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E01. Study of the operation of an automatic robotic line for assembly of electromechanical products using statistics and machine learning

Associate Professor at the Technical University of Sofia, scientific and applied interests in management of technologies for assembly, quality, automation, production and documentation.

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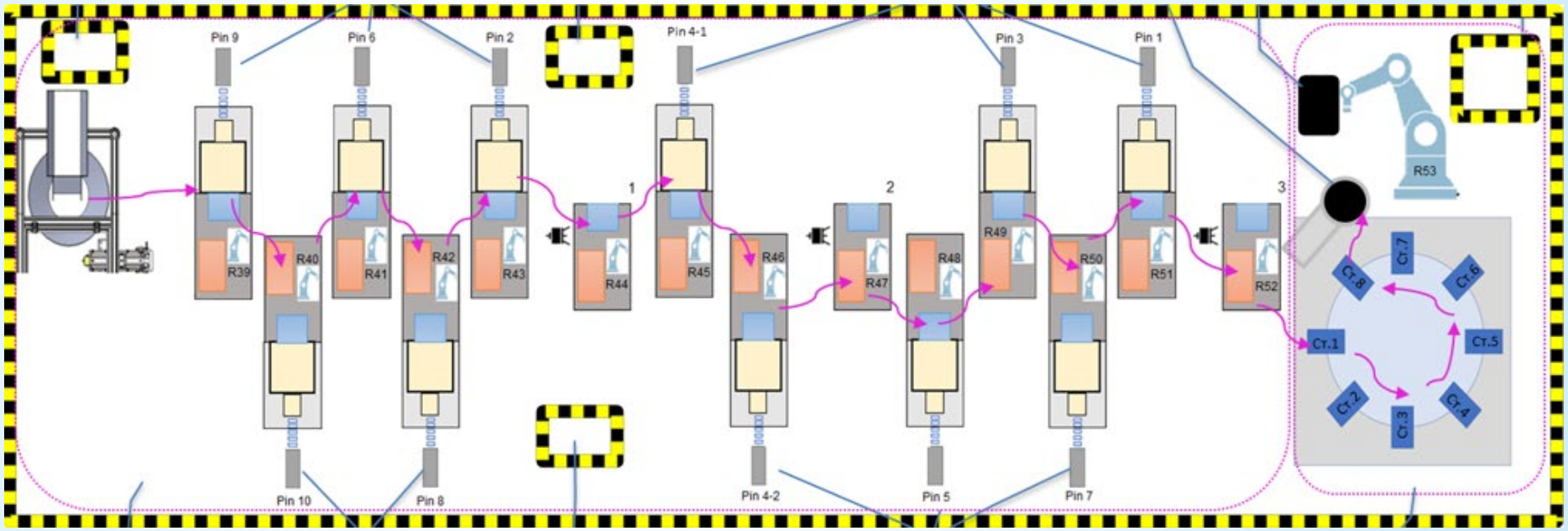
GOAL :

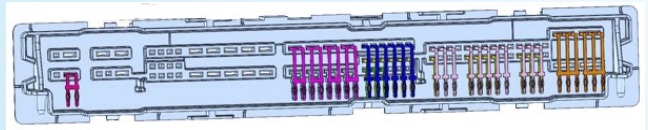
Research of a fully automatic flexible production line using statistics and machine learning.

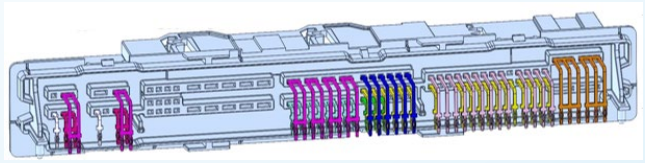
TASKS :

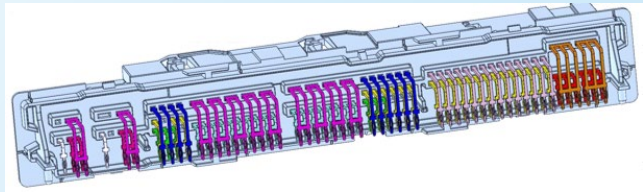
1. *Study the structure of the production line and determine the control points.*
2. *Realize flexible management according to the industry standard INDUSTRY 4.0.*
3. *Review the types of connectors to assemble and create a strategy for their flexible assembly using machine learning.*
4. *Defining the machine learning model and its implementation.*
5. *Statistical study of production line performance and determination of specific metrics for quality assessment.*
6. *Determining the benefits achieved after analyzing the results obtained.*
7. *Study and determination of the future development of the production line during its operation in order to increase the quality and stabilize it at a low cost of production.*

Structure of the production line according to INDUSTRY 4.0 and manufactured connectors

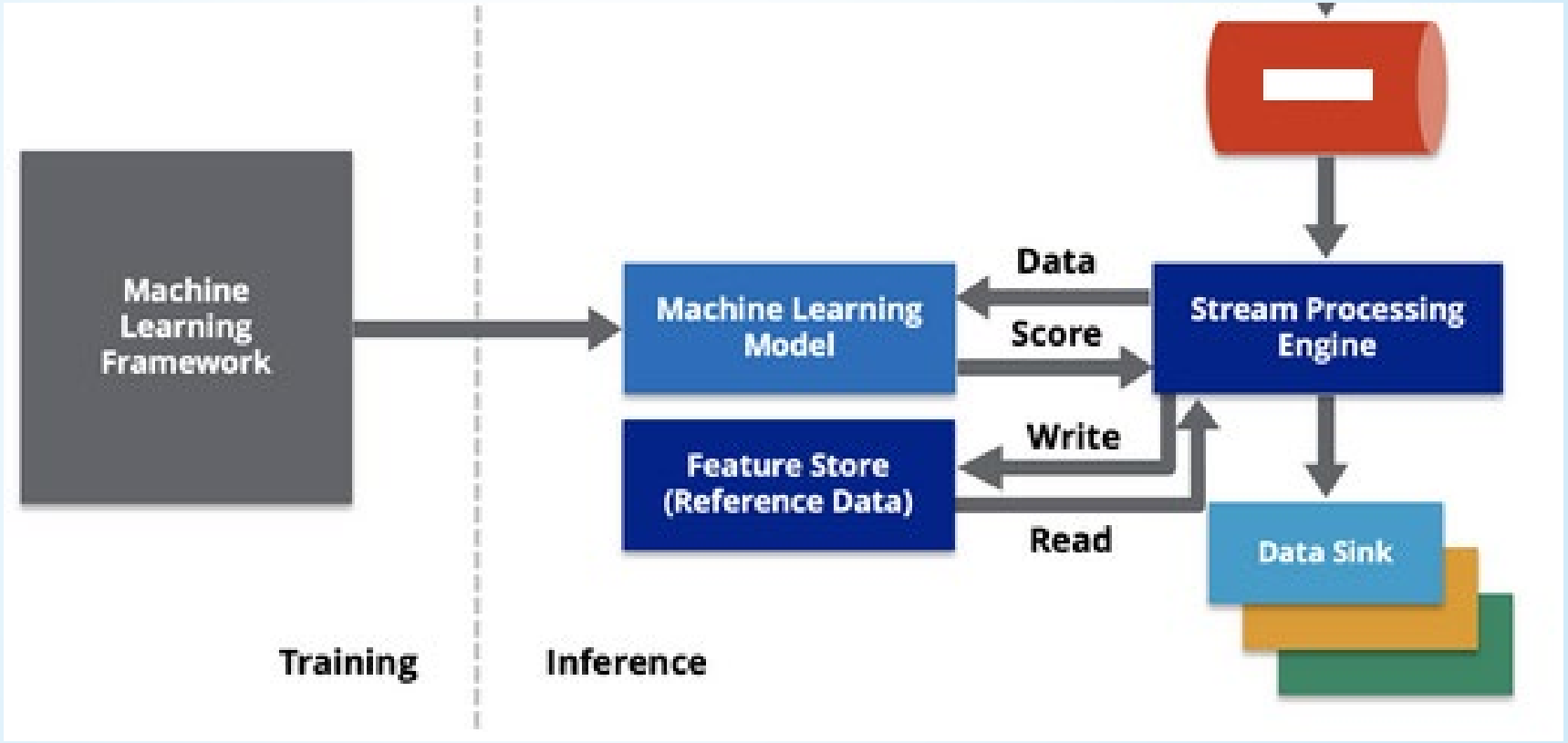




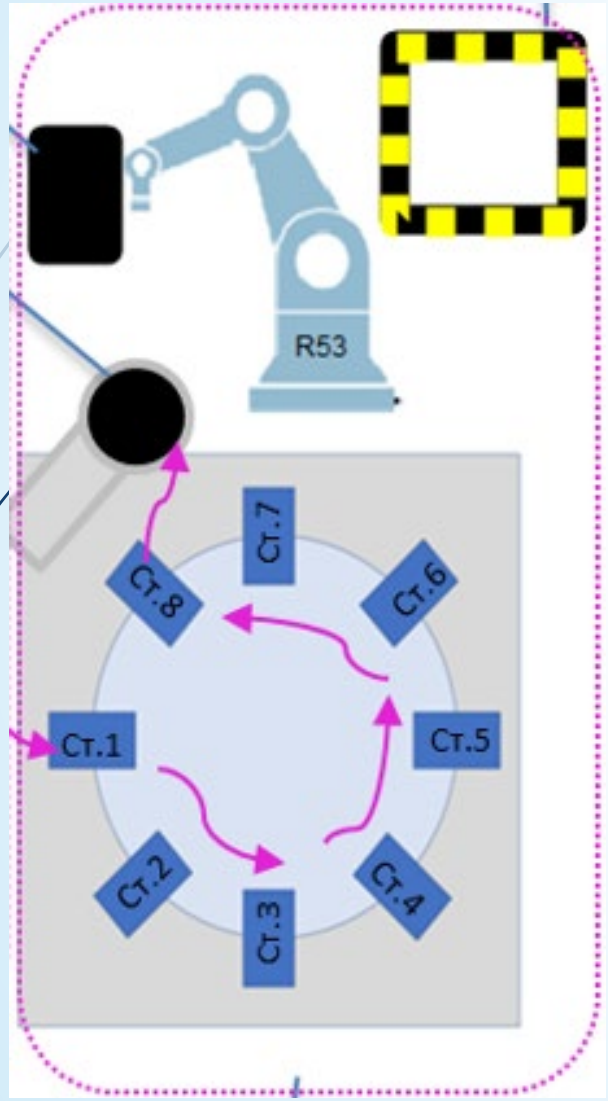




Machine learning model



CONTROL STATION



The control line works as follows:

Station 1 - Placing of connector in correct position.
Station 2 - Control of pins position (connectors A and C).
Station 3 - Control of pins position (connectors B, D and E).
Station 4 - Control of pins height.
Station 5 - Short circuit control via high voltage.
Station 6 and 7 - dummy stations.
Station 8 - Cleaning finished part by air and moving it to the exit by robot № 53.

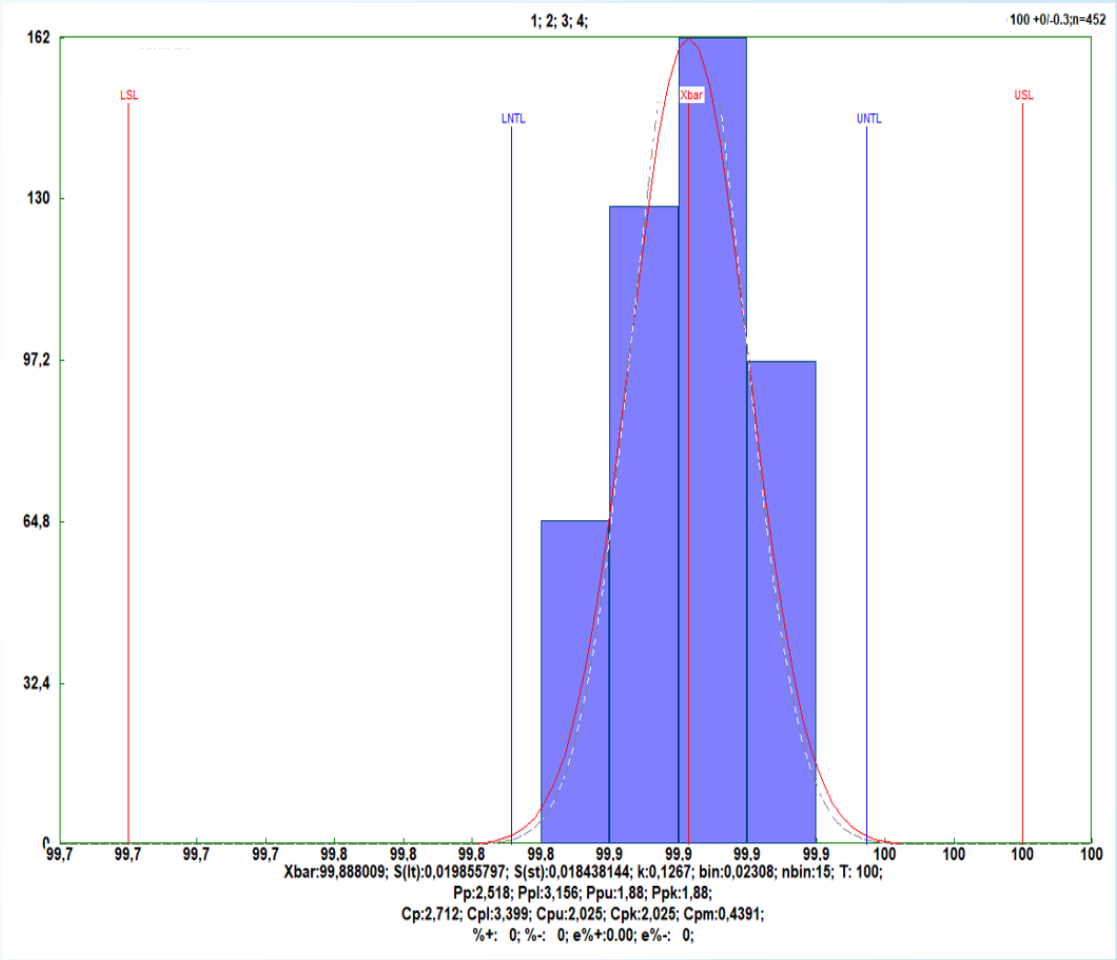
* NOK part – The robot separates 3 types of waste.

-NOK pins position,
-NOK pins height,
-NOK high voltage test.

* OK part - Laser marking station performs laser marking of OK finished parts.

RESULTS

Date	Core	100 +0/-0.3
01.07.2021	1	99.91
01.07.2021	2	99.92
01.07.2021	3	99.91
01.07.2021	4	99.88
23.07.2021	1	99.90
23.07.2021	2	99.88
23.07.2021	3	99.89
23.07.2021	4	99.90
23.07.2021	1	99.87
23.07.2021	2	99.89
23.07.2021	3	99.86
23.07.2021	4	99.90
24.07.2021	1	99.85
24.07.2021	2	99.87
24.07.2021	3	99.90
24.07.2021	4	99.86
26.07.2021	1	99.89
26.07.2021	2	99.89
26.07.2021	3	99.87
26.07.2021	4	99.89
27.07.2021	1	99.87
27.07.2021	2	99.88
27.07.2021	3	99.89
27.07.2021	4	99.87
27.07.2021	1	99.90
27.07.2021	2	99.87
27.07.2021	3	99.88
27.07.2021	4	99.90
28.07.2021	1	99.89
28.07.2021	2	99.86
28.07.2021	3	99.88
28.07.2021	4	99.87
28.07.2021	1	99.85
28.07.2021	2	99.90
28.07.2021	3	99.89
28.07.2021	4	99.89
28.07.2021	1	99.86
28.07.2021	2	99.92
28.07.2021	3	99.91
28.07.2021	4	99.91
30.07.2021	1	99.87
30.07.2021	2	99.90
30.07.2021	3	99.89
30.07.2021	4	99.87
31.07.2021	1	99.91
31.07.2021	2	99.88
31.07.2021	3	99.87
31.07.2021	4	99.89



Cpk = 2.025

Conclusions

- THE REQUIRED LEVEL OF DEFECT FOR THE PRODUCTION OF AUTOMOTIVE AND OTHER SPECIAL ELECTROMECHANICS;
- FULLY AUTOMATIC OPERATION OF THE ASSEMBLY LINE, WHICH IS A GUARANTEE FOR A STABLE PROCESS AND PRODUCTION OF PRODUCTS WITH SMALL VARIATIONS;
- MODULAR PRINCIPLE OF CONSTRUCTION WITH THE POSSIBILITY OF RAPID CHANGE AND SERVICE WITHOUT STOPPING THE LINE DUE TO THE AVAILABILITY OF FREE STATIONS IN THE CONTROL LINE;
- INDEPENDENT WORK BY PEOPLE - LOW COST OF SERVICE AND STABLE, PREDICTABLE OPERATION;
- LOW PRODUCTION COST DUE TO FAST PROCESS AND LOW LEVEL OF NON-CONFORMITIES;
- LARGE PRODUCTION CAPACITY, EASY PLANNING, MANAGEMENT, CONTROL AND EVALUATION OF THE OPERATION OF THE LINE;
- FLEXIBILITY OF WORK WITH THE POSSIBILITY OF VERY FAST READJUSTMENT TO PRODUCE NEW PRODUCTS;
- POSSIBILITY TO PRODUCE SEVERAL TYPES OF CONNECTORS AT THE SAME TIME AND CREATE SETS FOR SUBSEQUENT AUTOMATIC USE OF PACKAGED PRODUCTS;
- SECURE TRACEABILITY AND AUTOMATIC IMPACT SYSTEM FOR CONTINUOUS LINE IMPROVEMENT;
- INABILITY TO MAKE MISTAKES USING APPROPRIATE CONTROL PROCESSES AND POKA JOKE SOLUTIONS;
- CONTINUOUS ANALYSIS WITH TRACEABILITY FOR TRENDS IN THE DEVELOPMENT OF PROCESSES AND THE IMPACT ON THE STABLE OPERATION OF THE LINE;
- ABILITY TO CHANGE PACKAGING AND DIRECT USE IN SUBSEQUENT AUTOMATIC ASSEMBLY LINES;
- REDUCTION OF THE REQUIREMENTS TO THE TECHNOLOGICAL TOLERANCES FOR INSTALLATION / SOLDERING TO THE PRINTED CIRCUIT BOARDS AND MODULES.

Future development

- INTRODUCE WIRELESS COMMUNICATION AND USE IOT;
- DEVELOPMENT OF DEEP LEARNING, NEURAL NETWORKS AND ARTIFICIAL INTELLIGENCE;
- USE OF HIGH-PERFORMANCE COMPUTING TOOLS AND BIG DATA PROCESSING STRATEGY;
- ESTABLISHING AN ELECTRONIC CONNECTION OF THE ERP SYSTEM WITH SUPPLIERS AND CUSTOMERS AND AUTOMATIC RESOURCE PLANNING, INCLUDING THE AUTOMATIC ROBOT ASSEMBLY LINE;
- IMPLEMENTATION OF MES (MANUFACTURING EXECUTION SYSTEM) AND CONTINUOUS DEVELOPMENT;
- INCORPORATION OF BRAIN-MACHINE INTERFACE SYSTEMS FOR MENTAL CONTROL;
- CREATION OF DIGITAL TWINS, ALLOWING THE MANAGEMENT OF MANY ASSEMBLY LINES FOR ELECTROMECHANICS FROM ONE PLACE, EXPORTED TO THE CLOUD.

Thank you for your attention!

An African proverb: ***"He who looks well will finally see."***

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