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STOCK ANALYSIS OF THE PRODUCTION PROCESS USING FUZZY INFERENCE FOR DECISION MAKING: CASE STUDY

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ABSTRACT

The objective of the work is to propose a methodology for stock assessment and decision making in a phyto cosmetics company, using fuzzy logic. In this case study, we tried to answer the level of production and, consequently, the reasonableness of the stock. Such AI technique was chosen because it is the most suitable for better decision making. With the results obtained by the simulation with the real data, it was possible to verify that using the fuzzy logic technique the decision making had a greater precision for the applied scenario and this will bring benefits to the company, as well as the minimization of storage costs and weekly production beyond what is necessary. It is concluded that the methodology was able to achieve the established objectives, indicating by means of fuzzy logic a better decision making in the production of products.

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INTRODUCTION

The stock is used by almost all companies in order to obtain products available in demand peaks, something that is necessary and fundamental, in the literature (DANDARO; MARTELLO, 2015; BORGES, CAMPOS and BORGES, 2010; SILVA and VOLANTE, 2019; NOGUEIRA and NASCIMENTO, 2017; GONÇALVES, 2019) you can find how important inventory control is for companies, being an indispensable variable for the effectiveness of current institutions (DE ARAÚJO, LIBRANTZ and ALVES, 2009). And with the increase in globalization, there is a great growth curve in the use of information technologies by companies, ranging from productive systems to the administrative sector (DE CÁSSIA TOBIAS, 2018).

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Having a mechanism that assists in stock is a task that scares companies that operate in all sectors (ALAKAN et al., 2019), so computerized systems play a fundamental role in stock control and that nowadays it is necessary that companies companies use these tools so as not to lose market to their competitors (LUCAS and QUEIROZ, 2016), as they are instruments that optimize time, expenses and improve resource management. According to Pick, Diesel and Sellitto (2011), the constant use of a computerized system has a direct correlation with good management, both of the stock and of the institution itself, strongly increasing the gains. An alternative that has been widely used for the use of optimization is artificial intelligence (AI) (DE ARAÚJO, LIBRANTZ and ALVES, 2009), which integrated with the inventory management software enhances the company's gains and reduces losses, this use Integrated AI has been widely used in the control and management of stock of small, medium and large companies (FARHAT and OWAYJAN, 2017). The optimization of stock control is complex (VAN WINGERDEN et al., 2014; PRAVEEN, FARNAZ and HATIM, 2019) because it has N variables, due to this complexity it is expensive to carry out calculations by deterministic mathematical means, being viable to use of computational intelligence techniques to find an optimal solution to the problem. Inventory control is extensively studied and several techniques are developed in order to obtain an optimum point of optimization (BOISSIERE, FREIN and RAPINE, 2008), in any aspect of the stock, be it in costs, time or storage. The objective of the work is to propose a methodology for stock assessment and decision making in a phyto cosmetics company, using fuzzy logic.

THEORETICAL FOUNDATION

The Importance of Stock: Inventory plays a fundamental role for a company, since it allows the possibility of always having products available to sell (SILVA and RABELO, 2017; BRAIDO and MARTENS, 2013; BALLOU, 2006) and the correct inventory management allows the better decision-making (SILVA et al., 2018), in addition to minimizing expenses and increasing gains (PEREIRA and MACHADO, 2017; BAGATTINI, MARTINS and DA SILVA JACINTO, 2019). According to Mendonça and Pinheiro (2019), if the inventory control is not well managed, there can be serious problems, such as the large volume of products in the stock or the insufficiency of the stock, both directly damaging the earnings and in case there is little or no product in stock, the company may lose customers due to high demand and little product available. According to Clarindo, Campos and Araujo (2018), the stock cannot have a large quantity of products, and neither is it empty, to solve this problem it is necessary to use stock management software. Among these softwares is ERP (Enterprise Resource Planning), which integrates all the necessary stock data in a single system (MATENDE and OGAO, 2013; ABOABDO, ALDHOIENA and AL-AMRIB, 2019; JACOBS et al., 2007). If it were possible to know the exact demand for each product that a company sells and the products were delivered instantly when placing the order, there would be no reason to have stocks. Although there are ways to reduce the amount of stock, a gradual improvement of stocks and exclusion of stocks for certain products through advanced management mechanisms, today there is still a need for stock for the vast majority of companies, especially those that work with different products (GOEBEL, 1996).

Stock-Related Problems: Stock Levels, Sales Break and Stock Break

Various costs are involved in the maintenance of inventories, some of which may be rent, location or even capital immobilization in building installations and their maintenance, physical installations such as shelves, security, administrative costs, the stocked material itself, be it a finished product or in production process (intermediate storage of unfinished products), as well as its raw materials involved in the process (DANDARO and MARTELLO, 2015). A prominent point to be assessed is also the loss, damage or theft of goods or inputs, in the end, all of this turns into costs. In view of this scenario, the importance of the correct management of the organizations' stocks is evident (Dias 1999). The stock of merchants / products is necessary due to the discrepancy between demand and supply (BERTAGLIA, 2003). In the case of a stock level well above the demands for the product, the risk of loss due to maturity increases. Thus, reducing inventory levels means reducing costs, an objective that is sought by all organizations. Within this context, the concept of Just-in-time (JIT) stock seeks greater efficiency in maintaining stocks (CHING, 1999), since these are kept at levels that strictly meet the required demand, supplying the items at the exact moment when they are needed (HILLIER; LIEBERMAN, 2001). The JIT philosophy aims to meet demand instantly, with quality and without waste. It enables cost-effective production, as well as providing the exact quantity of items that is needed, at the right time and place, using the least amount of resources (CHING, 1999). Currently, sustaining maximum levels in inventory becomes a sensitive decision-making process because it directly implies costs for the company. When and how much to buy, it is directly linked to the level of safety and coverage stock and the role of the stock manager. Some items must be treated separately, as it is a high level of investment, which has a great financial impact on the company (BERTAGLIA, 2003). A well elaborated planning means that we avoid rework and losses in the roduction process, increasing the efficiency and quality of the product, generating an increase in productivity. Understanding how material handling works from its raw material to becoming a final product avoids fractional activities and promotes synergy in the processes. Inventory control management is directly connected to the company's profitability. The competence of the manager to guarantee the turnover of the goods without interfering in the supply of the production lines and consequently in the fulfillment of orders (FAUSTINO et al., 2020). It is essential that when maintaining inventories, meeting customer demands is considered. Supplying the customer with the correct product and in the appropriate quantity is paramount. Not meeting the customer's need means not converting a sale into profit, at best, since this is not the only problem that is the only problem (JAKONIS et al., 2017). If it is not possible to meet a consumer's demand for a specific item, he possibly will look for another place to make this purchase, it is also possible that this will lead the consumer to give up making all his purchases (not just that unavailable item) and look for the competitor for this, making sure that all the products on its shopping list are not sold and, consequently, are not reverted in profit. In a retail store, the variety of items sold and their quantities are high, which can make the loss of the sale of another item insignificant (DE AGUIAR et al., 2020). The problem of the lack or unavailability of items leads to yet another consequence, the wear and tear on the company's image. It is possible that the dissatisfaction generated by the lack of products reduces the consumer's confidence in the company or even does what he does not frequent the place anymore. The issue of dissatisfaction and loss of confidence is subjective and a variable that is difficult to measure. (GRUBOR; MILICEVIC; DJOKIC, 2017). If an item is unavailable it means that all units, even the ones in stock, have been sold and now the stock is zeroed. When use occurs it is said that the product is out of stock (RE). The consequence of the Stock Break is the Sale Break (RV), since if there is no product available, there is no sale. There are other reasons for the Rupture of Sales, such as competition, promotions of similar products within the same store, positioning of the products of the products on the shelves, among others. In this work, only the Sales Break motivated by the Inventory Break will be dealt with. Thus, from now on, this information will be implicit (DE AGUIAR et al., 2020).

Order Point (Replacement Point): The way in which the stock behaves can be visualized by a graph, known as Dente de Serra (FIGUEIREDO et al., 2020; ALMEIDA et al., 2017). The graph shows the maximum and minimum stock and the replacement point (ALMEIDA et al., 2017). According to Tófoli (2008) and Pozo (2000), the concepts of minimum and maximum stock can be defined as:

Minimum stock: it is the minimum quantity of a certain product that must be in stock.

Maximum stock: it is the maximum quantity that the stock can reach, if the maximum stock is exceeded it can generate unnecessary costs.
According to Moreira et al. (2001):

Replacement point: it is a specific level, which when reached indicates the time for replenishing the product.

The Sawtooth chart can be seen in Figure 1.

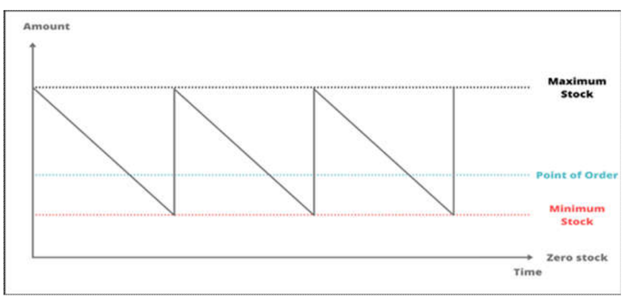

Figure 1. Sawtooth graphic

Artificial Intelligence: AI is a branch of computer science that focuses on the study of intelligence trying to imitate it (MOREIRA, 2017; WHITBY, 2004; POOLE, GOEBEL and MACKWORTH, 1998), and has several applications (SELLITTO, 2002; REZENDE, 2003), whether for decision making, optimization, learning or forecasting. An alternative that has been widely used for the use of optimization is artificial intelligence (DE ARAÚJO, LIBRANTZ and ALVES, 2009), also used in stock control (FARHAT and OWAYJAN, 2017), which in addition to optimizing facilitates management and making decision-making.

Fuzzy Logic: The fuzzy set theory also known as fuzzy logic was first coined by Lofti Asker Zadeh in 1965 in the United States (LEE, 1990). The fuzzy logic was initially conceived to solve several problems that have diffuse information as characteristics (NOGUEIRA and NASCIMENTO, 2017). The fuzzy logic, in contrast to the classic logic that is in binary, has its values defined in degrees of pertinence, indicating that everything in the fuzzy logic has its degree of pertinence, not limited only to true and false, but transiting in this interval (ZADEH, 1988).

The fuzzy inference system has some so-called main components, which Wang (1997) are:

Fuzzifier: Used to modify the data initially imputed in the system in degrees of pertinence, going from zero (minimum) to one (maximum).

Rules of fuzzy inference: These rules are imposed by the specialist and serve to shape the parameters to be followed by the system in order to contain a high degree of reliability on the system's ability to indicate a response closer to the experts who wrote the rules.

Inference engine: It is used to unite and process the rules imputed in the system, in order to generate numerical values to be defuzzified.

Defuzzifier: Transforms the values processed in the inference engine into final output values, which are presented in the final answer of the system where a linguistic response is associated.

According to Pagliosa (2003), the choice of the most suitable method to use it in the defuzzifier is the Centroide, also known as the center of gravity or Area Center. The Centroide method can be further detailed by Equation 1:

$$C = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i} \quad (1)$$

Where:

C: Centroide;
N: Number of imputed rules;
Wi: Degree of activation in the consequent action *Yi*.

MATERIALS AND METHODS

The material used for the development of this work was the modeling software called Matlab®. The technique used in the software was Fuzzy Logic, which in this case study seeks to answer the level of production and consequently the reasonableness of the stock. Such AI technique was chosen because it is the most suitable for better decision making.

Company Characterization: The company for which it was the subject of a case study, is located in Manaus. It works with phyto-cosmetic products, despite its small size, it has a high volubility of products, from phytocosmetic medicines for continuous use as well as beauty products such as perfumes and soaps. It is important to note that many of its products have a high durability and their minimum maturity period is over one year, giving the company a reasonable time to market its products, making a profit for the company.

A problem is the space for storing some specific products, such as alcohol and ice gel, due to the volume and quantity produced to serve its customers, as these two products occupy most of the stock, making the other products stay with a reduced space, making it difficult for the manager to find the products later.

For these two products mentioned above, it was noted through reports made by some employees, that the high turnover of these products sold per week is preferable to produce a larger quantity for the month. It is worth mentioning that the process that currently takes place in the decision-making company in relation to the production of the products is carried out by a production manager together with the inventory manager. based on previous work order reports. Figure 2 shows the process flow of the company that was the object of study.

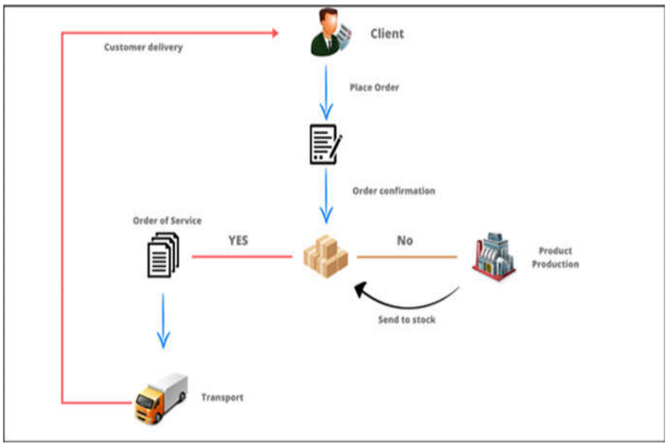

Figure 2. Company process

The company's process works through relationships with its customers, where the same prey for the quality of its products and a better cost benefit for its consumers. The methodology is applied through orders placed by online networks, directly with the administrative sales department, where they record pre-established orders, the same queries your stock level to give the same feedback to your customer as quickly as possible. confirms your orders.

After the order is confirmed, the stock makes the packaging of the products contained in the Service Order, sending it for transportation until it reaches its customers. Another point to be mentioned in this flowchart presented above, is that in the event of an extraordinary situation, a customer requests a large order. The company will do the procedure mentioned in the paragraph above, not having the quantity in its stock, due to having made several sales. The production is awaiting confirmation from the Administrative sector to start the production of new products to meet the demand demand and already make the replenishment of their stocks, which depending on the days of the week, or even keep products at their equilibrium point.

Model of the Fuzzy Inference System: In Figure 3, the specified Fuzzy model can be viewed, containing four input variables and one output variable, in which 108 rules were applied. The variables were chosen according to the data collected in the company. The input variables are named as follows:

Stock Status**:** Refers to the level of stored stock.

TimeInStock**:** Variable responsible for indicating the time the product has been in stock.

Sale**:** Variable that shows the quantity of products sold in the week.

Order**:** Indicates the number of orders placed by customers with the company. The output variable named Production indicates the quantity of products to be produced/manufactured by the company.

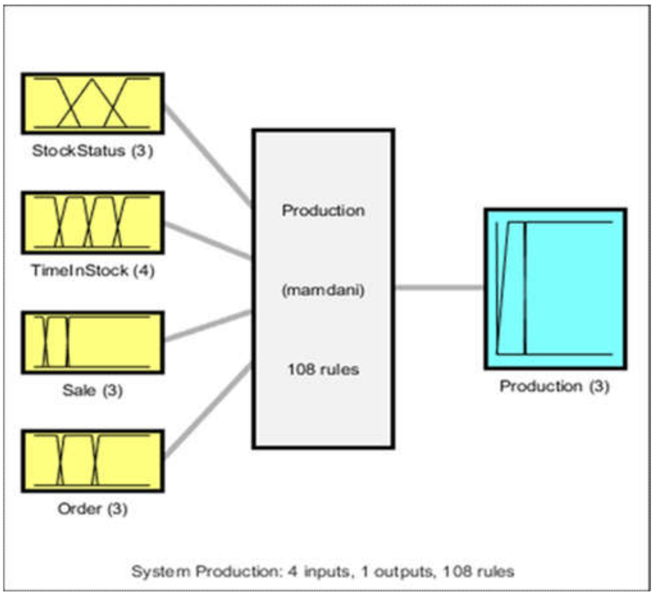

Figure 3. Fuzzy system model

The model shown in Figure 3 was developed using the Matlab® software in its 2016 version.

RESULTS

The results presented below demonstrate the final result of the fuzzy modeling as well as the details, together with the simulation divided into two stages, the first with random data and the second with real data.

Input Variables: Figure 4 shows the *StockStatus* variable, responsible for the level of stored stock, its unit of measure is treated in percentage, ranging from 0 to 100%, being classified into three levels of inference, namely:

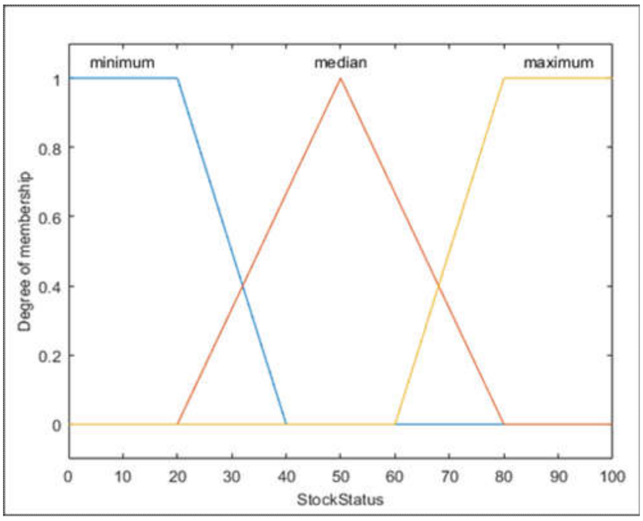

Figure 4. *StockStatus* Input Variable

***Minimum*:** This level goes from 0 to 20% in stability and from this percentage the membership drops from 1 to 0 gradually, reaching the 0 membership level at the exact moment that reaches the 40% percentage. Therefore, the total extension of this level of inference is 40 units (percentage). The *minimum* inference level is related to the minimum percentage that the stock should contain of products, making reference to the company's minimum stock. This level is formed by a trapezoidal function, therefore it has four values for its 4 points, being them (0, 0, 20, 40).

***Median*:** The level of inference called median is limited to the range of 20 to 80% as a whole, which consists of a triangular function, having 3 points (20, 50, 80), in which point 50 is the midpoint of the triangle , as well as the *Stock Status* variable.

***Maximum*:** This level has four points, so it is a trapezoidal function, its points are delimited in the following values (60, 80, 100, 100). The degree of relevance at this level ranges from 60 to 80% in an increasing, when reaching 80% the relevance remains stable until the end (100%).

Figure 5 shows the input variable *TimeInStock*, which is responsible for showing the number of days the product has been in storage in stock. This variable is divided into 4 levels of inference at intervals of 7 days (weekly), which are:

***Week1*:** This level is characterized by a trapezoidal function having its points fixed at (0, 0, 5, 7), in which from point 0 to point 5 the degree of relevance remains at maximum and from point 5 the degree of relevance membership falls until it reaches point 7, which indicates a level of zero membership.

***Week2*:** In the *week2* level it is also constituted by a trapezoidal function with the following indicated points (5, 8, 10, 14), in which from point 5 to point 8 the level of relevance grows from 0 to its maximum, which is 1, in the range from 8 to 10 the pertinence kills at most, and from 10 to point 14 it drops to zero.

***Week3*:** At this level of inference it is noted that the points of the trapezoidal function are (12, 15, 19, 21), from points 12 to 15 an increase in pertinence follows, whereas from 15 to point 19 the pertinence remains constant, from the point 19 to 21 there is a drop in membership, dropping from the maximum membership level of the fuzzy system and reaching its minimum level.

***Week 4*:** Level of pertinence formed by the 4 points (18, 22, 28, 28) of the trapezoidal function. This level follows the same model as the other levels of membership. With an elevation of relevance from the first to the second point and remains constant from the second to the third point.

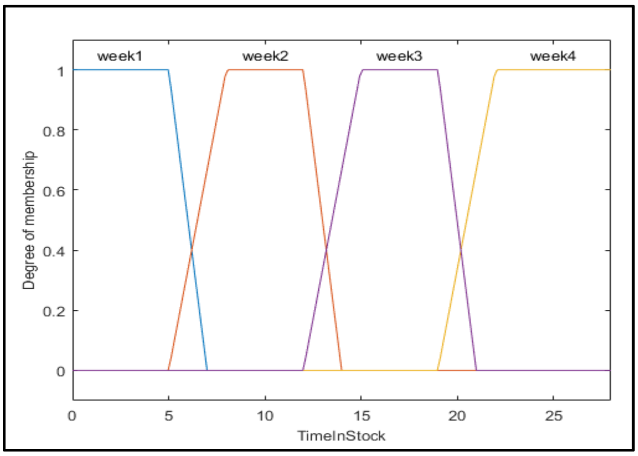

Figure 5. *Time In Stock* Inventory Variable.

Figure 6 shows the input variable called *Sale*, this variable is responsible for indicating the quantity of products sold within a week. Such variable is segmented into 3 levels of inference, named as follows:

Bad: Inference level that indicates how bad sales are in a given week, their trapezoidal function values are made up of the following segment (0, 0, 2000, 3000). The degree of pertinence gradually decreases from point 2000 to 3000, the last point having a degree of zero (false).

Good: At this level of inference it is formed by a trapezoidal function with the points indicated by the segment (2000, 3001, 7000, 7500), where the follow-up of points 2000 to 3001 has a degree of relevance being gradually increased until reaching its maximum level (Level of pertinence equal to 1), from point 3001 to 7000 the pertinence remains stable at its maximum level and from point 7000 the degree of pertinence falls.

Great: This trapezoidal inference has its origin at point 7000 and its degree of relevance rises to point 7501, remaining unchanged until point 25000. Its total range goes from 7000 to 25000.

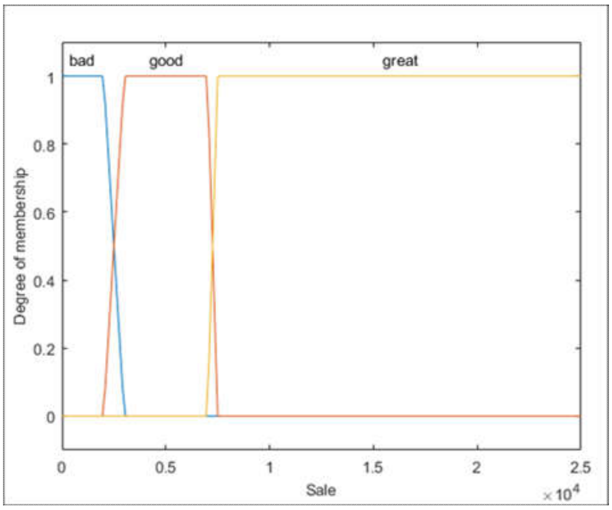

Figure 6. ***Sale*** **Input Variable**

Figure 7 shows the input variable named *Order*, this variable represents the number of orders placed by the company's customers and contains 3 levels of inference, namely:

Little: This level of inference is formed by a trapezoidal function and its points are made up of the following values (0, 0, 20, 25), from 0 to 20 requests the degree of relevance remains at 1 (maximum pertinence) and 20 requests up to 25 the degree of pertinence falls to its mark 0 (minimum pertinence).

Reasonable: Inference corresponding to the points (20, 25, 50, 55) of the trapezoidal function, from point 20 to point 25 at an elevation slope, points 25 to 50 do not change, maintaining a level of pertinence in 1 (maximum pertinence), the points in the range of 50 to 55 follow a downward trend, with point 55 being the point at which the degree of pertinence reaches its minimum.

Much: This level corresponds to the range of 50 to 100 and is also a trapezoidal function, its tracking of points are found in the values (50, 55, 100, 100) containing an ascension of relevance from point 50 to 55, while in range of points 55 and 100 the relevance does not fluctuate.

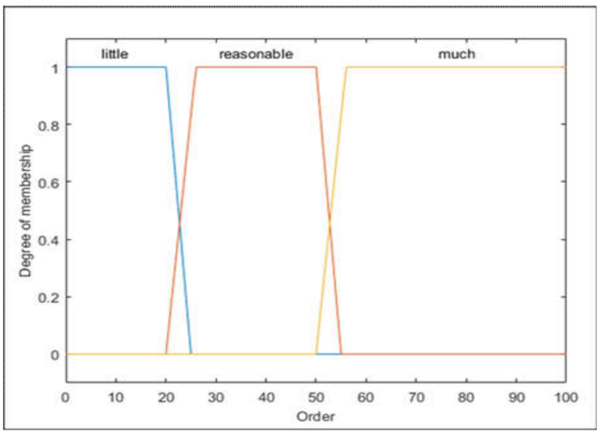

Figure 7. ***Order*** **Input Variable**

Output Variable: Figure 8 shows the output variable called *Production*, this variable is responsible for indicating the response that the system gives for better decision making. It indicates whether there is a need to produce or not, and its intensity, the answer can be classified into 3 levels, namely:

Not Produce: This level of inference indicates that there is no need to produce more products, its tracking of the points of the trapezoidal function is (0, 0, 0, 0).

Minimum Production: Minimum production is carried out to supply the stock up to the midpoint of stock. The mathematical function that constitutes this level of inference is the trapezoidal function with the following values at its 4 points (1, 5000, 12000, 12500), with a high degree of relevance from point 1 to point 5000, from point 5000 to 12000 the relevance remains unchanged, since the interval between points 12000 and 12500 has a drop that goes from the degree of relevance 1 to 0.

Maximum Production: Level responsible for informing the level of production to be made, so this level represents the maximum level of production. The function used to design this level of inference was the trapezoid with the following points (12000, 12500, 50000, 50000). The points that follow between the range 12000 and 12500 rise to the maximum of relevance, whereas the ranges from 12500 to 50000 do not fluctuate in their values.

System Rules: The rules of the modeled system are shown in Table 1, the rules in their entirety contain 108 lines, involving all possibilities, however in Table 1 only 9 is shown indicating the line to which it was inserted. The rules were made by a specialist together with company employees, in order for the modeling to be as efficient as possible for the case studied.

Surface Chart: The surface graph shown in Figure 9 demonstrates graphically and in three dimensions the behavior of the most influential input variables in the output variable, which is *Production*. Looking at Figure 9, it is possible to notice that the quadrant formed by the points (43 to 100) of the *StockStatus* variable and the points (50 to 100) of the *Order* input variable have a low variant in relation to the system, this indicates that the combined values of these two input variables if they have values imputed in this quadrant will impact a low or even zero production. Another important topic to be highlighted in the graph is the *Order* variable has a greater impact than the *StockStatus* variable, this can be detected by the great increase in the degree of relevance that exists from point 50 of the *Order* variable.

Simulation: Figure 10 shows the Matlab® toolbox with results from one of the simulations with random data. This toolbox shows the behavior of the inference levels visually. Table 2 shows the result of the simulation made with random data, divided into levels of linguistic inference and values. The data were made with random data to demonstrate the behavior of the system with a hypothetical scenario. The simulation with the real data is made and its results are shown in Table 3, in which it presents linguistic responses as well as responses in values.

The final result of the simulation made was that the production should manufacture around 7270 products, so that the stock would reach an optimum level. With this result it is possible to infer that the developed system can help in the decision making in relation to the production of products in the week, because the system indicates based on the modeling made by specialists a numerical value represented in units of quantity of products to be manufactured and subsequently stored in stock, taking into account the sale, the number of orders placed by customers, the level and time of products in the stock. In the current scenario there is the problem of control being more manual and this implies a delay in making decisions in relation to production and storage in stock, in order to minimize this problem the system was developed to help streamline this decision making.

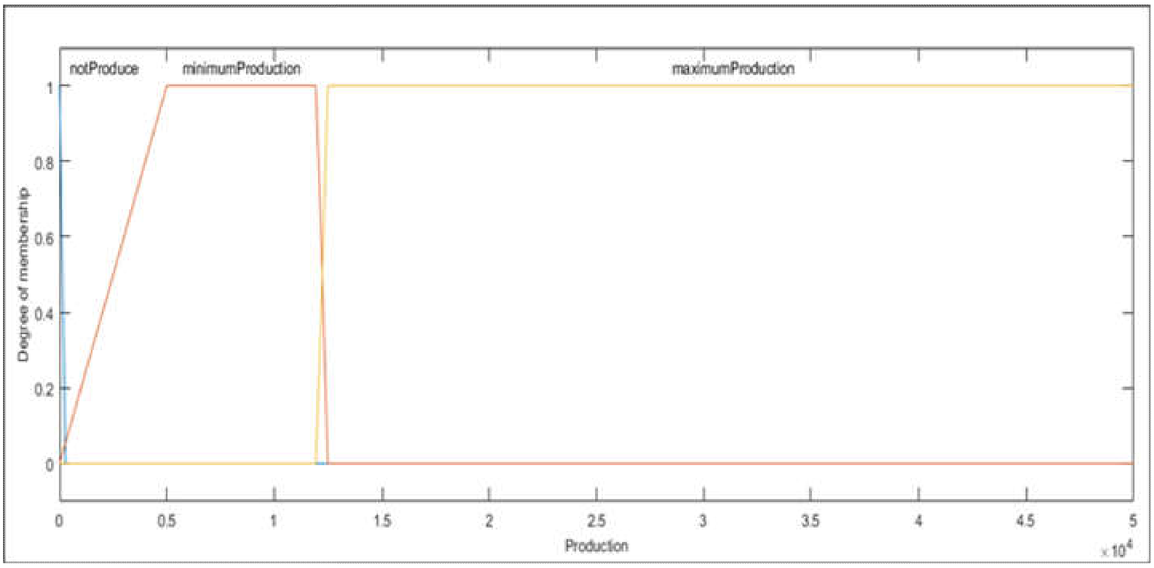

Figure 8. *Production* Output Variable.

Table 1. Fuzzy system rules

Rules	Input variables				Output Variable
	StockStatus	*TimeInStock*	*Sale*	*Order*	*Production*
1	*minimum*	*week1*	*bad*	*little*	*minimumProduction*
18	*minimum*	*week2*	*good*	*reasonable*	*maximumProduction*
35	*minimum*	*week3*	*great*	*much*	*maximumProduction*
65	*median*	*week1*	*good*	*much*	*minimumProduction*
38	*median*	*week2*	*bad*	*little*	*notProduce*
59	*median*	*week3*	*great*	*reasonable*	*minimumProduction*
97	*maximum*	*week1*	*bad*	*much*	*notProduce*
82	*maximum*	*week2*	*great*	*little*	*minimumProduction*
92	*maximum*	*week4*	*good*	*reasonable*	*minimumProduction*

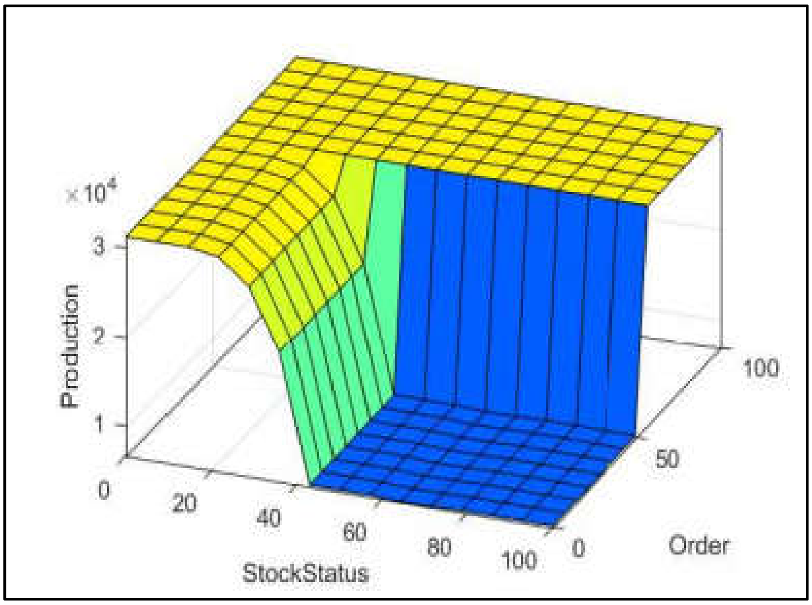

Figure 9. 3D Surface Graph

Table 2. Simulation with random data

Terms	*StockStatus*	*TimeInStock*	*Sale*	*Order*	*Production*
Linguistics	*minimum*	*week4*	*bad*	*little*	*minimumProduction*
Value	15 (%)	24 (days)	1500 (products)	15 (client)	7270 (products)
Linguistics	*median*	*week2*	*bad*	*little*	*minimumProduction*
Value	45 (%)	10 (days)	3000 (products)	10 (client)	7100 (products)
Linguistics	*maximum*	*week1*	*great*	*much*	*maximumProduction*
Value	90 (%)	3 (days)	15000 (products)	80 (client)	31300 (products)

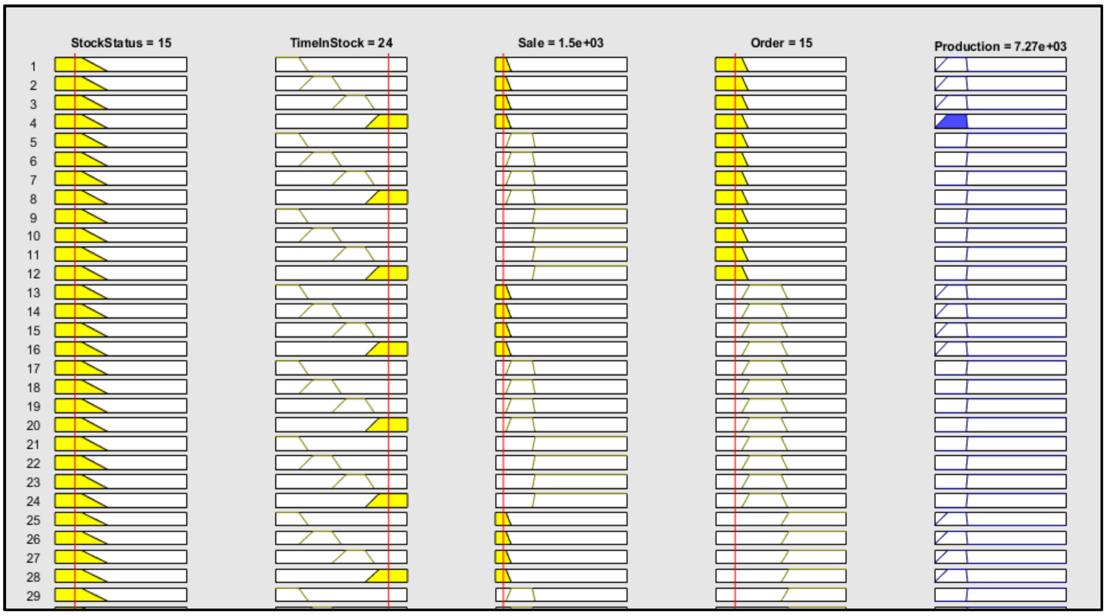

Figure 10. Simulation by the Matlab® toolbox

Table 3. Simulation with real data

Terms	*StockStatus*	*TimeInStock*	*Sale*	*Order*	*Production*
Linguistics	*maximum*	*week1*	*great*	*reasonable*	*minimumProduction*
Value	87 (%)	4 (days)	16490 (products)	31 (client)	7270(products)

So with the result obtained by the simulation (7270 products) with the real data, it is possible to verify that the decision making for this scenario would be the most ideal, and this would bring benefits to the company, as well as the minimization of storage and production costs. weekly beyond what is necessary. With the implementation of this system, decision making becomes more dynamic, since the stock manager has the possibility to guarantee the turnover of the goods, signaling at which time it would be ideal for a decision making and quantity of products to be produced. Another point to be addressed, from the moment there is an extraordinary order in addition to the standard quantity produced, the stock manager will signal to production his current capacity in the stock, thus meeting the demand demand without having a production break, because with the applied fuzzy methodology it would be possible to know at what time and how much to produce intelligently.

With the application of the proposed methodology, there would be the possibility of a better organization in the stock space, since knowing the quantity to be produced in a given week the flow of input and output of the stock would be more predictable, bringing to the accurate perception of its inventory control, thus avoiding product losses in handling. As it is a small business, employee turnover is a pre-existing problem that implies a cost for the company, because if the current employee is dismissed, it is necessary to hire a new professional, who should be trained to exercise the function and have the knowledge of the previous one. With this methodology, training is more agile, especially in relation to decision making that is already imputed in the fuzzy system.

FINAL CONSIDERATIONS

It is worth noting that no software was developed to be applied in the study company, the work carried out was based on the construction of the algorithm via Matlab® software using the artificial intelligence technique known as Fuzzy Logic. It is concluded that the methodology was able to achieve the established objectives, indicating by means of fuzzy logic a better decision making in the production of products.

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REFERENCES

ABOABDO, Shadi; ALDHOIENA, Abdulaziz; AL-AMRIB, Hashbol. Implementing Enterprise Resource Planning ERP System in a Large Construction Company in KSA. Procedia Computer Science, v. 164, p. 463-470, 2019.

ALAKAN, Aadhavan, et al. On the Optimality of Inventory and Shipment Decisions in a Joint Three Echelon Inventory Model with Finite Production Rate under Stock Dependent Demand. Procedia Manufacturing, 2019, 30: 490-497.

Almeida, Carlos Augusto et al. Aplicação De Ferramentas De Gestão De Estoque Em Uma Empresa De Comunicação Visual. Revista H-TEC Humanidades e Tecnologia, v. 1, n. 2, p. 29-46, 2017.

Bagattini, Guilherme Varella; MARTINS, Flavia Guska; DA SILVA JACINTO, Adriana. Desenvolvimento De Aplicativo Para Auxílio No Controle De Estoque De Embalagens Em Uma Empresa De Tecnologia. CIMATech, v. 1, n. 6, p. 195-204, 2019.

BALLOU, Ronald H. Gerenciamento da Cadeia de Suprimentos/logística empresarial; tradução Raul Rubenich.-. 2006.

BERTAGLIA, P. Logística e gerenciamento da cadeia de abastecimento. São Paulo, 2003.

BOISSIERE, Julien; FREIN, Yannick; RAPINE, Christophe. Optimal stationary policies in a 3-stage serial production-distribution logistic chain facing constant and continuous demand. European journal of operational research, 2008, 186.2: 608-619.

BORGES, Thiago Campos; CAMPOS, Magno Silvério; BORGES, Elias Campos. Implantação de um sistema para o controle de estoques em uma gráfica/editora de uma universidade. 2010.

BRAIDO, Gabriel Machado; MARTENS, Cristina Dai Prá. Gestão de estoques em uma pequena empresa varejista de autopeças:

proposição de um controle computadorizado de estoques. Revista Acadêmica São Marcos, 2013, 3.1: 103.

CHING, H. Y.; Gestão de estoques na cadeia de logística integrada - Supply Chain. Atlas. São Paulo, 1999.

CLARINDO, Jordana Gomes; CAMPOS, Filipe Rodrigues N.; ARAUJO, Maique Da Silva. Estoque Para Varejo: Estudo De Caso Em Uma Empresa Do Ramo Farmacêutico Do Norte Do Estado Do Espírito Santo. Brazilian Journal of Production Engineering-BJPE, v. 4, n. 1, p. 50-65, 2018.

DANDARO, Fernando; MARTELLO, Leandro Lopes. Planejamento e controle de estoque nas organizações. Revista Gestão Industrial, v. 11, n. 2, 2015.

DE AGUIAR, Fernando Henrique Olliveira et al. Comportamento Do Consumidor Frente À Ruptura De Estoque De Uma Empresa Varejista. South American Development Society Journal, v. 6, n. 16, p. 69, 2020.

DE ARAÚJO, Sidnei Alves; LIBRANTZ, André Felipe Henriques; ALVES, Wonder Alexandre Luz. Algoritmos genéticos na estimação de parâmetros em gestão de estoque. Exacta, v. 7, n. 1, p. 21-29, 2009.

DE CÁSSIA TOBIAS, Cristiane et al. Implementação da Ferramenta MRP: Análise de uma Empresa Siderúrgica do Sul de Minas Gerais. Revista de Ciências Gerenciais, v. 22, n. 36, p. 164-167, 2018.

DIAS, Marco Aurélio P. Administração de materiais. São Paulo: Atlas, 1999.

FAUSTINO, Cassiano Rodrigues et al. Utilização do sistema de identificação por rádio frequência no gerenciamento de estoque no setor automotivo. Research, Society and Development, v. 9, n. 7, p. e102973929-e102973929, 2020.

FARHAT, Jad; OWAYJAN, Michel. ERP Neural Network Inventory Control. Procedia computer science, 2017, 114: 288-295.

FIGUEIREDO, André Luiz Maciel et al. Aplicação Das Ferramentas De Gerenciamento E Controle De Estoque Em Uma Distribuidora De Autopeças. South American Development Society Journal, [S.l.], v. 5, n. 15, p. 135, fev. 2020.

GOEBEL, Dieter. Logística: otimização do transporte e estoques na empresa. Estudos em Comércio Exterior, v. 1, n. 1, p. 1-45, 1996.

GONÇALVES, Luiz Claudio et al. Avaliação dos principais fatores que impactam à gestão e controle de estoque do segmento de produtos médicos. Revista Eniac Pesquisa, v. 8, n. 1, p. 119-138, 2019.

GRUBOR, A.; MILICEVIC, N.; DJOKIC, N. The impact of store satisfaction on consumer responses in out-of-stock situations. Review of Business Management, v. 19, n. 66, p. 520–537, 2017.

HILLIER, F.S., LIEBERMAN, G. J.; Introduction to Operations Research. 7™ ed. McGraw-Hill Inc. New York, 2001.

JACOBS, F. Robert et al. Enterprise resource planning (ERP)—A brief history. Journal of operations management, v. 25, n. 2, p. 357-363, 2007.

JAKONIS, M. V. et al. Estudo de caso para minimizar rupturas de gôndolas em um mercado de pequeno porte. Revista UNINGÁReview, v. 32, n. 1,p. 125–136, 2017.

LEE, Chuen-Chien. Fuzzy logic in control systems: fuzzy logic controller. I. IEEE Transactions on systems, man, and cybernetics, v. 20, n. 2, p. 404-418, 1990.

LUCAS, Elaine Cristina; QUEIROZ, Stefânia Aparecida Belute. Influencia da Tecnologia da Informação no controle de estoques: estudo de caso. Revista de Iniciação Científica da Libertas, 2016, 4.1.

MATENDE, Samwel; OGAO, Patrick. Enterprise resource planning (ERP) system implementation: a case for user participation. Procedia Technology, v. 9, p. 518-526, 2013.

MOREIRA, Alessandro Felipe Miguez. Assistência à autonomia no domicílio com integração de Automação e Inteligência Artificial. 2017. PhD Thesis.

MOREIRA, Cynara Mendonça, et al. Estratégias de reposição de estoques em supermercados: avaliação por meio de simulação. 2001.

NOGUEIRA, Enyleide Lima; NASCIMENTO, Manoel Henrique Reis. Inventory control applying sales demand prevision based on fuzzy inference system. Journal of Engineering and Technology for Industrial Applications (JETIA), v. 3, 2017.

PAGLIOSA, A. L. (2003). Obtenção das funções de pertinência de um sistema neurofuzzy modificado pela rede de Kohonen.

PEREIRA, Silvania; MACHADO, Caio Pisconti. Métodos De Controle De Estoques Em Uma Empresa De Materiais De Construção No Noroeste Do Paraná. Revista de Administração do UNIFATEA, v. 14, n. 14, 2017.

PICK, Valdir Luis; DIESEL, Letícia; SELLITTO, Miguel Afonso. Influência dos sistemas de informação na gestão de estoques em pequenos e médios supermercados. Revista Produção Online, 2011, 11.2: 319-343.

POOLE, David I.; GOEBEL, Randy G.; MACKWORTH, Alan K. Computational intelligence. New York: Oxford University Press, 1998.

POZO, Hamilton. Administração de recursos materiais e patrimoniais: uma abordagem logística. Editora Atlas SA, 2000.

PRAVEEN, Umamaheswaran; FARNAZ, Ganjeizadeh; HATIM, Ghasib. Inventory management and cost reduction of supply chain processes using AI based time-series forecasting and ANN modeling. Procedia Manufacturing, 2019, 38: 256-263.

REZENDE, Solange Oliveira. Sistemas inteligentes: fundamentos e aplicações. Editora Manole Ltda, 2003.

SELLITTO, Miguel Afonso. Inteligência artificial: uma aplicação em uma indústria de processo contínuo. Gestão & Produção, 2002, 9.3: 363-376.

SILVA, Karen Milena; Volante, carlos rodrigo. A importância do sistema kanban para o gerenciamento e controle de estoque de uma empresa. Revista Interface Tecnológica, v. 16, n. 1, p. 629-640, 2019.

SILVA, Mislene Gontijo; RABELO, Maria Helena Silva. Importância do controle de estoques para as empresas. Revista Acadêmica Conecta FASF, v. 2, n. 1, 2017.

SILVA, Valdilene Gonçalves Machado et al. Controle de estoque: um estudo sobre a eficiência da gestão de estoque numa distribuidora atacadista em Divinópolis, MG. Research, Society and Development, v. 7, n. 5, p. 3, 2018.

TÓFOLI, Irso. Administração financeira empresarial: uma tratativa prática. Campinas: Arte Brasil, 2008.

VAN WINGERDEN, E., et al. More grip on inventory control through improved forecasting: A comparative study at three companies. International journal of production economics, 2014, 157: 220-237.

WANG, L. X. A course in Fuzzy Systems and Control. New Jersey: Pretice-Hall Internacional. ed: Inc, 1997.

WHITBY, Blay. Inteligência artificial: um guia para iniciantes. Madras, 2004.

ZADEH, Lotfi A. Lógica difusa. Computer, v. 21, n. 4, p. 83-93, 1988.

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