AI-Robot Machine

The AI-Robot machine is an industrial machine application to pack a finished product into boxes that consist of two types of products (in this project, the product is the syringe packets).

The product is packed in multiple layers inside the boxes.

The number of layers is configured by the machine's HMI display panel.

The machine has a computer-vision camera to classify the product into Good and Bad products which are then packed based on those criteria.

The qualified product is packed, and the unqualified product is rejected.

The training and configuration of the computer vision camera are done on a real product sample from the production lines with different orientations.

Project Scope:

Build a fully automated machine to pack any type of product by means of auto-manipulated actuators based on a quality inspection camera station.

Project Elements:

Embedded Back-End:

- *PLC programming manipulates the hardware parts based on specific inspection criteria.*
- *PLC communication to the database to send and receive the signals related to the inspection result and the machine parameter and measures.*

AI Back-End:

- *Python script to do some data science on the machine measurement to extract some process KPIs.*
- *Computer-Vision model to inspect the product based on the industry quality rules and policy.*
- *Python communication to the database for data integration and model prediction.*

Front-End:

- *HTML page with CSS style to monitor the machine condition and access the machine documentation (machine operation, Maintenance, and error codes manuals) from a website.*
- *Clear graph report for the machine speed, status, rejection rate, and production counter.*
- *Mobile-HMI for the machine control and monitor some machine features.*

Used Knowledge:

- *TIA Portal for Siemens programming.*
- *WinCC advanced V15 for HMI programming*
- *TIA Siemens scripts for PLC-HMI-Database communication*
- *Python scripts for data science*
- *Computer-Vision scripts for product classification (bad/good)*
- *Factory I/O Simulation software for machine motion and full project simulation.*

Generated Files:

- *TIA PLC project (Inc. PLC and HMI programming blocks and the communication scripts to the database).*

- *AI_Based_ROBOT.py to run on the embedded camera to capture the photo of the product and generalize the result.*

- *Visualization.py to extract some visualization from the database to reflect the machine status and production records.*

- *App.py is the flask app to run the front-end GUI to the user.*

- *Index.html which includes the setup of the user GUI.*

- *Style.css is the stylesheet of the end user GUI.*

- *TLVGG16Face.txt is the result of the training of the model on product#1.*

- *TLVGG16Back.txt is the result of the training of the model on product#2.*

- *Some database files to save the machine and Python script records.*

How to use:

Step1. Open the PLC project in TIA Portal software and start the simulation of the PLC project.

Step2. Start the simulation of the HMI project.

Step3. Start Factory I/O software and connect to the PLC simulator and start the simulation.

Step4. From the CMD on the file's location, start the Visualization.py

Step5. From the CMD start the AI_Based_Robot.py

Step6. From CMD start the App.py and get the generated IP address and open it in your browser.

Simulation:

Step1. After starting the Factory I/O simulation, press the start button either from the control panel or from the machine HMI to start the machine.

Step2. The machine will start sending the product to the inspection station.

Step3. The inspection station will detect the new product and will do an analysis of it and send the result to the PLC (either accept or reject).

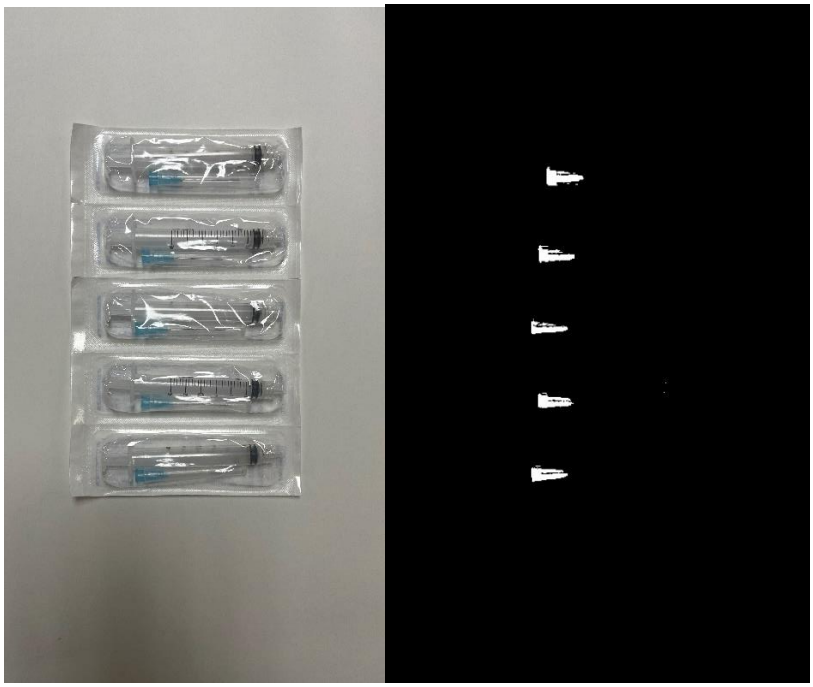
The photo is captured by the camera and then masked to detect selective colors (needle colors – in our simulation we selected 23G needle blue color) to detect and classify if it is an accepted or rejected product.

For the other product, the process is the same, but the camera is checking the printing quality on the packet.

If one or more needles are missing, the product is rejected.

If the printing quality is not good enough, the product is rejected.

Below is the original product photo and the mask.



Step4. The PLC will actuate the manipulator based on the received inspection result from the camera.

Step5. The manipulator will start packing the products into boxes.

Step6. During the process execution, the machine will send the machine and production data to the database.

Step7. The user can check the HTML page to access the machine records and documentation in real time.

Step8. The machine is performing an order packaging of the products.

(

layer1 == product1

layer2 == product2

layer3 == product1

and so on.

)

The project is customized training on the Keras VGG16 library by using a real product sample.

The implementation of the machine could be in medical, FMGG, or any other industry field.

The machine could be integrated with a palletizer.

The machine speed could be up to 17 cycles/min.

Project Photos:

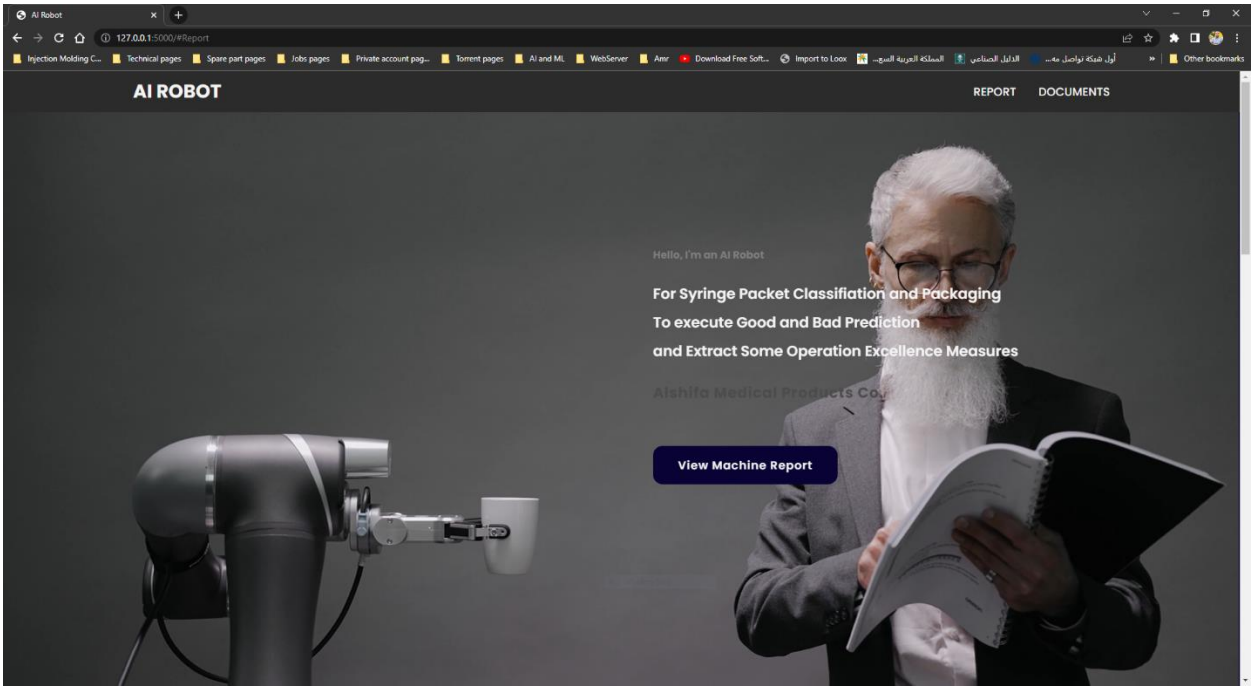
Machine Assembly:

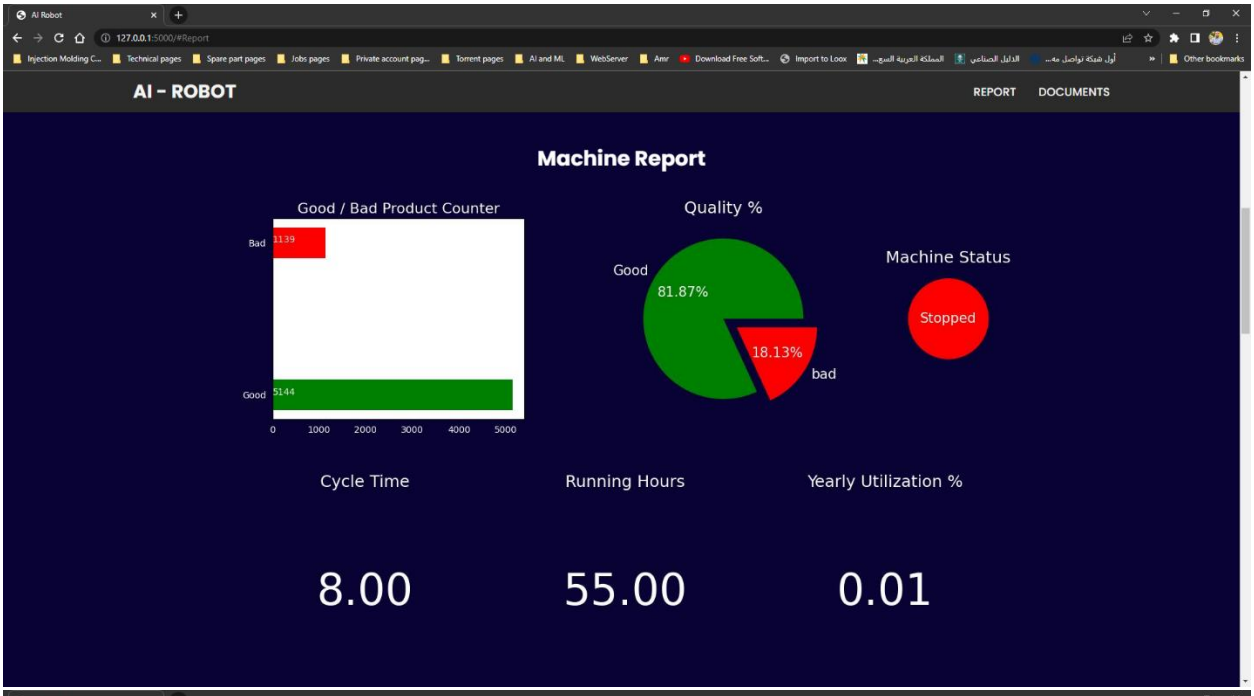

Factory IO
FILE
EDIT
VIEW
32 FPS
avg min max
28 4 60
Physics: 3 ms
Time scale: 1.00 / 1
Frame: 60443
CPU: 8.54 %
Objects: 44 + 0
FACTORY I/O v2.4.3 - Ultimate Edition - AI Camera With Pick and Place Actuator
Siemens S7-PLCSIM

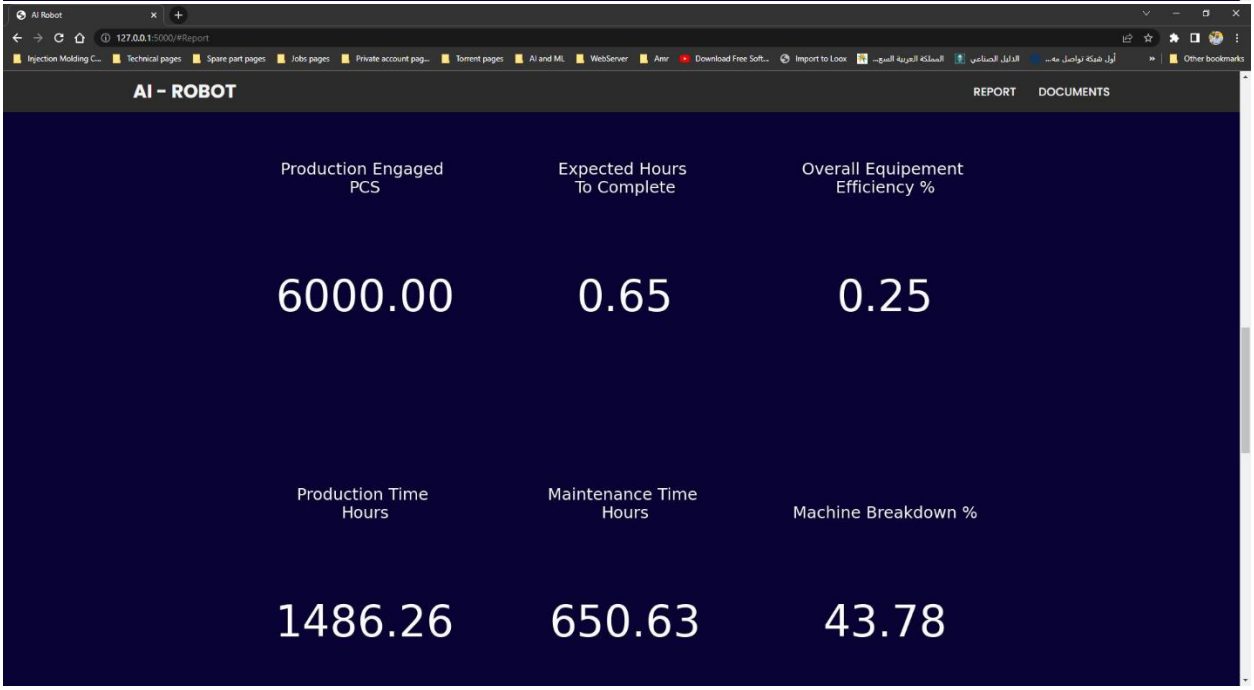

Factory IO
FILE
EDIT
VIEW
Pick & Place 1 (Moving XY)
Belt Conveyor (6m) 2 Encoder Signal A
Belt Conveyor (6m) 2 Encoder Signal B
Retroreflective Sensor 3
Retroreflective Sensor 2
30 FPS
avg min max
28 4 60
Physics: 5 ms
Time scale: 1.00 / 1
Frame: 67677
CPU: 7.43 %
Objects: 44 + 0
FACTORY I/O v2.4.3 - Ultimate Edition - AI Camera With Pick and Place Actuator
Siemens S7-PLCSIM

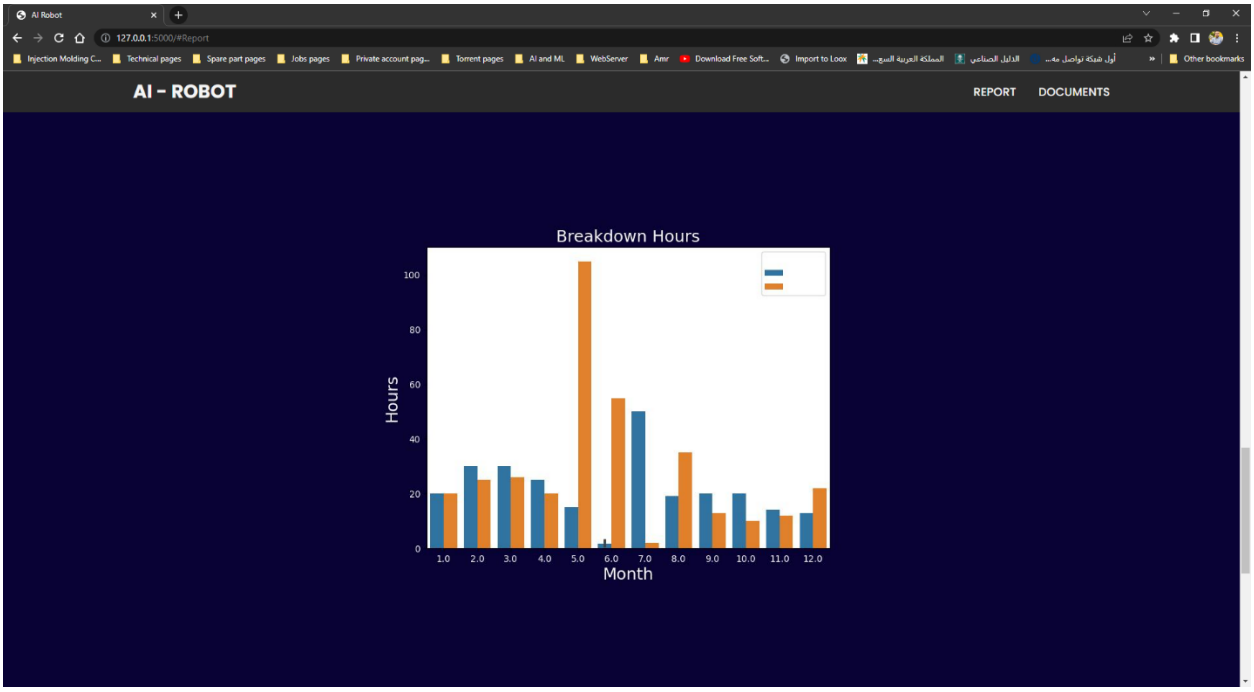
Machine Mobile HMI:

HTML GUI:


AI Robot
127.0.0.1:5000/#Report
AI ROBOT
REPORT
DOCUMENTS
Hello, I'm an AI Robot
For Syringe Packet Classifiation and Packaging
To execute Good and Bad Prediction
and Extract Some Operation Excellence Measures
View Machine Report


AI Robot
127.0.0.1:5000/#Report
AI - ROBOT
REPORT
DOCUMENTS
Machine Report
Good / Bad Product Counter
Bad
1139
Good
5144
0
1000
2000
3000
4000
5000
Quality %
Good
81.87%
18.13%
bad
Machine Status
Stopped
Cycle Time
8.00
Running Hours
55.00
Yearly Utilization %
0.01


AI Robot
127.0.0.1:5000/#Report
AI - ROBOT
REPORT
DOCUMENTS
Production Engaged PCS
6000.00
Expected Hours To Complete
0.65
Overall Equipement Efficiency %
0.25
Production Time Hours
1486.26
Maintenance Time Hours
650.63
Machine Breakdown %
43.78


AI Robot
127.0.0.1:5000/#Report
AI - ROBOT
REPORT
DOCUMENTS
Breakdown Hours
Hours
Month
0
20
40
60
80
100
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0

Machine Simulation: