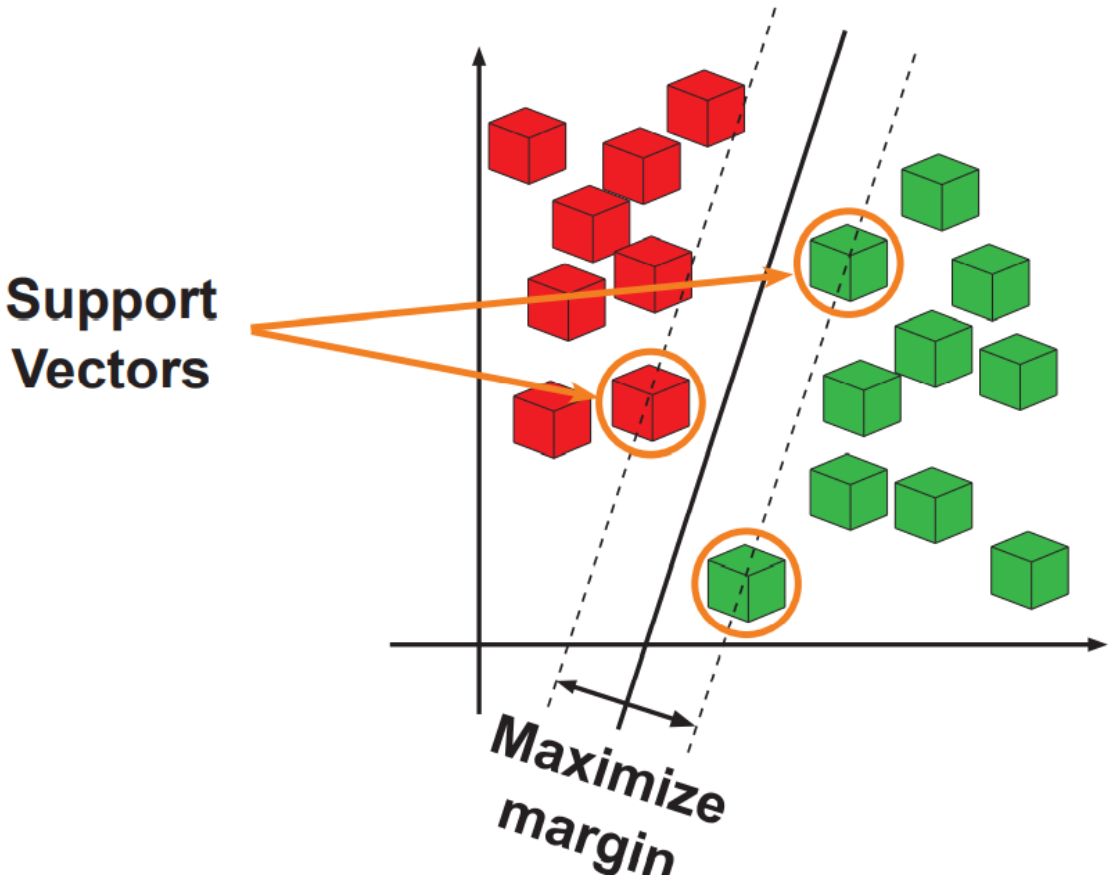
5. Iterate with other data OR Prepare for Integration

Decision Tree Classification



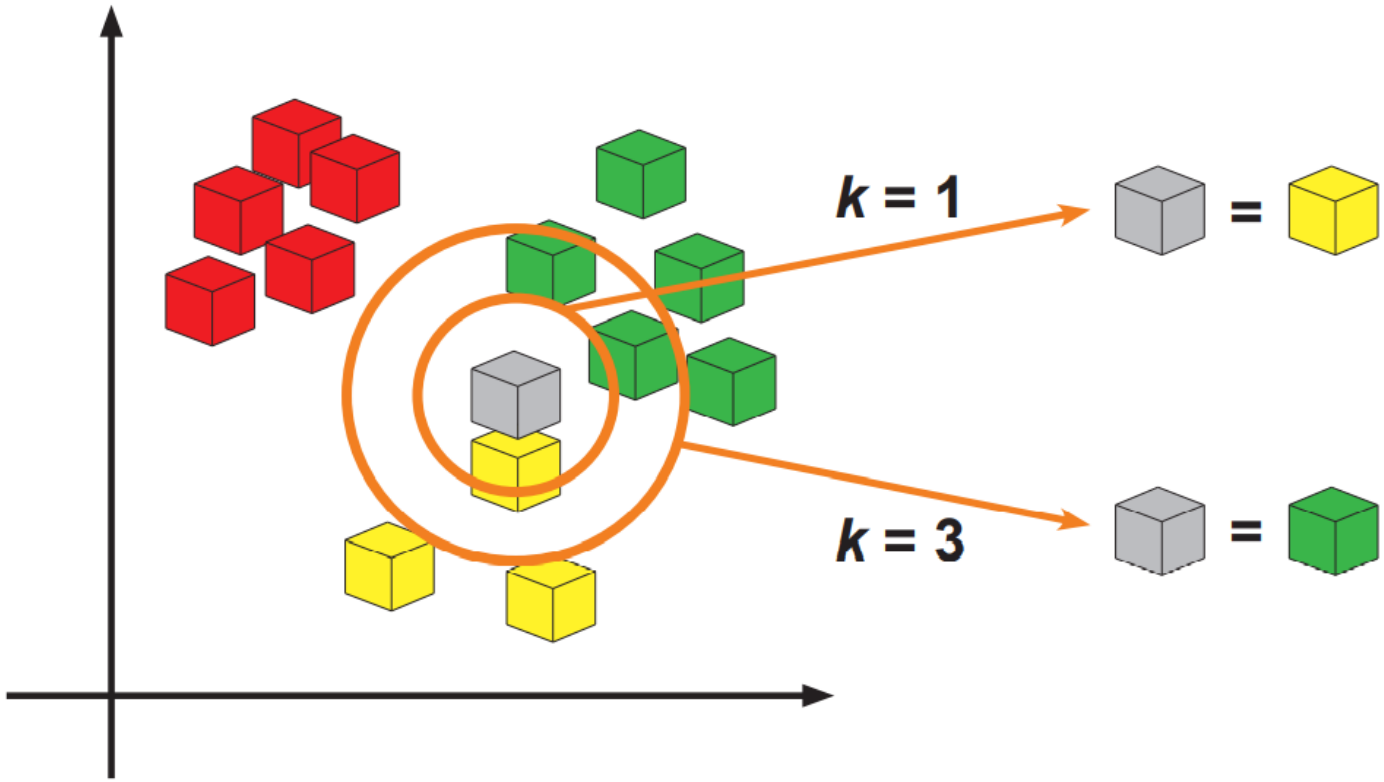
When the model is exported:
>> view(trainedModelTree.ClassificationTree)
>> view(trainedModelTree.ClassificationTree,'Mode','graph')

Support Vectors Machine Classification



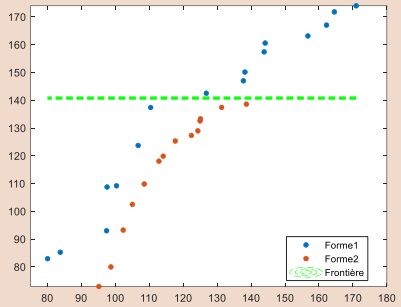
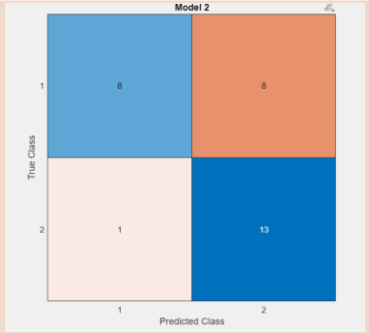
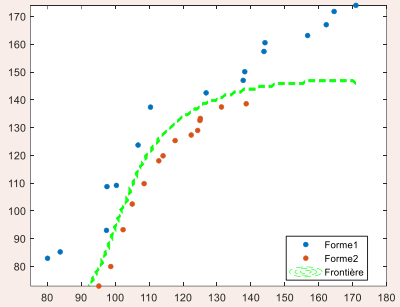
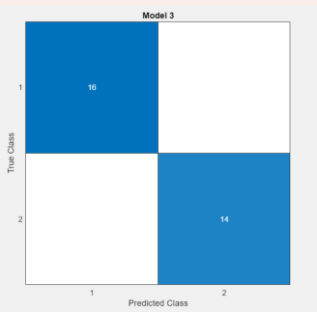
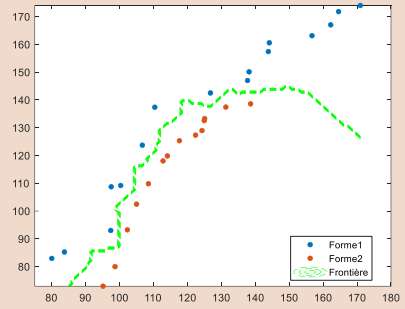
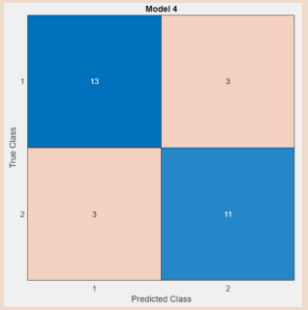
https://fr.mathworks.com/help/stats/support-vector-machines-for-binary-classification.html
https://fr.mathworks.com/discovery/support-vector-machine.html

K- Nearest Neighbor Classification



https://fr.mathworks.com/help/stats/classification-using-nearest-neighbors.html

Results

Method	Border	Confusion Matrix
Optimizable Tree Accuracy 70%		
Optimizable SVM Accuracy 100%		
Optimizable KNN Accuracy 80%		

Test different position of the camera, feature extractions and other objects

1- Camera position:
Apply the same Classification workflow with other data such as d11Avril177.xlsx
What do you conclude?
2- Other features with ++ Basic mix objects
Excel files: d21AvrilMm.xlsx
d21AvrilMm177.xlsx
3- Try with your own objects

Data Analytics Workflow

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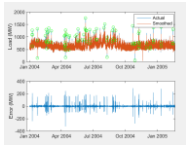
Sensors

Preprocess Data

Working with Messy Data



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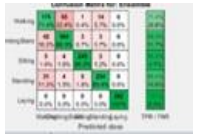
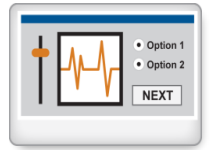
Parameter Optimization

Model Validation



Integrate Analytics with Systems

Desktop Apps



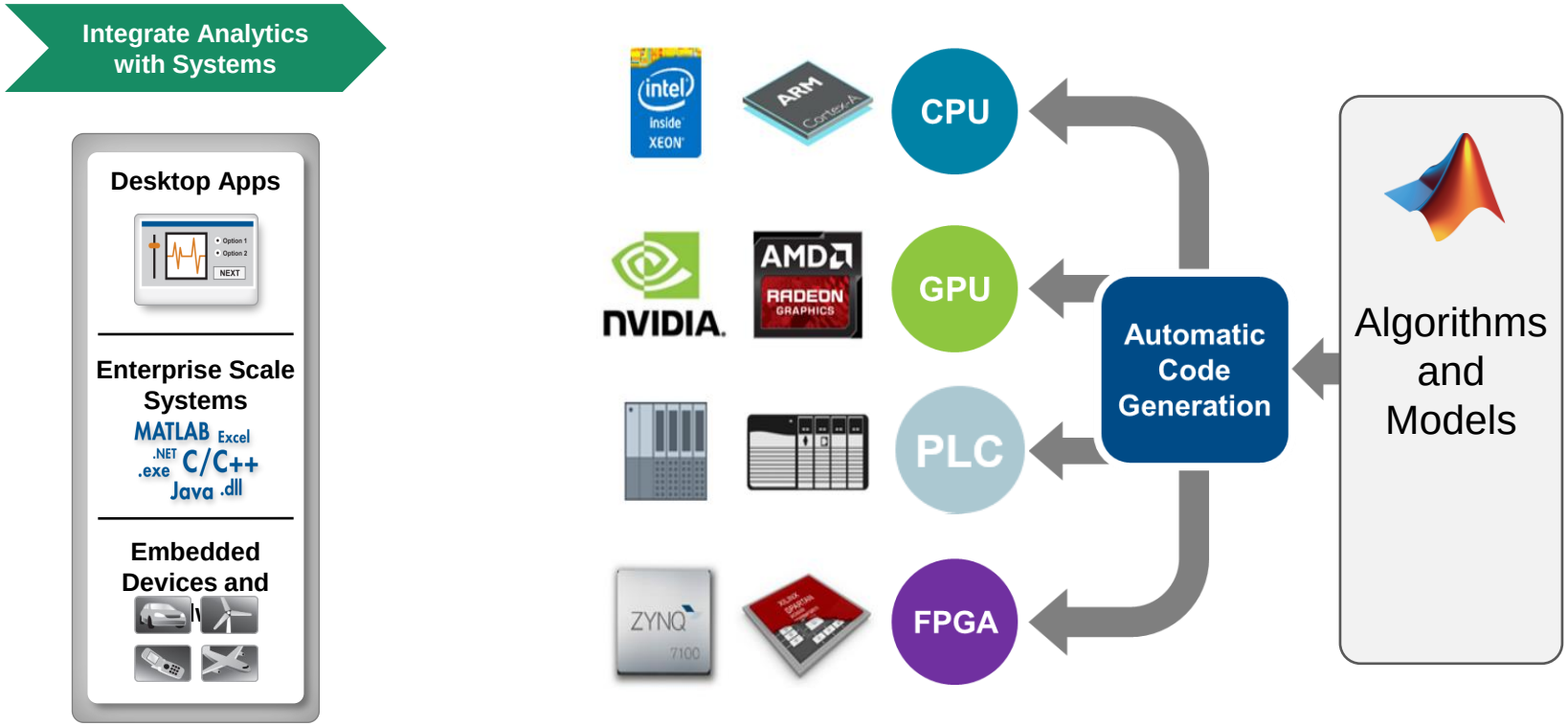
Enterprise Scale Systems

MATLAB Excel .NET C/C++ .exe Java .dll

Embedded Devices and Hardware

Deploy to Enterprise Infrastructure or Embedded Systems

AI models in MATLAB and Simulink can be deployed on enterprise systems or the cloud, or on embedded devices.



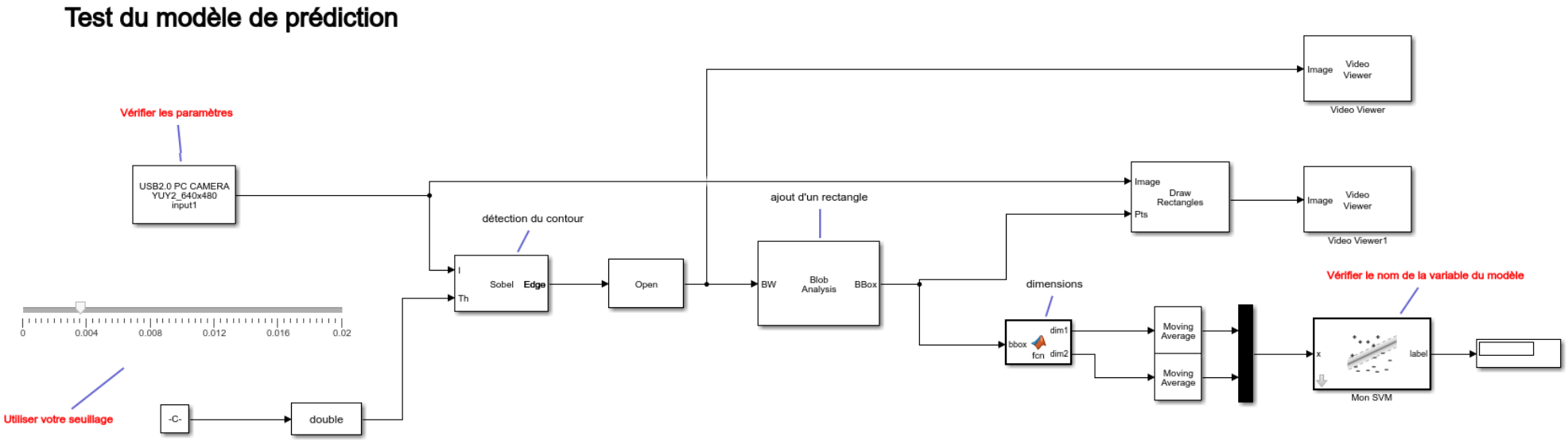
Prepare the deployment with Simulink

1- Open Sobel2.slx

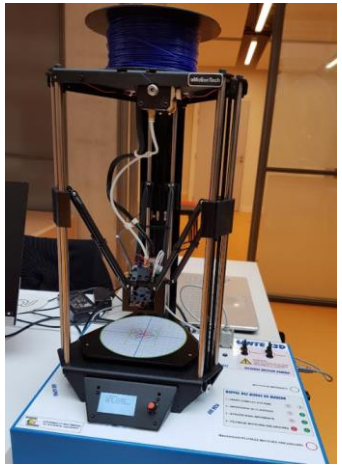
Change the SVM model name in the Classification SVM block

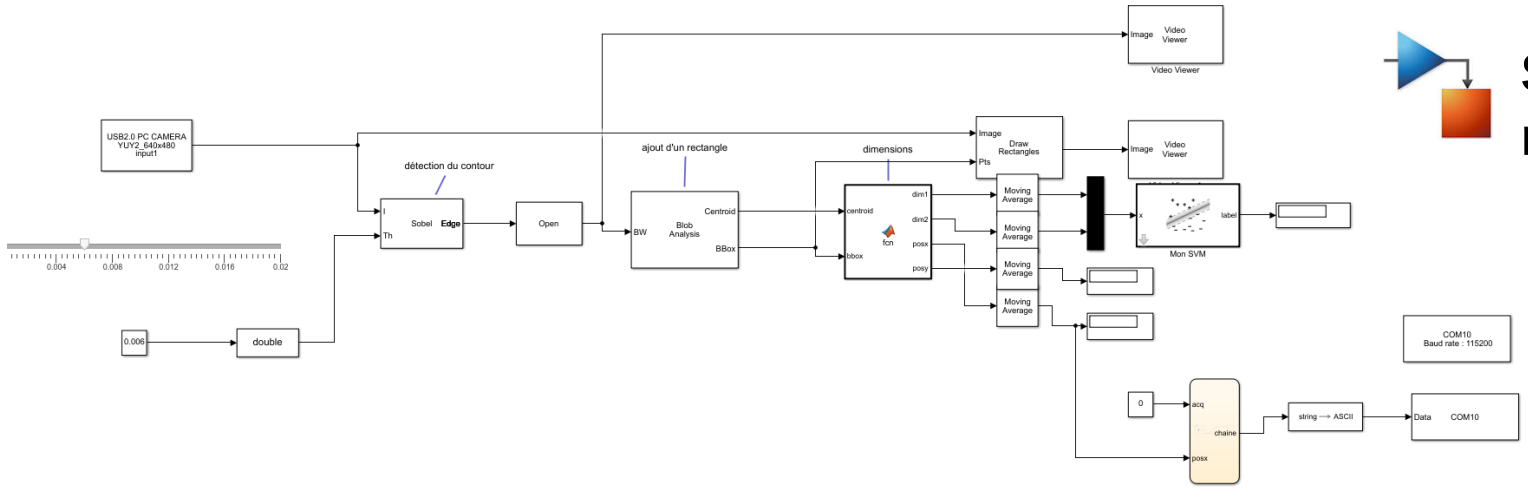
2- Verify the settings (camera, threshold)

3- Run the model

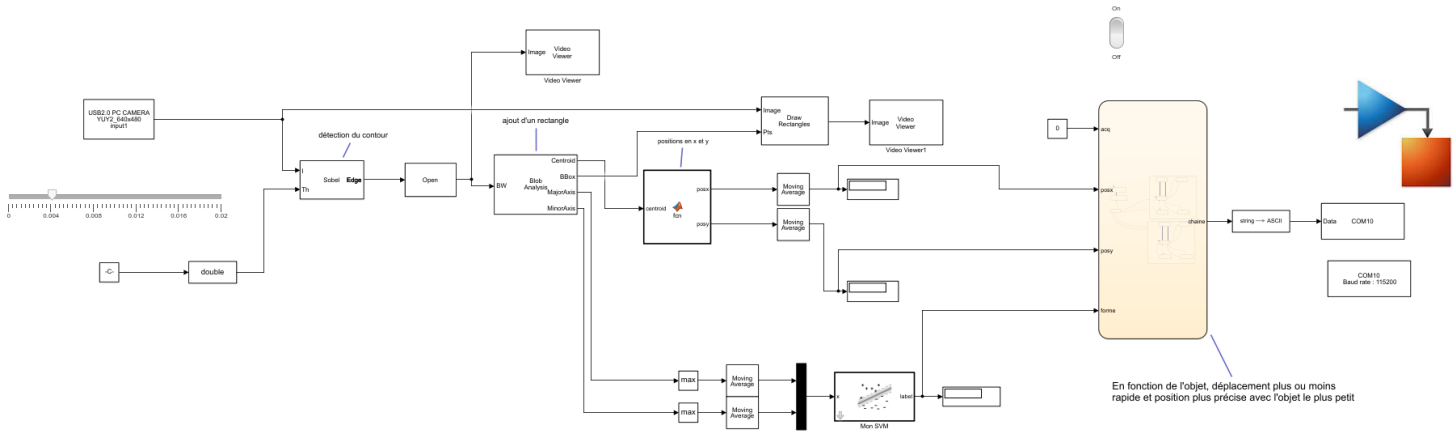


Control the position of the camera depending on the object





Sobel3.slx with the rectangle feature



Sobel33.slx with the Major and Minor axis feature

Key Takeaways and Further models on the Printer 3D

MATLAB and Simulink for IA

Access and Explore Data

- Files
- Databases
- Sensors

Preprocess Data

- Working with Messy Data
- Data Reduction/ Transformation
- Feature Extraction

Develop Predictive Models

- Model Creation e.g. Machine Learning
- Parameter Optimization
- Model Validation

Integrate Analytics with Systems

- Desktop Apps
- Enterprise Scale Systems
- Embedded Devices and Hardware

New Multi-Physics Project

MATLAB R2022a

HOME | PLOTS | APPS | PROJECT | PROJECT SHORTCUTS

New Shortcut | Organize Groups — MANAGE

Imprimante_indirecteV2_1
Imprimante_indirecteV2_2
Imprimante_indirecteV2_pos
Imprimante_indirecteV2_pos_etats — CAD ET CINÉMATIQUE

printer_model_sm3
test_slider — JUMEAU

motor_stepper_fullstep
motor_stepper_halfstep
motor_stepper_microstep — MOTEUR

C: ▸ work ▸ PASS ▸ Didastel ▸ Lusseau ▸ Imprimante3D ▸

Current Folder

Name
- Folder
  - CADfiles
  - documents
  - images
  - models
  - resources
  - utilities
  - work
- Project
  - Imprimante3D.prj

Project - Imprimante3D

Views
- Files
- Dependency Analyzer

Labels
- Classification

All | Project (52) | Layout:

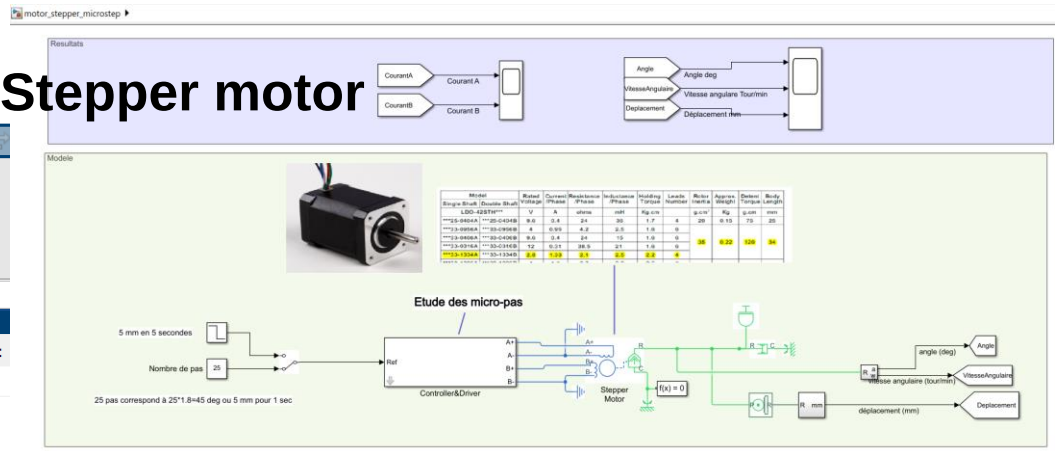
Name	Status	Classification
CADfiles		
documents		
images		
models		
+Friction		
Friction_lib.slx		
Imprimante_indirecteV2_1.slx		
Imprimante_indirecteV2_2.slx		
Imprimante_indirecteV2_DataFile.m		
Imprimante_indirecteV2_pos.slx		
Imprimante_indirecteV2_pos_etats.slx		
motor_stepper_fullstep.slx		
motor_stepper_halfstep.slx		
motor_stepper_microstep.slx		
printer_components_lib.slx		Design
printer_model_sm3.slx		Design
test_slider.slx		Design
resources		
utilities		
work		

Imprimante3D.prj (Project)

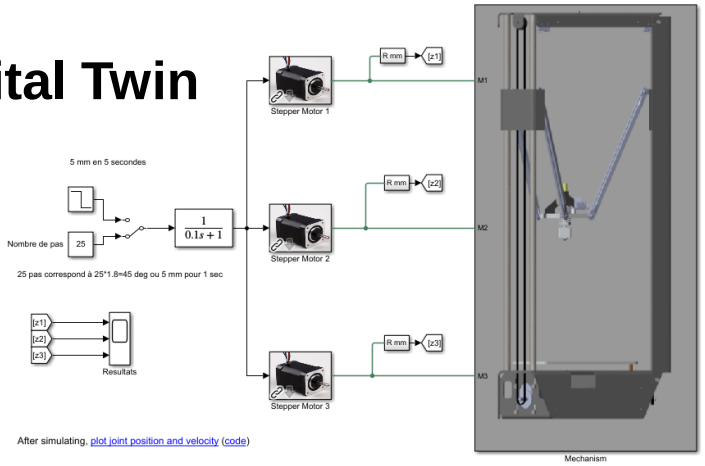
Command Window

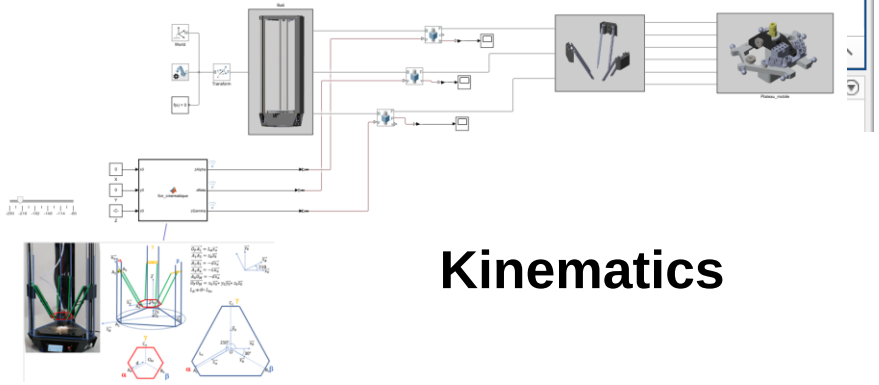
fx >>

Stepper motor



Digital Twin





Kinematics