SUPPORTED GLOVE PRODUCTION OPTIMIZATION WITH MACHINE LEARNING AND COMPUTER NETWORKING APPROACH

Nimshi A. Fernando
Department of Information Technology
Sri Lanka Institute of Information Technology Malabe, Sri Lanka
fernandonimshi@gmail.com

Roshima K. Hathnapitiya
Department of Information Technology
Sri Lanka Institute of Information Technology Malabe, Sri Lanka
roshimahathnapitiya18@gmail.com

Milochana G. Rathnayaka
Department of Information Technology Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
milochanalive@gmail.com

Oshada Senaweera
Department of Information Technology
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka oshada.s@sliit.lk

Yasas C. K. Alwis
Department of Information Technology Sri Lanka Institute of Information Technology
Malabe, Sri Lanka yasaslive@gmail.com

Vijani S. Piyawardana
Department of Information Technology Sri Lanka Institute of Information Technology
Malabe, Sri Lanka vijani.p@sliit.lk

I. INTRODUCTION

***Abstract*— A supported glove, also known as a partial glove, is a significant latex product that aims to provide safety and comfort during industrial hazards. Therefore, the essential requirement of supported glove manufacturing is to produce a quality product. This research paper attempts to optimize the supported glove manufacturing process through the machine learning (ML) and computer system and networking (CSN) approach. Convolution neural networks (CNNs) play a crucial role in identifying defective gloves during the quality checking process. Different models were tested to detect defective gloves, and VGG16 gave the highest classification accuracy. IEEE 802.11 defines security protocols such as wired equivalent privacy (WEP), wi-fi protected access (WPA), wi-fi protected access2 (WPA2), and WPA2 performed robust security mechanism. Moreover, using the production parameters such as compound viscosity, oven and former temperatures, plant temperature, humidity, the suggested system can predict the defect occurrence. The predictive model has achieved the best classification accuracy (CA) of 92% by using K Nearest Neighbor Classifier. Furthermore, the proposed wireless communication protocol has improved security, reliability, and implementation using a low-cost method. The result revealed a significant improvement in data communication by comparing it to the other methods in terms of encryption and authentication.**

Keywords- Machine learning, computer networking, convolution neural networks, classification accuracy, wired equivalent privacy, wi-fi protected access.

The rubber gloves industry in Sri Lanka meets over 5% of the global demand for a variety of gloves from disposable and reusable household gloves to industrial and surgical gloves with various specifications [1]. The supported glove is industrial protective wea r designed to protect the skin, especially the hands, from industrial hazards: cuts, chemical burns, punctures, and impact injuries. The supported glove consists of two main layers; the base layer stitched using yarn and a latex layer applied on top of the base layer.

The quality of gloves is very important for ensuring that they are fit for their purpose [2]. Therefore, one of the crucial concerns of the glove manufacturing industry is reducing defects in the final product. To maintain a competitive edge, glove manufacturing industries continuously look for ways to improve the quality of gloves while at the same time reduce the use of ra w materials and other resources [2]. As genera l all glove manufacturing process follows a standard procedure. However, it varies from factory to factory and batch to batch, depending on the requirement.

The supported glove manufacturing process is interconnected with multiple other processes such as the chemical measuring process decision-making process for a successful production. Therefore, it is essential to implement a centralized production process that provides efficient communication facilities with each process. However, when focusing on the Sri Lankan glove manufacturing industry, it is visible that there is a huge need for many implementations. Therefore, this research was conducted using the data of a supported glove manufacturing factory referred to as 'XYZ' in Sri Lanka. The focus was to observe the glove manufacturing process to identify existing shortcomings in the production and apply ML and CSN approaches to overcome them and increase productivity.

Currently, in the existing system of the factory, the data is gathered and kept in separate databases for each production plant. Since there is a lack of centralized data warehouse implementation among separate databases, it takes more than the required time for the decision-making process. Also, the data is communicated between the plant and head branch through the wired network in the existing system. Due to the issues in the wired network, the factory communication system is not fulfilled with security and mobility. Hence the data packets are lost within the communication process.

When focusing on chemical usage in glove manufacturing, proper chemical consumption measuring is much needed as it reduces chemical wastage and reduces unnecessary costs on ra w material. It implies a significant requirement to implement a way to measure the chemical consumption according to the required badge and other relevant criteria.

Glove production happens in a factory-based environment using machines such as ovens, tanks, and formers. Both environmental conditions such as temperature, humidity, and plant conditions such as oven temperatures, former speeds, latex viscosity contribute equally to the production process. Due to the variations in environmental factors and internal plant parameters, a series of glove defects: clinker defect, processing fault, webbing, shell damage, pinhole, over/poor dipping, penetration defect have occurred during the glove production process, which cause for huge losses. In this research, ML concepts are used to predict defect occurrence based on plant production parameters.

Generally, for any customer-based production, quality is the most crucial aspect which needs to be satisfied. At present, in the observed factory plant, the final glove's quality assurance is performed manually, which requires a significant number of human resources. During the quality checking process, human mistakes affect the glove industry drastically as it causes in releasing defective gloves to the market. Therefore, maintaining a sound quality assurance system based on visual inspection is much needed than manually quality inspection.

This research aims to implement a platform with a machine learning approach that takes different glove manufacturing process parameters as inputs to predict outcomes according to the production stages. In the proposed solution, centralized data warehouse implementation plays a significant role in the big data context. Druid is one of the best data warehouse solutions to enhance the decision-making process with appropriate response time. It is a cost-effective software solution that provides online analytical processing (OLAP), query processing, business intelligence (BI), and analysis data.

The solution includes a forecasting method to make predictions about chemical consumption based on the supported glove badge count and eliminate production downtime by establishing a proper communication mechanism between the production and chemical mixing departments. A machine learning model is built to predict defect occurrence by analyzing environmental factors and internal plant parameters as inputs. This study aims to implement a suitable model, which can be used in small- scale computer to perform quality assurance based on visual inspection.

The wireless network, which is suggested in this research, plays a vital role in modern industrial data communication. This research includes improved wireless protocol security, reliability, and low cost. The proposed protocol satisfies authenticity, confidentiality, integrity and mitigates an attack. The wireless technique compared with the wired has taken widespread because of its effectiveness, flexibility, and mobility. Wireless data communication executes under the different network protocols include WEP, WPA, WPA2, WPA3.

This paper is structured as follows. In section II includes the proposed solution for the above-addressed problems that occurred during the production process. Section III describes the results and discussions. This paper is concluded in section IV with future work.

II. RELATED WORK

According to the previous studies conducted, most of the defect prediction studies were conducted using images as the input parameters, and very few studies have been conducted on defect prediction using production parameters. In the paper [6], a binary decision tree was used to recognize the cold mill strip's defect patterns by extracting data from 7 standard defect patterns. According to the study, K Mean & Genetic algorithms were used to calculate each feature subset's fitness. In the study [7], supervised machine learning techniques were used to predict defective software. The study was conducted for the end product, and 20 machine learning models were implemented using publicly available seven different datasets. A random forest classifier was selected as the best model to predict the defective software. In the study conducted by Ke-Sheng Wang [8], zero-defect manufacturing (ZDM) is proposed. As mentioned in the study, data mining has made a practical impact on developing the ZDM system.

The papers [11],[12],[13],[14] use convolutional neural networks (CNN) to detect defects in production environments and all the researchers used the traditional training methods, which lead to large dataset requirements and high-performance computing. The study [15] used a binary feature histogram (BFH) for defect identification on glass surfaces. Kang and Phak [16] use Support Vector Machine (SVM) for defect identification for liquid crystal display (LCD) defects with good results. Furthermore, Mozaharal in [17] use Bayesian classifiers on fabric defect analysis with a good accuracy.

When consider studies conducted on chemical consumption, they are focused on raw material inventory management, raw material consumption, and price forecasting for the overall glove manufacturing process [3],[4],[5].

Additionally, some research have focused on data analytics tool which delivers appropriate response times and improves the decision-making process in a manufacturing setting. For designing reconfigurable architectures with decision-making Support [18], Giovanni Mariani et al. used a code and map functionality framework called druid. They have considered mapping decision and code modification functionality for developing a druid framework that utilizes the kernel process during the performance of the computing element. Fast online analytical processing for extensive data warehousing [19] has improved performance based on query processing under OLAP in big data. Consequently, the test protocol utilizes the processing and storage with query granularity and data schema.

For improve the data communication process, a compact Algorithm [20], have examined WEP, WPA, WPA2 and developed an algorithm based on RC4 encryption and additional security with matrix, solution for discrete logarithm problem and one-way hash function. The performance of different IEEE802.11 security protocol standards on 2.4GHz and 5GHz WLAN networks [21] was about the security protocol on wireless local a rea networks. This paper has identified different WEP, WPA, WPA2 issues that affected the system performance and identified different issues within WLAN. The research [22] had identified weaknesses and evolution of encryption protocol. They have introduced a mechanism to improve the security using RADIUS server certificate and a new exchange method from WPA3. WPA2-PSK key generation and WPA-2 encryption handshake were the authentication method in the protocol. In [23] has focused on fast and reliable communication using modification code of WPA to develop more reliable using SHA3 and cryptographic hashing algorithm. The paper [24] have proposed security model research on implementing Toeplitz Hash-based RC-4 in WSN. The algorithm was based on a combination of the Toeplitz hash function and stream cipher RC-4T algorithm with one way hash function. RC-4T algorithm is a security method for avoiding attack and memory utilization way.

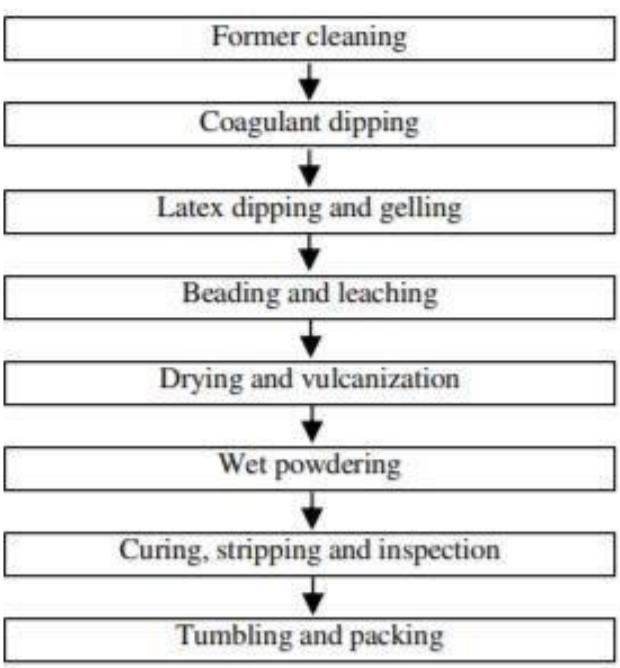

Fig. 1. General Glow Manufacturing Flow.

III. METHODOLOGY

Manufacturing process of the supported glove is as Fig. 1. Overall, this research is divided into four platforms, and each platform is addressed parallelly. The four platforms are shown in Fig. 2.

A. Centralized data warehouse implementation

A data warehouse is implemented to process the huge volume of data that generated from the factory's production process. Implementation of the warehouse was based on the open-source framework called Druid (Designing Reconfigurable Architectures with Decision-making support). The dataset contains plant parameters of the gloves manufacturing process. The Druid installation required Linux and Java8. Druid was performed Querying data, Roll up process, stream and batch ingestion, and BI process after loading the files. These processes were provided rea l-time analysis support for the decision-making process.

B. Chemical consumption forecasting for production

This study was conducted to forecast the chemical consumption based on production requirements. As shown in Fig. 1, from coagulant dipping to the wet powering stage, a list of chemicals was used in the manufacturing process. In this method's development, a sufficient amount of data was collected on glove count, glove weight, shell weight, glove size, total solid consumption (TSC), production time, speed of the production belt, and measurement of A B, C chemicals.

Data preprocessing was applied before model building, as data quality directly affecting the performance of the model. Since the data was collected in real-time, data quality assessment methods were conducted to preprocess the dataset

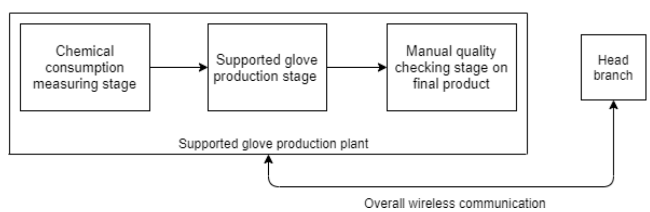

Fig. 2. Overall production process addressed in the study

A correlation analysis was conducted to identify the relationship between identified production parameters and chemical consumption. All the selected parameters have shown a high correlation with chemicals A, B, and C.

A set of suitable algorithms: Support Vector Mechanism (SVM), Logistic Regression, Decision Tree classifier, & Bayesian Regression models were testified to forecast the chemical consumption. Apart from the traditional methods, the neural network also tested against the data to check the models' effectiveness. The loss function, mean squared error (MSE), was used to determine each model's error function. By calculating the MSE for each model, choose the best model for chemical consumption forecasting.

Several models were tested to forecast the chemical consumption based on the glove badge count, and the following accuracies were achieved as shown in Table I. The decision tree regressor was proven as the most effective model to forecast the production chemical consumption with 42 MSE.

C. Defect occurrence detection using internal plant parameters and environmental factors

A supervised classification model is built to predict the defects that occur during the glove manufacturing process. Data was sourced by collecting a sufficient amount of process analysis reports and quality ana lysis reports for support glove production. The original dataset with 54 dimensions including viscosity, former cooling tank temperature, former cooling tank height, former temperature, cha in speed, six oven temperatures, humidity, room temperature, defect state, produced glove count, rejection state whether it rejects/ reuse was generated to build a classification

According to the data visualization conducted on finalized data , 46.8% of overall glove production was identified as a defective production and 37.6% of the production was subjected as reject, and only 9.1% were in reusable state which needed additional cleaning requirement. Before building the classification model, data preprocessing was conducted on finalized data set. Data Preprocessing is an essential and primary step in knowledge discovery; because the data obtained from the logs may be incomplete, noisy, or inconsistent [10]. Dimensionality reduction techniques were used to reduce the dimensions. In a real-time production, missing data is a common mistake and those were eliminated to enhance the performance of the classifier. Hot la bel encoding was applied to convert categorical variables into machine-readable form.

The correlation coefficient was conducted to ensure that the remaining dimensions have a connection with the defect occurrence. Since the supported glove manufacturing process is a multi-stage production, different data types (continuous and categorical) were gathered during the production process. In genera l, it is necessary to check the data basis for its distribution form before starting the correlation ana lysis [9]. According to the correlation ana lysis identified that the Height of the Pre-Coagulant tank, CTR (Chloroform Test Result), and Cha in speed have no dependency with defect occurrence and eliminated them.

Classification models were trained using a training dataset by using a split data ratio as 70/30 split. Several classification models were tested to predict the defect occurrence during ongoing production using production parameters. The following accuracies were archived as shown in Table II. The Neural Network model was tested with several optimizers such as Adam, Adagrad, Adadelta, and Stochastic Gradient Descent (SGD). The best accuracy for Neural Network was observed for optimizer Adam with 91% accuracy. K-Nearest Neighbors Model was selected as the most suitable model with 92% accuracy where the K = 1.

D. Quality assurance using pre-trained computer vision models

A set of supported glove surface images were used as the dataset of this study. The images were 3000 by 4000 high-resolution images with a sample size of 2000 images. The dataset includes images of glove surfaces with and without defects. Before constructing a classification model, all unusable images were removed. Although the images were taken manually, and the data set is relatively small, it can be automated by a simple camera with a Raspberry Pi module.

The cleaned images were placed in the directory structure for preprocessing. Preprocessing was applied such that the images were multiplied by the image data generator itself (Fig. 3). For preprocessing the images apply different parameters such as rescaling, rotation, width shift, height shift, zoom range, and flip horizontal as shown in Table III.

The cleaned images were placed in the directory structure for preprocessing. Preprocessing was applied such that the images were multiplied by the image data generator itself (Fig. 3). For preprocessing the images apply different parameters such as rescaling, rotation, width shift, height shift, zoom range, and flip horizontal as shown in Table III.

Testing and validation images were kept in a directory and were used to determine the model accuracies. Each model was run through each class to validate accuracy. First, a pre-train model is called and removes the predictive layer to a high accuracy model. This method helped to extract features from the data set using a pre-trained model which has good weights. Then the extracted features were stored in a file for future use. A sequential model consists of two dense layers, one drop out and one flatten layer created to classify the glove quality accuracy.

Then the previously extracted features are fitted to the model and measure the accuracy. The accuracy was between 0.40 to 0.56. A pre- trained model was combined with the custom model to improve the accuracy. Then the model was trained with images by providing a learning rate and callback. Using such techniques model improved its accuracy, and the same procedure rules repeated for all the pre-trained models. The models were able to obtain better accuracies between 0.62 to 0.99.

After analyzing several models shown in above Table IV to identify the defective gloves in the quality checking process, respective accuracy was given. The most accurate model was VGG19, with an accuracy of 95%. Each model's predictive layer/layers were removed, and a custom model was combined with it to train the model using data for the last three layers. The rest of the network was kept intact due to its high accuracy.

TABLE I.RESULTS OF CHEMICAL CONSUMPTION PREDICTION

Model	MSE
SVM	71.423204
Logistic Regression	80.227428
Decision Tree	42
Bayesian Regression	66.881450

TABLE II. RESULTS SUMMARY OF DEFECT OCCURANCE PREDICTION FOR ONGOING PRODUCTION

Model	Test Accuracy	
	Initial Attempt	Final Attempt
Decision Tree	0.757143	0.9167
K Nearest Neighbors	0.788214	0.9236
Random Forest	0.757143	0.9167
Cat Boost	0.739286	0.9190
XG Boost	0.703571	0.9167
Neural Network	0.721428	0.9190

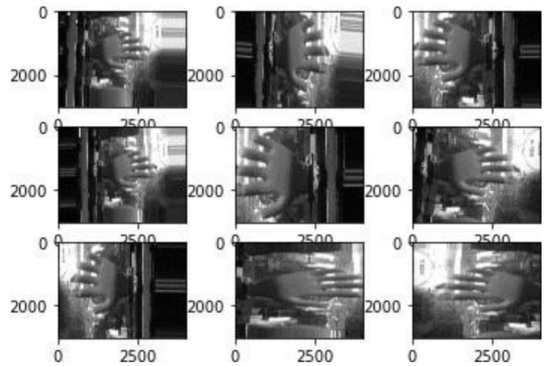

Fig. 3. Image data generator pre-processing for a sample image

TABLE III. PARAMETER LIST

Parameter	Value
Rescale	1.0/255
Rotation	3
Width Shift	0.2
Height Shift	0.1
Zoom Range	0.5
Flip Horizontal	True

TABLE IV. RESPECTIVE ACCURACIES OF DEFECT IDENTIFICATION ON FINAL PRODUCT

Model	**Accuracy**
VGG19	0.9913
VGG16	0.9710
Xception	0.9451
Resnet 101	0.6942
Resnet 50	0.6026

E. Wireless data communication protocol

There have been many implementations using wireless security protocols certified by the wi-fi alliance. WEP was the first encryption protocol that included problems such as not including key management, using the RC4 cipher algorithm, and easy to forge authentication messages. Due to mitigating these security issues, IEEE was developed WPA, an improved version for data encryption, authentication, and Integrity. Finally, the wi-fi alliance was defined as WPA2, which used Advanced Encryption Standard (AES) based on Cipher Block Chaining Message Authentication Code Protocol (CCMP) and WPA2 embedded with solid authentication and encryption standard.

The proposed WPA2 wireless security protocol is implemented to enhanced wireless security data communication protocol with a high level of security, reliability, and low cost. The designed wireless security protocol provided the best solution for discovered weakness in WPA2, such as exploited by various Daniel of Service (DoS) attacks, brute force attack, and man in the middle attack due to a problem in WPA2's pre-sha red key is derived from four-way handshake process.

The proposed WPA2 uses three main phases in implementation. The four- way handshake was improved to provide additional security. Modify the AES algorithm and write the code using Eclipse IDE for java developers. Applied the MAC address drop policy algorithm to improve the authentication technique. The proposed protocol performed the best standards for wireless data transmission between the two endpoints over the wireless network system.

IV. RESULT & DISCUSSION

The experiment was conducted on a hardware platform with Windows 10 64-bit operation system, Intel(R) Core (TM) i7-8550U CPU, and 16 GB memory. The entire machine learning platform was developed in TensorFlow deep learning framework by using Python as the programming language. Data warehouse was implemented in the Druid platform to provide a centralized data storage solution. The proposed networking protocol was developed on the Java IDE platform (Eclipse) using Java as the programming language. Furthermore, the development stages were used the Encryption algorithm, authentication method, and Kali Linux VM.

A web based applica tion: "PROPER GLOVE" system has been developed to optimize the glove production. A user friendly API was developed which can be applied and use to each production stage with relevant production details with/without computer literacy. Mainly this system has three functions.

1. Chemical consumption prediction system
2. Defect occurrence prediction system
3. Automated quality assurance system

At first, assigned worker of each production section can login to the system with proper credentials and insert production data related to each production stage. Once all the details are filed this will saved in a database. The data will be loaded into a centralized data warehouse which is implemented for decision making purpose.

In defect occurrence prediction system, after all the production parameters been inserted, the system can predicts the defect occurrence using plant parameters and environmental conditions. Based on the predicted results the production can be categorized into defective production or defect less production.

When the production is completed and final product is moved to quality inspection, automated quality assurance system, will be used to inspect the quality of each glove. The system is integrated with computer vision and IoT platform for maximum service.

The network attack was detected using Wireshark and Kali Linux VM with Aircrack-ng package used for Pre-Shared Key calculation. MATLAB software was used to test the consistency of the proposed module signal. Network performance statuses such as throughput, delay, and packet loss rate were collected using OPNET simulator software. The existing network performance statues were tested with the proposed network to get the best performance in the data communication system. The results show throughput and delay were increased and No packet lost. Hence the proposed protocol can accomplish customer requirements.

V. CONCLUSION & FUTURE WORK

This study aims to optimize the supported glove manufacturing process by applying machine learning and computer networking approach and build a desktop application which can be used to identify the production issues in the early production stage.

If defect occurrence can be predicted while the production is taking place, it helps identify, control, and eliminate the root causes. Also, such a system can save worker labor as well as time and capital used on production. The suggested visual inspection system for quality checking can be a significant cause to increase productivity. Whether defect predictions are performed for the ongoing processor for the final product, it is vital to continuously improve machine learning models for more reasonable accuracy due to the variations in sample distribution. The proposed system can predict defect occurrence only by analyzing production parameters and optimizing parameters according to necessity. Also, the proposed chemical consumption forecasting method eliminates unnecessary cost and waste on expensive chemicals.

The centralized data warehouse solution improves efficient decision-making between head office and production plants of XYZ glove manufacturing company. The study suggests a low-cost, secure, and reliable wireless communication protocol that improves communication between factory plants and head branches. As seen in the test result, the wireless protocol communicated between the server and programmable logic controller, requiring a hardware module to execute the wireless protocol. The protocol code can be enhanced using hardware devices, and GUI improvement will be made. Data communication can be visualized. As an overall optimization in the production process means and has significant practical and commercial value and importance, which can be further improved and applied in any industrial production.

REFERENCES

[1] Sri Lanka Export Development Board,"Rubber Glove Industry in SriLanka - EDB Sri Lanka", Srilankabusiness.com, 2021. [Online]. Available: https://www.srilankabusiness.com/rubber/rubber-glove-industry-sri-lanka.html. [Accessed: 20- Mar- 2021].

[2] A. H. Tan, C. Leei Cham and E. H. Ying Lim, "Analysis and Prediction of Glove Quality Based on Manufacturing Factors," 2020 IEEE International Conference on Power and Energy (PECon), Penang, Malaysia, 2020, pp. 420-425, doi: 10.1109/PECon48942.2020.9314405. IEEE.

[3] Difana Meilani, Dicky Fatrias, Amelia Andiningtias, "Decision Support System for Inventory Control of Raw Material," in *5th International Conference on Industrial Engineering and Applications*, 2018. IEEE.

[4] D. Yanwei, "Research on Requirement Forecasting of Raw Materials for Boiler Manufacturing Enterprise Based on Exponential Smoothing Method," 2010 Second International Conference on Computer Modeling and Simulation, Sanya, China, 2010, pp. 219-222, doi: 10.1109/ICCMS.2010.418. IEEE.

[5] Xue Shanliang, Cheng Sijia, Li Mengying,Yuan Yong,, "Feature Selection Algorithm Based on Sparse Score and Correlation Analysis," in *IEEE Intl Conf on Parallel & Distributed Processing with Applications, Big Data & Cloud Computing, Sustainable Computing & Communications, Social Computing & Networking*, 2019. IEEE.

[6] Kyoung Min Kim, Byung Jin Lee, Kyoung Lyou and Gwi Tae Park, "Design of a binary decision tree using the genetic algorithm and K-means algorithm for recognition of the defect patterns of cold mill strip," FUZZ- IEEE'99. 1999 IEEE International Fuzzy Systems. Conference Proceedings (Cat. No.99CH36315), Seoul, Korea (South), 1999, pp. 1081-1085 vol.2, doi: 10.1109/FUZZY.1999.793104. IEEE.

[7] R. G. Ramani, S. V. Kumar and S. G. Jacob, "Predicting fault-prone software modules using feature selection and classification through data mining algorithms," 2012 IEEE International Conference on Computational Intelligence and Computing Research, Coimbatore, India, 2012, pp. 1-4, doi: 10.1109/ICCIC.2012.6510294. IEEE.

[8] KS. Wang, "Towards zero-defect manufacturing (ZDM)—a data mining approach," no. 1, pp. 62–74, March 2013, doi:https://doi.org/10.1007/s40436-013-0010-9.

[9] F. Eger, C. Reiff, B. Brantl, M. Colledani, A. Verl, "Correlation analysis methods in multi-stage production systems for reaching zero - defect manufacturing," Procedia CIRP, vol. 72, 2018, pp. 635-640. IEEE.

[10] S. Samsani, "An RST based efficient preprocessing technique for handling inconsistent data," 2016 IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), Chennai, India, 2016, pp. 1-8, doi: 10.1109/ICCIC.2016.7919591. IEEE.

[11] Li Jian, Han Wei and He Bin, "Research on inspection and classification of leather surface defects based on neural network and decision tree," *2010 International Conference On Computer Design and Applications*, Qinhuangdao, China, 2010, pp. V2-381-V2-384, doi: 10.1109/ICCDA.2010.5541405. IEEE.

[12] H. Ando, Y. Niitsu, M. Hirasawa, H. Teduka and M. Yajima, "Improvements of Classification Accuracy of Film Defects by Using GPU-accelerated Image Processing and Machine Learning Frameworks," *2016 Nicograph International (NicoInt)*, Hanzhou, China, 2016, pp. 83-87, doi: 10.1109/NicoInt.2016.15. IEEE.

[13] Y. Deng, A. Luo and M. Dai, "Building an Automatic Defect Verification System Using Deep Neural Network for PCB Defect Classification," *2018 4th International Conference on Frontiers of Signal Processing (ICFSP)*, Poitiers, France, 2018, pp. 145-149, doi: 10.1109/ICFSP.2018.8552045. IEEE.

[14] S. Cheon, H. Lee, C. O. Kim and S. H. Lee, "Convolutional Neural Network for Wafer Surface Defect Classification and the Detection of Unknown Defect Class," in IEEE Transactions on Semiconductor Manufacturing, vol. 32, no. 2, pp. 163-170, May 2019, doi: 10.1109/TSM.2019.2902657. IEEE.

[15] J. Zhao, Q. Kong, X. Zhao, J. Liu and Y. Liu, "A Method for Detection and Classification of Glass Defects in Low Resolution Images," 2011 Sixth International Conference on Image and Graphics, Hefei, China, 2011, pp. 642-647, doi: 10.1109/ICIG.2011.187. IEEE.

[16] S. B. Kang, J. H. Lee, K. Y. Song and H. J. Pahk, "Automatic defect classification of TFT-LCD panels using machine learning," 2009 IEEE International Symposium on Industrial Electronics, Seoul, Korea (South), 2009, pp. 2175-2177, doi: 10.1109/ISIE.2009.5213760. IEEE.

[17] M. M. Mottalib, M. Rokonuzzaman, M. T. Habib and F. Ahmed, "Fabric defect classification with geometric features using Bayesian classifier," 2015 International Conference on Advances in Electri cal Engineering (ICAEE), Dhaka, Bangladesh, 2015, pp. 137-140, doi: 10.1109/ICAEE.2015.7506815.

[18] G. Mariani, G. Palermo, R. Meeuws, V. Sima, C. Silvano and K. Bertels, "DRuiD: Designing reconfigurable architectures with decision-making support," 2014 19th Asia and South Pacific Design Automation Conference (ASP-DAC), Singapore, 2014, pp. 213-218, doi: 10.1109/ASPDAC.2014.6742892. IEEE.

[19] J. Correia, M. Y. Santos, C. Costa and C. Andrade, "Fast Online Analytical Processing for Big Data Warehousing," 2018 International Conference on Intelligent Systems (IS), Funchal, Portugal, 2018, pp. 435-442, doi: 10.1109/IS.2018.8710583. IEEE

[20] . Badholia, V. Verma and S. K. Kashyap, "Wep, Wap and Wap2 Wireless Network Security Protocol: A Compact Algorithm: (Wireless Network Security Protocol)," 2019 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS), Greater Noida, India, 2019, pp. 239-243, doi: 10.1109/ICCCIS48478.2019.8974517. IEEE.

[21] T. A. T. Aziz, M. R. Abd Razak and N. E. A. Ghani, "The performance of different IEEE802.11 security protocol standard on 2.4ghz and 5GHz WLAN networks," 2017 International Conference on Engineering Technology and Technopreneurship (ICE2T), Kuala Lumpur, Malaysia, 2017, pp. 1-7, doi: 10.1109/ICE2T.2017.8215954. IEEE.

[22] K. Moissinac, D. Ramos, G. Rendon and A. Elleithy, "Wireless Encryption and WPA2 Weaknesses," 2021 IEEE 11th Annual Computing and Communication Workshop and Conference (CCWC), NV, USA, 2021, pp. 1007-1015, doi: 10.1109/CCWC51732.2021.9376023. IEEE.

[23] K. Monga, V. Arora and A. Kumar, "Analyzing the behavior of WPA with modification," 2015 International Conference on Communication

Networks (ICCN), Gwalior, India, 2015, pp. 53-56, doi: 10.1109/ICCN.2015.11. IEEE.

[24] R. K. Kodali, S. K. Gundabathula and L. Boppana, "Implementation of Toeplitz Hash based RC-4 in WSN," 2015 IEEE International Conference on Signal Processing, Informatics, Communication and Energy Systems *(SPICES)*, Kozhikode, India, 2015, pp. 1-5, doi: 10.1109/SPICES.2015.7091535. IEEE