

Optimum Shirt Design Prediction Tool for Apparel Industry

KPMK Leelarathne[#] and HRWP Gunathilake

Faculty of Computing, General Sir John Kotelawala Defence University

[#] maheshileelarathne@gmail.com

Abstract: The apparel industry is one of the world's major upcoming trends of industrial, economical science. Apparel industry has interconnected design producing and manufacturing issues have become a greater concern. In the domain of apparel product manufacturing and marketing optimization and prediction the design has played a significant part of increasing productivity, overall profit, the consumer demand, and requirements towards the actual factory. Industry has been challenged over and over before adapted by adopting new methods of designing and predict the optimum garment based on the past records and analytical data sets. In my study Time series Analysis and the trained model is used to determine and predict the optimal product under various production constraints. Time Series Analysis is one of the most accurate data analysis and forecasting technique and it is widely used in this research works. There are various kinds of both the traditional statistical methods and the more advanced artificial intelligence (AI) techniques that have been used in various existing systems in relevant to this domain. Both those methods may suffer considerable drawbacks in which the former's performance depend highly on the time series data's features whereas the latter ones are slow. Hence there need to pay attention for development of an intelligent time series forecasting system which is fast, versatile and can achieve a reasonably high accuracy. Anyhow with the development of computer technology, automated apparel management systems and Machine Learning models are latest popular, especially in products classification and prediction. The proposed work provides analytical

inferences from historical data of sales records for apparel industry and modelling them using time series analytics to make effective decisions by predicting and visualizing.

Keywords: Machine Learning, Apparel Management, Design Prediction, Optimization, Time Series Analysis, Products classification, Artificial Intelligence (AI)

Introduction

The apparel industry is the one of important and dominant sector which impacting on an economy of a country, especially, in developing country such as Srilanka. As well as one of the world's major upcoming trend of industrial phase. From increasing performance of textile manufacturing and tighter process quality control, technology has inserted intelligence at every node of textile supply, production chain. When it considers any apparel industry or garment factory, they may use to manufacture large number of design types per a particular time period, but out of all those manufactured design types it may have the demand for only several design types in the sales market. So, then it may occur a wastage in production and it affect to the overall productivity in the factory. Therefore, it is an important to determine the best-selling design types among the consumers and the textile marketplace. By the forecasting and deciding the optimum design type before manufacturing, it will be able to reduce the unnecessary wastage of the cost, time, resources, and labour etc. So, if it will be able to predict the optimum design and then it may be supportive to address the exact target in the consumer market. Therefore, the aim

of customer-centric product development should be to satisfy demands and requirements of the specific target group and to predict design products that attract user attention and evoke positive emotions. Consumer 's need on technological aspect of product designing is becoming a trend in textile product development to determine their success in the apparel market. The aim of this work is to narrow the research gap of failure to identify optimum garment design types among the market demand and develop a prediction system with time series forecasting models which establishes an efficient and optimum design in the production of apparel industry. The specific objectives are to Critically review the issues and challenges are facing the apparel production strategy, Analysis and forecasting the time series data, Design prediction model to predict the optimum design type for the future production, Implement the application model using appropriate technique and create a user friendly service management dashboard for a better visualization and then evaluate the performance using test data and analyze the data and statistics for further works.

Literature Review

Product optimization and planning to design prediction in the industry is one of the popular research problems that have been developing with various conceptual affective engineering methods and Machine Learning and Artificial Intelligence techniques. Even though there are no similar research works that have done in previously, to analysis and predict garment design in particular apparel company, the following studies were conducted on the analysis and studying areas of the different types of apparel production management systems according to various applications and the techniques had used.

S.K.Tyagi and B.K Sharma(Tyagi, International Journal of Computer Applications (0975 - 8887)) presented the

role of quality control and usage of data mining tools and techniques in Textile Industry. They provided the Computerization through Context-Analysis diagram of the quality control Laboratory in Textile Industry. PromodRaichurkar and RamachandranManickam(Raichurkar and Ramachandran, 2015) have done a detailed survey about Problems and challenges for rapid growth, Optical fiber application in textiles, Marketing Initiatives, Scheme for Integrated Textile Parks, Textile Education and Skill Development, and also reflects that wholehearted joint efforts from manufacturers, buyers, suppliers, government, and other stockholders are highly expected to accomplish the development of potential and sustainable textile industries growth in India.

(Moisanen, May,2014) provide an understanding of the key concepts and issues related to demand forecasting in the apparel industry to investigate the interesting concept of demand forecasting in the apparel industry through secondary research and utilize the findings in a real life. This case study utilizes the findings to c and endorse the most valid forecasting measure and methods by combines both quantitative and qualitative methods. SébastienThomassey, Choi, Hui and Yu, 2013) Proposed a review of the different constraints related to sales forecasting in the textile industry to generate a sale forecasting system. The different types of constraints taken to design the forecasting system is Horizon, Life Cycle, Aggregation, Seasonality, Exogenous variables. Avonigharde conducted a study on forecasting of clothing sales using regression and time series model. EngyShafik presented a Time series Forecasting Model for US Winter Season Apparels based on Seasonality, Economic Condition, Fashion Trends and Consumer Behaviour.

A Fuzzy Line-Balancing (FLB) model (Wong, Chan and Ip, 2001) is proposed to handle the

line-balancing problem of fabric spreading and cutting operations of the apparel manufacturing process using genetic algorithm. And the result indicated and was compared with that of FLB model under the dynamic manufacturing environment. (Li Xia Li, Fanxing Kong, 2011) In this paper, GM (1,1) model is applied to predict the apparel export volume, the results show that the prediction accuracy is better, the forecast shows that china's garment exports are still on the momentum of rapid growth. Optimize structure of our textile and garment industry chain to fight for advantageous position in textile and garment industry depends on brand, design, quality. (Chandadevi Giri , Thomassey, Jenny Balkow 2019) This approach to forecast the sales of fashion products based on deep learning and non-linear NN regression is presented in this paper. Results of this study seem promising for forecasting the future sales quantity of the products. This approach could benefit the designer and fashion retailers in order to carefully studying the sales of the current product and extracting the abstract features hidden in the particular product images, fashion designers and retailers can predict the nature and demand of the products in future.

This study on energy assessment from apparel industries: the context of Sri Lanka (Jananthan, Ameer and Shiyamini, 2006) has attempted to make some recommendation for the energy efficiency by doing a cost benefit analysis for the energy efficiency measures. Operating costs can certainly be reduced by performing energy analysis and diagnostics, leading to efficient energy conservation and management policies. (Tien-you, 2010) The integrated system for optimizing the management and control of apparel enterprise is presented in the paper. This integrated software is based on a custom system, the production department receives orders for production.

Methodology

Product type's analysis and prediction is one of the popular topics in today's research works. However optimum design prediction in the textile management and apparel industry is not much common research as much as in conduct related to any other common industry or field. Out of the all optimization and prediction-based models slightly challenging this research area in apparel industry because, even though the same factory, they have to manufactured varieties of design products and they are printed in different colours, different sizes and it may have different shapes in different garments. Not only that but also day by day the market demand of those products may differ from several categories such as age, gender, trends, profession, social status etc. This is a dynamically changing area and time evolved from the historical records and data in the domain. So, Time series analysis comprises methods for analysing time series data in order to extract important and useful statistics and other features of the data. Time series forecasting is the application of a model to predict future values based on historically prior observed values.

After selecting a topic for the research, initial information about related works for this research that have collected already were gathered by the literature review as well as have done interviews with the professionals who are involved with this apparel design production domain. Since there aren't the same research works that have been done, related proposed systems in textile management and apparel market analysis studies researches have been reviewed. When reading various journal papers and conference papers there were so many approaches and techniques that have been developed to enhance the productivity and design analytical based systematic approaches. The analysis was done mainly to identify the current systems available with

the advantages and drawbacks on such systems and get the ideas & preferences of individuals within the society in related to men's shirt design types' prediction with Time series Analysis. And also during the requirement gathering the required information and data collection process will be done by taking real time data and actual information from interview the several of apparel factories and the employees (production strategy, designers, and sales team) and also questionnaires have sent among the general community.

According to the requirement gathering by means of conducted discussions and interviews it could summarize and conclude with important details such as most of the apparel companies are incurring losses and non-profitable products due to the remaining unsold items, One major reason to remain unsold items is that the designs are less attractive and also the lack of proper matching between demands and supply, It needs additional storage space to keep store leftover garments in the outlets and factories until it clears the discounted wardrobe, The entire apparel industry is going to having overall wastage Including cost, resources, time because of the garment designs that are manufactured haven't sold as the target, now a day the stock clearance sales are mostly arranged for men's shirts and it has a never lower marketplace demand for the men's shirts and gents fashion variations can be easily narrow down when compare with women's fashion categories. This wide range of data will help to identify the exact actual problem definition and as well as increase the performance of the time series data analysis. Each data mining technique has represented different accuracy levels and has purposed the technique depends on each model objective. Few of data mining techniques and Time series analysis and forecasting methods have been considered as follows. As the first step few data mining

techniques were studied. Usually, a time series is simply a series of data points ordered in time. In a time, series, time is often the independent variable and the target is usually to generate a forecast for the future. Below are the several famous ways to model a time series in order to create predictions.

Several data mining techniques were considered as follows.

A. Naïve Bayesian Classifier

This algorithm based on Bayes theorem which calculates probability by counting the frequency and combination of values. Here, small amount of training data for the relevant classification is required.

B. Decision Tree

It is one of a simple algorithm to divide up a large data collection into smaller sets of simple decision rules. Iterative Dichotomiser 3 (ID3) is an algorithm that is used often. The J48 decision tree is the implementation of the ID3 algorithm.

C. Genetic Algorithm (GA)

Optimized solutions and search problems are provided by using inheritance, mutation, selection, and crossover. There should be a genetic representation of the solution domain and a fitness function to evaluate the solutions.

D. Neural Networks (NN)

It is a tool that is used for complex classifications and clustering. NN is a parallel, distributed information processing structure. Processing elements or nodes and unidirectional signal channels or connections consist of NNs. There are two modes in ANN. One is activation transfer mode while the other one is learning mode.

Time Series models are used for a variety of reasons and variety of scenarios, predicting future outcomes, understanding past outcomes, making decisions, suggestions, and much more. These general goals of time

series modelling don't vary significantly from modelling cross-sectional or panel data. Time series analysis is a statistical technique that deals with time series data, or trend analysis. Time series data means that data is in a series of time periods or intervals. The data is considered in three types:

- 1.) Time series data: A set of observations on the values that a variable takes at different times.
- 2.) Cross-sectional data: Data of one or more variables, collected at the same point in time.
- 3.) Pooled data: A combination of time series data and cross-sectional data.

However, the techniques used in time series analysis and forecasting have been considered as followed.

Moving average: The moving average model is probably the naivest approach to time series modelling. This model simply states that the following observation is the mean of all past observations. Although simple, this model can be surprisingly good and is a good place to begin. Otherwise, the moving average can be used to identify interesting trends in the data. It can define a window to apply the moving average model to smooth the time series and highlight different trends.

ARIMA Model: This is the most important and widely used methods of forecasting. The time series analysis assumes that the underline time series is stationary or can make stationary by differencing it 1 or more times. This method is also known as the Box-Jenkins method. Using the ARIMA (auto-regressive, integrated, moving average) method is an iterative, exploratory, process intended to best-fit your time series observations by using three steps—identification, estimation, and diagnostic checking—in the process of building an adequate model for a time series. The auto-regressive component (AR) in ARIMA is designated as p , the integrated component

(I) as d , and moving average (MA) as q . The AR component represents the lingering effects of previous observations. There are several the Methods for Estimating ARIMA Models including Least squares nonlinear and linear regression, Maximum likelihood method, Generalized method of moments

VAR Model: Multivariate time series analysis provides information on the interactions and relationships of a group of time series variables. For example, a multivariate time series model can examine the interaction of temperature, wind speed, and precipitation. The most common multivariate time series model is the VARMA model. The VARMA model is analogous to the ARIMA model and contains an autoregressive component and a moving average component. In the multivariate model, the moving average component is unusual, and the most common case is the pure vector autoregression (VAR) model. The VAR model is a flexible model that has shown great success in prediction and has been used for political and structural analysis. The autoregressive vector model represents a group of dependent time series variables as combinations of their own past values and past values of the other variables in the group

Naïve Method: As the name suggests, under this method the forecasted values are just equal to the last observation.

Seasonal Naïve Method: We know that there is some seasonality in our data, when such kind of time series are available the Seasonal Naïve Method provides better forecasting accuracy than the simple Naïve method. Naïve methods are very useful in economic and financial data

Design and Implementation

Under the design, mainly it must do the selecting the perfect analysis model type and designing the Time series model for the future prediction. It is considering how did evolve the most five categories of features in

shirt design according to the Time Series. Then after the analysis and model fitting then it can make predictions and the outcome will be display in the web application. This performs a non-linear functional mapping from the past observations of the time series to the future value. Mainly the design and implementation part have to be done under two basic phases; Analysis and forecasting time series data using the best appropriate model and create the model for the future predictions and secondly implement the web interface and dashboard visualization for display the final systematic output. Selected & determined what is the best model fit for the given dataset by using Akaike information criterion (AIC). It is a fined technique based on in-sample fit to estimate the likelihood of a model to predict/estimate the future values. In order to perform this AIC it has used the Likelihood Ratio Test with this formula; $LRT = -2\ln(L) - m$. By calculating and comparing the AIC scores of several possible models, could choose the one that is the best fit for this data; the one with fewer parameters has a lower AIC score and be the better-fit model. A good model is the one that has minimum AIC among all the other models. Finally, selected the best model fit: ARIMA model. In here the research domain is apparel industry. So, fashion trends and customer demands (emotions, choices) can be occurred seasonal changes, dynamic variations over the time. This data set is a time series data and it can be defined as a set of data that is made up of a sequence of data points taken at successive equally spaced points in time. And also by this research work I require to modelling time series data for forecasting (for predicting future points in the series)for the optimum best shirt design for future, in such a way that; a pattern of growth/decline in the data is accounted for (hence the auto-regressive part);the rate of change of the growth/decline in the data is accounted for (hence the integrated part);noise between consecutive time points

is accounted for (hence the moving average part) make future predictions. Finally, due to those reasons this research has decided to use ARIMA model with R for the time series analysis and design the model for further implementation of the tool. Furthermore when it considers this scenario and data set actually this is a class of models that evolve and explain a given time series based on its own past values, that is, its own lags and the lagged forecast errors, so that this model should be used to forecast future values. Not only that but also when it decides to fit an ARIMA model the first step in time series data modelling using R is to convert the available data into time series data format and data should be stationary. One of the major purposes to stationarize a time series is to be able to obtain meaningful sample statistics such as means, variances, and correlations with other variables. Such statistics are useful as descriptors of future behaviour only if the series is stationary.

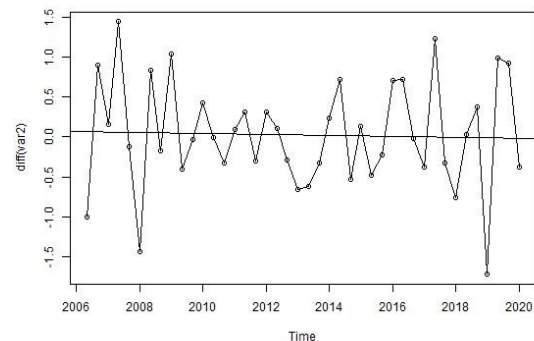


Figure 1: Time Series Graph of Actual Shirt Designs Data (15 years) Source: Output of fitted ARIMA model

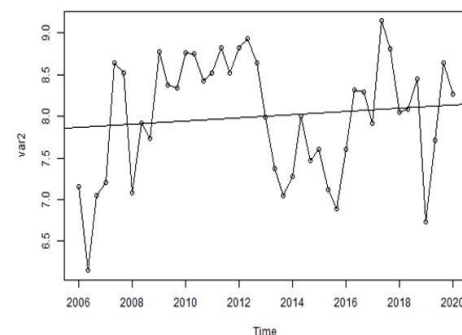


Figure 2: Differenced Series Source: Output of fitted ARIMA model

This is how the actual dataset looks like in Time Series plot. This suggests that the time series (actual) is not stationary and will require differencing to make it.

It is needed to do exploratory Analysis (EDA). Before performing any EDA on the data, it needs to understand the three components of a time series data: Trend, Seasonal, Cyclic.

The output will look like this:

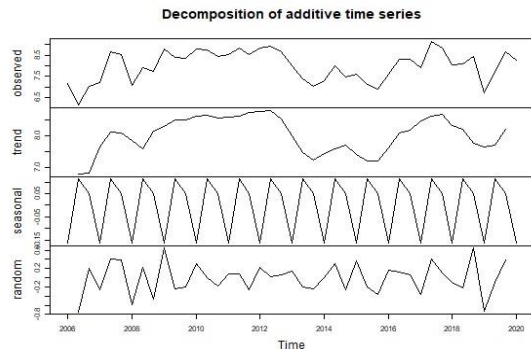


Figure 3: Differenced Series Source: Output of fitted ARIMA model

Here it gets 4 components:

Observed – the actual data plot

Trend – the overall upward or downward movement of the data points

Seasonal – any monthly/yearly pattern of the data points

Random – unexplainable part of the data

Observing these 4 graphs closely, we can find out if the data satisfies all the assumptions of ARIMA modelling, mainly, stationarity and seasonality. After that it can do ADF (Augmented Dickey-Fuller) Test for check the stationarity.

stationary, at least a difference order of 1 in some scenarios differencing order of 2 or more. The output looks like this:

Then finally, fit the model and start the forecasting.

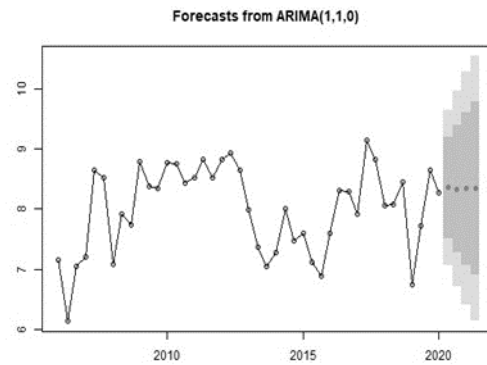


Figure 4: Forecast Plot of ARIMA (1,1,0) for next 4-time quarters Source: Output of fitted ARIMA model

The forecasts are shown in blue dots, with the 80% prediction intervals as a dark shaded area, and the 95% prediction intervals as a light shaded area. This is the overall process by which we can analyze time series data and forecast values from existing series using ARIMA. In here, have considered and gathered data of 15 years and divided a year into three quarters to analysis and forecasting the sales data of men’s shirt design.

Findings & Analysis

Basic research problem evaluation and brief comparison and analysis of reviewed systems have been represented in this section. A survey on the shirt design demands and customer perspectives in textile industry was held as the initial finding of this research to analyses this research problem moreover and to determine and measure about the factors which may consider of the general public (customer) when buying a new shirt. This Google form questionnaire-based survey was collected 75 responses. It consisted of 12 different question tips on regarding apparel marketplace demand, buying patterns of customers as well as main features and design factors of a men’s shirt to identify for the respondents. As well as this questionnaire has concerned 10 different features of a men’s shirt under separate four questions to determine what are the most

prominent and for what has the highest consumer demand. According to the responses, respondents were related to every category of age groups under both gender types. The total mark of the questionnaire was assigned as 10 here since there are 10 different characteristics (features) of a shirt. When considering about total average of consideration of the features by the public generally it could conclude with 5 dominant features with the highest scores in order the percentages as below. The most considerable and dominant feature is Design with 53.3% of percentage as the highest scored, and then second main feature with 46.7% next higher score is Collar. Then the Sleeves with 26.7% percentage as the third. Finally, out of all those survey results and analysis it has concluded to narrow down the best and main feature for a optimum shirt is the Design in order to develop the final system.

Propose System

In order to obtain a proper forecasting and prediction of these optimum shirt design type, this research work will propose a web application that analysis and forecasts the dominant features of a shirt which has considered in the designing and production process. It will take historical records of features as input of the system. Time series analysis is forecasting or prediction of future values using the historical data. Then it will recognize the time series data pattern and will provide the optimal category type in each feature. Then by combining those five optimal features results it may give the final shirt design for the next year. The main expected output of this research is user-friendly, fast, accurate, secure, customize and quality model with web application and dashboard. Further, it can be commercialized by introducing to Google App Store. This system will analysis with a wide range of perspectives, a wide range of distributed data records from history, under different seasons, different features of shirts. The novelty of this solution is there are not developed systems to analysis and predict the men's shirt design types in previously and especially in Sri Lankan context. Besides, there are not adverse ethical impact or social impact and security threat from this web application. An accurate and successful analysis of these can support professionals (Designers, production teams) observe patterns and ensure the smooth functioning of the production process of the factory. The most important part of this time series analysis is forecasting or prediction of future shirt design type using the historical data. These predictions help in determining the future course of design the garments and give an approximate decision about how the market and customer demand will look a year from current for any individual or group of people. By the dashboard it can see that harnessing operational data and displaying it

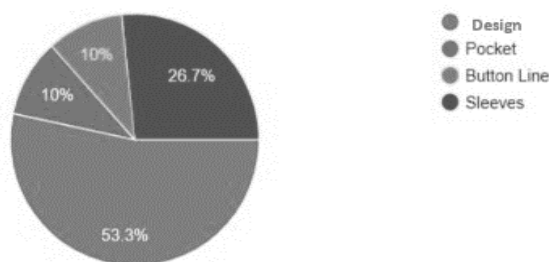


Figure 5. Pie charts of Shirt 's features selection Source: Questionnaire survey results

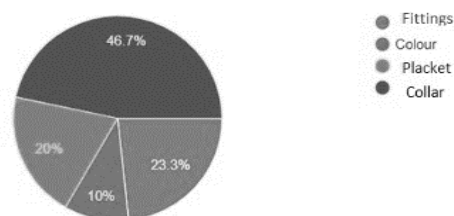


Figure 6. Pie charts of Shirt 's features selection Source: Questionnaire survey results

within an easy-to-understand visual chart allows for greater efficiencies within the business platform. For most of the manufacturers, having a single source of statistical represented in a simple data visualization engages stakeholders. Dashboard tools enable increased information sharing across the business, making it easier to identify under performance or inefficiency in processes. With this enhanced visibility and knowledge, improvement opportunities can be more easily identified, encouraging change and integrate real-time manufacturing data. The final proposed solution can be summarized as the following figures.

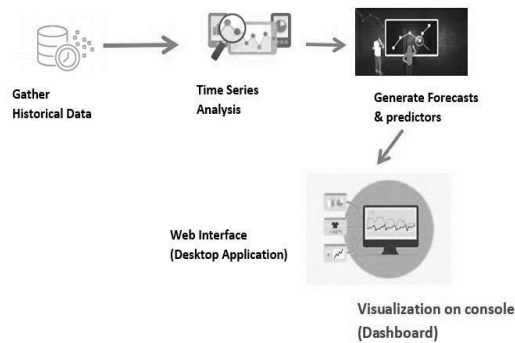


Figure 7. Methodology of the proposed solution Source: Questionnaire survey results

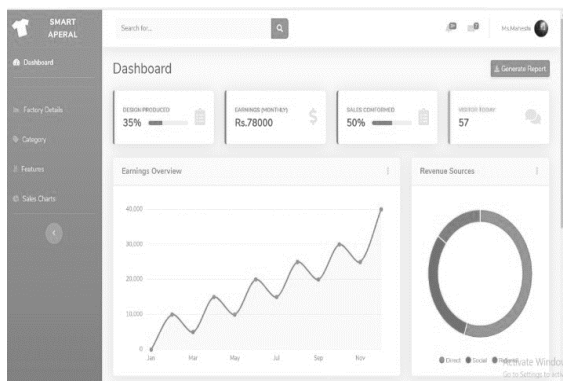


Figure 8. Dashboard interface of the proposed solution Source: Dashboard visualization

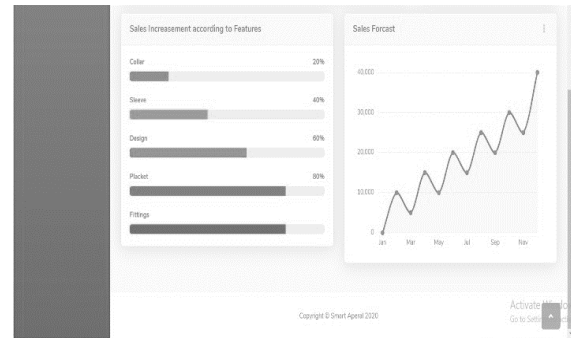


Figure 9. Dashboard interface of the proposed solution Source: Dashboard visualization

Conclusion & Future Work

To create highly accurate, efficient prediction model of product (Men’s Shirt) designs in apparel industry, this paper has been reviewed analytical techniques including Traditional statistical methods and Artificial Intelligence and machine learning techniques. Even though there are so many various textile management and related garment market analytical classification researches have been done already, there aren't existing system to predict the optimum shirt design type on overall apparel production strategy specially in Sri Lanka. Therefore, this paper has been gathered some related researches for this review. In most of these existing related works, artificial neural networks, Big Data Analytics, Genetic search and Artificial Intelligence have been enhanced the accuracy of the statistical process control or apparel productivity management, here a new system has been proposed by using machine learning techniques with Time Series Analysis in order to forecasting dominant features of a shirt which can be effected according to the particular optimum design type in the apparel production. According to the literature review and overall related works the novelty can be emphasized as there are not developed systems to predict the design types of the any of garment product in the Apparel industry in previously. This will be provided efficient, effective and optimum prediction on the shirt

designs in terms of time series analysis and forecasting and minimize the leftovers in the factories and then the overall wastage will be minimized. Not only that but also this will make predictions & suppose the bestselling designs among the target consumer market. As further work the potential benefit of developing this optimum prediction model is increasing the productivity, profit and in parallelly reduces the overall wastage of the apparel products to improve consumer habits. Moreover, to provide a convenient way to predict the customer market demands for these textiles designs and improve the systematic optimum design prediction method for apparel industry. To gain a conclusion on such a research study area the information on the effectiveness of a systematic solution may have gathered by reviewing related works and existing systems and then its evaluation summary gave the points to be considered in developing such a model in future.

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