Analysis of Reusability of Used Clothes Using Machine Learning Algorithms

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This Report Presented in Partial Fulfillment of the Requirements for The Degree of Masters of Science in Computer Science and Engineering

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APPROVAL

This Thesis titled **"Analysis of Reusability of Used Clothes Using Machine Learning Algorithms"**, submitted by **Md. Salauddin Rubel, ID: 0242220005103008** to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of **M.Sc. in Computer Science and Engineering** and approved as to its style and contents. The presentation has been held on 27-01-2024.

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We hereby declare that, this thesis has been done by us under the supervision of **Dr. Arif Mahmud, Associate Professor, Department of CSE** Daffodil International University. We also declare that neither this thesis nor any part of this thesis has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

With $45 billion in apparel exports in 2022, Bangladesh is the second-ranked country in the world for apparel exports also the second largest producer of textile waste. The Bangladeshi apparel sector is expected to generate US$10.15 billion in revenue by 2023. Purchasing power of Bangladeshi people have increased and expenses on apparel product has also increased. The habit of repeating clothes that worn once has decreased which makes our wardrobe filled with lots of rarely used clothes and after a certain time we throw them as a wastage. Our study is aimed to develop a machine learning algorithm to predict clothing reusability. For our model we use clothing type, fabric type, usage duration, damage, distortion and color information of a used cloths. We use Classification algorithms for constructing our predictive model. We have applied five classification machine learning algorithm which are Decision Tree, Random Forest, Naïve Bayes, Logistic Regression and SVM. With the given information of a used cloth our model can predict the reusability option for it, the options are: resale, reuse and turn into jhoot product. By reselling a used cloths one can earn save some money and on the other hand people having less money can get a good product. Reusing clothing items means using to create a new apparel item or using in home craft. The last option of reusing is turning into jhoot products, cloths which have used more than their average life cycle are used in jhoot. This research achieved model accuracy between 79% to 85% on predicting reusability of different apparel items. Future study will explore new machine learning approaches with larger dataset and also enable a system that will be useful for textile industry to achieve sustainability in clothing wastage.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Bangladesh ranks second globally in terms of garment exports as well as the second largest producer of textile waste. If all the textile waste can recycle locally in Bangladesh, it can save about $500 million [1]. 15% imports could decrease of 100% cotton waste recycled within Bangladesh. In 2021, nearly 1,000 tons of textile waste produced by Bangladesh [2]. Every year, the apparel sector manufactures up to 100 billion clothes from which only 1% of clothes are repurposed into new clothes and only 20% of textiles are repurposed annually for reuse or recycling [3]. Over 400,000 tons of pre-consumer textile waste are created annually in Bangladesh, making it one of the world's top manufacturers of textile scraps; only 5% of this waste gets recycled domestically.

The latest report presented sufficient proof for other markets, such as Vietnam, Turkey, India, Malaysia, and Indonesia, asserting that there exists a $4.5 billion potential for textile recycling. By the end of 2021, Bangladesh is predicted to generate 200 tons of textile waste per month, which the study Circular Fashion Partnership by Global Fashion Agenda (GFA) referred to as a noteworthy accomplishment in light of the worldwide pandemic [4].

Synthetic fibers, which can take hundreds of years to naturally decompose and release hazardous chemicals into the environment, are used to make most modern fabrics. When they break down, discarded textiles can produce greenhouse gas emissions and occupy a lot of room in landfills. Recycling clothing can lessen the requirement for newly produced fibers by reusing existing fabrics and fibers. This reduces pollution by saving electricity, water, chemicals, and dyes.

Since the 1990s, consumer behavior has shifted towards regular garment buying, leading to an increase in textile waste in landfills. The effect that our clothing has on the environment is something that most people hardly think about. Significant amounts of

chemicals, water, energy, and other natural resources are needed in the production of textiles. A single cotton shirt requires 2,700 liters of water to produce, according to the World Resources Institute. In addition, throwing away garments in the trash not only wastes money and resources but also takes a landfill over 200 years to break down the materials. From the figure below is representing decomposing time of different fabrics [5].

Figure 1.1.1: Fabrics Decomposing Time

1.2 Motivation

We all loves new cloths and change clothing styles frequently. Due to fast fashion number of cloths purchasing increased and the number of unused cloths in our closet is also increased. On the other hand, the price of cloth is getting higher day by day, we spend a lot of money for our clothing. But every time we do not receive the value of our money in our apparel products. The fashion industry is responsible for 4% of the world's carbon dioxide emissions, which is equal to the combined emissions of France, Germany, and the UK. Among all the value chain's polluters, material production accounts for 70 percent of greenhouse gas (GHG) emissions associated with the fashion industry. The fast production and consumption of apparel by the fast fashion sector can have a negative influence on the environment by increasing waste output, water use, and greenhouse gas emissions. Our study is aim to reduce the clothing wastage by reusing and recycling it by using machine learning algorithm to predicting clothing reusability.

1.3 Research Objective

Our model is developed for analyzing used clothes to determine its further reusability. Textiles that are recyclable have various advantages, contributes to resource conservation by minimizing the requirement for new materials. There are many cloth recycling and reselling methods, but our model help individuals to find what is best for them according to current cloth condition. By using our model, we can determine whether the clothes are suitable for reuse, resale or used them as a jhoot product. We have a dataset build according to clothing life expectancy of different type of cloths. When any individual want to best use of his/her used cloth, then by using machine learning algorithm our model we help them to decide. As a result, the best use of textile garments product will be insured and wastage will be decreased.

1.4 Research Questions

Every system has complex components, leading to questions about its functionality. Some issues could have been avoided, and frequent ones require clarification and description. The questions to follow from the start are:

- What will be the most appropriate for used clothes: resale, reuse or jhoot?
- What is the appropriate algorithm for finding clothing reusability?
- Importance of cloth recycling in Bangladesh?
- How Machine Learning can help to decide apparel item recycling method?
- What are the impacts of cloth recycling in environment?
- Which classification algorithm is best fitted for the dataset?

1.5 Expected Outcome

The expected outcome of our experiment is shown below.

- Development of an accurate prediction model for used apparel item recycling.
- Establish a proper method to determine better way of cloth reusing.
- Minimize clothing wastage.
- Ensuring future use of used cloths item in terms of their condition.

1.6 Report Layout

The report is divided into six chapters, each of which will be followed by instructions:
In Chapter 1, we covered the introduction of this research in this section of the research. We discussed in details about the importance of apparel item reusing prediction. We have also discussed about research objective, research motivation, research questions and expected outcomes.

In Chapter 2, we reviewed the existing work on apparel item recycling and reusing. We discussed about other author's problem-solving approaches, limitation, implemented method and result analysis. We have also discussed research scope and challenges in this chapter.

In Chapter 3, in this particular section we mainly discussed the research methodology. Data collection procedure, statistical analysis and implementation requirements also have discussed on this chapter. This section also shows figures of different statistics.

In Chapter 4, results of this research is showed in this section of our study. We also showed the result of five classifier that we used for our prediction in this chapter. We have also compared five classifiers.

In Chapter 5, impact of our study in society and environment is discussed on this chapter along with research ethics. The importance of our work and the role in sustainability also showed in this chapter. We have also suggested two recycling methods using our proposed model.

In Chapter 6, This is the final part of our study, discussion and conclusion of this research is shown here. We have also discussed about the future work and limitations of this work in this section.

CHAPTER 2

BACKGROUND

2.1 Introduction

The fashion business is one of the most pollutants on the planet, second after oil. Fast fashion contributes greatly to this environmental load due to its short manufacturing cycles and low-cost materials. These clothes not only consume a large amount of water and energy, but they also leak chemicals into our ecosystems. We can make better decisions about our clothes consumption if we recognize the adverse effects of rapid fashion.

2.2 Related Works

The increasing rate of purchasing and the trend to keep clothing for a short period of time leads towards a rise in clothing disposal. [6] Author have discussed about two methods for sustainable clothing disposal which includes donating to charities and giving away to family or friends. Their study only focused on two country and the solution is rarely effective, they discuss about the behavior of consumers but not giving the consumers a compact solution.

[7] In this paper, the researchers tried to find the recycling behavior and clothing disposal patterns of consumers with the influence of gender, age, and ethnicity. The study aims to explore how consumers' involvement in waste recycling and environmental attitudes influence clothing disposal patterns, given the widespread promotion of waste recycling and environmentalism. They have discussed about the clothing consumption process in different sector. Their clothing disposal patterns consist of eight constructs measuring. LISREL (linear structural relations) model is used for analyzing for sophisticated reliability test. They have proposed a relationship between independent variables (environmental attitude and waste recycling behavior) and dependent variables (clothing disposal patterns). Their study only covers four types of disposal patterns, and the user data is collected from college students which doesn’t reflect the whole scenario.

[8] Sun-Kuk Noh have proposed a methodology by applying Deep Learning and Intelligent IoT for classifying recycled clothing. They have used CNN for object recognition and Their IoT devices includes the components of a Raspberry Pi and a camera, which takes images of recycled clothing and transmits the image data to the AI, which uses transfer-learned AlexNet to identify the clothing being photographed. Setup for their experiment is costly and using it on real life application does not provide a reliable solution. The research is based on classifying used clothing rather than finding a recyclable solution. Their study has classified clean clothing with 74% accuracy and overall accuracy is 68%.

A unique fusion approach was developed by Flavio de Barros and Ana Paula [9] to enhance the categorization of multi stream images. The experimental findings demonstrate that the suggested technique has a quicker convergence time and an operational switch flexibility using four datasets and distinct backbones. Moreover, the suggested fusion showed resilience and stability even in the presence of inputs that are distracting. There isn't a foolproof method yet. They have achieved a 63:21% obtain in accuracy, and their method overamplifies the signal to the point that the default hypermeters are insufficient to train a competent model.

[10] The lead researcher conducted an educational seminar on textile and clothing recycling at a donation processing center, assessing its effectiveness and success after few months. The study found that donating clothing to charity's thrift stores, some for foreign assistance, reduces waste, creates jobs, and serves the needy. After six educational sessions, donating to church or charity became the preferred disposal option, while throwing in the trash became the least desirable. The study found that consumer education positively impacts recycling attitudes, suggesting that increased exposure to textile and apparel recycling is necessary to enhance participants' understanding. The study's limitations include limited populations and small follow-up survey.

Author has discussed about Clothing design impacts aesthetics, function, cost efficiency, durability, serviceability, and recycling likelihood. Factors like fiber composition, fabric finishes, construction, logos, accessories, and labeling influence end-of-life options for

consumer and corporate clothing. In their opinion, the current linear consumption models of garments are unsustainable, leading to a push towards circular economies. Limited resources and landfill capacity contribute to increasing disposal costs, especially in MEDCs. Initiatives to introduce circular economies include altering garment design, substituting raw materials, and developing recycling technology. Challenges include ensuring consumer value is not compromised by environmental impact reduction measures. The design phase of garments involves factors such as durability, composition homogeneity, industrial recycling compatibility, yarn and fabric structure, coatings and printed surfaces, adhesives and lamination, joint selection, assembly time, and labeling. [11] The study shows some simplified model for corporate clothing and also technical design for recycling of clothing. Further development is needed to explore opportunities for modular garment design and the integration of disassembly technology in garment production.

Sustainable clothing and textile consumption by addressing waste disposal and the role of symbolic consumption and fast fashion in contributing to the societal issue of increased consumption is discussed in this paper [12]. Recycling clothing and textiles for rugs, mattresses, and furniture is decreasing but expected to increase due to environmental and economic reasons. However, practical problems like sorting mixed materials and removing zippers and buttons need to be addressed. The network approach has drawbacks, including potential conflicting views among stakeholders and making the decision process more difficult and time-consuming due to the large number of stakeholders involved.

2.3 Scope of the Problem

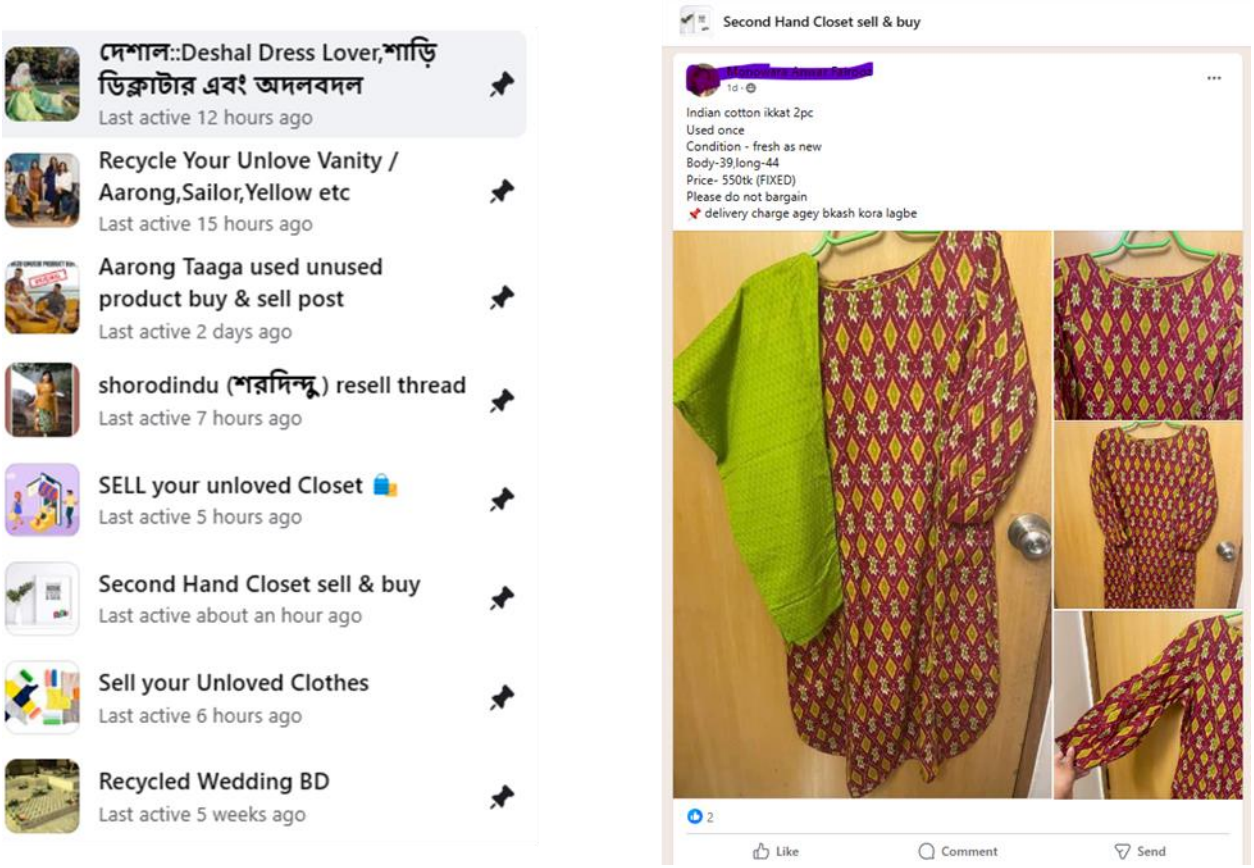
Our model's job is to identify used cloth's condition and find a better way for further usage. Due fast-forwarding fashion, we have purchased a lot of garments product all over the year. But all of the product is not used frequently and some of them remain unused. After a certain time, we throw them as a waste which makes our environment polluted and economically we do not get the value for money products. On the other hand, there are people who are seeking for used cloth in low price or very poor people want them as a

donation and there are many other methods to reuse them as a new cloth. Problem with current used cloth recycling solutions is describe below:

Reselling in Social Platform: Apparel items that have used for a few times and in a good condition, reselling can be one of the best options. It reduces clothing wastages and provide a reliable clothing using cycle. Poor people cannot afford apparel items that are expensive. On the other hand, rich people are purchasing more and more clothing items in trends of fast fashion [13]. Buying too much clothing leads to a cozy wardrobe and the habit of not repeating once used cloths makes a bound of unused cloths. People having less wealth can used those unused clothes if they sell it on cheaper price. But the habit of reselling has not been grown that much.

There is no specific physical market has been established where one can sell there used cloths to the needy people. In Bangladesh there is also a lack of well-established website where anyone can sell their used clothing's. Most of the people are dependent on different social media to sell their used clothing items. Several Facebook groups has been created where anyone can post for selling used clothing items, But the main problem of these group is, there are some rules of inviting more people to the groups and some groups even ask for money for each post. For our study we have joined more than 20 such group to observe their activities.

The main concern is finding a real buyer, because there are lots of fake account in Facebook. By using fake account scammer are buying product from seller but they do not pay the money to the seller. So, seller have a bad experience in reselling in social media. There is also a opposite scenario in some case where fake selling post have been posted by fraud seller and after being paid, they blocked the buyer.



(a) (b)

Figure 2.3.1: (a) Facebook group for reselling, (b) Facebook post for reselling

From above figure we can see some Facebook groups names figure (a) where anyone can sell their used products. In figure (b) we can find the member response of a group. We have observed for a while and found that the response is not satisfactory and it is very hard for a seller to find an authentic buyer. From the above section we have seen some difficulties that one faces while selling their used clothing on social media platform. Another big problem is trust issue between seller and buyer. Fraud in online purchasing is increased day by day. To overcome all of these problems we have to build a specific platform for selling used apparel items. Build a well-structured and user-friendly website or mobile app can solve this problem. In our country there are some website where we can resell our used products. But those websites are not based only on reselling apparel items and lack of promotion and technical issues users are not interested that much. So, building a new

platform for selling used clothing have a good opportunity. To ensure user authenticity KYC can be applied [14]. The platform should also ensure the financial security of user and the payment methods should be monitored carefully. Several promotional events should be taken to introduce the platform, that will generate an adequate amount of people visiting the platforms which indemnify the rate of reselling used clothing items.

Wall of Humanity: This is also known as "Manobotar Deyal", which is based on donating used or unnecessary clothes to the poor people. We can see this type of setup in most of city area in South Asian country. This is a very impactful method of cloth reusing and it's ensured clothing rights of poor people. The main problem with this noble purpose is exploit by some dishonest people. As there is no monitoring system on this kind of setup, some unscrupulous people mostly e.g. drug addicted people take advantage of it. They took more cloths than their need and sell them to flea market to earn money for their drugs. Another problem is, some people donate clothes which have already expire the clothing lifecycle and it cannot be wearable.

Figure 2.3.2: Wall of Humanity in Local Area

Instead of donating on "Wall of Humanity" we can donate our used clothing to local charity foundation. Now a days a lots of charity foundation are established for people in need.

These foundations ensure the proper distribution of used clothing. Another way of making this type of project effective is providing a monitoring system with volunteers. For identifying a cloth which is donatable or not, our algorithm can be used.

Lack of Brand Lead Recycling: To achieve sustainable fashion practices apparel brands play an important role. Some international clothing brands such as American Eagle, Madewell, The North Face and Lindex have given discount policy by returning customers used clothing [15]. In Bangladesh there is no such brand that have this kind of policy. For our study we have a survey of 50 people of different age and profession. We have data of most preferred cloth brands of Bangladesh.

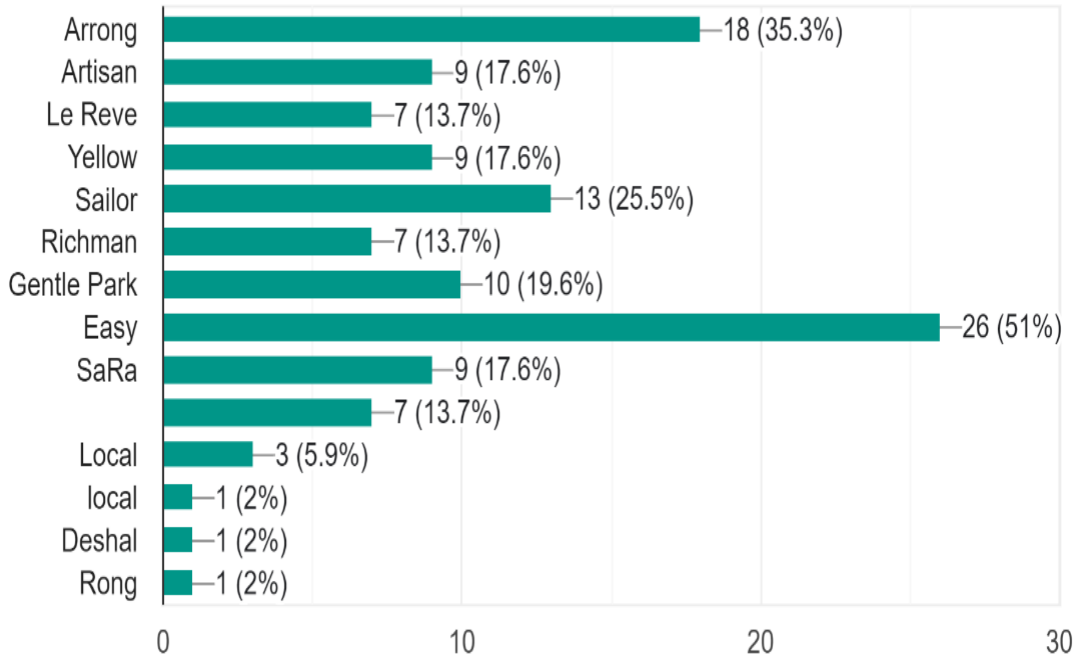


Figure 2.3.3: Most used clothing brands in Bangladesh

From the above figure we can see the top clothing brands of our country by user preference. Among all the brands there are no such policy of used cloth recycling. They do not even offer a discount on returning used clothing of their own brand.

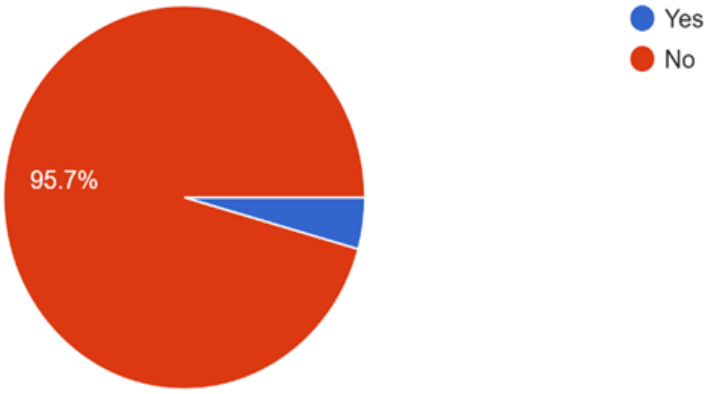


Figure 2.3.4: Response of Customer Getting Discount from Returning Used Cloths

In our survey, we have asked the participant about the discount from their favorite brands by returning there used clothes. From Figure (2.3.4) we can see that 95.7% of participant reposes that they do not get any discount. To achieving a sustainable fashion industry our local brand should pay attention on this fact.

2.4 Challenges

Our goal is to make proper use of garments cloths and after using a frequent period, we want to ensure its reusability in terms of using period and condition. During our study we have faced some challenges, in this section we will discuss about it. The first challenge we faced is collecting dataset for our research. There is no particular dataset for this problem is present in internet. The second challenge we faced in decision making phase of dataset making. By comparing with average life cycle of apparel items we make a dataset manually with reusability decision. We also faced some challenges on choosing the right classification algorithm for our research prediction.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This section of the paper contains an outline of our proposition and the methods we implemented to support it. It provides us with complete data as well as practical strategies. After looking into every existing strategy, we have discovered all the conveniences of ways, together with their limitations and all possible outcomes. Various strategies yield varied results, but we should always aim for the best outcome. This study's chapter describes our recommended methodology.

3.2 Data Collection Procedure

In our research, we investigate to find the more reliable alternative reusing method of used textile garments cloths. Reusing of cloths can be done by reselling it, if the condition is good, we can also reuse the cloths to make new cloth or household product or we can use them a jhoot product for making new fabric or products. We have a lot of used clothing in our wardrobe but we don't know the proper way of reusing it. Sometime used cloths looked like new but when we reuse it, the cloths may tear off because the fabric life-cycle of the fabric have already been over. When we want to resale it, we do not receive the proper price or we buy reused cloth with higher price. So, we use five classification algorithm Decision Tree, Random Forest, Naïve Bayes, Logistic Regression and SVM algorithm to determine the most reliable way to reusing or recycling.

APPAREL		HOUSEHOLD FURNISHINGS
Bathing Suits.....2	Fabric, lined & unlined.....3	**Bedspreads**.....6
Bathrobes	Rubber and plastic.....3	**Blankets**
Lightweight.....2	**Shirts**	Heavy wool and
Heavy or quilted.....3	Dress.....2	Synthetic fibers.....10
Wool.....3	Sports.....2	Lightweight.....5
Blazers	Wool or Silk.....2	Electric.....5
Cotton and blends.....3	**Ski Jackets**	**Comforters**.....5
Imitation suede*.....3	**(including Down)**.....2	Down.....5
Wool.....4	**Skirts**.....2	Fiberfill.....3
Coats and Jackets	**Slacks**	**Curtains**
(Outerwear)	Lounging & active sport.....2	Sheer.....3
Children's.....2	Dress.....3	Glass Fiber.....3
Cotton and blends.....3	**Socks**.....1	**Draperies**
Down.....3	**Sport Coats**	Lined.....5
Fur.....10	Cotton & synthetic blends.....3	Unlined.....4
Imitation fur or suede*.....3	Imitation suede*.....3	Sheer.....3
Leather and suede.....5	Wool and wool blends.....4	Glass fiber.....4
Plastic.....2	**Suits**	**Sheets & Pillowcases**.....2
Wool.....4	Cotton and synthetic.....2	**Slipcovers**.....3
Blouses.....3	Summer-weight wool.....3	**Table Linen**
Choir Robes.....6	Imitation suede*.....3	Fancy.....5
Dresses	Silk.....3	Other.....2
Casual.....2	Washable.....2	**Towels**.....3
Office.....3	Winter-weight wool.....4	**Upholstery Fabrics**.....5
Silk.....2	**Sweaters**.....3	
Evening	**Ties**.....1	
High Fashion.....3	**Underwear**	
Basic.....5	Foundation garments.....1	
Formal Wear.....5	Panties.....1	
Gloves	Slips.....2	
Fabric.....1	**Uniforms**.....1	
Leather.....2	**Vests**.....2	
Rainwear & Windbreakers		
Film & plastic coated.....2		

Figure 3.2.1: Average Life Expectancy of Textile Items in Years (Nonwoven Only)

We collect our data of average life expectancy of textile items from International Fabricare Institute (IFI). From the above figure we can see the average life expectancy of different nonwoven textile items [16]. There is no proper dataset that classify the reusing method of used cloths. We gathered our data from IFI's report of life expectancy of different apparel items. In our research we have work with 8 different apparel items. Each apparel item has their own type of fabric, based on fabric the life cycle is changed. We not only work with the life expectancy of fabrics but also some other essential elements of apparel product. The other elements that we should consider during the decision-making phase of recycling or reusing apparel items are:

i. **Cloth Used Duration:** number of years the apparel item has been used.

ii. **Distortion:** any distortion in apparel items that makes the item longer or smaller than the original size. We measure the distortion level into three level which are: low, medium and high.

iii. **Color**: color of the apparel item is very important because any changes of color saturation have a direct impact on its reusability. We also measure the color level into three level which are: low faded, medium faded and high faded.

iv. **Damage/ Number of Holes:** most common problem with our cloths is number of holes or damages happened to it. Usually when the number of holes is between 1 to 3, we may consider it for using again. But when the number is increased the usability decreased proportionally. For our study we measure the number of holes up to 10.

3.3 Statistical Analysis

For our study, we collect average life expectancy data of 8 apparel item, which are: Blazer, Shirts, Blouses, Sweaters, Uniform, Formal, Evening-Basic and Evening-High with different fabric type. After that we measure another 4 key elements of an apparel item, then combine them with different pattern which make a proper dataset for performing decision tree algorithm. Size of our dataset is 3240 after performing combination of different items, by using AI we are able to classify the reusability of used clothing items.

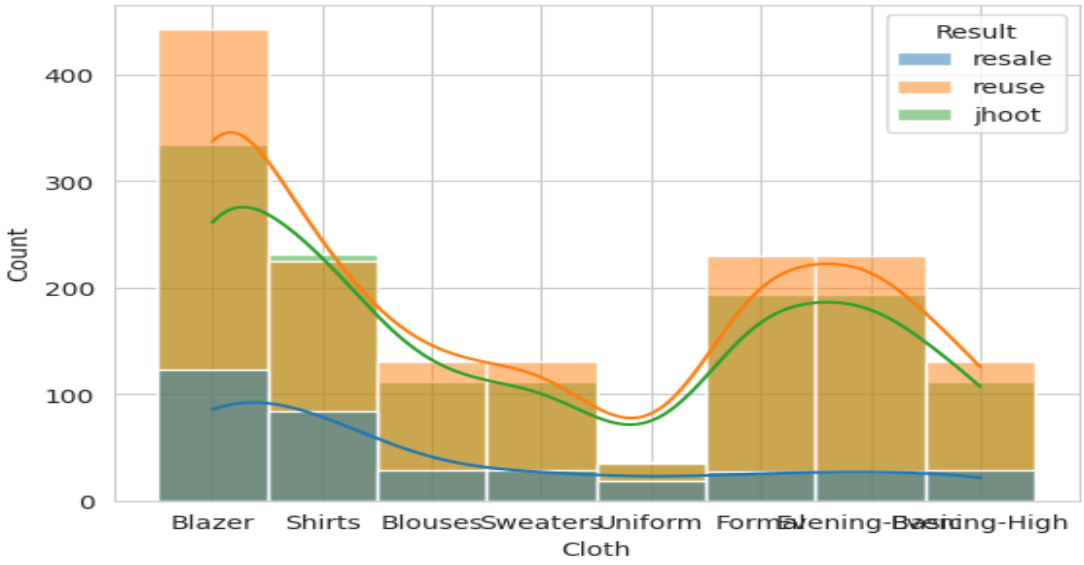


Figure 3.3.1: Apparel Item Reusability Result With Our Proposed Model

From the above figure we can see the reusability result of different apprel items. In our dataset we have work with eight clothing items. After applying decision tree classification we have a result column which represent the reusability of used clothing items. From above graph we can see that all of our clothing item reusability have been divided in three parts: resale, reuse and jhoot, if we see the first item from the list which is represnting blazer in this case, there count have been more than 400, the bottom part is represnting result of resale from the used cloths. The middle part is representing the result of jhoot and the top part is representing the result of resale. All the other items are also represent by same graphical plot. If we observe all the results, we find that the ratio of resale, reuse and jhoot is very close. There are three lines between the graphs which represent the average result of ecah clothing items.

3.4 Proposed Methodology

With the use of classification algorithm apparel items reusability model is developed. In order to classify apparel item reusability a variety of action must be taken. Following fig. is the block diagram which is the proposed model workflow of this work. First step involves gathering necessary data of clothing usage such as type of cloths, fabric type, used duration, distortion, color and number of holes or damages. The second step is data preprocessing which include data cleaning and preparing data for analysis. It is very important part because several tasks included this phase can improve data quality. Features extraction is also very important in prepressed data. Whether a cloth is reusable, resaleable or use as a jhoot products extracted characteristics and accompanying labels are used to train a machine learning or statistical model. In this step, the model's parameters are optimized, the data is fed into it, and the model's internal models to correctly categories cases of cloth reusability. Using validation approaches like cross-validation, the trained model's generalization capability is estimated by evaluating the model's performance on unseen data. This stage aids in determining which model is optimal and in optimizing its hyperparameters. To predict reusability the trained model is used, the model takes input of relevant data and produces a prediction or usability of clothing item.

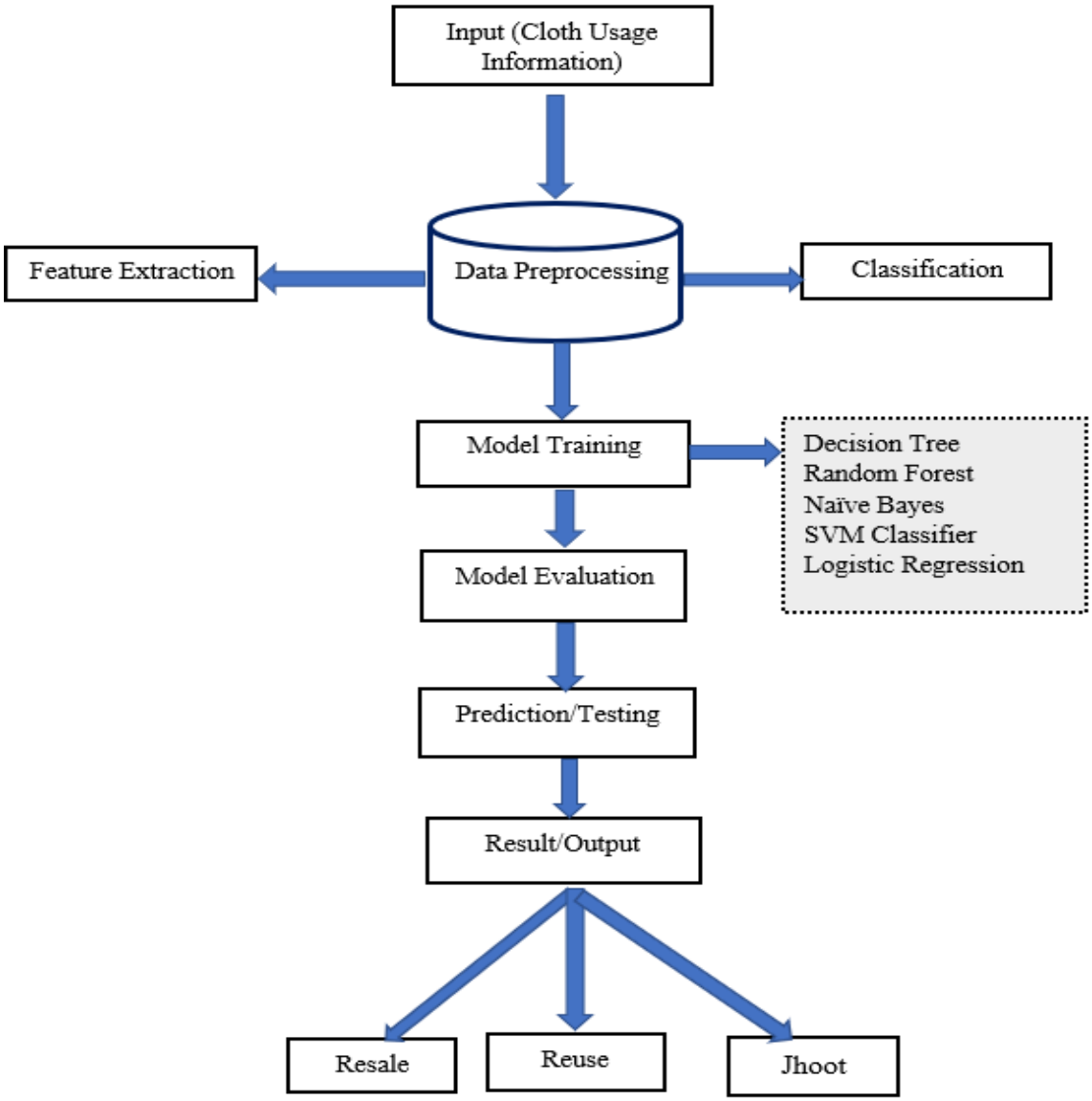


Figure 3.4.1: Block Diagram of Proposed Model

The model's predictions are examined and evaluated. In order to comprehend the performance of the model, this stage entails evaluating accuracy, precision, recall, and other assessment measures. Any patterns, trends, or insights that could help improve future forecasts can be found with more investigation.

3.5 Implementation Requirements

To implement this project there are some requirements, which are:

Hardware or Software Requirements:

•Web IDE: Google Colab

•Operating System: Windows 7 or above.

•RAM: Minimum 2GB

•Google Chrome or Other Internet Browser

•High Speed Internet Connection

Advance Libraries:

•Python

•Pandas

•Numpy

•Sklearn

•Plotly

•Seaborn

•Matplotlib

•Scipy

CHAPTER 4

EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Introduction

This chapter focuses on the descriptive analysis of research data and the experimental results of our project. This plays an important role to try every approach or thought that is available. There's nothing like using good judgement and testing it. Through the implementation of my recommended approach as a flexible framework, we have successfully tested our concept. The report's internal and external importance of the framework we employed is managed in this part. The starting and ultimate construction restrictions of the casing are also shown in this section.

4.2 Performance Evaluation Metrics

The accuracy analysis will be used to evaluate the performance evaluation measures presented in the thesis paper. Predictive modelling commonly uses measurements such as accuracy, precision, recall, F1 score. The study will look into whether these markers are useful for predicting breast cancer and whether they correctly reflect the model's performance. Furthermore, the study will consider any biases or limitations in the chosen measures that may have an impact on how the accuracy results are understood.

Table 1: Accuracy Metrics

Name	Equation
Accuracy	$\frac{TP + TN}{TP + TN + FP + FN}$
Precision	$\frac{TP}{TP + FP}$
Recall	$\frac{TP}{TP + FN}$
F1-Score	$\frac{2 * Precission * Recall}{Precission + Recall}$

4.3 Decision Tree Classification

Decision Tree is a supervised learning approach that may be used to address regression as well as classification issues, however it is most commonly employed to solve classification problems. It is a tree-structured classifier, with core nodes representing dataset attributes, branches representing decision rules, and leaf nodes representing outcomes. A decision tree has two nodes: the decision node and the leaf node. Decision nodes are used to make decisions and have several branches, whereas leaf nodes represent the results of those decisions and do not have any more branches. It is a graphical depiction of all possible solutions to a problem/decision under certain criteria. Applying decision tree algorithm to our dataset we have accuracy score of 79%.

Table 2: Classification Score of Decision Tree

	precision	**recall**	**f1-score**	**support**
0	0.85	0.90	0.87	273
1	0.55	0.62	0.58	76
2	0.80	0.73	0.76	299
accuracy			0.79	648
macro avg	0.73	0.75	0.74	648
weighted avg	0.79	0.79	0.79	648

4.3.1 Correlation Matrix

A correlation matrix is a statistical tool used to determine the relationship between two variables in a data collection. It is a table with each cell holding a correlation coefficient, with 1 indicating strong association, 0 indicating neutrality, and -1 indicating weakness. The matrix of correlation values can be used to assess the degree and direction of

correlations between variables, which can help with data analysis, feature selection, and model construction.

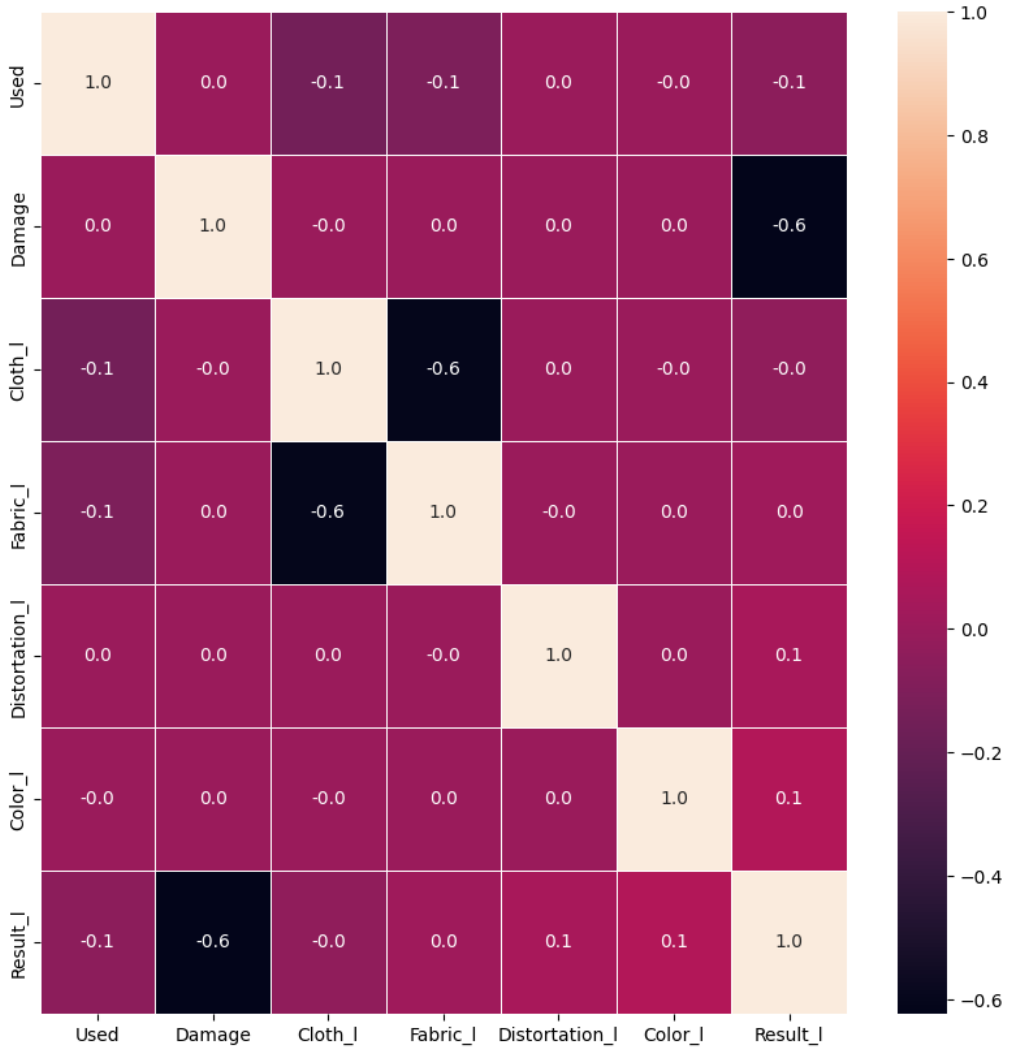


Figure 4.3.1: Correlation Matrix for Variables

I use Decision Tree Classifier for evaluating accuracy. The accuracy of these models in my experiment is seen in the adjacent table.

4.3.2 Gini Index

The Gini Index measures randomness, impurity, or entropy in a dataset by eliminating impurities in a decision tree model from root nodes to leaf nodes. It captures how far the

Lorenz curve falls from the 'line of equality' by comparing areas A and B. The Gini coefficient is calculated as A / (A + B), where incomes are shared equally, and the Lorenz curve is the 'line of equality'.

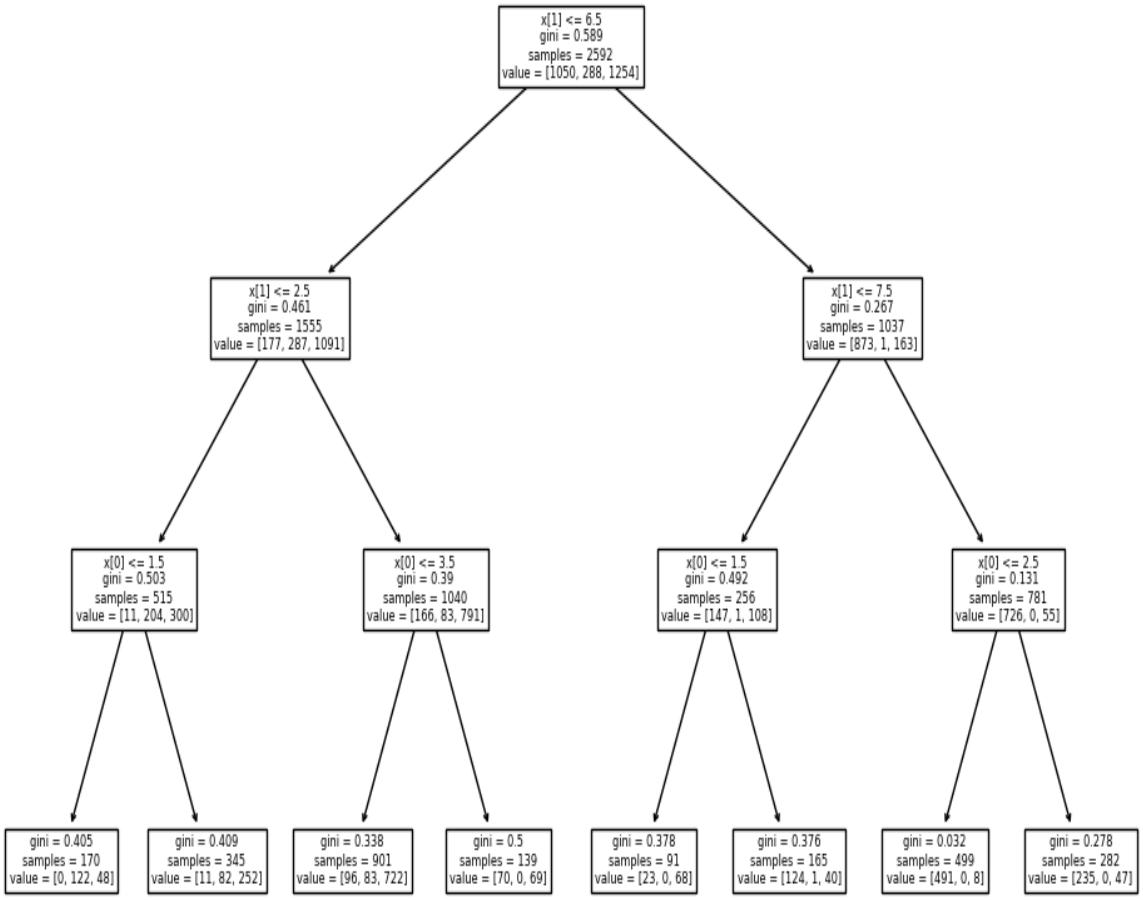


Figure 4.3.2: Gini Index of Our Model

4.3.3 Entropy Index

The Gini Index measures randomness, impurity, or entropy in a dataset by eliminating impurities in a decision tree model. It captures the Lorenz curve's distance from the 'line of equality' by comparing areas A and B, where incomes are shared equally, and the Lorenz curve is the 'line of equality'.

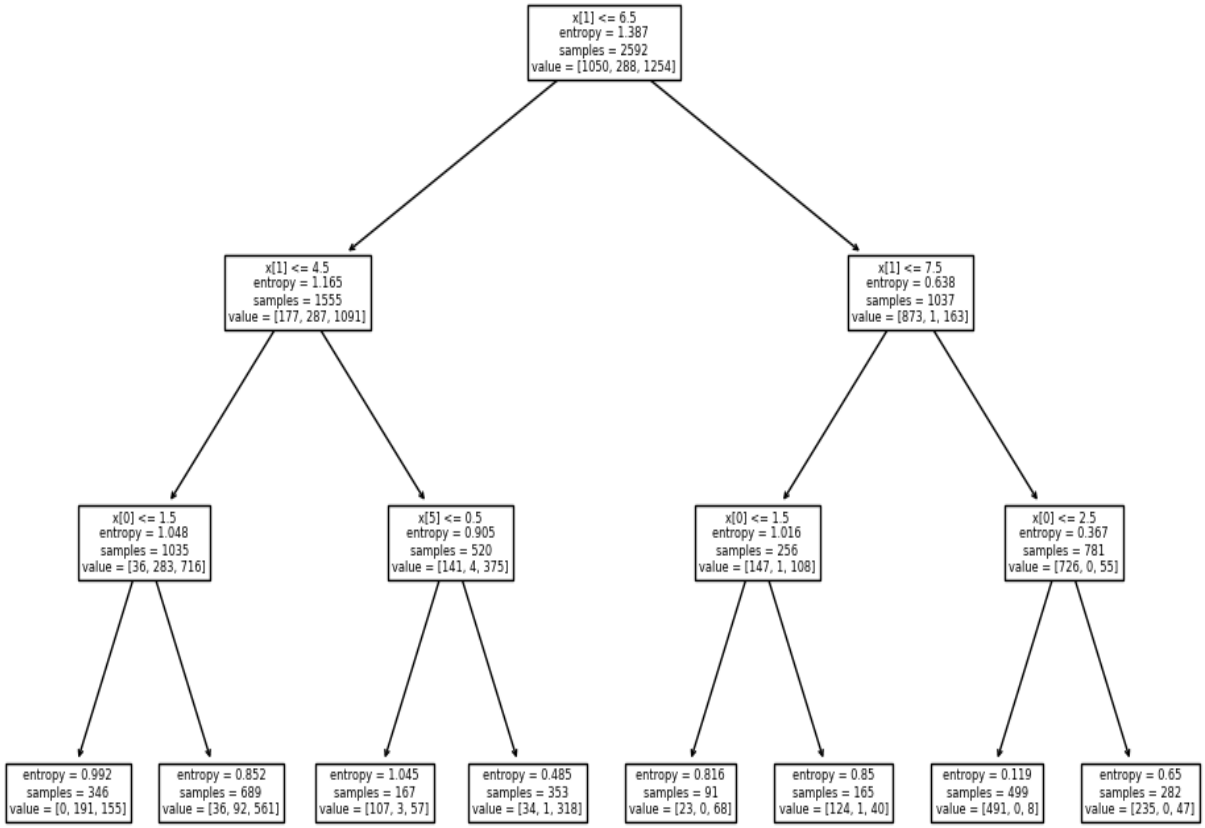


Figure 4.3.3: Entropy Index of Our Model

4.4 Random Forest Classifier

Random Forest is a classifier that averages decision trees from diverse datasets to improve predicted accuracy. It reduces overfitting and improves accuracy by having more trees. It can handle both classification and regression tasks, and can handle large, high-dimensional datasets. In our dataset we measure the accuracy with 10 decision trees and 100 decision trees. Model accuracy score with 10 decision trees is 88% and the accuracy with 100 decision trees is also same.

Table 3: Classification Score of Random Forest

	precision	**recall**	**f1-score**	**support**
0	0.86	0.86	0.86	437
1	0.55	0.45	0.50	118
2	0.77	0.80	0.79	515
accuracy			0.79	1070
macro avg	0.73	0.70	0.71	1070
weighted avg	0.78	0.79	0.78	1070

4.5 Naïve Bayes

The Naïve Bayes algorithm is a supervised learning technique that solves classification issues. It is based on the Bayes theorem. One of the most straightforward and efficient classification algorithms, the Naïve Bayes classifier facilitates in the rapid development of machine learning models with rapid prediction capabilities. Being a probabilistic classifier, it makes predictions based on the likelihood that an object will occur. The Naive Bayes Model comes in three different forms, for our study we have use gaussian model.

The Naïve Bayes algorithm is a supervised learning technique that solves classification issues based on the Bayes theorem. It is efficient and straightforward, aiding in the development of machine learning models with rapid prediction capabilities. As a probabilistic classifier, it makes predictions based on the likelihood of an object occurring. The Gaussian model assumes features have a normal distribution, assuming continuous predictors' values are drawn from a Gaussian distribution. Accuracy score of our dataset using Naïve Bayes with Gaussian distribution is 82%.

Table 4: Classification Score of Naïve Bayes

	precision	recall	f1-score	support
0	0.85	0.85	0.85	325
1	0.86	0.56	0.68	96
2	0.79	0.86	0.82	389
accuracy			0.82	810
macro avg	0.83	0.75	0.78	810
weighted avg	0.82	0.82	0.81	810

4.6 Logistic Regression

Supervised learning uses algorithms like logistic regression to predict a categorical dependent variable. This technique uses a predetermined collection of independent factors to predict the dependent variable's output, providing probabilistic values within a range of 0 to 1, rather than providing a precise value between 0 and 1. This method is widely used in machine learning techniques. Logistic regression and linear regression are similar in their applications, with linear regression solving regression problems and logistic regression solving classification problems. The independent variable should not be multicollinear, and the dependent variable must be categorical. Applying Logistic Regression on our dataset we have accuracy of 82%.

Table 5: Classification Score of Logistic Regression

	precision	recall	f1-score	support
0	0.87	0.91	0.89	281

1	0.91	0.30	0.45	71
2	0.77	0.87	0.82	296
accuracy			0.82	648
macro avg	0.85	0.69	0.72	648
weighted avg	0.83	0.82	0.81	648

4.7 Support Vector Machine

Support Vector Machine (SVM) is a widely used supervised learning technique for classification and regression issues, primarily applied to machine learning classification challenges. It aims to identify the optimal decision boundary for dividing n-dimensional space into classes, simplifying future data classification. We refer to this optimal decision boundary as a hyperplane. SVM selects the extreme vectors and points to aid in the creation of the hyperplane. The technique is referred regarded as a Support Vector Machine since these extreme situations are known as support vectors. Examine the picture below, where a decision boundary or hyperplane is used to classify two separate types:

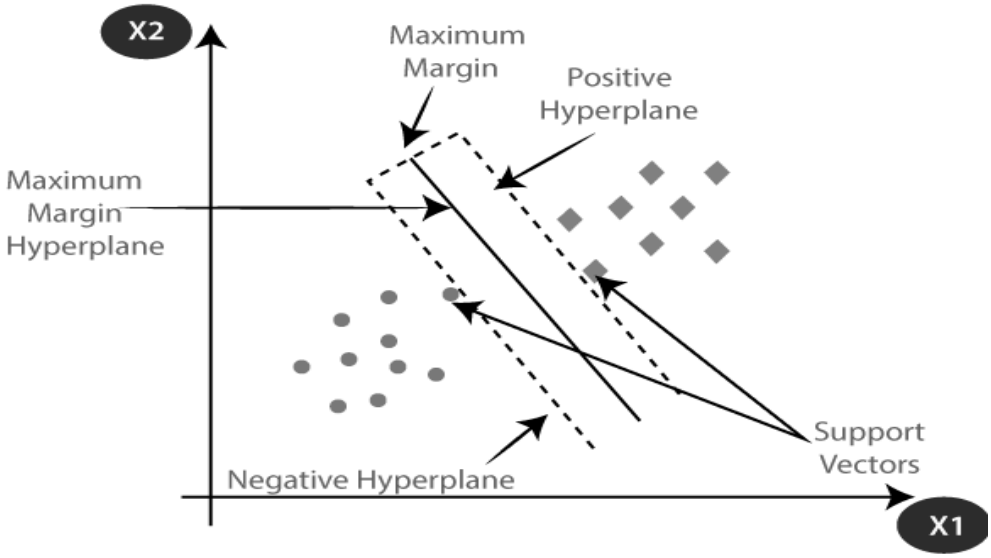


Figure 4.7.1: SVM Classifier Hyperplane

After applying SVM classifier to our dataset we have obtain accuracy score of 85%. SVMs are useful in all fields and real-world situations where handling data through the addition of higher dimensional spaces is required. In order to construct the supervised learning models, this involves considering elements like choosing the kernel to execute, fine-tuning hyper-parameters, and dedicating time and resources to the training phase.

Table 6: Classification Score of SVM

	precision	**recall**	**f1-score**	**support**
0	0.90	0.88	0.89	272
1	0.79	0.54	0.64	68
2	0.81	0.88	0.85	308
accuracy			0.85	648
macro avg	0.83	0.77	0.79	648
weighted avg	0.85	0.85	0.84	648

4.6 Discussion

To obtain higher accuracy we have used five classifier algorithms to our dataset. It is hard to choose one algorithm over other algorithm because based on data set the accuracy is changeable. Classification algorithms which we applied to our dataset are: Decision Trees, Random Forest, Logistic Regression, Support Vector Machine and Naïve Bayes. We have discussed briefly in previous sections. The choice of algorithm depends on the problem and available data. For high-dimensional data, Random Forest or Naïve Bayes classifiers are suitable. Support Vector Machine is suitable for imbalanced data. Support Vector Machine is ideal for modeling complex relationships between variables. Logistic

Regression or Naïve Bayes classifiers are suitable for handling missing values. Decision Trees or Logistic Regression are suitable for simple and interpretable models.

Table 7: Classification Score Comparison

Classifier	Class	Accuracy	Precision	Recall	F1 Score
Decision Tree	Jhoot	**0.79**	0.85	0.90	0.87
	Resell		0.55	0.62	0.58
	Reuse		0.80	0.73	0.76
Random Forest	Jhoot	**0.79**	0.86	0.86	0.86
	Resell		0.55	0.45	0.50
	Reuse		0.77	0.80	0.79
Logistic Regression	Jhoot	**0.82**	0.87	0.91	0.89
	Resell		0.91	0.30	0.45
	Reuse		0.77	0.87	0.82
Naïve Bayes	Jhoot	**0.82**	0.85	0.85	0.85
	Resell		0.86	0.56	0.68
	Reuse		0.79	0.86	0.82
Support Vector Machine	Jhoot	**0.85**	0.90	0.88	0.89
	Resell		0.79	0.54	0.64
	Reuse		0.81	0.88	0.85

From the above table we can see the performance of different algorithm to our dataset. In our dataset have 3 classes which are Jhoot, Resell and Reuse. From section 4.2 we have shown how to calculate accuracy matrix. For better understanding the accuracy score we have another table below:

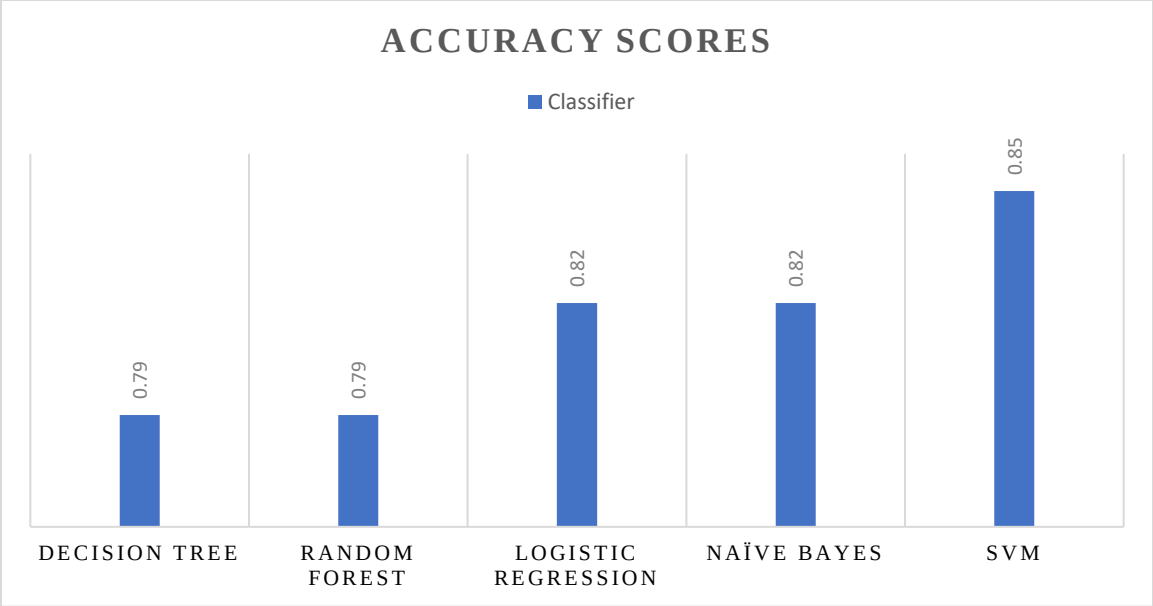


Figure 4.6.1: Accuracy Scores of Five Classifiers

As we can see from the table, we achieved higher accuracy in SVM and the lower accuracy in both decision tree and random forest. Random forest classifier Can become computationally expensive for large amounts of data, less accurate and robust compared to SVM but computationally faster. As our dataset is small decision tree classifier is Prone to overfitting, sensitive to small variations in the data. Logistic regression is a complicated technique that can handle a large number of data points, whereas Naive Bayes is a simpler method that works well with smaller data sets. In our case both of the algorithm produces accuracy score of 82%. Naive Bayes treats features as independent, while SVM considers interactions between them to a certain extent, provided a non-linear kernel is used, as the main difference in feature-based models. Out of five classification algorithm SVM have performed better than other algorithms and have the higher accuracy of 85%. SVM is effective in high-dimensional spaces with a clear separation between classes, where the number of dimensions exceeds the number of samples, and is relatively memory efficient.

CHAPTER 5

IMPACT ON SOCIETY, ENVIRONMENT, AND SUSTAINABILITY

5.1 Impact on Society

Clothing donation is an essential element of sustainable living since it brings an economical remedy to the problem of consumer waste. By giving your unwanted clothing, you are not only decluttering responsibly, but also promoting textile reuse and recycling. This act of generosity supports a system that prioritizes sustainability over disposability, encouraging people to think twice before discarding clothing. It's a simple yet effective method to contribute to a more environmentally friendly way of life. Some of the benefits of recycling clothes:

Reduce Your Water Consumption: The manufacture of textile materials generates a large amount of water waste. Water, the source of life, may require immediate assistance at any time if we do not become aware of certain activities that endanger it. Recycling clothes reduces water usage and pollution, which is beneficial to all people and living things.

Reduce Your Carbon Footprint: On the other hand, global warming is a widespread issue that is producing changes in our planet's temperature and general living conditions. The gases released into the atmosphere when fibers are processed to make garments have a negative impact on the environment and add to the impending warming. Recycling clothes improves the entire world as well as our current and future quality of life.

Encourage A More Sustainable Fashion Industry: Clothing goes through significant chemical procedures for design and fabric preservation. At this stage, extremely hazardous compounds are discharged, which, in sufficient quantities, might have disastrous and toxic consequences. Recycling garments might help to avoid this.

Develop Responsibility for Biodiversity: Excessive cultivation of materials such as cotton or linen, which are not inherently harmful but can wreak havoc by consuming a large amount of land for this purpose, can be avoided, as can unsuitable methods of raising animals for the purpose of extracting their wool or fur.

5.2 Impact on Environment

A comprehensive life-cycle assessment (LCA) commissioned by the European textile reuse and recycling industry has revealed that reusing textiles saves large amounts of CO2 and water when compared to making new clothes. Even with global exports for reuse, including transportation emissions, the environmental effect of reusing textiles is 70 times lower. More particular, the study discovered that reusing high/medium-quality clothing saves a huge 3kg of CO2. While reuse requires only 0.01% of the water used to make new garments [17].

By avoiding the use of virgin fibers, recycling textiles helps to cut down on the following: the extraction of raw materials; transportation that contributes to the greenhouse effect; the manufacturing of fibers; and the use of energy, water, and chemicals like pesticides, dyes, and insecticides. One of our main concerns is using fewer virgin resources from the world, wasting less, and turning waste—used plastic bottles, textiles, industrial fibers, etc.—into new clothing. We have a chance to redefine ourselves by embracing the environmental problem.

5.3 Ethical Aspects

Every user's security and privacy must be respected in this research project. Our research data have gathered all of the data by hand. This study did not use any previously published data. The outcomes that we have given are accurate. This research contains no misleading information. During our research, no animals suffered damage. Every stage of the research is done carefully with my supervisor guidance.

5.4 Sustainability Plan

Reusing and recycling discarded materials, fibers, and textiles is a practical way to help the apparel sector become more sustainable. According to a U.S. Environmental Protection Agency assessment, textiles contribute significantly to greenhouse gas emissions. An increase in textile recycling is an attempt to lower greenhouse gas emissions. According to the existing situation, recycling clothing would have the same impact as taking one million cars off the road annually. Our proposed method will help decide a proper reusing method and it will be impact tremendously to achieve sustainability. Without a doubt, this research will live on in the field of technology for quite a while. In the future, we hope to improve both the accuracy and the data range. We intend to utilize more algorithms in the future to compare and evaluate which one generates the highest level of accuracy. For recycling used clothing we have designed two recycling area which are textile recycling and household recycling. Both of the method is applied with our prosed model.

5.4.1 Textile recycling processes

To obtain a sustainable and reliable fashion industry textile recycling can be very effective. From the figure below, we can see the step of textile recycling of used clothing items. The process starts with collection used clothing. The decision of reusing clothing can be determining after applying our proposed methodology. After finding reusable items it will be sort based on color and quality. Items that are not reusable should be used as a jhoot products. Cloths sorted in color and quality then processed for cutting and break down into pieces. For making better quality fabric and adding extra longevity it will then mixed with new materials. After that spinning the fibers and processed for analyzing the grade of the yarn. If the yarn grade is below clothing standard than it will be used in other industries. Good quality yarns then proceed for knitting. Thus, the recycling process ends. From a used clothing fabric to a new good graded yarn the recycling process can be very useful for clothing wastage management and a lot of money can be saved.

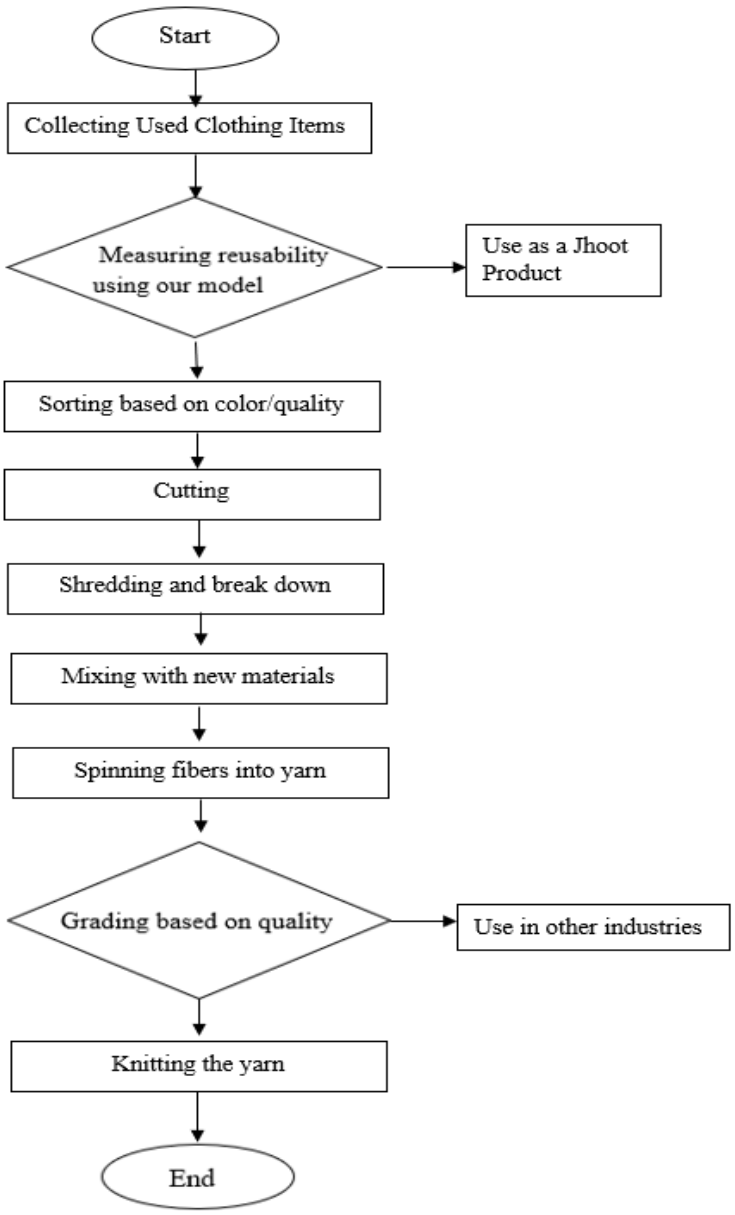


Figure 5.4.1: Textile Recycling Process Using Our Prosed Methods

5.4.2 Household Textile Recycling

Household Textile Recycling: Recycling used clothing items in house could be the most important solution of used cloths reusing. In our day to day life, a lots of clothing items we have used and after a few times we do not re-ware it. With proper recycling method we can reware it or we turn them into a new usable item. The process of household recycling starts

with collection used clothing. Applying our model to determine the reusability of used clothing.

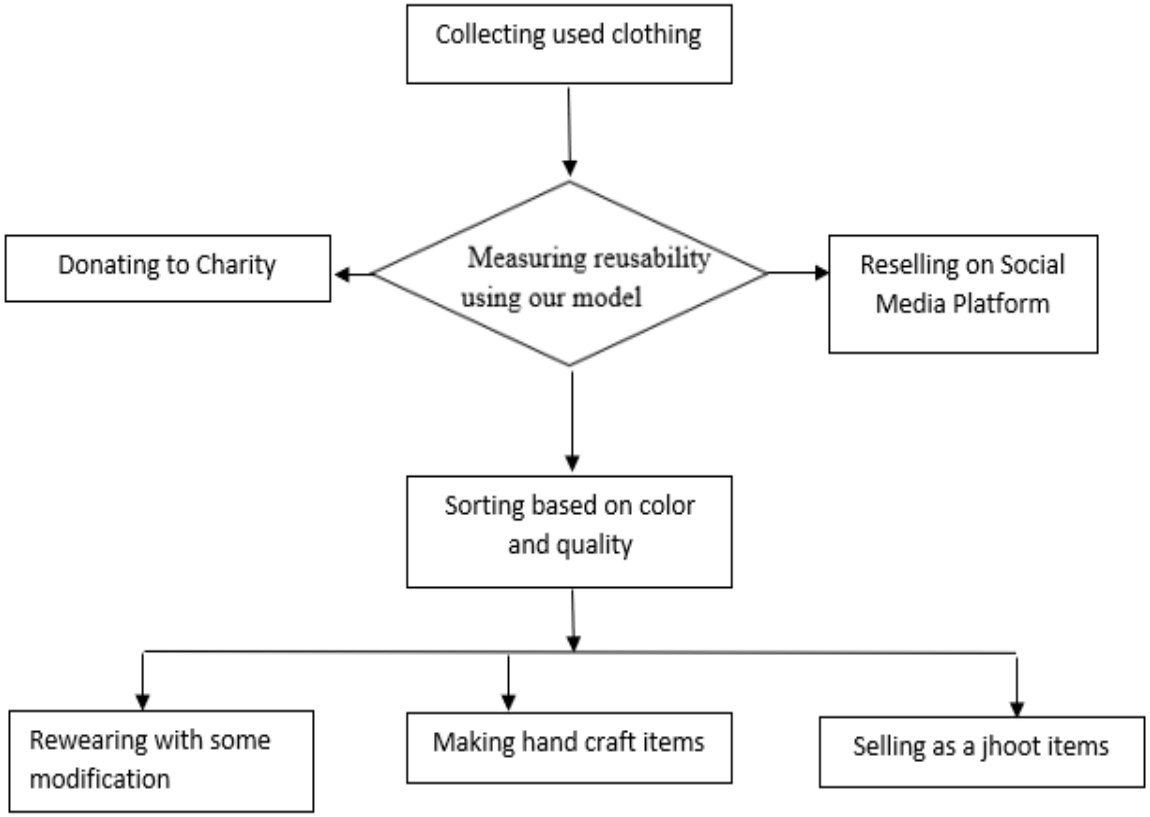


Figure 5.4.2: Household Recycling Process Using Our Prosed Methods

If the quality of the cloths is good and the life cycle of clothing fabric is within the usable period, then we can sell it to different social media platform or a specified used cloth reselling platform. We can also donate our used cloths to local charity. If our model predicted resale or reuse, then it can be donatable. In our model we do not donate as a new option because anyone can donate a few times used cloth which is resalable. They can also donate clothing that can be reusable and the quality is still good enough of re-wearable. Now in our house hold recycling process the next step is sorting the clothing based on color and quality. After sorting them, there are option of reusability in our model. First one is rewearing the cloths with some modification such as: adding extra clothing pieces to any hole of the clothing or shorten the clothing to make new deigned clothing items. Another reusability is making used clothing item into a hand craft item. There are lots of video on

social media of handmade clothing craft. The last option is selling the item as a jhoot product. Instead of throwing the bad quality clothing into dustbin, we can sell them as a jhoot product. There are lot's of usability of jhoot product in different industry sector.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Summary of the Study

Following the investigation's end, we determined that due to lack of apparel item reusability model every year a large number of clothing items turns into wastage. Cloths that have been used for a long period of time should not throw into trash, it takes a long time to decompose. But the fabric of that cloths can be used in other form of fabric that can be useful. Due to fast fashion repeating one cloth several times is decreased. But the price of the cloths has increased and using period is decreased, that makes more and more used clothes in our closet. On the other hand, some people want to wear expensive cloths in low price, they are looking for used clothes. So, there is a gap between these two types of consumers. Our study is classifying the cloths reusability that help an individual to decide what is the best way of reusing his/ her clothing's. We used Decision Tree Classifier to classify our used clothing items reusability. If your cloth condition is good then our model will suggest it for resale, from which cost in clothing item will decreased. When the cloth is not applicable for resale then our model will suggest it to reuse. We can reuse by turning that apparel item into another new items or use them as a jhoot products. With the help of machine learning algorithm our proposed method is very effective to achieve clothing reusability.

6.2 Limitation

In our study we tried to cover most of the apparel item reusability aspects. But there is some limitation in our study which we will try to solve to achieve maximum usability. Firstly, we should increase our dataset size with more variety of data. The number of literature review could be more. Applying more classification algorithm to find the most reliable one.

6.3 Conclusions

Classifying the used apparel item for further use by applying machine learning algorithm is the primary goal of this study. For our study we use five classifier algorithm and it is clear that SVM is very reliable in classifying used cloths. The validation accuracy of this model is 82%. We have combined the data of average life cycle of apparel items with some key elements to decide the reusability. This model can predict the reusing method with varied degree of accuracy with some factors such as: cloth type, fabric type, used duration, number of damages, size distortion and color of the apparel item. To can achieve more accuracy by adding more data to our dataset. We want to ensure the clothing rights for everyone at the same time reducing clothing wastage, which help us to have a good impact on our environment. For further progress of our study we will host a website from where people from all around the country can know about the reusing scope of their used clothing's. Our model will help to decide on this scope and more data will be collected and the accuracy will be increased. The apparel sector of Bangladesh can achieve a tremendous sustainability by reusing and recycling apparel items. Our study will play an effective role in apparel industry and also in daily household apparel item using. Bangladesh will be able to reduce its textile wastage and Bangladeshi people will find a better way of clothing item reusing.

6.4 Implication for Further Study

For this study, we have recommendations. In my work, I'm using machine learning classification to increase the model's accuracy. There are numerous algorithms, techniques, and datasets for a big number of datasets. Therefore, that model will predict apparel item reusability more precisely. In future we will –

- Apply more Machine Learning Algorithms
- Improve our Dataset with more data
- Add more parameters in our dataset
- Improve accuracy
- Adding more cloth reusability methods

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Reusability of Used Clothes

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