DOI: 10.37394/232022.2023.3.14

Simulation of a flexible manufacturing system for machining some industrial parts

PAUL CIPRIAN PATIC
Valahia University of Targoviste, ROMANIA

Abstract**:** One thought about this work because we consider that the operating procedure of flexible systems could be introduced in most factories that propose and have as a priority large-scale production. The mode of operation and planning of each robot is very close to reality thanks to the 3D simulation, made in the Alice three-dimensional graphic environment. With this procedure, one can highlight the main characteristic of a flexible manufacturing system, that is, the flexibility obtained through automation and at the same time the saving of working time. Thanks to the fact that a computerized machine system is used, any piece can be executed, at any time and in any quantity, representing an advantage for any factory that uses this system. Another major advantage is the development of new programs that allow the solution of numerous problems related to the coordination of the various components of the system and the optimal operation of the machine.

Keywords**:** Graphic Programming, Flexible manufacturing system Industrial Robot, Simulation, 3D Objects.

Received: April 25, 2022. Revised: August 23, 2023. Accepted: September 24, 2023. Published: October 6, 2023.

1. Introduction

THE chronology of flexible manufacturing systems begins in 1968, when Cincinnati Milling Machine implemented the first SFF, officially registered as a manufacturing and commercial trademark, under the name "Variable Mission Manufacturing System".

The new system implements revolutionary notions at that time, widely used even today in the profile industry, such as: modular equipment with automated tools, automated replacement of the working head and pallets; the machines, the conveyor for transporting the tools, connected to a central computer, various indications grouped around the machines and controlled automatically in a waiting line, in random order; flexibility, to make a family of benchmarks in small batches [1].

The short duration of time, to respond to the constructive changes of the benchmarks and the change of models.

The first SFFs performed mechanical machining operations by chipping, symbolizing a replacement of the traditional structure, on groups of machines, in the manufacture of landmarks.

From the above, it shows that an authentic SFF is necessary to involve several processing centers and material handling systems embedded in the computer control hierarchy.

Moreover, even an SFF is advised by the constraint of a random trajectory of landmarks, instead of the recent situation, in which landmarks are modified and moved in a straight direction, between stations, work points, as is done in specialized automated systems, of transfer line category.

Sometime the terms "Computer Manufacturing System - CMS" and "Variable Mission Manufacturing - VMM" were used synonymously with the concept of SFF. In a flexible manufacturing system, the numerically controlled (NC) devices are coordinated by the computer, the landmarks are handled by robots and the finished products, transported to their characteristic destinations, by means of automatically controlled vehicles (AGV). Both tool sheds and automatic tool change systems are a structural part of the manufacturing system [3].

As changes occur in the constructive design or product technology, they are incorporated into computer programs or databases. In 1980, Cincinnati Milacron was the first company to describe and present a "genuine SFF" at the Chicago Machine Tool Fair, USA.

In the 90s, Cincinnati Milacron initiated a revolutionary new concept in flexible manufacturing, called the module family typed "Flexible Manufacturing Cells - CFF", later named "Chronos".

Regarding the Flexible Manufacturing System, there is a diversity of notions, which express the points of view of different producing companies, consumers, of national and international organizations.

The need for this diversity allows the analysis of a special range of opinions regarding what the manufacturing technology of the 21st century means [7].

A flexible manufacturing system is characterized as "an autonomous production facility, which can be used in an active and heterogeneous market, with a minimum reaction period from the moment the manufacturing order enters the system until the realization of a salable product, using a minimum amount of capital".

A limited definition in the field of processing technologies is the following: "An SFF is an integrated complex, controlled by a computer, made of numerically controlled machine tools, automatic material and tool handling equipment and automatic control and testing equipment , which, with a minimum of interference and change time, can adapt any product belonging to a specific family that is included within the limits of its forced competence and in accordance with a predetermined manufacturing program [10].

A broader, descriptive definition is the one belonging to the "US Office" for "Technology Assessment", according to which an SFF is a manufacturing unit capable of making a class of discontinuous products, under the conditions of minimal human intervention [9].

It is made up of workstations equipped with production equipment (machines, tools or other equipment for manufacturing, assembly, or thermal transformations), connected by a material handling system, which moves the landmarks from one workstation to another and which functions as an integrated system, under full programmable control.

SFFs can also be studied from the point of view of robotics.

Robots are characterized as "equipment capable of performing a variety of execution, manipulation and/or movement functions, in relation to programmed instructions and/or impulses from various sensors".

A robot can be successfully used in a multi-product assembly line, to perform execution and/or movement tasks. Robots can be associated in three large categories:

- accessible robots;
- various robots;
- various robotic cells.

At the same time, the use of diverse robots, with different levels of industrial incorporation, appeared recently, being able to rank the "multirobot" systems in two broad directions:

- autonomous multirobot assemblies;
- cooperative multirobot assemblies.

Robots constitute a class of technical systems that imitate or substitute human or intellectual human functions [12].

This is done by associating different types of manipulation or locomotor systems, determining the anthropomorphic character of the robot, with different types of computing or logic equipment that determine its intellectual functions. Robots perform their activity in a concrete environment, whose characteristics may remain constant or variable over time.

Robotics is an interdisciplinary branch of engineering and science that includes mechanical engineering, electronic engineering, computer science, and others.

Robotics deals with the design, construction, operation and use of robots, as well as computer systems for their control, sensory feedback and information processing [5].

Robotics is a branch of engineering that involves the conception, design, manufacture and operation of robots.

This field overlaps with electronics, informatics, artificial intelligence, mechatronics, nanotechnology and bioengineering.

Robots are made to manipulate by lifting, modifying or destroying a certain object.

They are used most of the time for the purpose of replacing the human, allowing them to perform some tasks in place of the human.

So, the hands of a robot are also called "effectors end", and the arm is represented as a manipulator.[4]

Typically, robots are used to perform difficult, dangerous or monotonous work for humans. Lifts heavy objects, paints, welds, handles chemicals and performs assembly work for several days without suffering from fatigue.

Finally, as one knows, the robot's governing structure is a hierarchical structure. This driving principle is due to the special complexity of the systems that are part of the robot and the difficulties created by the imposed operating tasks.

The hierarchical organization of the robot control systems is vertical, each level hierarchically covering the inferior level in relation to the driving problems addressed. A level of control communicates with the immediate inferior level through control instructions and receives from it characteristic information which, together with the decisions provided by the immediate next level, allows it to determine the future strategy of action [8].

Robot systems generally include a variable number of hierarchical levels depending on the complexity and degree of intelligence of the driving system used.

2. Simulation with Alice 3D Graphic Environment

To carry out the simulation in Alice we need acquired knowledge, such as: java programming language, 3d rendering using 3DMax.

Alice is software that can be very useful to a large category of specialists, with its help we can put into practice a simulation of real life, using object-oriented programming. Being very intuitive, the 3D Alice graphic environment can be downloaded for free, it has evolved a lot in recent years [13]. Alice 3D is a program that helps us create 3D applications (creating a game or a video).

With the 3D objects in Alice, we can create an animation as close as possible to reality, programming each object, such as: robots, vehicles, different objects.

Alice proposes an interface in which commands are presented that help us move objects and allow us to run the application to see what the connection between the programming of objects and their behavior in the graphical simulation is. Alice was thought and developed later to solve three problems on that we meet in educational programs: almost all programming languages that we know are created to have additional complexity, that is why Alice is thought in such a way that we can use object-oriented programming as easily as possible [11].

Those who use the program can imagine a virtual world and can place objects from the program's gallery by the "drag and drop" method of objects.

The Alice software is united with the IDE, that is, the menu and the development environment help us to program with as little difficulty as possible, the programming structure is based entirely on object-oriented programming [2].

To create an animation or a game we need certain steps:

- ***Defining the scenario*** - we think about something from real life and want to simulate it in the 3D application. One must choose the objects we need and the programming of the chosen objects.

- ***Animation projection for the script***: visual, textual or both.
- ***Realization of the application***.
- ***Running the application.***

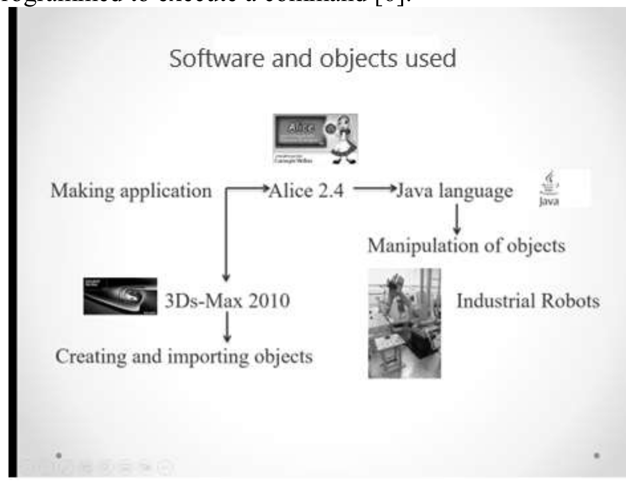
3. Presentation of the Graphic Interface of the Project

When we open the program, a dialogue box appears on the screen, "Select project", it has 6 tabs: « tutorial, recent worlds, templates, examples, Textbook and open a world [14].

Preparing the graphic environment for work and calling the own libraries/libraries to extract the industrial robots used in the application.

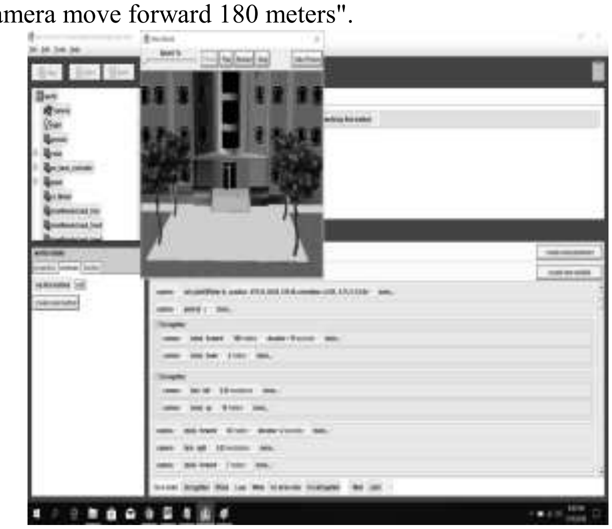
4. Simulation of a Flexible Manufacturing System for Machining Industrial Parts

The application is called "Simulation of a flexible manufacturing system for machining industrial parts". Once the animation starts, you can see how each industrial and mechanical robot was programmed. To create the animation, one used object from the Alice gallery, but we imported some objects that we converted with the help of 3Ds Max 2010. In making the graphic simulation one used 3D objects, all programmed to execute a command [6].

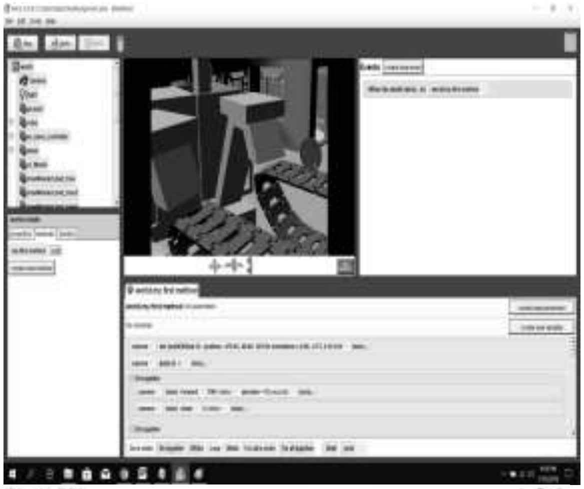


Running the application

To begin with one used an automatic camera positioning command and one set the camera so that wherever we are in the virtual world when we give it "run" the camera is positioned in the place set by me. After positioning the camera this is followed by another command, for moving forward "camera move forward 180 meters".



Once we entered the factory, we met the robots and the presses used to make the parts.



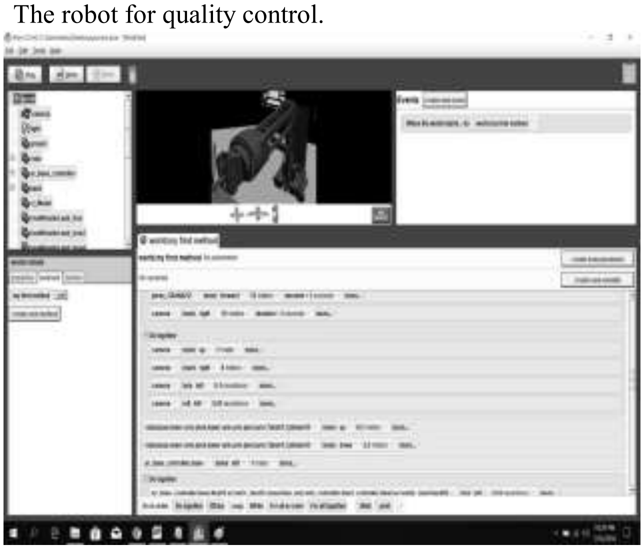
For the piece to be able to move on the tape, one used the following command:

Once it reaches the end of the strip, the drilling robot will start, using the command:

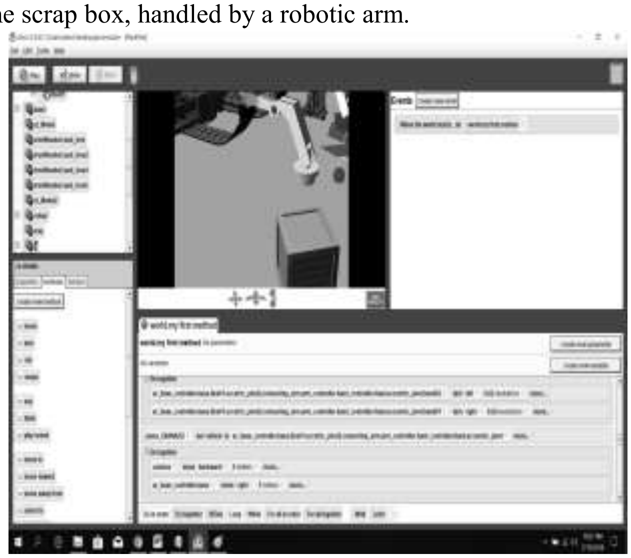
Immediately after the robot finishes drilling, a red or green LED lights up. Green shows that the part is ready for transport and red it must go through quality control.

DOI: 10.37394/232022.2023.3.14

The robot for quality control.

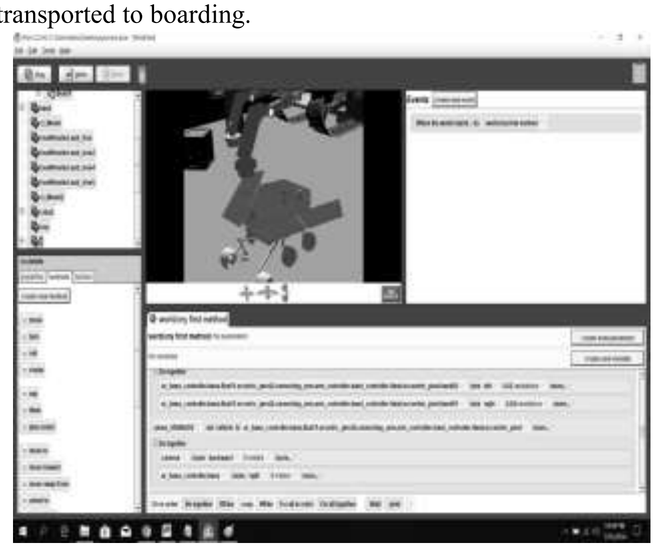


If the part does not pass the quality test, it will be added to the scrap box, handled by a robotic arm.

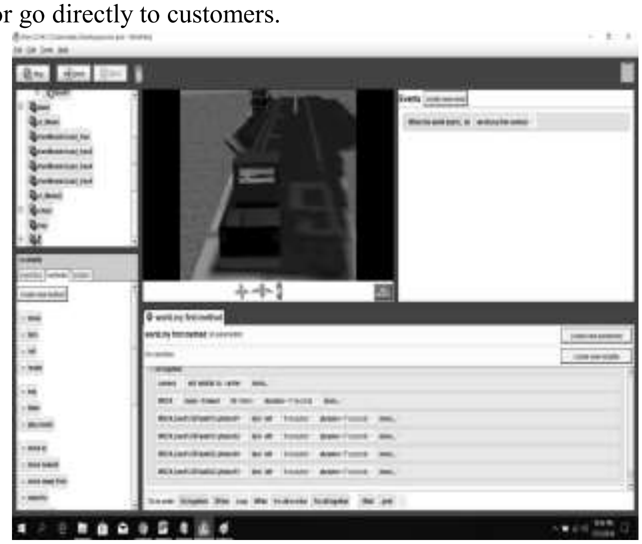


The robot for cutting the piece.

If the LED lights up green, then the piece will be picked up by a mobile robot operated by a robotic arm and will be transported to boarding.



Outside the factory, there is a car for transporting manufactured parts. Thus, the parts can end up in a warehouse or go directly to customers.



Factory overview

5. Conclusions

Making this graphic simulation, one had to use the different knowledge such as: interactive java language, object modeling in 3DMax, object-oriented programming, flexible manufacturing system, industrial robots. Flexible Manufacturing System illustrates an automated assembly that unites several machines through a handling system, and the actions that take place inside the system are carefully monitored and checked by means of a computer. The advantage that a flexible manufacturing line has over an automatic production line is to be able to produce several types of products simultaneously. This particularity is decisive in a production line because it allows various modules to be able to modify a part of the part. When transformations of products or production programs occur, the system is technically competent to adjust for new configurations of the required example. Flexible manufacturing systems work and have group technology implemented, so no system can work completely flexibly and manufacture an infinite number of parts. Such a system is subject to the production of parts and these are included in a class of processes, sizes and types. As a conclusion, a flexible manufacturing line is planned in such a way that it can create a limited number of products. Another well-conceived notion in Alice is the development environment because it presents the concept of object-oriented programming. When we use object classes, methods, parameters, the program allows us to view and control objects in the interface. Programming using software that offers 3D simulation is considered a successful job, bringing a major contribution to the development of technology, thus canceling the degree of difficulty encountered in using some devices. The idea of implementing flexible manufacturing systems is a necessity for all large manufacturers to be able to guarantee the quality of the manufactured product. This acquisition is obtained using automated machine tools, which require a high investment cost, calculating the profit capacity with the manufacturing expenses.

References

[1] Calangiu A., Expert system for learning industrial robots from flexible manufacturing cells, Transilvania University of Braşov Publishing House, 2011.

[2] Dann Wanda P., Cooper Stephen, Pausch Randy, Learning to Program with Alice, 2015.

[3] Dumitriu, A., Mechatronics,"Transilvania" University Publishing House, Braşov, 2006.

[4] Ispas, Viorel, Applications of kinematics in the construction of manipulators and industrial robots, Romanian Academy Publishing House, Bucureşti, 1990.

[5] Kovaks, FR., Cojocaru, G., Manipulators, Robots, and their Industrial Applications, Facla Publishing House, Timişoara, 1982.

[6] Lache Simona, Flexible manufacturing and assembly systems, Transilvania University of Braşov Publishing House, 2002.

[7] Niculescu-Mizil G., Flexible processing systems, Technical Publishing House, Bucharest, 1989.

[8] Patic P. C., Zemouri R., Modeling and Simulation of a Conveyor used in the Home Appliance Industry, Proceedings of the 34th International Business Information Management Association - IBIMA 2019, 13-14 November 2019, Madrid, Spain, Vision 2025: Education Excellence and Management of Innovations Through Sustainable Economic Competitive Advantage, pp. 4045 - 4054.

[9] Patic P. C., Mainea M., Pascale L., Mantescu G., Informatic system used for simulation of a Robotic Arm, 31st International Business Information Management Association - IBIMA 2018, 25-26 April 2018, Milan, Italy, Innovation Management and Education Excellence Through Vision 20202, Vols. I –XI, pp. 4788 - 4795.

[10] Patic P. C., Simulation of a Educational Mobile Robot, Proceedings of the 36th International Business Information Management Association - IBIMA 2020, 04-05 November 2020, Granada, Spain, Education Excellence and Innovation Management through Vision 2020.

[11] Pop, E., Leba, M., Egri, A., Robot driving systems, Didactical and Pedagogical Publishing House, Bucureşti, 2001.

[12] Selig, J.M, Introductory Robotics, Ed. Prentice Hall, 1992.

[13] http://www.alice.org.

[14] https://www.java.com/en/java_in_action/alice.jsp.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The author contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The author has no conflict of interest to declare that is relevant to the content of this article.