Benchmarking simulation software features: a comparison between two COTS software in a fashion environment

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KEYWORDS
Simulation, Commercial Off-The-Shelf (COTS), Manufacturing, Anylogic, Simio, Discrete Event Simulation (DES), Comparison.

ABSTRACT

Building a simulation model is a good practice for comparing and evaluating different design alternatives. In recent years, many companies in the fashion industry have shown a great interest in simulation topics. However, there is a lack of research papers that discuss the comparison of simulation software in the context of fashion. This paper proposes an analysis of the capabilities and features of two commercial simulation software packages, Anylogic and Simio. The article presents a benchmarking analysis based on a case study in the fashion industry.

1. INTRODUCTION

Over the last 20 years, the flexibility required by next-generation industries has demanded features like overconnectivity and data management. The Industry 4.0 paradigm has become a major part of intelligent manufacturing systems (Derigent, et al., 2021). Fashion products cover a wide range of items and change frequently according to consumer demands and trends. Due to the high interest of consumers in fashion products, the fashion industry is one of the most important industries globally. As a result, companies continually invest in new technologies to improve their business (Spahiu, et al., 2021). Moreover, the present situation of all companies shows that Industry 4.0 technologies are essential for fashion industries to remain competitive in the global market (Majeed & Rupasinghe, 2017). The main technological trends in industrial production are system integration, IoT, big data, additive manufacturing, automation, and simulation (Gilchrist, 2016). Of all these technologies, this paper discusses the application of simulation in the fashion industry.

The first field of fashion companies to use simulation models is supply chain management. The complex interdependency between all the actors within the logistic chain makes it extremely difficult to find an optimal configuration (Iannone, et al., 2007). Simulation is one of the best decision-support tools, allowing you to test different what-if scenarios and to choose appropriate solutions (Oliveira, et al., 2016).

As manufacturers are often reluctant to experiment with new control architectures on their production systems mainly due to risk aversion considerations, they prefer to first assess the control architecture using simulation before implementing it on a real scale (Attajer, et al., 2021). Consequently, simulation and digital twin models have gained more importance for manufacturing businesses. Furthermore, the fashion industry has started to build innovative product-driven control architectures with the use of simulation systems. The aim of this paper is to compare two commercial simulation software packages (Anylogic and Simio) to understand their capabilities in building a model of the fashion industry.

This paper also aims to propose guidelines regarding the development of discrete event simulations in fashion industries. The paper is structured as follows: Section 2 reviews the related works in literature concerning technological improvements in the fashion industry and the use of commercial simulation software in these industries. Section 3 provides an analysis of the requirements in the fashion industry to create a strong model. Then, Section 4 illustrates how the case study is conceived in Simio and Anylogic. Section 5 shows the comparison between the features of the two software packages. Finally, Section 6 provides the results of the comparison in terms of the strength and quality of features.

2. LITERATURE OF INDUSTRY 4.0 IN FASHION INDUSTRY

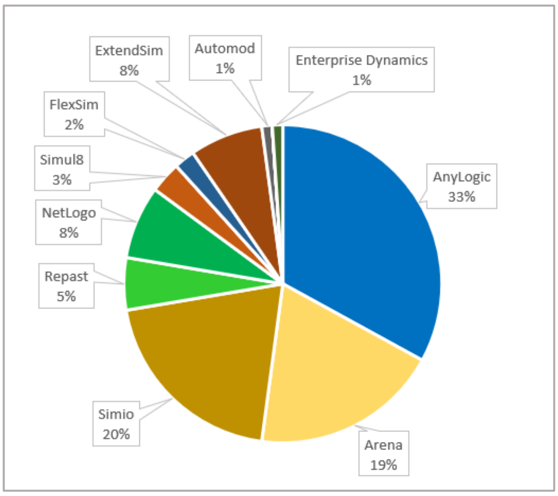
In the last few years, customers have been changing and the outfit market has been adapting to this. The traditional Slow Fashion approach is characterized by long trends and standard time in development, production, and distribution. This approach is now changing into the recent Fast fashion philosophy. Fast fashion is focused on the quick response to the customers, the volatile demand and short life cycle products (dos Santos, et al., 2021). These demands for high performances are forcing industries to turn into smart factory, able to combine high speed with customization of products (Grieco, et al., 2017). To do this, it is necessary to introduce the Industry 4.0 innovations in companies. Today, new manufacturing technologies, digitalization and interconnection are probably the newest characteristics of a business model for the present and for the near future (Derigent, et al., 2021) (Schuh, et al., 2017). Due to this, manufacturing industries are now characterized by high complexity,

various sources of uncertainty, and nonlinearity. On one hand, hard constraints must be easily satisfied by software and programs. On the other hand, projects are often executed in systems with high uncertainty (Song, et al., 2018) (Lin & Chen, 2015) (Nagasawa, et al., 2015). These characteristics make it difficult to apply traditional theoretical methods to optimize productivity and to maximize uptime and to reduce lead-time (Zhang, et al., 103123 (2019)). Simulation modelling is conducted to gain insight into these complex systems, testing new resource policies and new concepts before implementing them (Mourtzis, 2020). Many applications of simulation in low-tech context, including fashion companies, can be observed in literature (Fani, et al., 2017) (Macchion & Fornasiero, 2021) (Fani, et al., 2021) (Fani, et al., 2020). Other important paper deals with the technological level of four large textile industries, highlighting innovations that can improve their business. The interviews have shown that only one company has simulation among its technologies, but with low usage. Instead, 50% of companies consider this technology to be important for improvement and innovation of their industries (Falani, et al., April 5-8, 2021). Other papers and articles discuss characteristics of models and systems developed by the experts (Attajer, et al., 2021). However, it's also important to describe features of simulation software that can be used to realize these models (Swain, 2019). Some papers focused on finding frameworks for simulation software selection (Tewoldeberhan, et al., 2002) (Azadeh, et al., 2010) (Gupta, et al., 2010). Also, there are articles that realize ranking of commercial software (Dias, et al., 2016) (Abar, et al., 2017). Instead, there are fewer articles dealing with the comparison of commercial simulation software in terms of features and usability.
This paper tries to fill this gap, by presenting a comparison between the features of commercial simulation software. As a starting point, the features reported in this article take their cue from the paper by Fumagalli et al. (Fumagalli, et al., 2019) which creates a framework to compare simulation software.

3 REQUIREMENTS FOR SIMULATION OF A FASHION INDUSTRY

The first step in realizing a case study is to define the type of work environment. This allows understanding the needs and criticalities related to it. The Job-Shop environment best fits the company considered for the case study, as it is very flexible but has complex and difficult production flow management. In Job-Shop, the production plans consist of small lots and a wide variety of products, making production management extremely complex. Therefore, the first necessary feature of simulation software is the ability to make data-driven models that allow quick changes to input parameters such as production mix, resource capacity, production cycle, and quantity of SKU. The second aspect required is the presence of an interface that can easily model the physical structure of the plant. Specific libraries are required to represent the physical model. Also, the third necessary feature is the presence of libraries with logical blocks in the simulation software to build a working model with the right functionality. In addition, it is necessary to graphically represent the simulation model. The fourth essential feature concerns the presence of 2D and 3D animation tools. Finally, the last necessary requirement is the ability to use Agent-Based Modeling, in addition to classical Discrete Event Simulation.
The second step is represented by the definition of the sample of simulation software that must be compared. The large number of simulation software on the market makes it difficult to choose the most appropriate one for making the comparison. Initially, the simulation software most used in the last period was considered. To do this, we took the simulators used at the 2017 WSC. The most widely used were AnyLogic, Simio, and Arena, as shown in Figure 1.
The first two possess specific libraries for building material handling simulation models, making them easier to use than Arena. For these reasons, Anylogic and Simio were chosen to realize this case study.

Figures 1: Simulation models diffusion (adapted from Winter Simulation Conference website)



4 CASE STUDY IN SIMIO AND ANYLOGIC

4.1 Case study definition

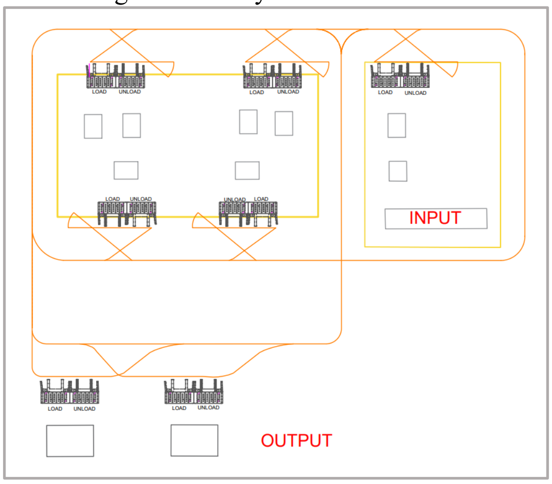
The realization of the case study is divided into three phases, the first two of which are built externally to the applications and only carried out once, while the last one is realized twice in both simulators. Phase 1 involves analyzing the real plants in terms of structure and objects. This analysis includes the layout and information of the plant, such as productivity and resources. In Phase 2, the results of Phase 1 are conceptualized in the form of inputs, such as CAD layout and database. Phase 3 involves model development after importing the inputs from Phase 2 into both simulators.

4.2 Input of the Case Study

First, in literature you can observe some models use as case studies of manufacturing industries (Attajer, et al.,

2021) (Yang, et al., 2018) (Cao, et al., 2019) (Macedo, et al., 2021) (Silva, et al., 2016). These models can be used as examples to take inspiration. The aim is to create simple but complete models that allow you to compare many features of the two software. Two main inputs to build a data-driven model are: the physical layout of the plant and the information in database. The layout is realized using AutoCAD 2D and is composed by four units. The transport within each unit is performed by operators, while in those between one unit and the other the products are moved from the Automated Guided Vehicles (AGV). 2D layout is shown in Figure 2.

Figure 2: 2D layout made on AutoCAD



Once the 2D CAD is created, it is imported into the simulators, on which the physical model is built. The other main input is the database that contains all the information needed to parameterize the model. This object is created using Microsoft Excel. The case study presents two different SKUs, fourteen workers, three AGVs, and about twenty resources. First, it is necessary to divide the information into several classes of tables. As a result, a database can be considered as a set of interacting tables. All the classes created for this case study are shown in Table 1. After creating the database, it will be imported into both simulators. The following paragraphs describe the model constructions, first in Simio and then in Anylogic.

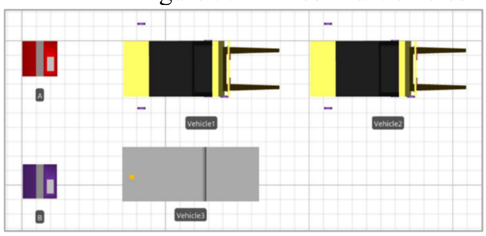
Table 1: Classes in which database is divided

NAME	*DESCRIPTION*
DB RESOURCES	Represents all resources that process entities, such as machines, workbenches and warehouses
DB PRODUCTION PLAN	Contains each order generated in the plant, describing SKU, quantity, time and date of arrival
DB WORKERS	List of operators that model can used as human resources during simulation
DB AGV	List of AGV that transport entities, describing the capacity and the id connected to each vehicle
DB PRODUCTION CYCLE	Contains all parameters related to production, such as the id, the SKU type, the work-phase, the resource and the production time

4.3 Model building in Simio

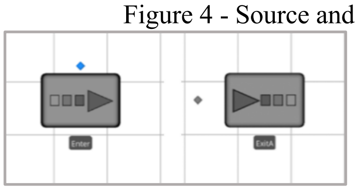
The model structure is derived from the 2D plan that was previously imported. First, entities must be created. They have several properties to manage their operations, with the most important being the sequence of travel nodes and the production plan table. These properties are imported from the database. The other objects are vehicles and operators. The vehicles move along paths between different bays, while the operators move within the sector in free space. The entities and vehicles created in the model are shown in Figure 3.

Figure 3: Entities and Vehicles



The system has one entry and two exits for entities. Entities are created by a Source block, simulating the entry of goods into the plant. Instead, the Sink block is used to simulate the output of finished products from the model. These two types of blocks are illustrated in Figure 4.

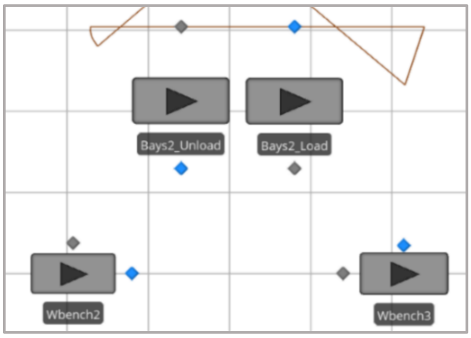
Figure 4 - Source and Sink blocks



After defining the objects, it is necessary to create bays and workbenches inside the sectors. The bays are modeled using two Server blocks: one to simulate unloading and one to simulate loading of entities. Instead, workbenches are modeled with a single Server block. As an example, one sector composed of bays and workbenches is shown in

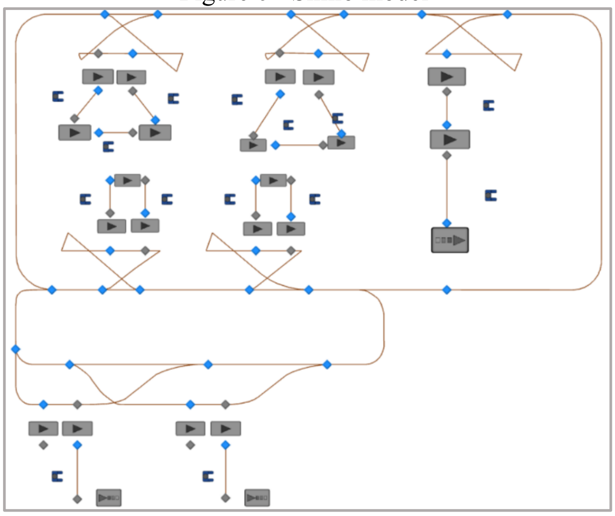
Figure 5.

Figure 5 - Sector, bays and workbenches



Both types of resources are associated with workers and vehicles through properties of Server blocks. Workers move in free space, while vehicles move on guided paths. By repeating these operations for the other sectors, both the physical and logical structure are realized. Then, the complete model is built and represented in Figure 6.

Figure 6 - Simio model



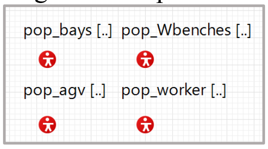
After building the system, it is necessary to produce usable output data. Variables are created and then assigned at specific points in the model. This assignment is performed using Add-on Processes. Once the construction of the Simio model is completed, the same plant needs to be modeled in AnyLogic.

4.4 Model building in Anylogic

The layout of Anylogic's model is derived from the 2D CAD drawing. In the main window, only the essential parameters and physical structure of the plant are displayed. This structure comprises paths and nodes, while the logical blocks are located in other pages that represent various types of objects such as AGVs, workers, bays, and workbenches. The objects constructed in this model are grouped into different populations, with one for each object type. These populations are illustrated in

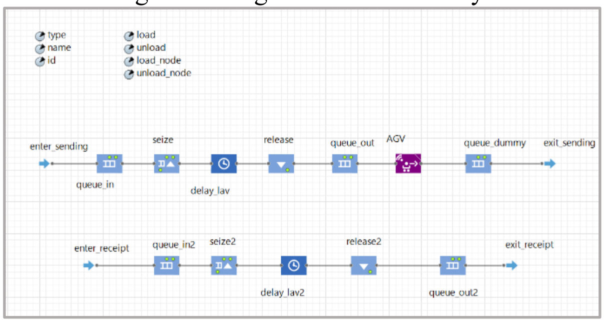
Figure 7.

Figure 7 – Populations



After creating the objects and their respective populations, the next step is to build the logical structure that simulates the system's operation. Each population contains logical blocks and parameters that are specific to that object type. An example of a logical system is the one that illustrates the operation of the bays, which is depicted in **Errore. L'origine riferimento non è stata trovata.**.

Figure 8 - Logical Structure of bays



This object contains two lines: one for sending the entities and another for receiving the goods. Specifically, the first line models the production and sending of entities to the next cluster, while the second line simulates the reception of entities and their delivery to the next workbenches. Functions written in Java are used to connect the logical structure and manage the system's operation. These functions are illustrated in **Errore. L'origine riferimento non è stata trovata.**. The ability to use ad-hoc functions allows for models with high flexibility and customization. These functions can also be used to extract Key Performance Indicators (KPIs) from a log file where runtime information is stored.

5 MODEL COMPARISON

5.1 KPI analysis

The aim of this chapter is to perform a benchmarking between two software programs used in Chapter 4. The first step is to validate the models by using four indicators to compare the performance of the Simio and AnyLogic models. The Key Performance Indicators (KPIs) chosen for validation are productivity, lead time, transit time of AGV, and occupation of workers. These were selected because they are easy to derive and are important for companies in the fashion industry. They allow for the identification of inefficiencies in the plant and the level of customer service, highlighting possible improvements to be implemented.

First, it is necessary to define the Warmup period to exclude invalid data. This definition is made by analyzing productivity in ten different runs with a duration of twenty days. In both models, productivity shows steady performance after three days. Therefore, the analysis of parameters only considers the following seventeen days.

Table 2 – Productivity

SIMIO	A	B	Tot	ANYLOG IC	A	B	Tot
04/01/22	55	55	110	04/01/22	55	55	110
05/01/22	55	55	110	05/01/22	55	55	110
06/01/22	55	55	110	06/01/22	55	55	110
07/01/22	55	55	110	07/01/22	55	55	110
08/01/22	55	55	110	08/01/22	55	55	110
09/01/22	55	55	110	09/01/22	55	55	110
10/01/22	55	55	110	10/01/22	55	55	110
11/01/22	55	55	110	11/01/22	55	55	110
12/01/22	55	55	110	12/01/22	55	55	110
13/01/22	55	55	110	13/01/22	55	55	110
14/01/22	55	55	110	14/01/22	55	55	110
15/01/22	55	55	110	15/01/22	55	55	110
16/01/22	55	55	110	16/01/22	55	55	110
17/01/22	55	55	110	17/01/22	55	55	110
18/01/22	55	55	110	18/01/22	55	55	110
19/01/22	55	55	110	19/01/22	55	55	110
20/01/22	55	55	110	20/01/22	55	55	110
Total	**935**	**935**	**1870**	**Total**	**935**	**935**	**1870**

Table 3 - Lead Time Average

	Average LT (sec)		
	ANYLOGIC	**SIMIO**	**DIFFERENCE**
A	2009,15	2015,28	-6,12
B	2286,07	2279,57	6,49
Total			**0,37**

Table 4 - Transit Time Percentage

	% TRANSIT TIME		
	ANYLOGIC	**SIMIO**	**DIFFERENCE %**
pop0	34,70%	34,85%	-0,15%
pop1	34,98%	34,80%	0,18%
pop2	33,74%	33,79%	-0,05%
Total			**-0,02%**

The statistical comparison of KPIs is done using Minitab software. The analysis performed is called a Paired t-test, which is a method used to test whether the mean difference between two sets of observations is zero. The results of this statistical procedure allow for validation of the models created in Simio and AnyLogic. It is then necessary to discuss the collection of features and compare them in both simulators.

Table 5 - Occupation Time Percentage

	% OCCUPATION TIME		
	ANYLOGIC	**SIMIO**	**DIFFERENCE**
Worker1	11,45%	11,46%	-0,02%
Worker2	7,68%	7,66%	0,02%
Worker3	11,46%	11,41%	0,05%
Worker4	28,68%	28,64%	0,04%
Worker5	42,94%	42,88%	0,06%
Worker6	11,51%	11,52%	-0,02%
Worker7	28,62%	28,68%	-0,06%
Worker8	42,94%	42,92%	0,02%
Worker9	11,47%	11,50%	-0,03%
Worker10	49,59%	49,64%	-0,05%
Worker11	11,46%	11,46%	0,00%
Worker12	49,67%	49,64%	0,03%
Worker13	68,75%	68,73%	0,02%
Worker14	57,26%	57,29%	-0,03%
Total			**0,02%**

5.2 Feature's benchmarking

This paragraph describes in detail the set of characteristics on which the benchmarking of simulators is based. Some of these features are obtained from literature, others from simulator's support handbooks. This set of properties is placed in a table divided in five categories (Tewoldeberhan, et al., 2002):

- Technical Compatibility: represent principal features of hardware and software compatibility and the integrated tools.
- Model Building: covers all items describing capabilities during model implementation by the software, including additional functions and input or output capabilities.
- Animation: contains the items related to graphical interface, the compatibility with graphic programs (CAD) and the realization of 2D and 3D animations or real time animations.
- Support and Education: reports characteristics of the available courses, online or offline, the presence of tutorials and the active support of developers. It is related to all the mechanisms that software-house use to help and train users about the use of their programs.

- Additional Information: represent the integrative features, difficult to classify, such as the presence of student version, vendor's comments and the new features developed by software-houses.

The comparison between features is divided in five areas and is shown in the following Tables.

Table 6 - Technical Compatibility

FEATURE	*ANYLOGIC*	*SIMIO*
SUPPORTED OPERATING SYSTEMS	Windows, Mac, Linux	Windows
COMPATIBLE SOFTWARE TO PERFORM	Excel, Acces, any database, OptQuest, Stat::Fit, Any Java/DLL library	Microsoft Azure, Wonderware, OptQuest, .Net Programs, Excel
CONTROLLED OR RUN BY AN EXTERNAL PROGRAM	Models can be exported and launched on Java applications	Wonderware, .Net Programs
CONNECTIVITY	Using Anylogic Cloud, web service for users	Using cloud with Simio and Microsoft Azure portals
MULTIPROCESSOR CPU SUPPORTED	YES	YES

Table 7 - Model Building

MODEL BUILDING

FEATURE	*Anylogic*	*Simio*
INPUT FROM (TEXT, SPREADSHEETS, DB)	Input from spreadsheets, particularly Excel, very flexible; once generate the tables you just need to import them on Anylogic.	More limited import; you need to create columns with default content type (vector, time, entity); only after you can import.
INPUT DISTRIBUTION FITTING	Default distributions easy to use; Custom distributions need to be defined through Java language.	Default distribution very easy to use, selectable from drop-down menus; Custom distribution are complex and inefficient.
GRAPHICAL MODEL CONSTRUCTION	Fast to execute during logical construction, but required assignment of graphical elements with Java language.	Very simple and fast, after the creation of logical blocks the graphics are selectable from a drop-down menu.
OUTPUT ANALYSIS SUPPORT	Log buildable from scratch; maximum customization; it is necessary to create in Java the functions to log.	Automatical Report Summary useful to know basic KPIs. Personalization of Log more complicated to implement.
OPTIMIZATION	OptQuest is used by default; custom optimization algorithm can also be created.	OptQuest is used by default; is unknowed the possibility of creating custom optimization algorithm.
RUN TIME DEBUG	YES	YES
MODEL BUILDING USING PROGRAMMING	Extremely strong programming, is the strong point of the program through the use of object-oriented language.	Modeling using programming is not excellent; is designed to building model without this features.
BATCH RUN / EXPERIMENTAL DESIGN	Create a flexible interface to perform parameter's changes and batch run.	Scenarios can be launched manually and with multiple replicas.
WARM UP	YES	YES
MULTIPLE RUN	YES	YES
DISCRETE MODELING	YES	YES
AGENT BASED MODELING	YES	YES
CONTINOUS MODELING	YES	YES
MULTIPLE LOGIC	YES (Strong features, it works very well)	YES (Is not as good as in Anylogic)

Table 8 – Animation

FEATURE	*ANYLOGIC*	*SIMIO*

ANIMATION	Simple to implement, whille requiring at least basic knowledge in Java to assign animations.	Simple and quick to realize, being able to select from drop-down menu the animation of objects.
ANIMATION EXPORT	YES	YES
REAL-TIME VIEWING	YES	YES
2D/3D ANIMATION	YES / YES	YES / YES
CAD DRAWING IMPORT	YES	YES

Table 9 – Support

FEATURE	*ANYLOGIC*	*SIMIO*
USER SUPPORT	YES (Interactive and available support, quick and clear; for small dubts you can use structured guides and tutorials)	YES (The support deals more with hardware/software problems; model development is mainly managed by blogs; also there are excellent tutorials)
CONSULTING AVAILABLE	YES	YES
TRAINING COURSES	YES	YES

Table 10 - Other Information

FEATURE	*ANYLOGIC*	*SIMIO*
PROFESSIONAL VERSION	17000 $ + 2500 $/year	4500 $
STUDENT VERSION	Free (Limited)	Free (Limited)
MAJOR NEW FEATURES (SINCE 2015)	Addition of specific libraries: Material Handling, Road Traffic and Logistic Transport.	New libraries for manufacturing industries, industry 4.0 and new industrial processes.
VENDOR COMMENTS	Unique simulator to integrate in an excellent way multiple simulation logic: Discrete Event, Agent-Based and System Dynamics.	Added innovation take flexibility and rapid modeling to new heights.

5.2.1 Technical Compatibility

Analyzing the first aspect, AnyLogic can work on three operating systems, while Simio is only compatible with Windows. Both applications are suitable for many external programs. AnyLogic's ability to adapt to the Java language is extremely important because it makes this software more flexible for users with programming knowledge. However, this feature also makes AnyLogic more difficult to use for new users compared to Simio. Both software have good connectivity and cloud capabilities.

5.2.2 Model Building

Both AnyLogic and Simio offer numerous functions for managing inputs. The first program allows for better customization thanks to the presence of the Java language. Graphical construction is easier in Simio because it does not require programming knowledge to create interactive models. Both applications have debugging functions, batch run, and experimental design. Regarding model building with programming, Simio can only use simplified programming, while Anylogic allows for the integration of code strings and functions in Java. Both software have varied libraries, including features specific to manufacturing industries. All three simulation logics are executable in both Simio and Anylogic, but only the latter allows for the creation of multiple-logic models.

5.2.3 Animation

Both applications have 2D and 3D animation. Importing interactive layouts from CAD is easier in Simio, as in Anylogic, it is necessary to use programming language. Other aspects of animation are very similar between the two simulators, so it is not possible to make a precise judgment.

5.2.4 Support

Online support, guides, and training courses for users are available in all software. It is impossible to determine which support is better, and therefore, there are no evaluations, only comments on this aspect.

5.2.5 Other Information

In this section, the most interesting characteristics are the price of licenses and the major new features. Anylogic's professional version has a price of $17,000 plus $2,500 per year, while the same version in Simio costs $4,500. Both simulators offer free student versions, but these come with several limitations, such as duration, the number of objects, and the absence of debugging functionality.
The major new features represent the latest developments in terms of libraries and building functionalities. Both software programs have updates of libraries in material handling and industry 4.0.

6. CONCLUSION

This paper discusses the capabilities of two commercial simulation software programs for building a model of a manufacturing industry. After reviewing the literature on the use of simulation in the fashion industry, the requirements for creating a model of a manufacturing plant are presented. A case study of a Job-Shop served by AGV is then conducted, adhering to these requirements. The implementation of the case study on Simio and Anylogic enables a comparison of the features and capabilities of these commercial simulation software programs. The benchmarking of the simulators is shown in Figure 11 and Figure 12.

It can be observed from these tables that Anylogic has rich libraries, making it a good software for realizing a manufacturing system. This application is better than Simio for building models with high customization and complex logic, due to the presence of multi-paradigm simulation and the object-oriented Java language. Multiple logics allow for the integration of Agent-Based modeling with DES modeling and Continuous modeling, expanding Anylogic's capabilities to effectively model complex scenarios. However, the significant presence of Java entails considerable difficulties for users with less knowledge in programming.

Simio, on the other hand, has fewer specific libraries, and more limitations for customization and flexibility, due to the low presence of programming languages. Simio seems to lend itself more to the development of systems with processes having less variability. However, Simio has very strong 2D and 3D animation features, and is characterized by ease of use and a simple interface that allows new users to easily learn simulator commands. Simio has a lower price than Anylogic, but it has less efficient support and assistance.

Due to the significant differences between the two packages, each of them is better suited to different contexts. To realize a model with low customization and in less time, it is advisable to use Simio. However, to obtain a highly customized, scalable, and parameterized model, it is advisable to use Anylogic.

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