PROGRAMMING AND SIMULATION OF A ROBOTIC CELL FOR DEPALETIZING SUPPORT TRAYS WITH CHOCOLATE PRODUCTS

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ABSTRACT: The aim of the paper is to prepare the offline simulation for a depalletizing application employed in food industry. The 3D assembly was created in CATIA V5. After the design stage, the entire cell was exported in Process Simulate where the off line programming and simulation will be performed. Another stage of the research was to identify all the sensors present in the robotic cell. In terms of including intelligent algorithms in the virtual model, the current paper illustrates the preparation of the data sets.

KEYWORDS: Process Simulate, sensors, mapping, flowchart.

1. Introduction

This paper aims to present the first stages of an offline simulation approach in Process Simulate environment, namely: the specific sensors of the depalletizing cell together with their detailed presentation. The sensors mapping represents their assignment in the application, where they have to be placed. In order to have an overview of the whole approach, the flowchart must be created with all the processes and their relationships.

Following a market study in the chocolate industry, the links between buyers and products were identified. In terms of intelligent algorithms, the data sets (customers + ingredients) were also created employing the information available on the net regarding customer preferences, which will be further used of intelligent model training. The advantages and drawbacks of the Machine Learning procedure, as well as the main stages to solve the learning problem are illustrated in Fig. 1.

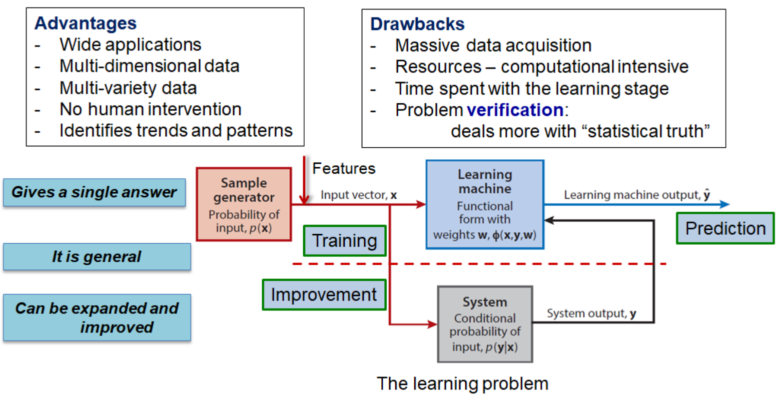


Fig. 1 – Machine learning general strategy

2. State of art

At present Artificial Intelligence (AI) is very popular in industry, especially in food industry. It helps producers to sort the ingredients, to ensure the supply chain, to generate information about the market and consumers, the management of the warehouse, including the development of new products. [1] AI enters the picture and transforms the old products by understanding consumer preferences from datasets. These include preferences about aromas, texture, and flavor, which help to improve chocolates sales on the market or any other food item. [2] Although attempts have already been registered, this work is original in the sense of implementing advanced algorithms in a classical robotic cell for the chocolate industry.

3. 3D CAD description of the cell in the virtual environment devoted to offline programming and simulation

The 3D assembly of the cell was created in the CATIA V5 software. The assembly was then exported, component by component, with the .jt extension to be compatible with the Process Simulate environment (Fig. 2 and Fig. 3).

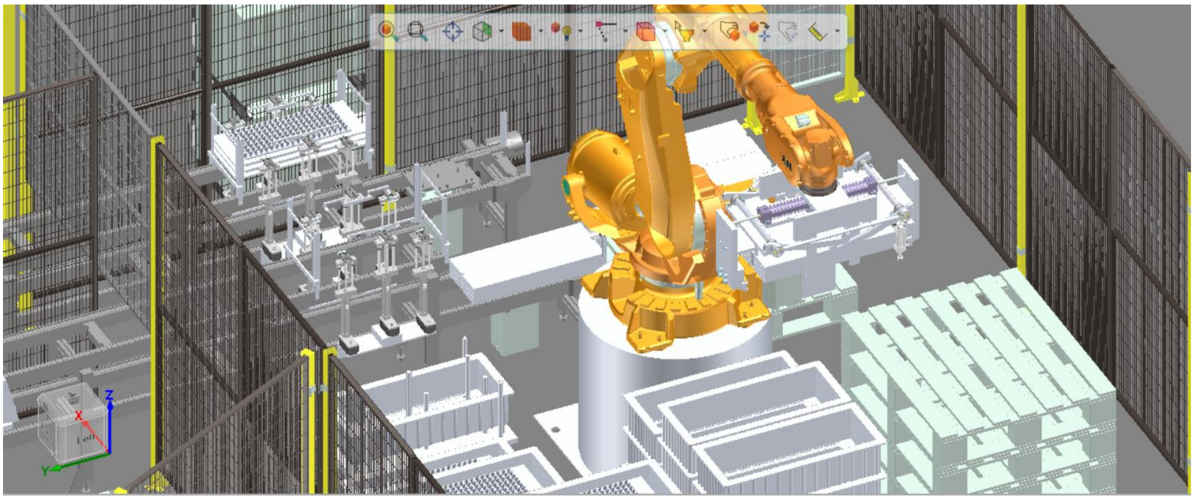


Fig. 2 – 3D model of the main cell in Process Simulate

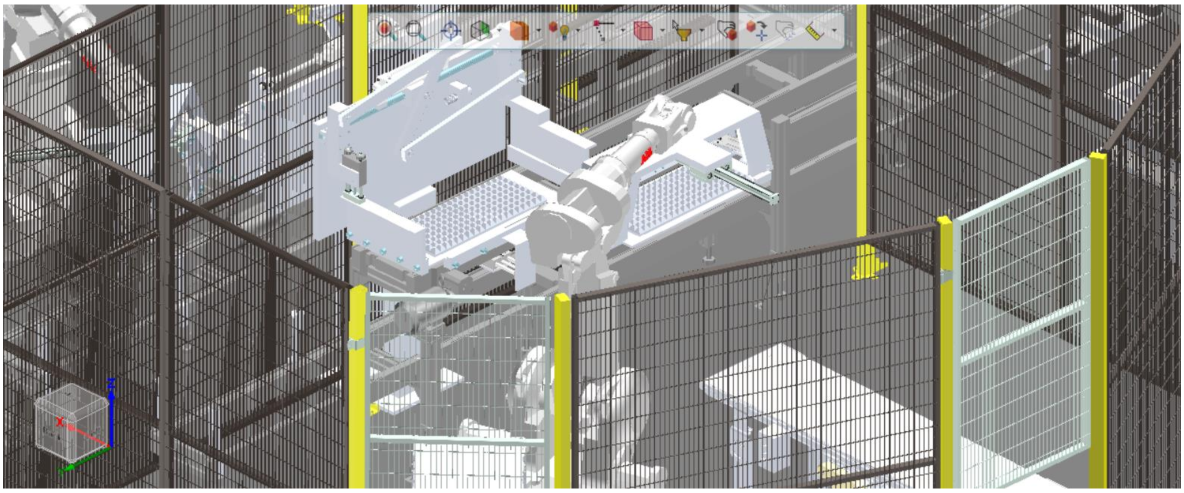
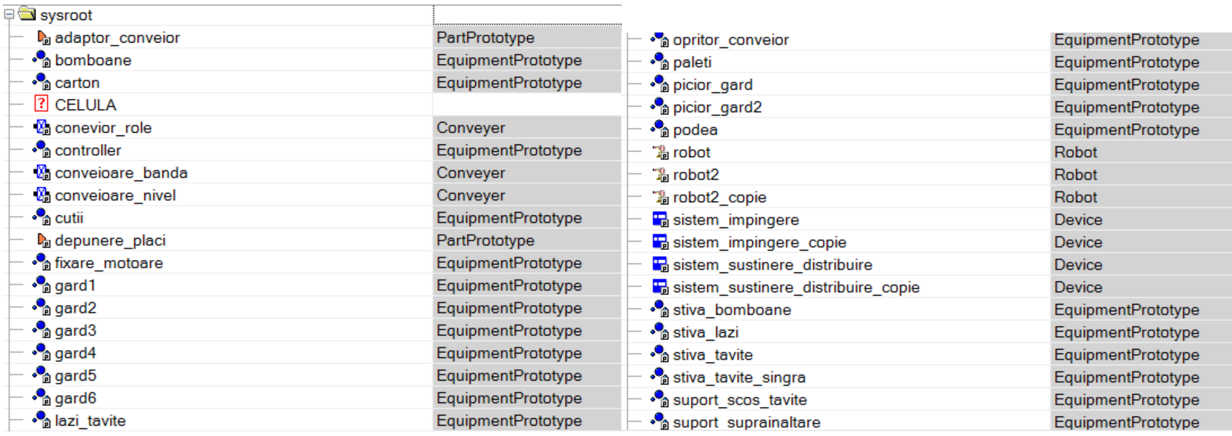


Fig. 3 – 3D model of the secondary cell in Process Simulate

In order to include all the elements in Process Simulate we need to specify what type of element they are. For fixed elements EquipmantPrototype was chosen, while for mobile devices - Device, for robots - Robot and conveyors – Conveyors (Fig. 4).



sysroot	
adaptor_conveior	PartPrototype
bomboane	EquipmentPrototype
carton	EquipmentPrototype
CELULA	
conevior_role	Conveyer
controller	EquipmentPrototype
conveioare_banda	Conveyer
conveioare_nivel	Conveyer
cutii	EquipmentPrototype
depunere_placi	PartPrototype
fixare_motoare	EquipmentPrototype
gard1	EquipmentPrototype
gard2	EquipmentPrototype
gard3	EquipmentPrototype
gard4	EquipmentPrototype
gard5	EquipmentPrototype
gard6	EquipmentPrototype
lazi_tavite	EquipmentPrototype
opritor_conveior	EquipmentPrototype
paleti	EquipmentPrototype
picior_gard	EquipmentPrototype
picior_gard2	EquipmentPrototype
podea	EquipmentPrototype
robot	Robot
robot2	Robot
robot2_copie	Robot
sistem_impingere	Device
sistem_impingere_copie	Device
sistem_sustinere_distribuire	Device
sistem_sustinere_distribuire_copie	Device
stiva_bomboane	EquipmentPrototype
stiva_lazi	EquipmentPrototype
stiva_tavite	EquipmentPrototype
stiva_tavite_singra	EquipmentPrototype
suport_scos_tavite	EquipmentPrototype
suport_suprainaltare	EquipmentPrototype

Fig. 4 – Elements defined in the Simulation environment

After inserting all the cell's components, the mechanisms are built. This is done by defining the fixed elements in a link and the mobile elements in different links. They are connected by a rotational of translational axis (Fig. 5).

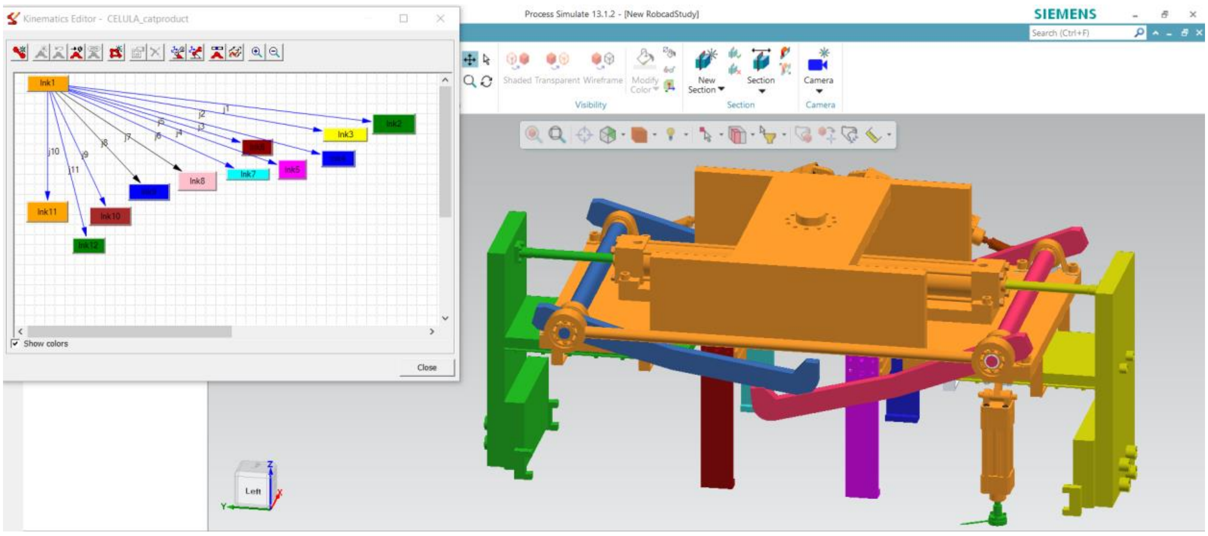


Fig. 5 – Definition of the effector kinematics

On Fig. 5 for each pair (link) a color is assigned both in the tree and on the 3D model. For example, orange color shows the fixed elements, while the moving elements are represented by the different colors. All couplings start from link1 because there are fixed elements and all other couplings depend on link1. All the links are prismatic since all the movements are linear.

4. Operational flowchart

In order to have an overview of the whole process, the flowchart must be designed. This is a sequential diagram of people or things actions involved in a complex system or activity.

Fig. 6 illustrates the process flowchart with the following symbols:

- rectangles - processes;

- rhombuses - sensorial elements;
- parallelograms - input / output data.

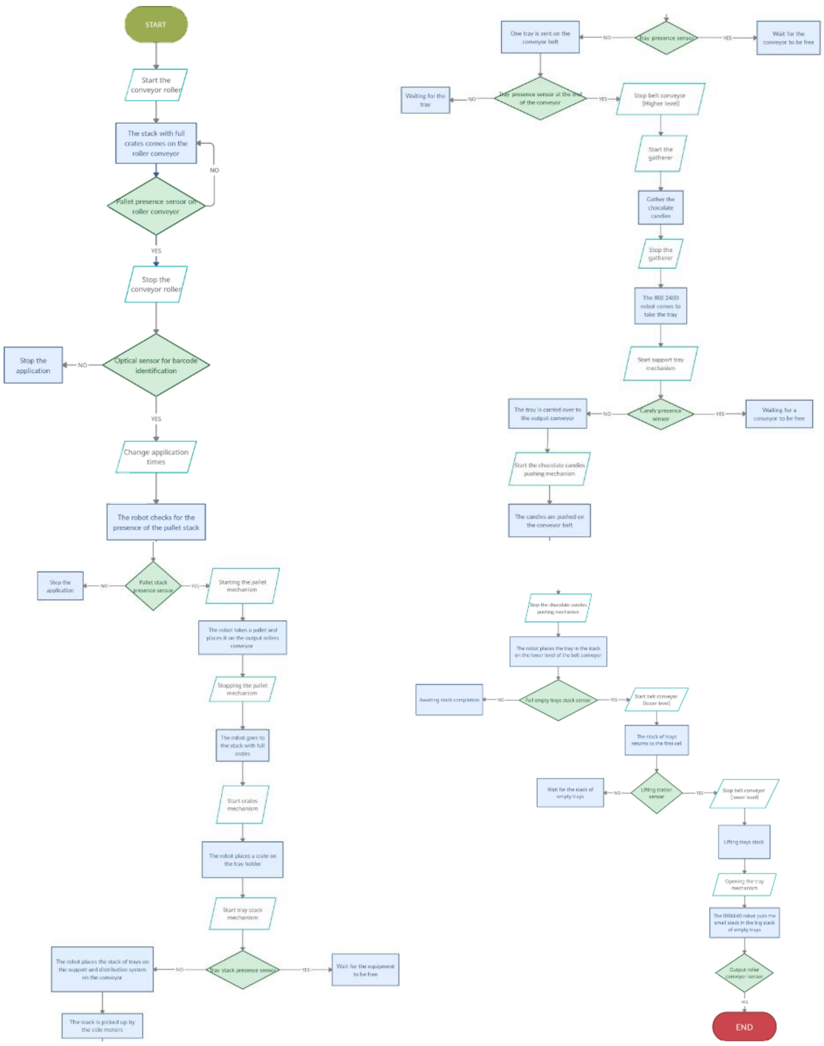


Fig. 6 – Flowchart of the process

The ABB IRB 6640 robot takes a pallet from the pallet stack and places it on the output conveyor. Then it takes the crates containing the trays together with the chocolate candies and place them on the tray support to remove the stack of chocolate trays from the crates. The chocolate together with the trays are lifted by the robot using another type of mechanism and placed on the support and distribution system with the role of sending them one by one, on the upper level of the belt conveyor. The now empty crate is placed on the output pallet, on top of the others. The final step is to put the pallet on which the crates arrived in the pallet stack. This last operation is performed with a claw gripper.

After the chocolate candies are removed from the belt conveyors in the first cell, they end up in a second cell where they are stacked by a special system to be picked up by an ABB IRB 2400 robot and pushed from the trays on two belt conveyors. They exit the system and move to the packing station.

It is easy to follow the programming steps on the flowchart because it clear which activities are done in parallel and what condition are needed to start/stop specific actions.

5. Sensor mapping

Sensors are vital elements in a robotic cell. They help to run the process accurately, without accidents and with a high productivity. Because the robotic cell is devoted to the food industry in which no metallic materials are allowed, the sensors that detect the presence of the objects have to be capacitive sensors. Most of the sensors need only two logic values (1 or 0). These values are of digital type. The only sensor that requires continuous electrical signals is the camera, since it has to recognize all the crates barcodes.

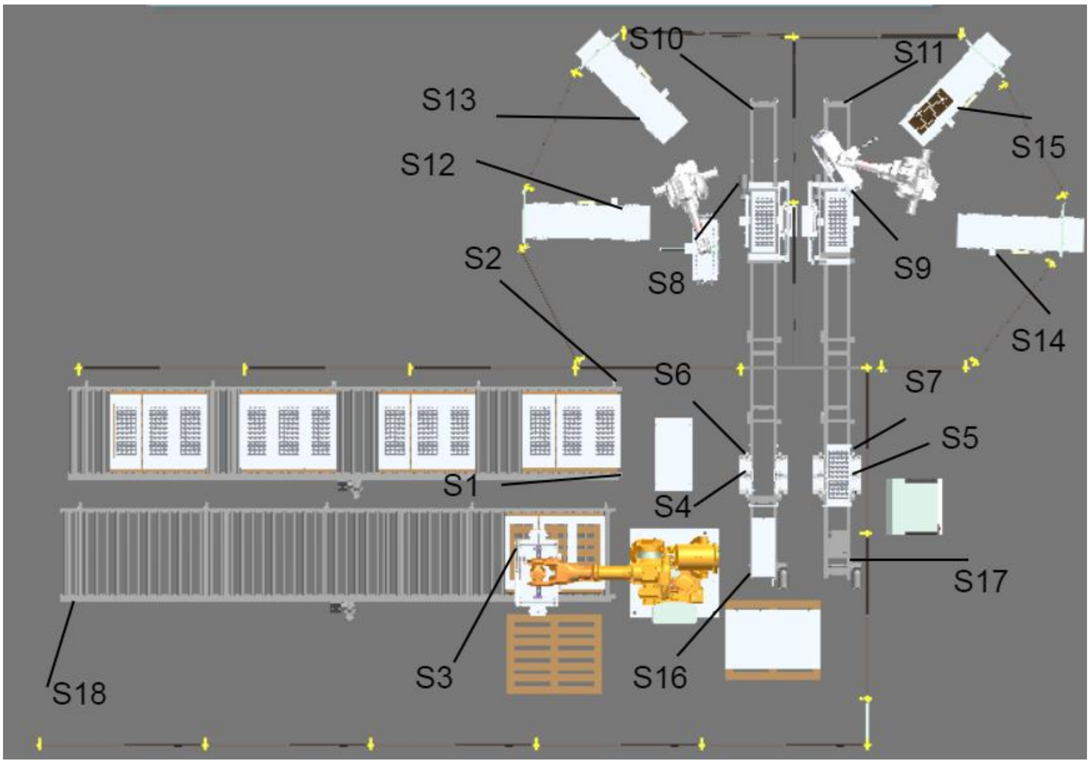


Fig. 7 – Sensor mapping

Table 1 describe each sensor type and the corresponding logical function. Analog Sensors **measure the external parameters and give an analog voltage as an output**. They produce a continuous output signal or voltage which is proportional to the quantity being measured.

Table 1 - Sensors

Nr.	Sensor type	Signal type	Logical function
S1	optical	analog	identifies the barcode specific to each type of chocolate candy
S2	capacitive	digital	stops the roller conveyor
S3	force	digital	detects the presence of the pallets
S4,S5	force	digital	detects the presence of the stack of trays
S6,S7	capacitive	digital	detects the presence of the tray start the side motors in the distributor to place one tray on the conveyor
S8,S9	capacitive	digital	detects the presence of the tray start the squeezing mechanism

S10,S11	capacitive	digital	detects the completion of the stack of empty trays start the belt conveyor (lower level)
S12,S13,S14,S15	capacitive	digital	detects the presence of candies on the output conveyors let the robot know if it can put the chocolate candies on the conveyor
S16,S17	weight	digital	detects the stack of empty trays reached start the lift system announces the robot to take the stack
S18	capacitive	digital	detects the empty pallet stack; stops the output conveyor

6. Datasets

To use a Machine Learning procedure in order to make original and customized recipes, a set of input data is needed. These are represented by two tables: customers and ingredients. The principle is to get new recipes knowing the type of chocolate and the favorite ingredient of each customer.

The “group” column was employed to sort the ingredients of the same type, so that not to put more ingredients in the same category. The data was generated randomly in Excel software, but it follows real-life studies found on the web [1],[2],[3].

gender	age	chocolate type	ingredient
1	32	milk	caramel
2	26	black	caramel
2	22	milk	simple
2	39	black	hazelnut
2	29	white	hazelnut
2	17	white	caramel
2	42	black	hazelnut
1	24	milk	orange
2	16	milk	caramel
2	26	milk	hazelnut
1	16	white	caramel
2	15	milk	caramel
1	41	white	orange
2	18	white	almonds
2	32	milk	hazelnut
2	18	milk	almonds
2	32	black	hazelnut
1	26	milk	hazelnut
2	23	milk	almonds
2	26	milk	hazelnut
2	17	black	hazelnut
1	26	milk	hazelnut
1	27	black	simple
2	39	milk	almonds
2	20	black	caramel
1	15	white	caramel
2	28	milk	caramel
2	26	white	caramel
2	25	black	hazelnut
1	19	black	simple
2	44	black	caramel
2	24	black	hazelnut
1	29	milk	hazelnut
2	39	black	caramel
2	32	black	caramel
1	32	milk	caramel

name	associated chocolate	grup
potato chips	black	1
almonds	black	1
peanuts	black	1
pretzels	black	1
goat cheese	black	2
parmesan	black	2
blue cheese	black	2
raspberries	black	3
grapes	black	3
strawberries	black	3
bananas	black	3
peppers	black	4
pumpkin	black	4
fennel	black	4
walnuts	milk	5
hazelnuts	milk	5
pecans	milk	5
Gruyere cheese	milk	6
Asiago cheese	milk	6
coconut	milk	7
orange	milk	7
apples	milk	7
cherries	milk	7
peanut butter	milk	8
honey	milk	8
caramel	milk	8
blackberries	white	9
blueberries	white	9
lemon	white	9
lime	white	9
Macadamia nuts	white	10
cashews	white	10
caviar	white	11
matcha	white	12
cardamom	white	12
saffron	white	12

Fig. 8 – Ingredients (left) and customer (right) datasets

The formulae (1), (2), (3) and (4) are based on the RAND function that generates numbers between (0;1), which can be interpreted as percentages. A similar function is RANDBETWEEN which generates a number between a given interval. Both this functions are integrated in an IF function that makes the program respect the conditions given by the operator.

An example is the "gender" column: the formula shows that there are 67% female customers, while only 23% are male costumers. From this formula, it is also revealed that the chocolate is most popular with the young adults with the ages between 25–34. For the most popular chocolate receipt, it is shown that the women and men prefer the milk chocolate more then other chocolate types. The favorite ingredient is peanuts with a 37% of fans between the costumers.

Gender = IF(RAND()<0,67;RANDBETWEEN(2;2);RANDBETWEEN(1;1)) (1)

Age = IF(RAND()<0,03;RANDBETWEEN(45;90);(IF(RAND()<0,17;RANDBETWEEN(35;44); (IF(RAND()<0,49;RANDBETWEEN(15;24);RANDBETWEEN(25;34)))))) (2)

Chocolate type = IF(A2:A37=1;(IF(RAND()<0,18;"black";(IF(RAND()<0,56;" white"; "milk")))); (IF(RAND()<0,2;" white";(IF(RAND()<0,55;"black";"milk"))))) (3)

Favorite ingredient = IF(RAND()<0,02;"portocale";(IF(RAND()<0,12;"migdale";(IF(RAND()<0,39; "caramel";(IF(RAND()<0,76;"alune";"simplă"))))))) (4)

6. Conclusion

The robotic cell is ready for the simulation and offline programming. Future work will focus to include the sensors in Process Simulate environment and link the mechanisms. Regarding the intelligent recipes, the generated data sets are prepared for including them in the Learning model, improving and smart predictions attempts that will allow to tune the simulation events with the manufacturing times required by the smart recipes.

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