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Improvement of the Pattern Drafting Process in the Textile Sector using the Dobot Magician Robotic Arm

Raúl Ernesto Navarrete López, MBA Ever Ángel Fuentes
(Bogotá, Libre University, Colombia)

Abstract: *This study shows how to optimize the drafting process by simulating a Colombian textile company and implementing the Debot Magician Robotic Arm, with the purpose of reducing raw material waste, operating times and error in the process, thereby increasing precision when Drafting. This investigation arises from the need of the textile companies whose demand requires them to automate processes that are traditionally manual and may affect the productivity and quality of their products. As part of the methodology used, a mixed approach was developed and this includes an literature review and experimental laboratory tests. To develop this approach, engineering methods were implemented, including matrices, diagrams, characterizations, among others, in order to validate the effectiveness of the Robotic Arm implementation. To conclude, the results show that automation reduces process time by 50% compared to the manual method, which indicates that it meets the established effectiveness criteria, representing an alternative that can contribute to standardizing the process, reducing waste and improving the competitiveness of the textile sector.*
Keywords- *Automation, Robotic Arm, Drafting, Process, Textile Sector.*

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I. Introduction

Over the time, the textile industry in Colombia has grown and it is now a fundamental part of the country's economy contributing to the increase in the country's gross domestic product (GDP), which means that it significantly boosts the economic growth, due it generates jobs for hundred of people. However, this economic growth is no exception to social and environmental repercussions, since, as is well known, mass textile production contributes greatly to the economy of many families, but it also brings with it the pollution of water and atmospheric resources and the generation of solid waste produced daily in the country, which greatly compromises not only the communities surrounding the industry but also the biodiversity [1].

The Pattern Drafting process defines the basis for the clothing manufacturing and determines criteria such as: fit, design , and the material consumption in an environment where the pattern is made manually by an operator with the variables such as skill, precision errors, raw material waste and idle time during the workday influencing the outcomes [2]. For this reason, it was proposed to automate the pattern drafting process in order to increase precision and standardize the process.

This study proposed the implementation and use of the Dobot Magician Robotic Arm (DOBOT), using the writing kit and pattern drafting software [3], with the purpose of increasing the product quality by improving precision, effectiveness, and quality of the pattern drafting process in a real-world scenario in a small and medium sized enterprise (SME) in the textile sector. This would lead to less waste of raw material and in this way, resulting in greater efficiency in terms of mold change times.

II. Methodology

This study presents a methodological development based on an exhaustive literature review of similar projects implemented in textile companies in various countries, including Peru and Spain, among others, as well as information from websites, specialized manuals, and videos directly related to the pattern drafting process. This stage allowed an in-depth understanding of the activities and conditions required for pattern drafting, identifying the best practices and the limitations of the manual method currently used by many SMEs [4]. Based on this review, it was possible to establish the basis for structuring the automation proposal using Dobot, where a simulation process was carried out under controlled laboratory conditions, comparing it with the traditional method performed by an operator, which facilitated the comparison between the two methods.

Consequently, it was decided to implement DOBOT, which comes with a writing kit consisting of a pen holder and a pen, and also the Dobot Studio software. This requires images and patterns to be digitized or converted to SVG format in order to be 100% compatible with the Dobot software, which would guarantee the reproduction and precision of the designs. To complement the process, clothing molds were used, which allowed for the validation of the times between the manual and automated processes. As already mentioned, this technique allowed for use under controlled laboratory conditions, facilitating the observation of the use and performance of the Robotic arm during the pattern drafting process.

The methodological process was designed by applying engineering methodology tools designed to describe the pattern drafting process, identifying variables, and analyzing the possible causes of low productivity, this involved developing flowcharts for each area, characterizing the production activities, raw material storage and the internal delivery of materials and supplies. Additionally, theoretical time estimates were made under the standards established in the SAM " Standard Allowed Minutes" [5], calculating the standard allowed time (SAT) value, incorporating performance adjustment factors (PAF) and also an operational tolerance. The diagnosis began with the formulation of the central question focused on the causes of increased pattern drafting times, making it possible to identify, classify, and prioritize key variables that emerged from the literature review and were the starting point for the development of affinity matrices, SWOT prioritization, EFE, EFI, and process operation diagrams (POD), where they were related in order to determine the position of the process in relation to its environment and recognize internal and external factors that affect its performance.

Finally, technical guidelines were established for configuration, assembly, and operation, including calibration processes, height adjustment, drafting speed, an importing the patterns in SVG format for the robotic arm, considering its X, Y, and Z coordinate system. Based on the above a training program was developed for personnel (operators) with no experience using the Arm. The program is structured into nine hours distributed over three sessions, which include equipment recognition, individual practices, experimental evaluation and feedback. During the validation stage a test was carried out in the laboratory with a sample of 6 participants, in which the time taken to draft the patterns with the DOBOT was recorded and compared with the reference time for manual production, which was between 30 and 40 minutes. For effectiveness, it was established that there was a 10% margin for improvement with respect to the initial condition, calculating the percentages of reduction using a simple rule of tree and incorporating the incidence of human error present in the manual process.

III. Results

The results of the study are shown in accordance with the mythological order established above, in order to provide maximum consistency between the investigation and the findings obtained. The first step is to characterize and select the critical variables of the pattern tracing process, then show the contributions resulted from the implementation of DOBOT, culminating in the training process and presenting the results obtained in the pilot test, where the effectiveness of the automation of the tracing process is validated.

3.1 Process characterization and time estimation.

To develop this, the sub-processes linked to the pattern drafting process were taken into account, including: receipt of the design, taking measurements, pattern creation and transformation, verification, digitization and printing/marking and archiving. Detailed data is shown in table 1.

Table 1- Activities and estimated time in the pattern drafting process.

Activity	**Tool/Technique**	**Time (min)**	**Comments**
Receive the design	Technical sheet/ digital manual	2	Depends on the clarity of the design and a specifications
Analyze the design	Check of proportions, style, fabric	4	May take longer if the design is complex
Take measurements	Measuring tape/ body scanner / 3D avatar	4	Manual: 15–20 min; 3D: 5–8 min
Develop the base pattern	Manual with rules / CAD	12	CAD can reduce times by up to 40%
Transform the pattern	Style adjustments, tweezers, extensions	10	Depends on the number of sizes/variants
Digitize the pattern	Digitizer tablet / software CAD	6	Direct CAD saves up to 70%
Verify and correct the pattern	Virtual test / fabric test / review	6	May include repetitions
Print and mark the pattern	Plotter /Manual printing / laser cutter	3	Manual is slower; automated is faster
Classify and archive the pattern	Physical or digital (database)	3	Digitization improves traceability

The result was at MT time of approximately 50 minutes per item, however, when applying the Performance Adjustment Factor (PAF) [6], which depends expressly on the operator and their overall performance in the process. It is taken in accordance with the scale in table 2.

Table 2- Performance Adjustment Factor

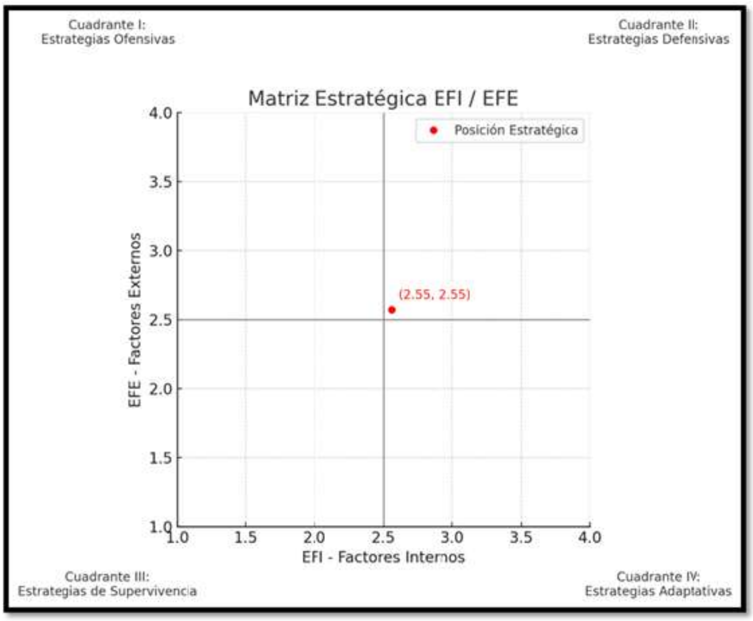
Operator performance	**PAF (approximate)**
Low	1.10 – 1.20
Average	1.00
High	0.90 – 0.95

Regarding tolerance (TS), 10% will be taken into account, considering that this weighting is taken from between 5% and 15% of the MT, as shown in the equation (1):
Equation 1. Tolerance TS
TS=50 × 0.10 =5 minutes
Finally, the Standard Time Allowed (STA) is determined [7], as shown below in the equation (2):
STA: Standard Time Allowed
MT: Measured Time
PAF: Performance Adjustment Factor
TS: Tolerance time
Equation 2. Standard Time Allowed
STA= MT X PAF + TS = (MT X PAF) + TS = TOTAL TIME IN MINUTES
STA= 50 × 1.10 + 5 = 55 +5 = 60 minutes

The previous result shows that the entire pattern-drafting process takes 60 minutes (1 hour) per garment under normal working conditions.

For SWOT analysis (Strengths, weaknesses, opportunities, and Threats)[8] and both the Internal Factors Assessment (IFA) matrix [9] And the External Factor Assessment (EFA) matrix [10], it was taken into account the weighting of the key elements to define the strategic position of SMEs, obtaining as a result that it is slightly above average in a defensive zone, as shown in the figure 1.

Figure. 1 - IFA vs EFA chart



It means that companies operate in relatively favorable conditions, but with significant threats, suggesting that they should take advantage of their internal strengths to counteract external threats, especially in terms of competition and market changes.

3.2 Diagnosis and prioritization of critical variables

Thanks to the bibliographic review [11], 19 variables were identified and classified according to human, technical, organizational, and external factors. See table3

Table 3- Variables classification

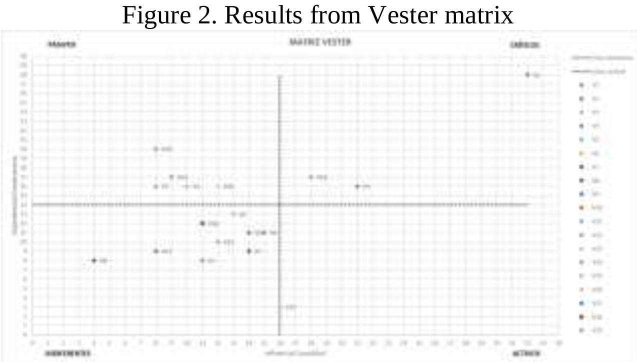
Category	Identified causes
Human factors	V1 Staff with insufficient technical training V7 High operator turnover V10 Lack of supervision and control V2 Delays in taking measurements V4 Rework due to human error
Technical factors	V14 Outdated drafting tolos V12 Slow or inadequate design software V15 Lack of pattern digitization V17 Slow or insufficient printing equipment V3 Poor process standardization
Organizational factors	V11 Poor workload planning V16 Lack of coordination between departments V5 Frequent design changes V18 Lack of standardized procedures V19 Absence of time control
External factors	V13 Delays from material suppliers V9 Changes in customer requirements V8 New regulations affecting processes V6 Logistical problems with the delivery of supplies

Among the most notable variables are the lack of pattern digitization, out of date patterns making tools, reprocessing due to human error, and lack of time control. For the development of the Vester matrix [12], the values obtained in the KJ affinity matrix [13] were classified according to their influence and dependence which allowed the prioritization of interventions on active and critical variables, as shown in Table 4 and Figure 2 below:

Code	Variable	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	INFLUENCE
V1	Staff with insufficient technical training	0	3	0	3	0	0	0	2	0	0	0	1	0	0	2	0	0	0	0	11
V2	Delays in taking measures	3	0	2	3	2	2	0	1	2	2	1	3	0	3	2	1	0	2	3	32
V3	Poor process standardization	1	2	0	1	0	0	2	1	0	0	0	0	0	0	0	0	0	3	0	10
V4	Rework due to human error	3	3	2	0	1	2	0	0	0	2	2	1	0	2	2	1	0	0	0	21
V5	Frequent design changes	0	3	0	0	0	0	0	0	2	0	1	0	0	0	0	2	0	0	0	8
V6	Logistical problems with the delivery of supplies	0	2	1	0	0	0	2	0	0	0	0	0	3	0	0	2	0	0	3	13
V7	High operator turnover	0	1	0	2	0	0	0	1	0	1	3	0	0	0	0	2	0	2	2	14
V8	New regulations affecting processes	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	4
V9	Changes in customer requirements	0	3	0	0	2	0	0	0	0	1	0	0	0	2	0	0	2	2	3	15
V10	Lack of supervision and control	0	0	2	0	0	1	2	1	0	0	2	2	0	2	0	1	1	0	0	14
V11	Poor workload planning	0	0	0	0	2	0	3	0	2	0	0	0	0	0	0	2	0	0	3	12
V12	Slow or inadequate design software	0	3	0	0	0	0	0	0	0	0	0	0	0	3	2	0	1	0	0	9
V13	Delays from material suppliers	0	3	2	0	2	2	0	1	3	0	0	0	0	0	0	0	0	0	3	16
V14	Outdated drafting tools	1	2	0	2	1	0	0	0	0	3	0	2	0	0	2	0	3	2	0	18
V15	Lack of pattern digitization	0	3	0	2	3	0	0	0	0	0	0	3	0	2	0	0	2	0	0	15
V16	Lack of coordination between departments	0	0	3	0	3	2	0	0	1	0	0	0	0	0	0	0	0	0	3	12
V17	Slow or insufficient printing equipment	0	0	0	2	0	0	0	0	0	0	0	3	0	3	0	0	0	0	0	8
V18	Lack of standardized procedures	0	0	3	1	0	2	0	1	0	0	0	2	0	0	0	2	0	0	0	11
V19	Absence of time control	0	0	0	0	0	2	0	0	0	2	1	0	0	0	0	3	0	0	0	8
	DEPENDENCY	8	28	16	16	16	13	9	8	11	11	10	17	3	17	11	16	9	12	20	251

Table 4- Vester Matrix

Figure 2. Results from Vester matrix



Based on the Vester matrix and the affinity diagram, the results were obtained for the development of the operations diagram of the process DOP [14], which broke down the process into 9 operations and 6 inspections, highlighting the most demanding activities in pattern drafting, pattern transformation, size grading, prototype testing, and cutting drafting/marking.

After conducting prioritization analysis [15], it was determined that the priority is to seek the best alternatives for increasing productivity, since this is the option with the greatest influence on the process.

3.3 Configuration and technical contribution of the Dobot Magician

The Dobot Magician[16] work on 4 axes or joints that allow movement in the X, Y and Z coordinates and rotation of the tool. Its reported repeatable accuracy is ±0.2 mm and it has a maximum reach of 320 mm, which makes it suitable for tracing tasks when the patterns fit the work area, which is shaped like a lunette according to the software used. This allows us to compare manual and automated pattern making in terms of qualitative comparison of the process, as shown the table 5.

Table 5. Qualitative comparison between manual pattern making and with Dobot Magician

Criteria	**Manual Pattern making**	**Pattern making with Dobot Magician**
Precision	Depends on the skill of the operator; human errors may occur	High precision through digital programming and repeatability
Speed	Slower process due to manually steps	Faster for repetitive task; reduces time
Initial cost	Low (traditional tools)	High (equipment, maintenance, training)
Learning curve	Manual practice and traditional knowledge	Training in software and robot operation
Standardization	Lower; variations between operators	High; identical patterns to the digital file
Errors and waste	Greater probability of waste due to human error	Less waste due to precision and control

Contributing greatly to generating greater precision, repeatability and standardization in exchange for a higher initial investment and the need for ongoing training.

3.4 Training and operational standardization protocol

It was designed a nine hour training course [17] distributed over three sessions, mainly focused on operators and/or personnel without experience in handling the Dobot Magician Robot [18], for which at least 1 instructor, 1 assistant and 1 Dobot Magician are required, distributed, according to the operator's needs as shown in table 6:

Table 6. Suggested session distribution.

Session	**Duration**	**Main contact**
1	2 h	Presentation, kit assembly, calibration, basic movements
2	4 h	Importing layouts, adjustments, trace tests
3	3 h	Project implementation, diagnosis, maintenance and evaluation

Additionally, common errors were documented with corrective actions and a final assessment was proposed consisting of a practical and theoretical part , see table 7.

Table 7. Training questionnaire

Date:	Place:
Name complete commando home in magician:	
What does the Home command do in Dobot Magician?	
a. Move the arm to the center of the table. b. Set the initial reference point for the arm. c. Lift the pen automatically. d. Save the current position.	
What file formats are supported for tracing in the Dobot writing module?	
a. JPG / PNG b. SVG / PLT c. PDF d. DOCX	
What is the purpose of the SyncPos function before executing a path?	
a.To synchronize the speed of the arm. b. To calibrate the pen. c. To align the starting point of the path with the position of the arm. d. To automatically turn off the arm.	
Which parameter can you adjust to prevent the pen from scratching the surface?	
a. Reduce the speed of the Y axis b. Increase the pen down height(PenDown) c. Lower the pen down height (PenDown) d. Change the pen color.	
SCORE:	

Finally, the most common errors and the most effective way to counteract them are shown in the Table 8.

Table 8. Common errors and ways to solve.

Problem	Probable cause	Recommended solution
Interrupted strokes/ missing lines	Insufficient drop height (Pen too high)	Lower the pen slightly or reduce speed
Blurred strokes or smudging	Pressure too high or speed fast	Raise the pen slightly and/or reduce speed
Stroke does not start/ image marked in red	Image outside the ring area	Rescale the image so that it stays within the limits
Loose pen tip/movement	Pen holder not secured properly	Adjust the pen holder screws and writing kit clamps
Software does not respond when importing SVG	Format not compatible	Simplify the SVG (less nodes), and save as SVG "clean" or PLT

3.5 Validation through pilot testing

The Pilot Test was carried out under controlled laboratory conditions with a sample population of Six Students (n=6), where the tracing times were recorded using the Dobot Magician robotic arm for each participant. These times ranged from 9.50 and 16.45 minute per participant. When compared to the manual reference time of between 30 and 40 minutes and a validation criterion of 10%, a simple rule of three was applied. See equation (3)

Equation 3. Percentage
Reference time min ⟶ 100%
Sample time min ⟶ X
X – 100 = % total

In all the cases, a significant decrease can be observed, as shown in table 9.

Table 9. Trace times with Dobot Magician and reduction compared to the manual method

Sample	Time with Dobot (min)	Manual time (min)	Decrease (%)
Student 1	9.50	40 (reference)	76.25
Student 2	11.30	40 (reference)	71.75
Student 3	10.15	40 (reference)	74.62
Student 4	14.52	40 (reference)	63.70
Student 5	16.45	40 (reference)	58.88
Student 6	10.05	40 (reference)	74.88

For the pilot test a reference time of 40 minutes was taken for the manual process. The average reduction calculated was 70.01%, with minimums around 58.9% and maximums around 76.3%, thus supporting the effectiveness of the proposed improvement, using process automation with the Dobot Magician robotic arm.

IV. Discussion

As a reference, mention is made of article [19] from the university of Pamplona, entitled "Propuesta de Automatización en la Industria de la Confección". When comparing the studies, it appears that both have similarities in terms of the central point regarding automation in the textile sector. Both the present study and the article used as a reference agree that the industry depends heavily on operational labor, which generates reprocessing, prolonged times in the activities that comprise the process, and variability in the quality of the final products. From a critical perspective, it is clear that both studies emphasize the same need to "modernize and automate processes in the sector" in order to make them more competitive. While the present study addresses the drafting of patterns with the Dobot Magician Robotic Arm, the other expands the scope to the entire productivity chain where they share the main idea that technology is the best alternative for improving efficiency, productivity and process control.

Now, when discussing the methodological approach, there is also a starting point for solving the problem through bibliographic review, as in the analysis of certain processes that are the basis for the development of their own technological proposals. However, it should be noted that this study is only based on experimental tests using simulations and time measurements, while the article from the university of Pamplona maintains a more projective and prospective approach, proposing smart factory models and the integration of new technologies without reaching experimental validation. This makes the present study more applied to a process, while the reference study only shows a macro view of the future of the textile sector.

A closer look reveals another difference between the two studies from a technological perspective. Although this study is based on only one of the manufacturing processes, it seeks to implement an alternative that significantly reduces tracing times and improves precision using the Dobot Magician Robotic Arm. The automation article examines all the activities that make up the production process, including: 3D design, automated spreading, CNC cutting, robotic sewing, RFID and IOT, this allows automation to be seen as an interconnected niche within the industry since both studies agree that the digitization of patterns and the integration of software and hardware are pillars for the transformation of the textile sector.

To conclude from a personal point of view, it can be seen that both articles converge in that technological evolution is part of an increase in productivity, reduction of human error, idle time during the workday and better use of raw materials. However this article shows a quantifiable result through data that demonstrates the reduction of time in the tracing process, while the article on automation discusses the benefits based on technological guidelines and comparative studies, what leads to believe that total automation is the ideal for the sector, its implementation usually begins with specific and scalable solutions such as the proposal to use the Dobot Magician Robotic Arm, which serve as a starting point for more integrated models in the textile industry.

V. Conclusion

The characterization and diagnosis showed that manual drafting and low digitization are determining factors in prolonged times and pattern reprocessing. The configuration of the Dobot Magician, combined with structured training, made it possible to standardize the drafting procedure and significantly reduce times in the pilot test, fulfilling the validation criterion (>10% reduction). It is recommended to complement the implementation with file preparation protocols (Clean SVG), quality control, and periodic training updates.

In conclusion, laboratory tests validated the effectiveness of the proposed improvement, demonstrating that the use of the robotic arm in the pattern drafting process increases productivity, reduces technical errors, and boosts the competitiveness of small and medium size enterprises in the textile sector. Therefore, the implementation of the method is recommended, along with a continuous training program for staff, in order to maintain the results achieved and promote continuous improvement in the process.

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