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Original Article

Design of a Recording Equipment for the Underwear Inventory Process

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Abstract *- Global business growth has been driven by the adoption of customized strategies and independent inventory management systems. In Peru, the commercial emporium of Gamarra stands out for its competitive prices, especially in the wholesale of underwear. This article aims to design a registration equipment for the company Creaciones Luytex in Lima, optimizing its underwear inventory process. The project implements a system based on LabVIEW software, which, through serial port communication, acquires the weight of underwear packages of 25 dozen, in addition to using a webcam for label recognition. The information obtained is automatically stored and updated in an Excel file, allowing precise control of inputs, outputs and stock. Test results showed a significant reduction in inventory recording time, from 20 minutes to only 2 minutes. The mechanical design of the equipment has a safety factor and resistance within optimal ranges, ensuring its reliability.*

Keywords *- Registers, Clothing inventories, LabView, Excel, Inventory managers.*

1. Introduction

Inventory management is a critical practice for both private and state-owned companies as it enables strategic decision-making and ensures operational efficiency, especially in omnichannel retailing, where inventory replenishment must be precisely coordinated across multiple channels to address demand uncertainties and service level requirements while optimizing the allocation of products between physical stores and online fulfillment centers to minimize logistics costs and ensure timely product availability [1]. In the competitive market, optimizing inventory management from product launch is crucial for efficiency and competitiveness in small businesses like the MSME clothing manufacturer in the Gamarra Commercial Emporium where poor warehouse planning, lack of item coding, and unclear schedules lead to stress, delays, and underutilized capacity with effective coordination with production and procurement departments being essential to reduce service times and improve operational efficiency [2]. Inventory management is essential in today's uncertain retail environment, requiring effective policies to ensure a continuous supply of materials, spare parts, and finished goods by monitoring customer demand and optimizing inventory levels, preventing production disruptions and improving performance [3]. Modern warehouse management systems allow continuous inventory tracking and real-time order processing [4]. In Peru, the textile trade is a key sector, with Gamarra, located in La Victoria, Lima, serving as its main commercial hub [5]. This district hosts over 39,000 businesses and nearly 80,000 workers, offering competitive prices and various products. Micro and small enterprises in Gamarra face space limitations in their warehouses, leading to inefficiencies such as a lack of planning and item coding, causing delays in production and underutilization of warehouse capacity [6]. Additionally, customers waste a lot of time searching for specific stores, which affects satisfaction and loyalty [7]. One of the companies operating in this sector is Creaciones Luytex, which is managed by a team consisting of a manager, two salespeople, and a storekeeper. Currently, the manager and storekeeper conduct inventory management manually using Excel [8], verifying stock levels and tracking inputs and outputs to support decision-making. However, this real-time inventory process is inefficient, particularly in product classification and counting, leading to delays in stock updates. As a result, the company experiences lost revenue and missed business opportunities when customer demands cannot be met promptly, highlighting inefficiencies in the system. Additionally, manual inventory management results in prolonged counting times, difficulties in tracking stock levels, inaccuracies, and increased costs due to overstocking or stockouts [9]. To address these challenges, an optimized inventory management system has been proposed, integrating automation through LabVIEW and Excel. This system involves designing specialized recording equipment for the undergarment inventory at Creaciones Luytex in Lima. The solution capitalizes on key garment attributes, such as labels that indicate brand and size [10]. By implementing machine vision in LabVIEW, garments can be classified based on their labels, while package weight measurement allows for precise inventory tracking. Using a scale as a reference tool, the system determines the exact number of garments in a package, automatically recording stock levels, inputs, and outputs in a digital inventory. Additionally, the integration with Excel ensures that inventory data is updated in real time, facilitating immediate access to stock information and improving decision-making. This semi-automated approach significantly enhances efficiency, reduces errors, and optimizes inventory management.

2. Materials and Methods

2.1. Kanban Methodology Overview

The Kanban methodology is a visual management tool that helps organize and optimize the workflow in various processes, particularly in industrial environments and software development. Its approach is based on visualizing tasks using a board divided into columns representing different stages of the process, such as "To Do," "In Progress," and "Done." This visualization provides clear, real-time control over the status of each activity. One of the fundamental principles of Kanban is limiting Work In Progress (WIP), which prevents team overload and encourages the completion of tasks before starting new ones. Additionally, this methodology fosters continuous improvement through the observation of workflow, detection of bottlenecks, and the implementation of incremental adjustments to optimize performance.

2.2. Implementation at Creaciones Luytex

This research applied Kanban methodology to optimize workflow efficiency, reduce task overload, and improve the overall process [11]. Specifically, an inventory recording system was developed and implemented at Creaciones Luytex, aiming to enhance the inventory management of underwear through a weight control system and label recognition, using materials such as steel, acrylic, and aluminum, alongside software tools like LabVIEW and Excel.

2.3. Equipment and Components Used

For the design of the recording equipment, careful selection of materials was crucial. Mechanical components will include AISI 304 steel, acrylic, and aluminum, while the control system will incorporate an external webcam, a load cell, a development board with the ATmega328P microcontroller, an external load cell, and an analog-to-digital converter module [12].

2.3.1. Inventory Management

The inventory process for product delivery begins with the delivery of goods by the supplier, following the manager's instructions. Then, the manager receives the products, and the suppliers take the merchandise to the warehouse, where the warehouseman performs a manual count to verify that the delivery matches the order. Subsequently, the warehouseman sends the manager the details of size, brand, model and quantity of the garments. This data is recorded in an Excel file, updating the company's underwear inventory. The inventory process for receiving 150 dozen includes supplier delivery (15 min), product receipt (15 min), verification (15 min), registration (15 min), and updating (15 min), see Figure 1.

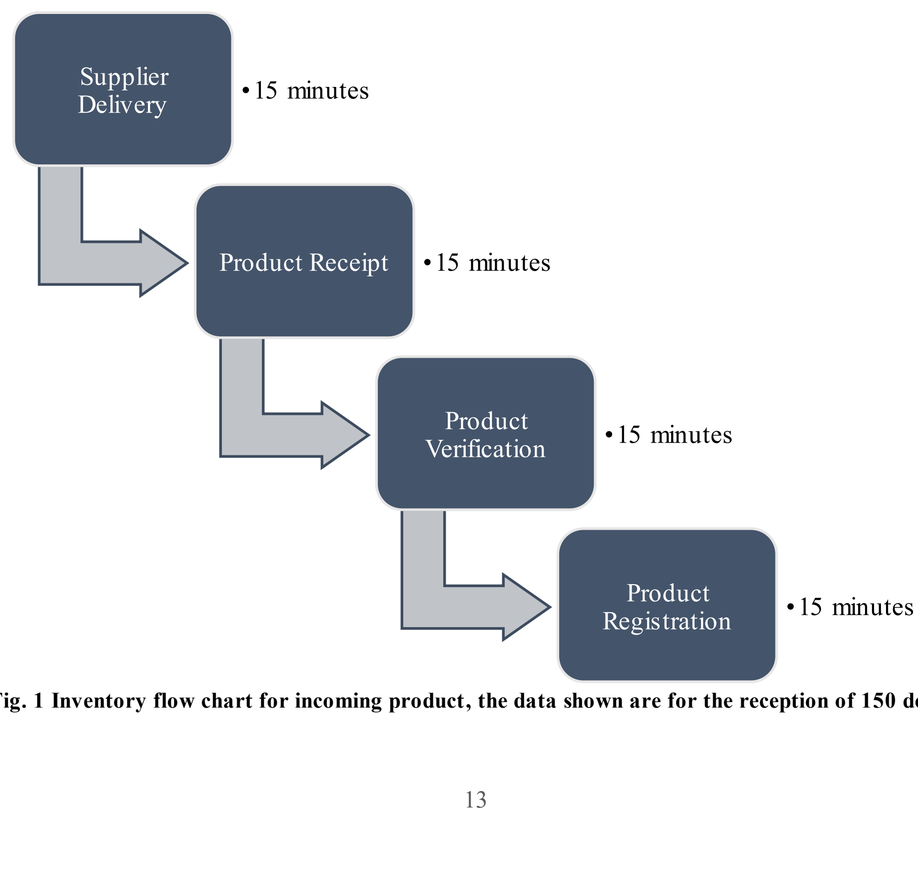


Fig. 1 Inventory flow chart for incoming product, the data shown are for the reception of 150 dozen

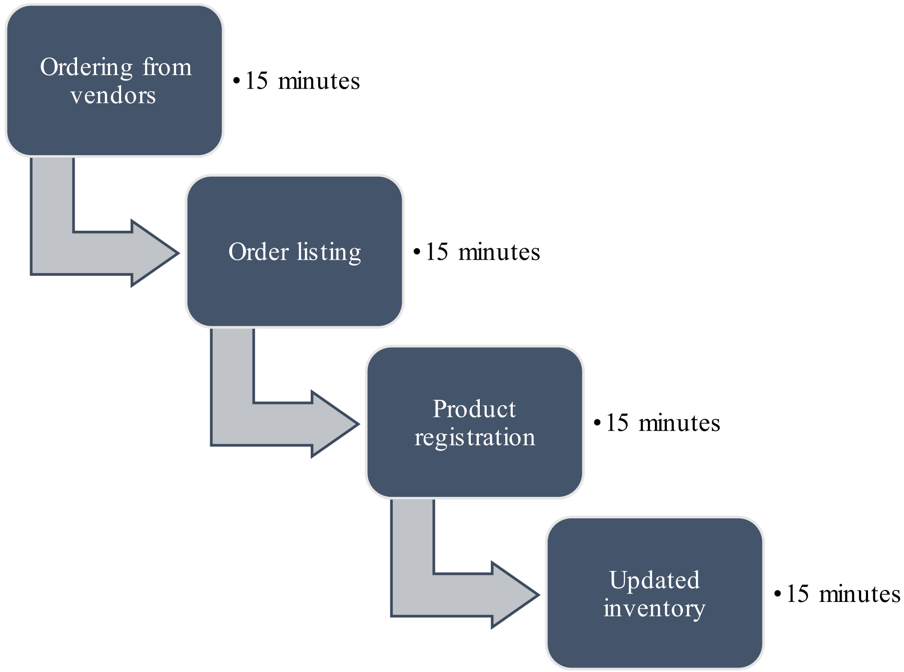


Fig. 2 Inventory flow chart for outgoing product, the data shown are for the reception of 25 dozen

The inventory process for outgoing products begins when the saleswomen inform the manager or warehouseman of their order. The warehouseman prepares the order, quickly counting the products by brand and size. The manager then records the data in an Excel file, updating the company's underwear inventory. For issuing 25 dozen, the steps include ordering from vendors (15 min), order listing (15 min), product registration (15 min), and inventory updating (15 min), see Figure 2.

2.3.2. Control System

Three key tools were used in this research. The first was software compatible with the ATmega328P microcontroller, an open-source C language programming interface. This allowed the algorithm development for the recorder equipment, using the HX711.H library, to manage the connections of the previously mentioned materials. The second instrument was NI LabVIEW, a programming software in G language, with a customizable graphical interface. This environment is versatile and suitable for simple and complex projects, allowing integration with PLCs and the ATmega328P microcontroller to control various processes. Through LabVIEW, code was developed for data acquisition, label recognition through image processing and pattern detection, and weight reading. These data were sent to Excel for storage and processing of information from the webcam and the weight signals.

2.3.3. Electronic System

It is based on data acquisition by means of mass measurement. The load cell connected to the ATmega328P microcontroller and the HX711 module[13] converts the analog signal into digital, which is sent to LabVIEW through a serial port. The HX711.H library is used for calibration, assigning the corresponding pins for data transmission and the calibration factor is adjusted according to the load system. Once calibrated, the equipment is ready to measure and record the weight of the products in the weighing program (see Figure 5).

2.3.4. Mechanical Design

Autodesk Inventor software was used to carry out the mechanical design of the recording equipment, which facilitated obtaining the safety coefficient and the Von Mises stress.

Likewise, the parts were designed and assembled, and drawings were prepared that included the corresponding dimensions. Next, the type of material used is specified, and a simulation of the exploded view of the recording equipment was made through a video and a drawing, as shown in Figure 3.

2.3.5. Image Acquisition and Processing

In relation to inventory, it is necessary to collect information such as size, brand, model and product code. For this reason, the data provided by each product type label will be used as shown in Figure 4(a). Label recognition is performed with LabVIEW software, using a webcam with adjustable light and autofocus to ensure correct illumination. Vision Acquisition libraries are used for continuous image capture, and Vision Assistant for image processing, using tools such as RGB GREEN and Pattern Matching to identify label patterns, see Figure 4 (b).

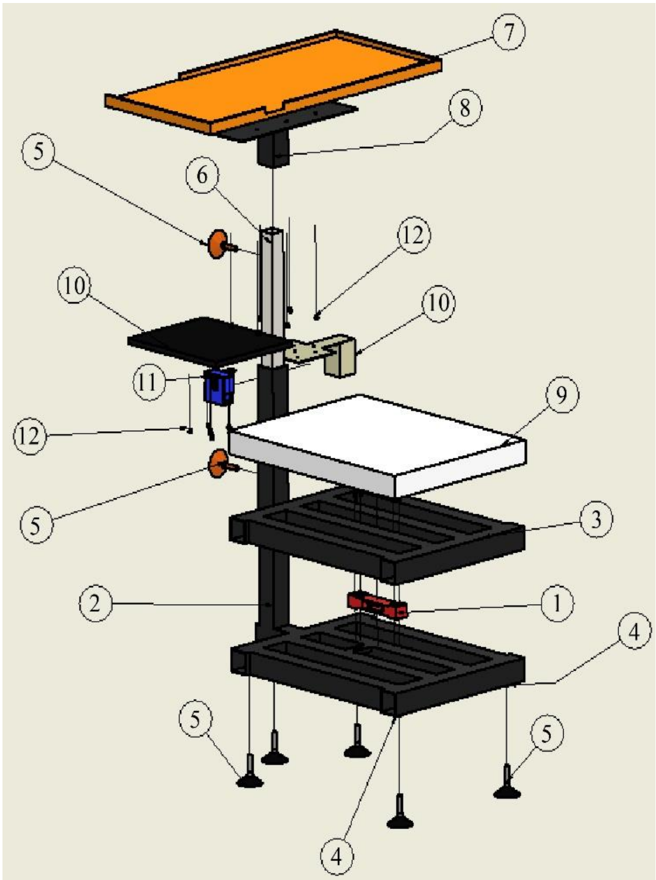
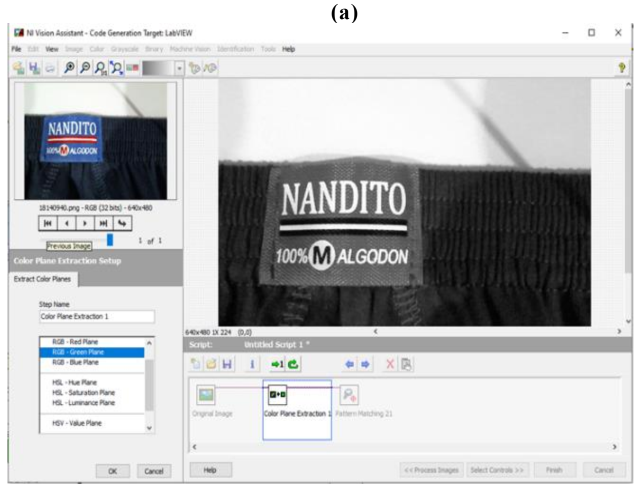


Fig. 3 Elements that make up the structural design

(a)



(b)

Fig. 4 (a) Extraction of label parameters, and (b) RGB color plane extraction tool.

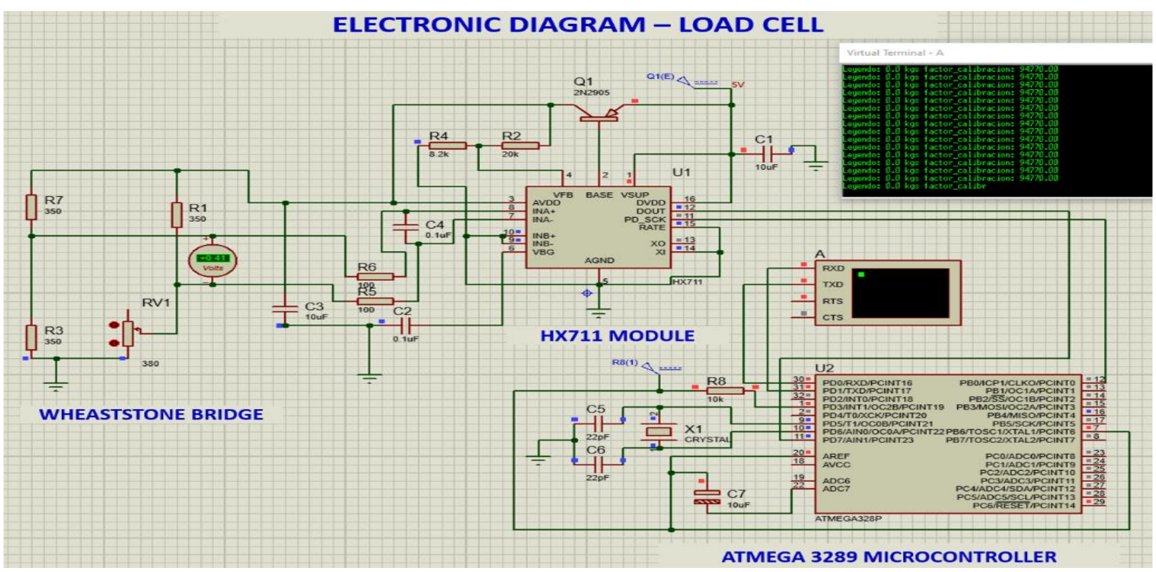


Fig. 5 Simulation of electronic diagram - load cell

In the programming code, the comparison tool is used to optimize the signal, allowing an LED to light up dynamically each time a label is detected. In String format, the data displays the brand, size and model parameters through conditional cycles. In addition, an error dialog is included to report code failures. The interlinked File Dialog and Vision. Acquisition modules allow selecting and addressing the folder where the images are located, which are then shown graphically on a Display indicator. To avoid flickering of the images in real time, the Imaq Create and Imaq Copy functions are used, ensuring a smooth display of the preprocessed and processed images, as shown in Figure 4.

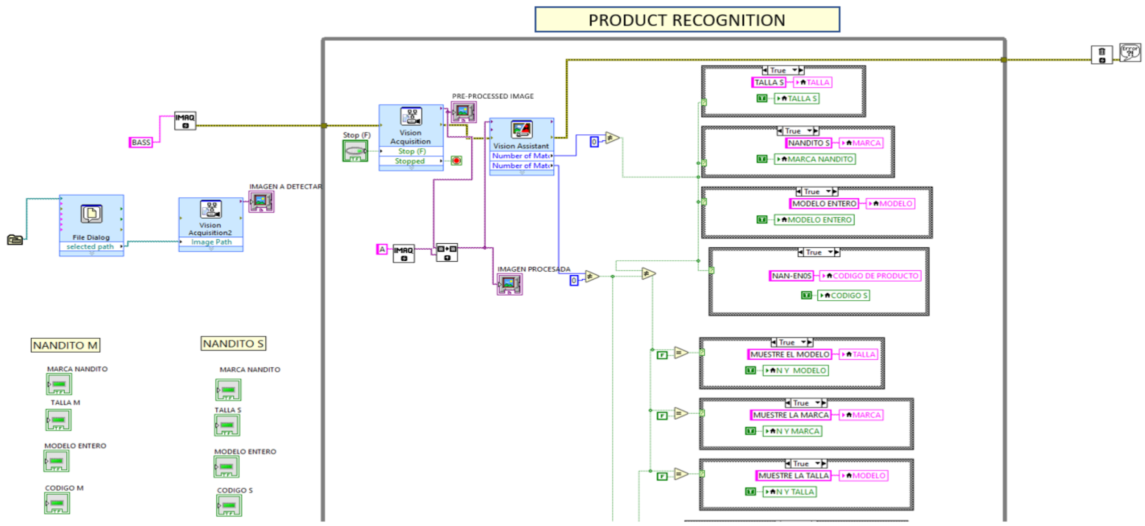


Fig. 6 LabVIEW label recognition interface

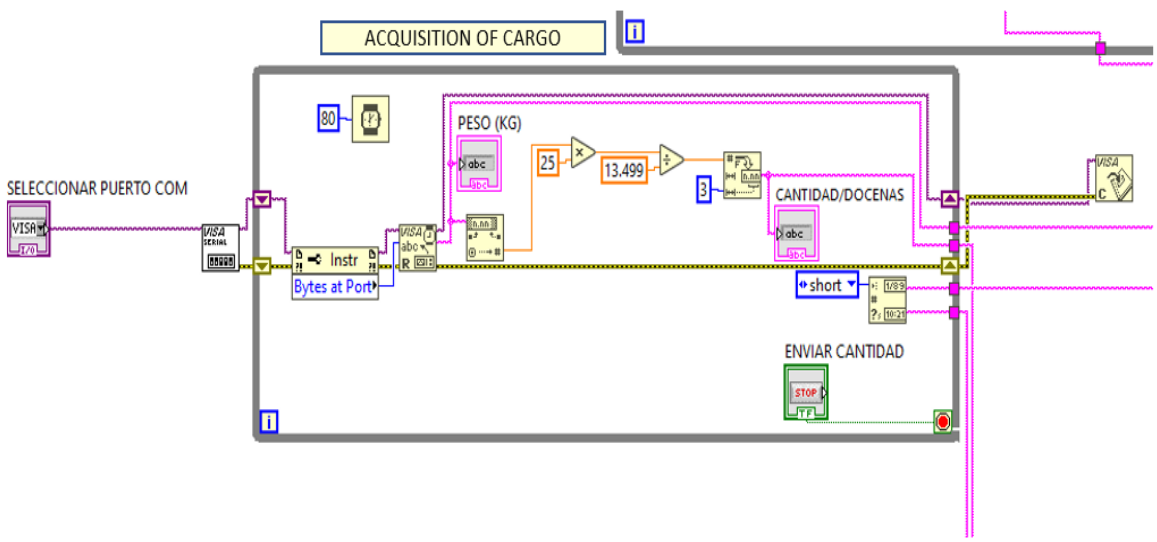


Fig. 7 Serial communication in LabVIEW (weight reading)

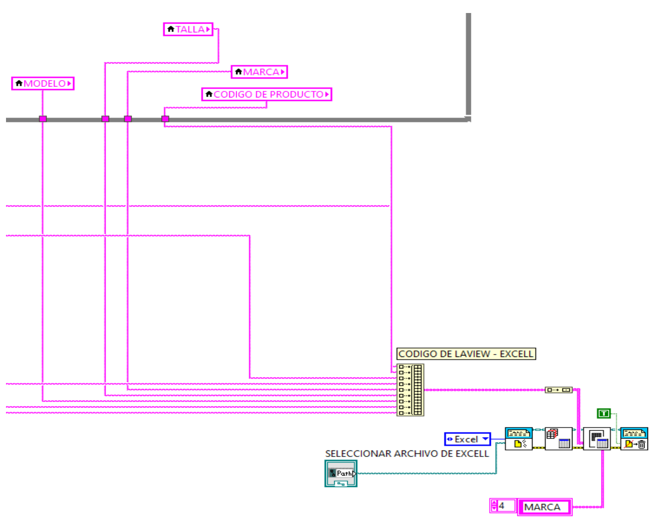


Fig. 8 Data export to Excel from LabVIEW

In the programming code, a comparison tool is used to optimize the signal by activating an LED each time a label is detected. The data, sent in String format, dynamically displays the brand, size and model parameters through conditional cycles. In case of errors in the code, a warning dialog box is displayed. The modules "File Dialog" and "Vision Acquisition" are interconnected to select and address a predetermined path to store the images, which are graphically shown on a Display indicator. To avoid flickering of both preprocessed and processed images, the "Imaq Create" and "Imaq Copy" modules are used. This is illustrated in Figure 6. To read the serial port of the ATmega328P microcontroller-based board, a code is developed that displays the weight of the package in kilograms on the interface. Using the Serial Visa tool, the COM port is selected, and the weight data of String type is converted to a numeric value. Then, a mathematical operation consisting of multiplying by 25 and dividing by 13,499 was performed to obtain the value in terms of dozens, as illustrated in Figure 7. Data from LabVIEW is sent to Excel using the Build Array tool, which allows String data to be packed. Subsequently, all the data is organized with the same tool. The Report Generator tool assigns the data into specific columns, such as weight, product code, date, time, brand, size, model, product status and quantity. Finally, the Excel file is selected with the Create Report tool, in .xls format, to store the information in an orderly and accurate manner, see Figure 8. For the development of the graphical interface, several key parameters were included, such as product code, brand, size, model, product status, weight, quantities in dozen, time, date and quantity. The interactive environment includes visual indicators, such as virtual LEDs that light up when the product mark is detected, as shown in Figure 9. It also has a window for selecting and saving data to a specific Excel path, a COM port selector, and a picture box that shows real-time sampling. Once the data has been loaded, the "Send product recognition" and "Send quantity" buttons allow the information to be exported to an .xls file. In addition, three graphics are presented: preprocessed image, processed image, and image to be detected. The first two are continuously updated, while the last one is static.

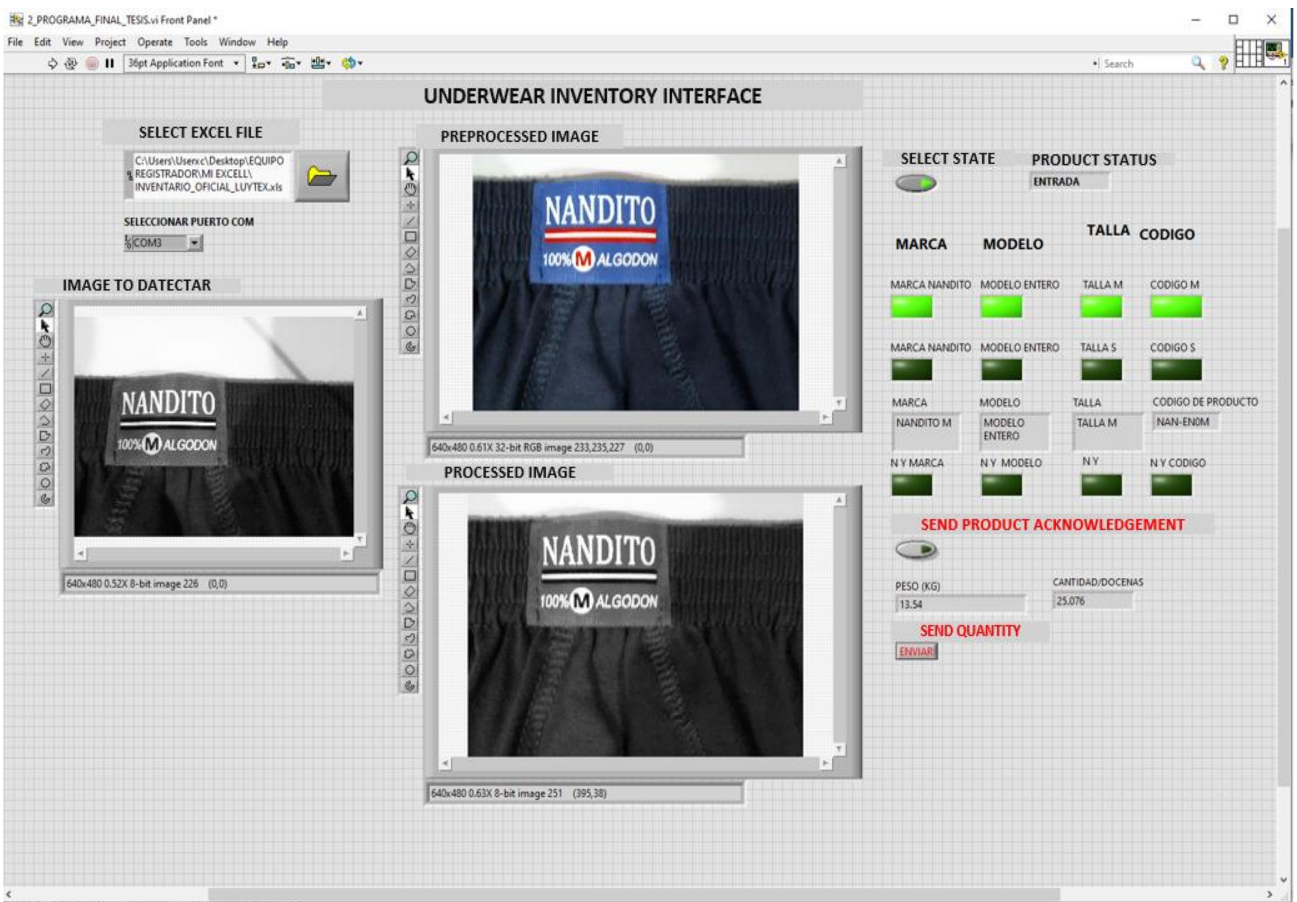


Fig. 9 Graphical interface of the recording equipment

The data is sent to a file in Excel format, where parameters such as weight, product code, date, brand, size, model, product status and quantity are recorded. Additionally, a macro is used in Excel to manage the recording of data related to stock, inputs and outputs. This macro automatically updates the underwear inventory movements based on the data obtained from LabVIEW.

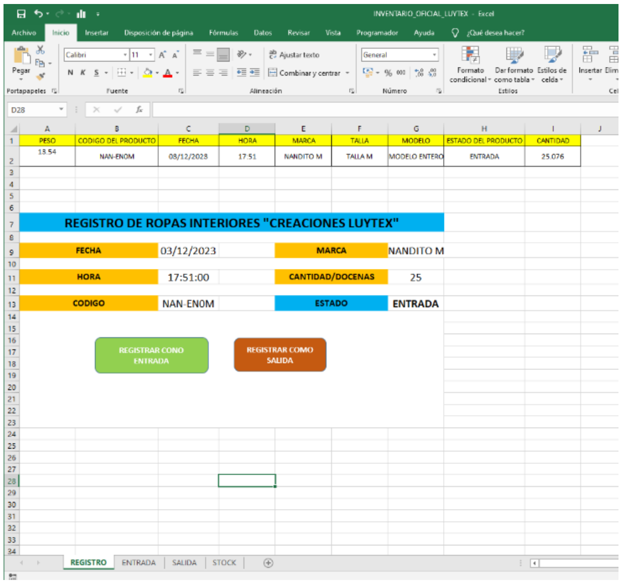


Fig. 10 Inventory register in Excel

In the inventory recording interface, the data obtained in the first rows, such as date, time, code, brand and quantity, are displayed. For the inventory update, you can select between recording as "input" (highlighted in green) or "output" (highlighted in red), as illustrated in Figure 10. When "record as input" is selected, the data is automatically saved and stored in the Excel sheet corresponding to the Inputs. The parameters recorded include date, time, product code, brand, size, model, description and quantity, as shown in Figure 11. Similarly, the same logic was applied for the output process, which is why by selecting "record as output", the information is automatically saved and stored in the Outputs sheet, recording parameters such as date, time, product code, brand, size, model, description, and quantity. This is illustrated in Figure 12. Finally, the inventory stock movements are automatically updated, providing key information such as product code, brand, size, model, description, receipts, issues, stock, cost per dozen and total cost. These parameters can be seen in Figure 13.

PRODUCT ENTRY

DATE	TIME	PRODUCT CODE	BRAND	SIZE	MODEL	DESCRIPTION	CANTIDAD
03/12/2023	17:51:00	NAN-ENOM	NANDITO M	M	ENTERO	Men's full brief, size: M	25
09/11/2023	09:13:00	NAN-ENOM	NANDITO M	M	ENTERO	Men's full brief, size: M	25
06/11/2023	12:56:00	NAN-ENOM	NANDITO M	M	ENTERO	Men's full brief, size: M	5
06/11/2023	12:56:00	NAN-ENOM	NANDITO M	M	ENTERO	Men's full brief, size: M	5
06/11/2023	12:56:00	NAN-ENOM	NANDITO M	M	ENTERO	Men's full brief, size: M	5

Fig. 11 Inventory entry record

PRODUCT OUTPUT

DATE	TIME	PRODUCT CODE	BRAND	SIZE	MODEL	DESCRIPTION	QUANTITY
6/11/2023	12:56:00	NAN-ENOM	NANDITO M	M	ENTERO	Full Brief, Size: M	5,1
6/11/2023	12:56:00	NAN-ENOM	NANDITO M	M	ENTERO	Full Brief, Size: M	5,1

Fig. 12 Inventory issue register

INVENTORY STOCK

PRODUCT CODE	BRAND	SIZE	MODEL	DESCRIPTION	INPUTS	OUTPUT	STOCK	COST X DOZEN	TOTAL COST
NAN-ENOS	NANDITO	S	ENTERO	Men's full brief, size: S	0	0	0	S/ 17.00	S/ 0.00
NAN-ENOM	NANDITO	M	ENTERO	Men's full brief, size: M	65	10	55	S/ 25.00	S/ 1,379.25
NAN-ENOL	NANDITO	L	ENTERO	Men's full brief, size: L	0	0	0	S/ 17.00	S/ 0.00
NAN-ENOXL	NANDITO	XL	ENTERO	Men's full brief, size: XL	0	0	0	S/ 17.00	S/ 0.00
NAN-ENOXXL	NANDITO	XXL	ENTERO	Men's full brief, size: XXL	0	0	0	S/ 17.00	S/ 0.00

Fig. 13 Automatic stock update in Excel

3. Results and Discussion

The use of the ATmega328P microcontroller and the HX711 module allowed for the accurate acquisition of the weight of the packages, which is why this system was integrated with LabView software to obtain and process the data, generating detailed reports in Excel allowing efficient recognition of the labels through image processing with tools such as Vision Acquisition and Vision Assistant. The automation of the inventory register allows the automatic registration of incoming and outgoing products, updating inventory data such as weight, product code, brand, size and quantity for incoming and outgoing products in real time, thus optimizing the inventory management process and reducing possible human errors.

3.1. Control System of the Recording Equipment in the Inventory Process

Efficiently with the assigned functions for the inventory process of underwear at Creaciones Luytex - Lima. The interface and data communication developed in LabVIEW operate successfully, as demonstrated in the tests conducted with the prototype. This system enables the automated sending of data to Excel, facilitating the inventory's updating, recording, and storage, including product counting. According to the results in Table 1, the registration process takes 2 minutes and 23 seconds when executed by a single operator, processing a package of 25 dozen Nandito brand M-size panties. To ensure the accuracy of the tests, the weight of the Nandito package was determined using a reference standard, which was compared with the values previously established in the study.

This system optimizes time and reduces workload, demonstrating its effectiveness in inventory management. The results indicate a significant reduction in inventory registration time with the implementation of the automated system. To validate this improvement, a statistical analysis was conducted comparing the times of the manual process (80 minutes for 150 dozen) and the automated process (2 minutes and 23 seconds for 25 dozen). The time per dozen metric revealed an 82.2% decrease, from 0.533 minutes/dozen (manual) to 0.095 minutes/dozen (automated). Furthermore, a repeated measures t-test applied to the automated process samples confirmed that the difference is statistically significant ($p < 0.05$), with a minimal standard deviation (±0.2 minutes), highlighting the consistency of the system.

Table 1. Recording equipment inventory process

Quantity (dozen)	Description	Time	Workers
25	Nandito underwear	2 minutes and 23 seconds	01
50	Nandito underwear	4 minutes and 46 seconds	01
75	Nandito underwear	6 minutes and 9 seconds	01

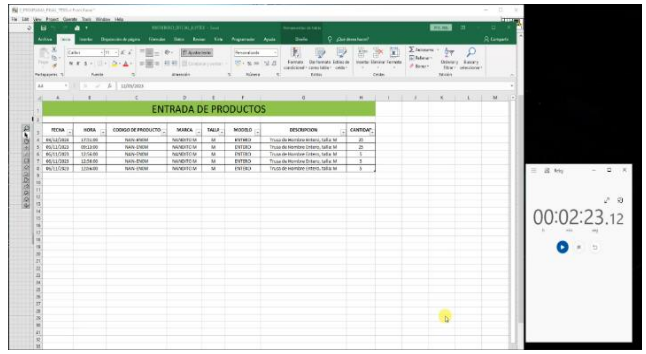


Fig. 14 Functioning test

3.2. Full Integration with Excel for Inventory Management

The information processed in LabVIEW is sent to Excel, where incoming and outgoing products are recorded. The use of Excel macros allows the stock to be updated automatically, providing detailed information about the inventory status, costs per dozen, and total cost.

3.3. Mechanical Design

Using Inventor software, a recording equipment was designed and the applied loads were analyzed, including those of a standard laptop (14.72 N) and the largest underwear package (166.77 N). In addition, the maximum load that the equipment design can withstand was evaluated, which is 392 N, considering a 40 kg cell. The results showed a minimum safety factor of 1.85, which indicates that the equipment does not exceed the maximum load, does not present a risk of rupture in the mechanical system and does not approach the elasticity limit, thus demonstrating its resistance for proper operation.

Table 2. Result of structural analysis

Type of Analysis	Result
Minimum Safety Factor	1.85
Von Mises Stress	111.8 MPa

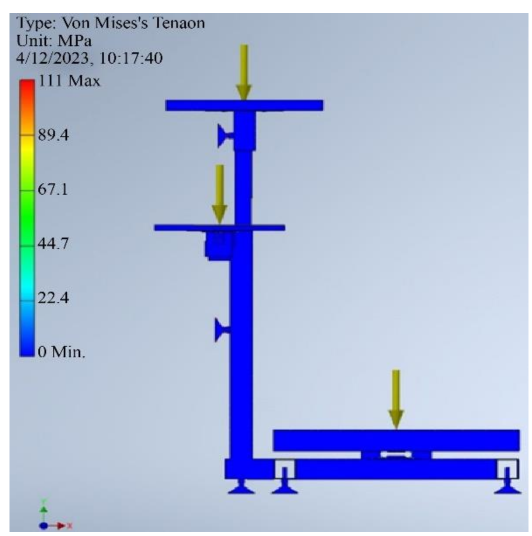


Fig. 15 Limit of elasticity of mechanical design

3.4. Comparison of Results

Table 3. Presentation of improvements

Appearance	Before	After
Personnel Involved	Two workers: an administrative and a storekeeper.	Automated recording equipment assists in the inventory process, with personnel supervising the process.
Inventory Process	The storekeeper counts the garments manually.	Automated prototype that registers garments quickly.
Registration Time (Regular Season)	It takes 80 minutes to register 150 dozen undergarments.	The recording equipment takes 2 minutes and 23 seconds to record 25 dozen undergarments.
Registration Time (Campaign)	Check-in time is extended because employees also handle in-store sales during the campaign season.	The registering equipment maintains a constant speed, even during campaign periods.
Impact on Efficiency	A slow manual process that generates delays in updating inventory and affects customer service during peak season.	Fast and efficient automated process reduces check-in time, frees staff for other tasks and improves inventory management.

3.5. Statistical Improve

The automated inventory system replaces manual counting, significantly improving efficiency. Previously, two employees took 80 minutes to register 150 dozen garments. Now, automated equipment records 25 dozen in just 2 minutes and 23 seconds, ensuring faster stock updates, reducing delays, and enhancing customer service.

Table 4. Compared results

Category	Before (Manual Process)	After (Automated Process)
Personnel Involved	2 workers (Administrative + Storekeeper)	1 (Supervision only, automated process)
Inventory Process	Manual Counting	Automated Prototype
Registration Time (Regular Season)	150 dozen (1,800 pieces)- 80 minutes	25 dozen (300 pieces) -2 min 23 sec

4. Conclusion

The implementation of automated recording equipment for the inventory of underwear at Creaciones Luytex has proven to be an effective solution to optimize the process of recording and updating data, especially compared to the manual method previously used. The results of the tests conducted indicate a significant improvement in time efficiency, reducing the inventory recording process for 150 dozen garments from 80 minutes to an average of 2 minutes and 23 seconds for 25 dozen, suggesting that the new system will allow substantial time savings in regular and campaign seasons. From the mechanical design point of view, the recording equipment has a safety coefficient of 1.85, which ensures its reliability under the expected operating loads.

The yield stress of 111.8 MPa has not been exceeded, which ensures that the structure of the equipment is robust and suitable for continuous use in the inventory process. This analysis demonstrates that the equipment is structurally safe and strong. The integration of technologies such as the ATmega328P microcontroller, LabVIEW and Excel has made it possible to automate the data acquisition and recording process, eliminating human errors and speeding up stock updating. The use of image processing for label recognition and the connection with Excel through macros ensures a continuous flow of real-time data, improving accuracy and inventory management.

Sustainability is a crucial aspect in inventory management [14], especially in the textile sector, it is therefore necessary to analyze and improve current procedures to increase profitability and optimize the use of available resources, which is why the implementation of an automated recording equipment for the inventory of underwear is a strategy that will allow. This project surpasses state-of-the-art techniques by optimizing inventory through a weight control system and label recognition using LabVIEW and Excel. This approach significantly enhances accuracy and efficiency, and unlike previous methods, this model demonstrates superior processing time performance compared to using only Excel. While there are various inventory systems for clothing, specialized solutions for undergarments (such as underwear) remain scarce in literature and practical applications. The proposed system addresses this gap by offering a tailored, automated solution for Creaciones Luytex, combining mechanical robustness, real-time data processing, and seamless Excel integration to redefine inventory management in this niche sector.

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