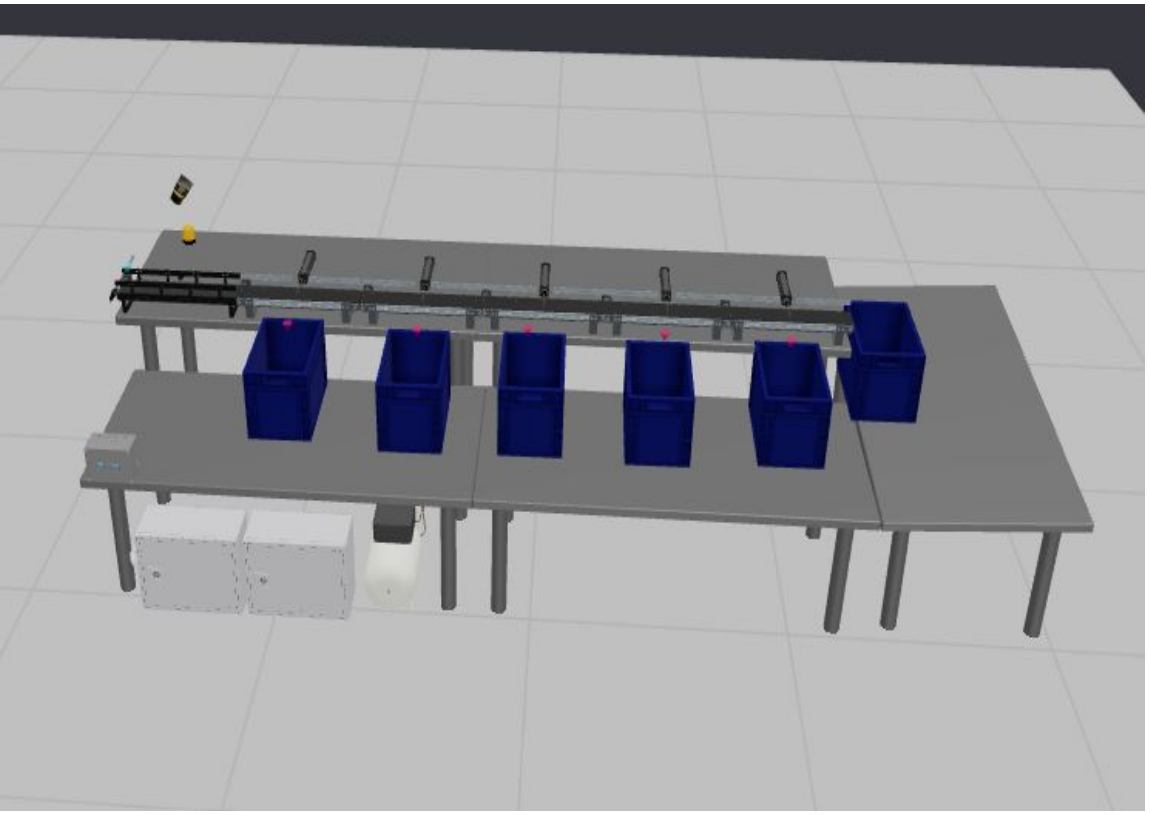

Virtual Intelligent Machines Project 2025

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VP711A: Virtual Intelligent Automation

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This presentation explores the Virtual Intelligent Machines Project 2025, detailing the design, implementation, and evaluation of a virtual sorting system integrating PLC logic, machine vision, and digital twins.

Outlines

- Case Study: Virtual Model of a Production Sorting Line
- System Overview & Implementation
- Challenges & Solutions
- Domain Adaptation Using Real and Virtual Object Data for Image Classification
- Evaluation of Vision Algorithms for Classification and Object Detection

Case Study - Project Background

- **Objective:** Design a virtual sorting line to classify and sort five objects.
- **Technologies used**: Simumatik, Codesys (PLC), Python (CNN for vision system).
- **Components**: Virtual model, PLC programming (SFC), and vision algorithm.

CODESYS

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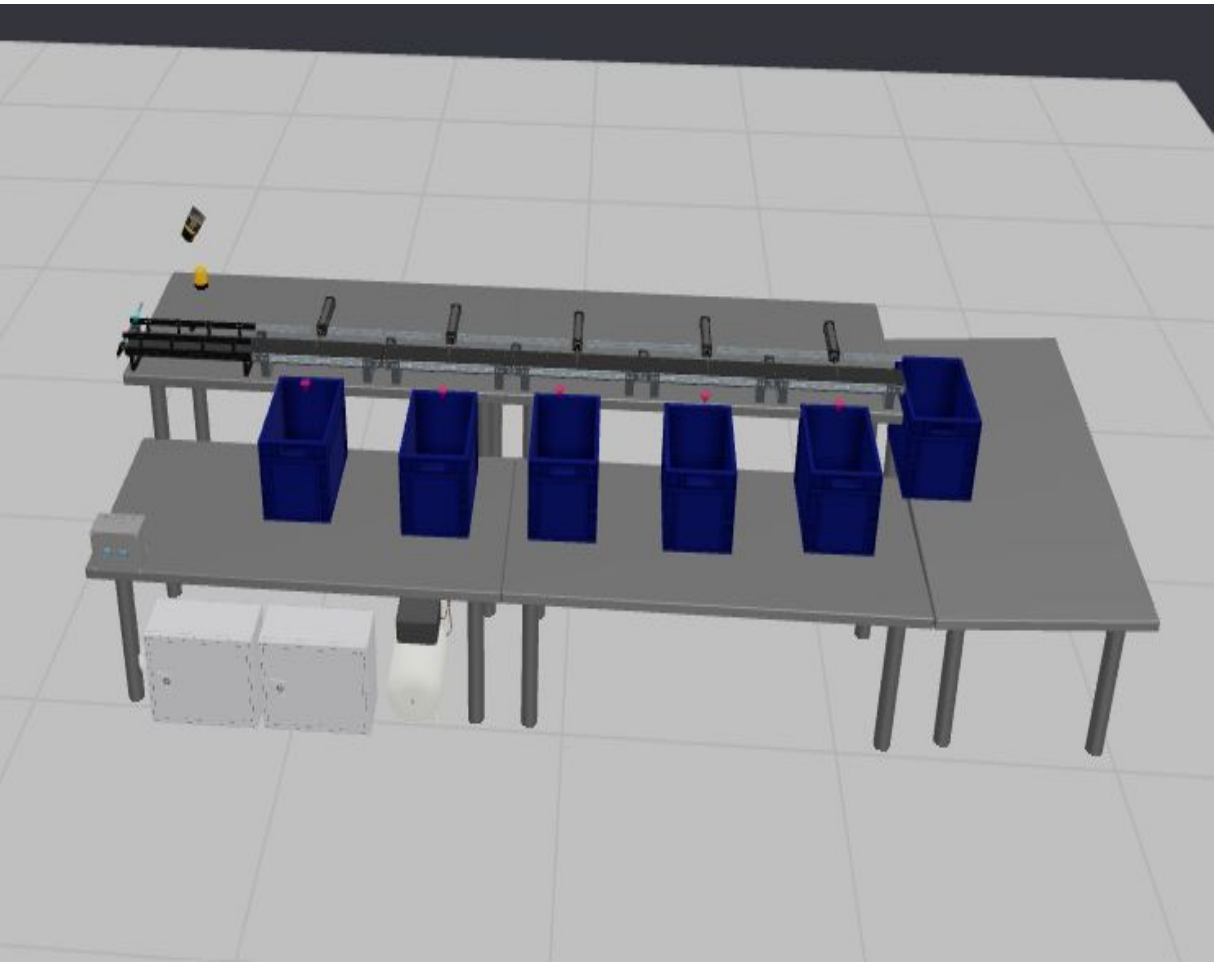
CODESYS SERVER

System Overview



- **Virtual Model:** Simulated sorting line in Simumatik.
- **PLC Programming:** Control logic in Codesys, using ***Sequential Function Chart (SFC).***
- **Vision System:** CNN trained with image data for object classification, ***(Virtual images)***
- **Video:** Show the alarm scene and completed virtual sorting line in Simumatik.

Components of Sorting Line

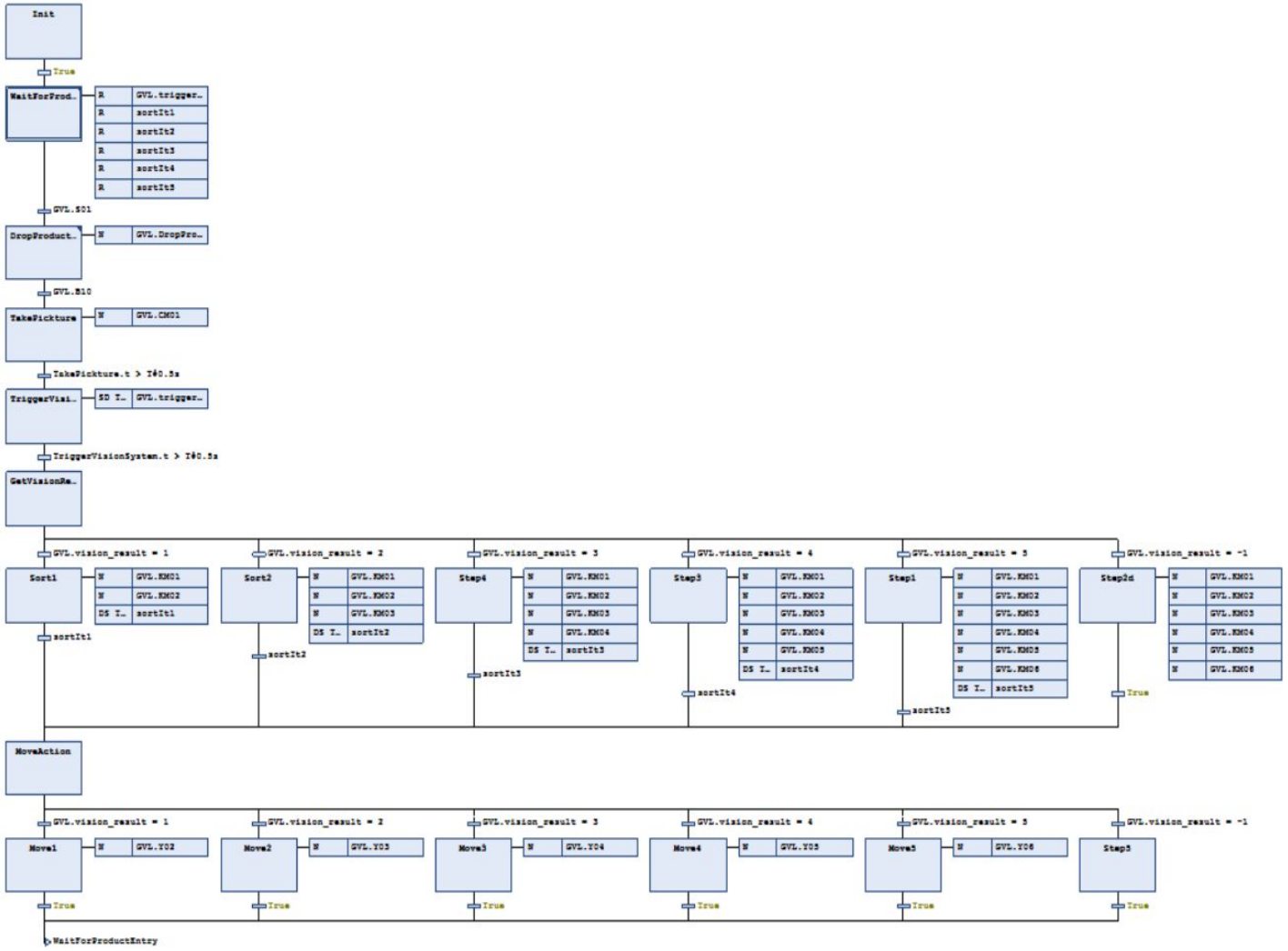
Table 2: Components of basic sorting line

Name	Type	Parent	Library	Component name in library	Position (x, y, z)			Rotation (x, y, z)		
base	**Assembly**	**System**	-	-	**0.000**	**0.000**	**0.000**			
TABLE_1	Component	base	Public/Others	Table	0.000	0.000	0.000			
base_sorters	**Assembly**	**System**	-	-	**0.580**	**0.000**	**0.000**			
SORTER_BOX_1	Component	base_sorters	Public/Products	Plastic box	0.000	0.000	0.610			
TABLE_SORTERS	Component	base_sorters	Public/Others	Table	0.120	0.000	-0.253			
control_electic	**Assembly**	**System**	-	-	**0.880**	**-0.330**	**0.150**			
BOX_ELECTRIC	Component	control_electic	Public/Electric	Electric box medium	0.000	0.000	0.000			
FQ01	Component	control_electic	Public/Electric	Three-phase circuit breaker	0.030	-0.140	-0.050			
K01	Component	control_electic	Public/Electric	DC Relay 24V 2xNO	0.030	-0.160	0.070			
KM01	Component	control_electic	Public/Electric	DC reversing contactor	0.030	-0.130	0.070			
KM02	Component	control_electic	Public/Electric	DC reversing contactor	0.030	-0.090	0.070			
PLC	Component	control_electic	Public/Controllers	PLC 16DIO 4AIO OPCUA	0.030	0.070	-0.020			
PS01	Component	control_electic	Public/Electric	Power supply	0.030	-0.070	-0.030			
W01	Component	control_electic	Public/Electric	Industrial socket	0.090	-0.200	0.000	0.000	0.000	-90.000
control_pneumatic	**Assembly**	**System**	-	-	**0.880**	**0.100**	**0.150**			
BOX_PNEUMATIC	Component	control_pneumatics	Public/Electric	Electric box medium	0.000	0.000	0.000			
COMPRESSOR	Component	control_pneumatics	Public/Pneumatic	Pneumatic compressor	0.000	0.350	-0.155			
Y02	Component	control_pneumatics	Public/Pneumatic	Directional control valve 3/2-way solenoid	0.035	-0.100	0.000	0.000	-90.000	0.000
hmi	**Assembly**	**System**	-	-	**1.000**	**-0.600**	**0.545**			
BOX_HMI	Component	hmi	Public/Electric	Electric box small	0.000	0.000	0.000			
S01	Component	hmi	Public/Electric	Pushbutton NO	0.050	-0.030	0.000			
S02	Component	hmi	Public/Electric	Pushbutton NO	0.050	0.030	0.000			
input_conveyor	**Assembly**	**System**	-	-	**0.300**	**-0.500**	**0.750**			
B01	Component	input_conveyor	Public/Electric	Inductive sensor*	-0.050	0.000	0.080			
M01	Component	input_conveyor	Public/Electric	DC_motor	-0.080	-0.240	0.050			
RB01	Component	input_conveyor	Public/Conveyors	mini conveyor 500 x 100 mm	0.000	0.000	0.050	0.000	0.000	90.000
sorter_conveyor_1	**Assembly**	**System**	-	-	**0.300**	**0.005**	**0.750**			
B02	Component	sorter_conveyor_1	Public/Electric	Inductive sensor*	-0.050	0.000	0.080			
C02	Component	sorter_conveyor_1	Public/Pneumatic	Single-acting pneumatic cylinder 16cm	-0.170	0.000	0.110			
M02	Component	sorter_conveyor_1	Public/Electric	DC_motor	-0.080	-0.240	0.050			
RB02	Component	sorter_conveyor_1	Mine/VP711A	mini conveyor 500 x 100 mm with gap	0.000	0.000	0.050	0.000	0.000	90.000
product_entry	**Product Entry**	**System**	-	-	**0.300**	**-0.650**	**1.100**			

VGG16 & SVM-Based Vision System for Object Classification

```
Total samples: 752
Class distribution: {'apples': np.int64(96), 'car': np.int64(98), 'cup': np.int64(168), 'scissors': np.int64(300), 'screw_driver': np.int64(90)}

Normalizing features...

Training SVM classifier with grid search...
Fitting 5 folds for each of 12 candidates, totalling 60 fits

Best parameters found:
{'C': 100, 'gamma': 0.0001}

Model accuracy: 98.01%

Saving model to ./model.p

Training completed successfully!
PS C:\Users\HP\OneDrive\Desktop\New_DATA_Thessyrain>
```

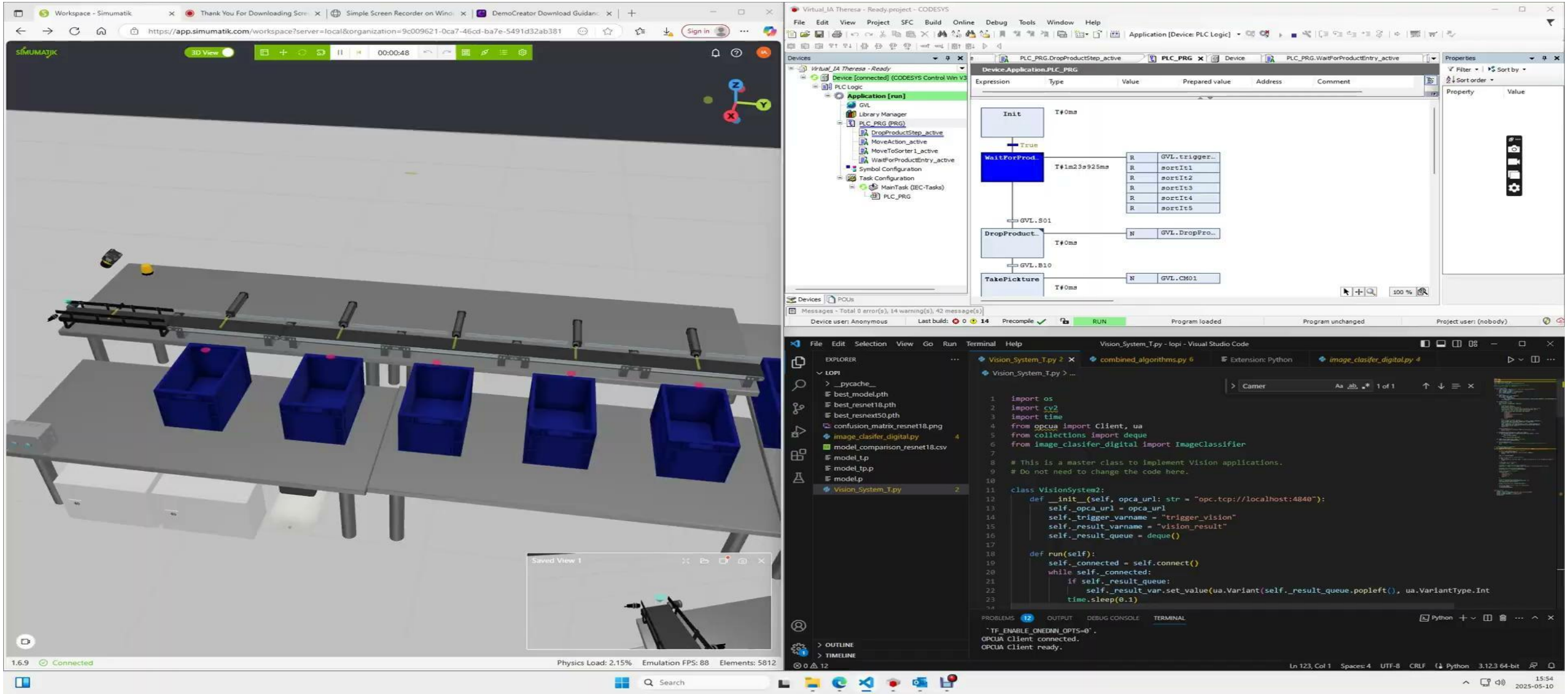
PLC Logic & Error Handling



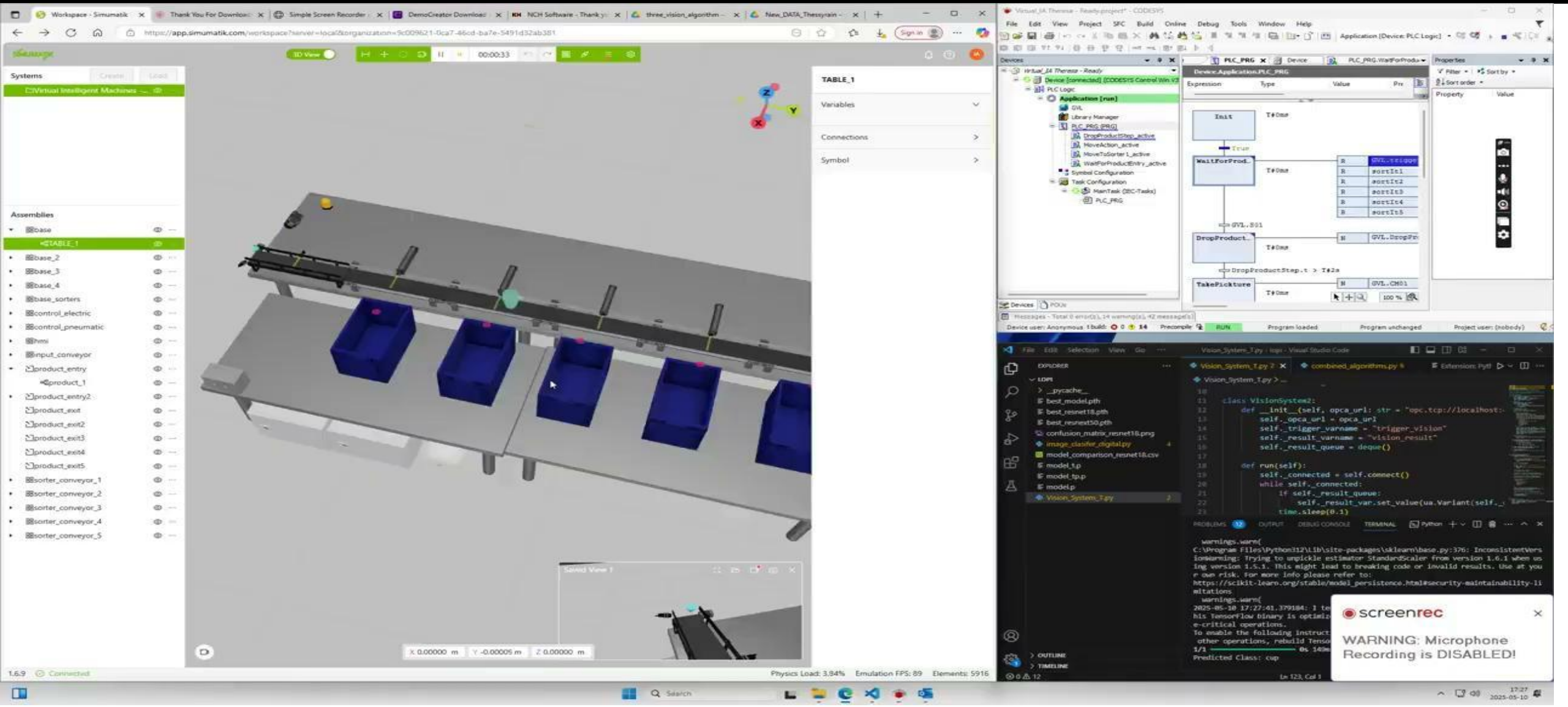
Screenshot: PLC control logic flowchart.

- Implemented in Codesys using **SFC logic.**
- **Steps:** *Start → Drop Object → Detect → Classify → Sort*
- **Error Handling:** If an object is not detected by the sensor after a while, the system triggers an alarm & resumes.
-

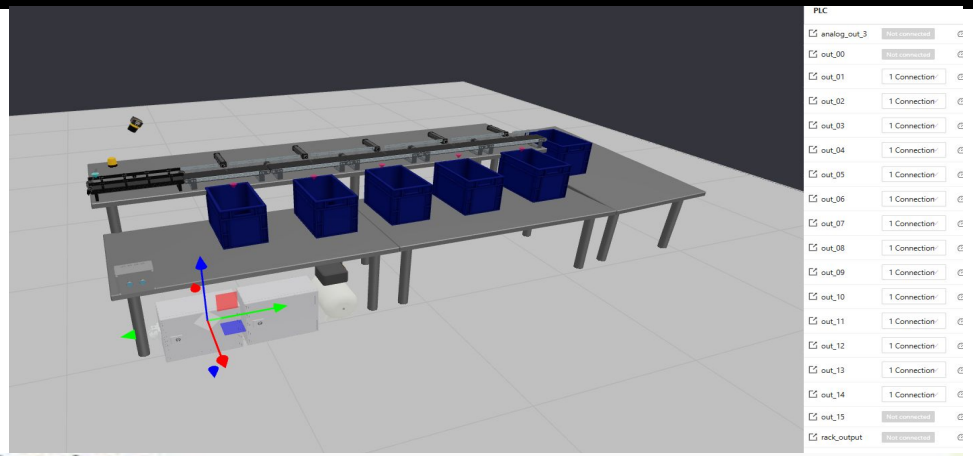
Video - Alarm Scene

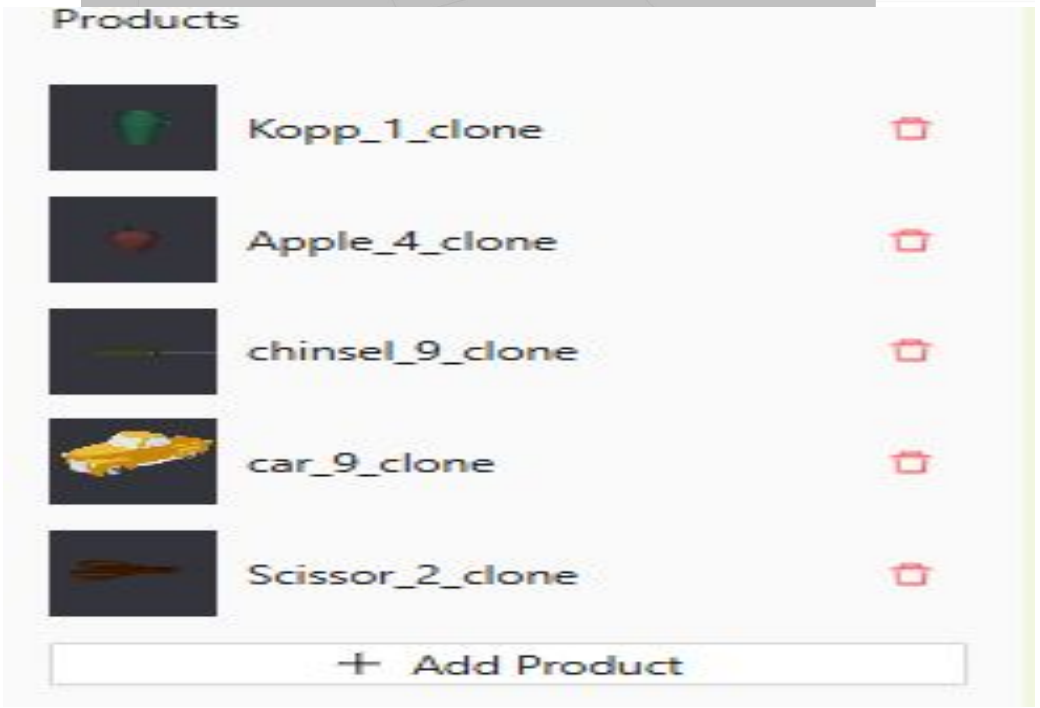


Video - Completed Sorting Line



Virtual Model - Design & Challenges





- Built a modular conveyor system with six sorting boxes.
- Integrated sensors and pneumatic cylinders for sorting.
- **Challenges:** Object scaling issues, misalignment of input/output configurations.
- **Solution:** Editing of the objects on simumatik to introduce some variance properties & precise I/O mapping for input/output configuration.

THANK YOU