DESIGN AND FABRICATION OF WASTE FABRIC SEGREGATION SYSTEM

V. G. Pratheep,
Department of Mechatronics Engineering,
Kongu Engineering College,
Erode, Tamil Nadu, India.
vgpratheep@kongu.ac.in

A. Muralidharan,
Department of Mechatronics Engineering,
Kongu Engineering College,
Erode, Tamil Nadu, India.
muralidharana.19mts@kongu.edu

N. Prithivi Rajan,
Department of Mechatronics Engineering,
Kongu Engineering College,
Erode, Tamil Nadu, India.
prithivirajann.19mts@kongu.edu

M. K. Suganesh,
Department of Mechatronics Engineering,
Kongu Engineering College,
Erode, Tamil Nadu, India.
suganeshmk.19mts@kongu.edu

***Abstract*— In textile industries, after large production of textiles like t-shirts, tracks etc., a vast amount of fabrics waste is produced along with it. These waste are called as pre-production waste in industrial terms. The fabrics waste is collected as bundle and moved further to recycling process or sometimes ends up as landfill. The bundle consist of various materials, colors and patterns of textile fabrics. It is then separated by people manually into individual bundles without any machines and then separated bundles are collected back by industries and recycled to raw material. This segregation process is a tedious and time consuming work and our motive is to automate the segregation process easier and rapidly. Our proposed solution for waste fabrics segregation consist of several levels of process. First, the waste bundle must be separated into smaller units and separation is done using mechanical setup. After dividing into smaller units, selection of particular color or pattern is done using color and image recognition sensors. The part of selection and identification process of the particular color or pattern is pre-programmed with an algorithm in the controller of the system. Finally, the respective response for separation of a particular unit is sent to the controller which is interfaced with segregating mechanical setup. Here the waste will be sorted based on color and the rest of waste which is not separated is recycled back. This way, the process of segregation is increased rapidly and done easily**

Keywords—Pre-production textile waste, color sorting

I. INTRODUCTION

We are surrounded with textiles. The worldwide textile business is vast nowadays. The waste generated can be classified into pre-production waste and post consume waste. The pre-production waste is concentrated in our system. About the pre-production waste fabrics generated, there is only two options available, it is either discarding the waste fabrics as landfills or segregation and recycling of the waste fabrics. Either way, it is disadvantage to the environment and loss in terms of recycling industrial units. About the recycling process, there are only few industries which is interested in turning back the waste fabrics back to raw material. These industries distribute the waste fabrics to small scale household units to segregate the materials based on colors and after that the segregated materials are recycled. But mostly the waste fabrics are not processed and ended up in landfills. This is due to lack of interest of textile industries in recycling process because it is rather easier to discard the waste fabrics than to recycle them.

The segregation process is done by human labors by their bare hands. This makes the process more complicated and takes more time for segregation. This is one of the reasons, industries does not involve in the recycling process. If the process can be automated and human labors can be replaced, this process could be done in a wide range and the pile of waste fabrics ended up in landfills can be reduced to zero. We came up with a solution of a complete system to separate the pile of waste fabric and segregate them based on color.

II. LITERATURE REVIEW

The main objective of the project is to design, construct and evaluate an effective system to separate the waste materials and segregate it rapidly based on color. By switching from traditional segregation techniques to a fully automated system, production will increase and recycling will be simpler, which will result in less waste fabric being disposed of in landfills. Instead of contributing to pollution, this approach will improve textile waste fabric recycling.

A. Literatures Related To Existing System

Textile industry contribute significantly to a country's economic growth. Even if they contribute to economic progress, they also contribute significantly to the generation of pre-production waste. These industries simply dispose of waste without giving it a second thought. One of the reasons for dumping waste rather than recycling is the traditional procedure of manual segregation.

The manual process is tedious work, requires too much of labors and takes long time. There are other existing system for segregation of textiles based on type of materials and color but they are used in recycling of textiles which people dispose after use. These processes involve expensive methods like near infrared spectroscopy. A lack of equipment and technology were identified as the main barriers to recycling. Besides technology, the sole prerequisite for recycling apparel waste is to collect and sort it by color and/ or fiber content.

Han et.al, (2015) said about upcycling as a design strategy for product lifetime optimization and societal change. This paper aims to analyze the innovative ways in which UK based upcycling designers are recreating style and value from discarded materials, and the benefits of this process[3].

Hu et.al, (2022) proposed a study on an online rapid sorting method of waste textiles based on near-infrared spectroscopy and the generative adversity network, which utilized the deep learning algorithm is used to intensely mine the potential distribution information about the original spectral data, as well as the generative adversity

network is employed to construct the digital data set to compensate for the unequal distribution of the original data set. The results of the tests suggest that the strategy may successfully improve the fullness of the given data and the model's accuracy[4].

Kulkarni et.al, (2017) developed an automated system for object sorting based on color detection. With the images captured from USB camera, colors of objects are identified using color detection algorithm. This detected color is used as object sorting parameter by Raspberry Pi. This system uses image processing algorithm for color detection using HSV model. HSV indicates Hue (H) Saturation (S) and Value (V) of color[5].

Nørup et.al, (2018) proposed a project to design and evaluate a system for assessing the numbers and quality of fabrics in household waste, with the goal of reducing the amount of things disposed of alongside ordinary household waste. The specific goals are to define what defines a textile fraction and quality, to create a quality assessment that includes product kind, manufacturing process, and fibre composition, to assess the method in a specific waste sorting campaign, and to compare the findings[8].

Pandey et.al, (2020) published about solutions for sustainable fashion and textile industry which contains sustainable fashion and textile industry and green solutions including eco-innovation, eco-selection, effluent treatment, eco-labelling, utilization of textile wastes, reuse and prevalent recycling practices[9].

Waste management in the format of fabric patchwork from confection industries not only reduces environmental effect but can also be repurposed in the field of household linen craft. When confectionery waste is recycled, it produces quilted fabric trash that is used by craftspeople and others in need. Suryani, Hamidah, et al. (2017) are very interested in investigating clothing waste management, particularly in Makassar [10].

Tomovska et.al, (2014) proposed an investigative research to characterise apparel cuttings waste, define the existing level of apparel waste cuttings management, and determine Macedonian top management attitudes toward managing apparel cuttings. The bulk of garment manufacturers dump their cutting waste, along with community rubbish, on open fields. The production of garment trash not only represents a waste of precious materials and energy, but it also generates environmental issues and costs to collect, transport, and manage the waste[11].

Habich (2007) offered a summary of automatic sorting methods that have been utilised in trash processing for over ten years to sort light packaging. These devices use Near-Infrared (NIR-) sensors to differentiate between different polymers. Aside from NIR-sorting, which has so far only been effectively applicable with light or transparent plastics, inductive sorting, optical sorting (mostly by colours), and X-ray sorting are potential waste processing technologies[2].

Zhang et.al, (2021) present a fusion neural network-based multi-objective sorting system. The attitude information of the object is obtained by two different networks in this proposed system in order to fully utilise the advantages of the two networks, and normal vector estimation based on point cloud processing and grasping sequence reasoning based on average depth calculation are proposed[12].

Decision-making in textile manufacturing typically takes several parameters into account, which adds to the complexity. Lu et.al, (2021) present a decision support system for the textile manufacturing process that combines the ANN model, AHP, and Q-learning[7].

B. Summary Of Literature Survey

From all the literatures, we have surveyed and we gained some knowledge about the existing system of the pre-production waste maintenance system available in various places around the world, methods used to recycle the waste, problem faced due to the waste, various solutions proposed for maintenance, other systems to recycle & segregate the waste produced post-customer usage and methods used to segregate the materials based on color or materials fiber.

III. METHODOLOGY

A. Existing System

About the existing system, the segregation and sorting of the textile pre-production waste is done by people manually by bare hands and without any interference of machines in the process. The waste generated by mass production textile industries is sold for some price to small scale industries and house hold units. Then the waste is segregated and sorted based on different colors manually. This process becomes tedious and complex one and takes a long time due to its large quantity. After the sorting and segregation of materials based on colors and/or fiber content, it collected back by agents of the recycling textile units. The lack of modern technology is identified as one of the barriers of the recycling of the pre-production waste and so the textile industries dispose the waste as landfills rather than sending to recycling units. Fig. 1 shows the existing method of segregation of textile waste done manually in a warehouse.

1) Drawbacks: The drawbacks of the existing system are as follows

- Lack of equipment and technology to segregate and sort.
- Requires too much human labors.
- Tedious and complex due to large quantity of materials.
- Take too much time due to manual sorting of material.

Figure 1. Existing system of textile waste segregation

B. *Proposed Solution*

Our proposed solution is a complete machine vision system to segregate the large units of materials to individual smaller units and then sorting them based on colors. This system can be divided into two sections, in first, the large material to the other side of the system. These nails are placed in two rows to provide output in two individual conveyor section and arranged equidistantly to provide time of interval between two consecutive materials. The cylindrical section is driven by a 12V geared DC motor which also drives the conveyor section in the sorting section. These geared motors are used to produce more torque and less speed. After the material reaches to the sorting section, it is first sensed by an IR sensor and then consecutively a RGB color sensor determines the color of the material passes through the conveyor. The data of the object detection, color determination and separation of the color by the actuator is controlled a main controller (Arduino UNO R3). The controller is connected to a L298 which is used to control the direction of the motor used. Each motor is responsible for one individual color.

In order to obtain high efficiency, and reliability, the system was designed based on the following considerations:

- The system must increase the production rate of segregation and sorting.
- The system must encourage textile industries to recycle rather than disposing as landfills.
- The system must reduce all manual work involved in the segregation process.
- The system should work as a complete machine vision system with less human intervention.
- The system should be enough to entire sorting process in a single stretch in less time.

1) Advantages: The main advantages of using proposed system will be as follows

- It breaks down the complex part of segregation into simple terms.
- It increases the rate of segregation and sorting the material even more rapid.
- It acts as complete automated system which reduces human intervention.
- This would encourage recycling more than disposing as landfill or incineration.

IV. WORKING PRINCIPLE

The textile pre-production waste is fed by a feeder conveyor in the first section. This feeder is driven by a 12V geared DC motor. Then the waste reaches to material picking mechanical assembly. This assembly consist of sharp nails placed over a cylindrical pipe in two rows. These nails are long enough to pick and place a single piece of waste from the feeder section to sorting section. For every rotation of the cylindrical section, each and every nail pick and place a single material to the other side of the system. These nails are placed in two rows to provide output in two individual conveyor section and arranged equidistantly to provide time of interval between two consecutive materials. The cylindrical section is driven by a 12V geared DC motor which also drives the conveyor section in the sorting section. These geared motors are used to produce more torque and less speed. After the material reaches to the sorting section, it is first sensed by an IR sensor and then consecutively a RGB color sensor determines the color of the material passes through the conveyor. The data of the object detection, color determination and separation of the color by the actuator is controlled a main controller (Arduino UNO R3). The controller is connected to a L298 which is used to control the direction of the motor used. Each motor is responsible for one individual color.

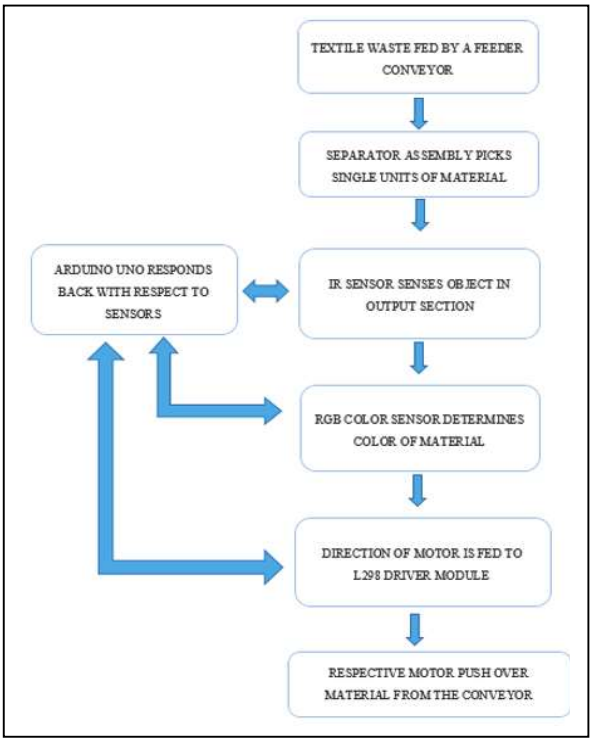

Figure 2. Workflow of waste fabric segregation system

Whenever a particular color is sensed, the respective motor responds according to it. The motor is linked to a rack and pinion assembly which is used to push over the material from the conveyor to output box. The motor is placed between two conveyor sections so that it could be used to push over the material in both sides whenever the color is sensed. These motors are also 12V geared DC motor with more rpm for rapid movement of rack and pinion assembly. For multiple colors, respective number of motor are required. Finally the materials will be based on color and then the residual and unsorted materials can be recycled. Figure 2 depicts the workflow of the system.

V. COMPONENTS DESCRIPTION

A. *Brief Description Of The Design*

The setup consist of mechanical components like geared DC motors for more torque and low rpm purpose, rack and pinion assembly, pillow block, conveyor belt, nails, bolts and nuts, fabrications and electrical components like Arduino UNO, IR sensor, RGB color sensor, L298 driver module, connecting wires and power source for the system. All the parts work with synergy to perform the segregation of textile pre-production waste. Table 1 shows the components mainly used in the system.

S.no	Components	Description
1.	Micro controller	Arduino UNO R3
2.	IR sensor	5V dc, Range : up to 20 cm
3.	RGB color sensor	28.4x28.4mm, 2.7V to 5.5V dc
4.	L298 Driver module	5V DC, 43 x 43 x 26mm, 26g
5.	Gear Motors	12V dc, 45rpm, 100rpm, 300rpm
6.	Pillow block	Shaft Diameter : 20 ~ 60mm
7.	Rack and pinion assembly	-
8.	Conveyor Belt	-
9.	Separator fabrication	-
10.	Clamps, bolts and nuts	-

TABLE I. LIST OF COMPONENTS

VI. FABRICATION PROCESS

A. CAD Modelling

The design specifies the position and placement of the every individual parts and depicts the relation between input and output section of the system. First, a feeder conveyor continued by separating fabrication and finally output conveyor section consist of consecutive level of sensors and actuators. Figure 3 depicts solidworks model of the system.

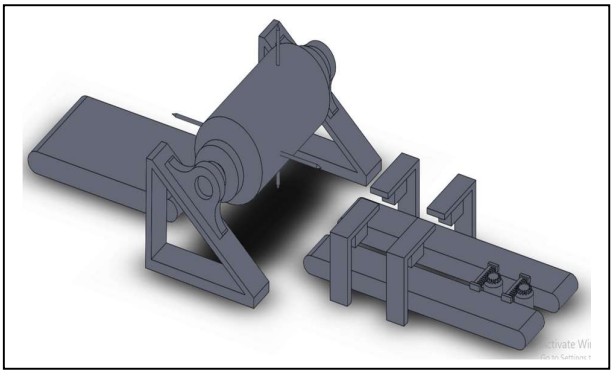

Figure 3. Solidworks model of the system

B. Electrical Section

The system consist of electrical components equal to the mechanical section. It consists of microcontroller circuit, obstacle detection sensor circuit, color recognition sensor circuit and motor driver control circuit interfaced with two actuators. Figure 4 shows electrical circuit of system.

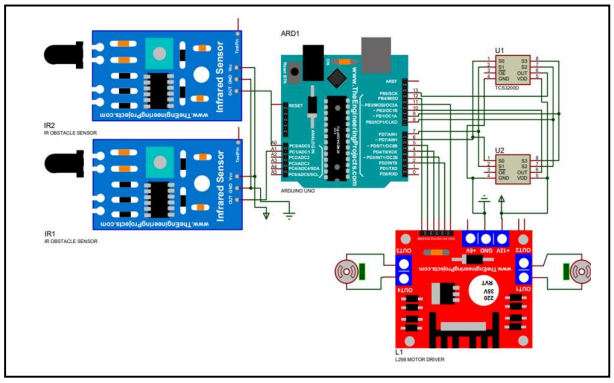

Fig. 4. Electrical circuit of system

VII. CONCLUSION

Textile pre-production waste management system deals with tonnes of materials daily in industrial terms. But to establish and observe the working principle of the waste fabric segregation system, a miniature version of the system is developed for a minimum quantity of the waste and to segregate at least two colors (Red and Blue). Thus, the system offers a sustainable approach for processing the waste into individual units and then segregate them based on two colors. For an industrial approach, this can be further more developed with more actuators for multiple colors segregation and the separating fabrication can be enhanced more to divide multiple individual items at a time. We are certain that this system will reduce all the manual work, increase rate of segregation and encourage the textile industries towards recycling rather than discarding as landfill which would reduce a part of pollution. The initial cost of the model system developed was estimated at Rs. 6000. The cost estimation of the system may increase when it is built in industrial terms. About the results we obtained, for 1kg of waste material fed as input, red and blue color material is segregated in 20 minutes with generation residual waste (i.e.) the materials which does not reach output section and materials with other colors.

REFERENCES

[1] Aus, R., Moora, H., Vihma, M., Unt, R., Kiisa, M. and Kapur, S., 2021. Designing for circular fashion: integrating upcycling into conventional garment manufacturing processes. Fashion and Textiles, 8(1), pp.1-18.

[2] Habich, U., 2007. Sensor-based sorting systems in waste processing. International SymposiumMBT.

[3] Han, S., Tyler, D. and Apeagyei, P., 2015. Upcycling as a design strategy for product lifetime optimisation and societal change.

[4] Hu, J., Yang, H., Zhao, G. and Zhou, R., 2022. Research on Online Rapid Sorting Method of Waste Textiles Based on Near-Infrared Spectroscopy and Generative Adversity Network. Computational Intelligence and Neuroscience, 2022.

[5] Kulkarni, A.B., Jaisingpure, P.S. and Lenina, S.V.B., Automated Object Sorting Based On Color Detection.

[6] Lau, Y.L., 2015. Reusing pre-consumer textile waste. SpringerPlus, 4(2), pp.1-2.

[7] Lu, Z., He, Z., Tran, K.P., Thomassey, S., Zeng, X. and Hong, M., 2021. Decision Support Systems for Textile Manufacturing Process with Machine Learning. In Machine Learning and Probabilistic Graphical Models for Decision Support Systems (pp. 107-123). CRC Press.

[8] Nørup, N., Pihl, K., Damgaard, A. and Scheutz, C., 2018. Development and testing of a sorting and quality assessment method for textile waste. Waste management, 79, pp.8-21.

[9] Pandey, R., Pandit, P., Pandey, S. and Mishra, S., 2020. Solutions for sustainable fashion and textile industry. Recycling from Waste in Fashion and Textiles: A Sustainable and Circular Economic Approach, pp.33-72.

[10] Suryani, H., Dirawan, G.D., Yahya, M. and Tahmir, S., 2017. The Waste Management Of Clothing Home Industries in Makassar City, Indonesia. Pollution Research, 36(2), pp.205-211.

[11] Tomovska, E., Jordeva, S., Trajković, D. and Zafirova, K., 2014, November. Pre-consumer apparel waste mangement in Macedonia. In Book of proceedings 6 th International Conference of Textile (pp. 247-253).

[12] Zhang, H., Liang, H., Ni, T., Huang, L. and Yang, J., 2021. Research on multi-object sorting system based on deep learning. Sensors, 21(18), p.6238