Real-time Machine Vision-based Quality Inspection System for Small and Medium Enterprise

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Project Registration

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Type (Nature of project)	[ ] **D**evelopment [ ] **R**esearch [ ] **R**&**D**					
Area of specialization						
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Plagiarism Free Certificate

This is to certify that, I am Abdul Wajid S/D/o Abdul Khaliq, group leader of FYP under registration no CUI/ **SP17/BCS/079** /LHR at Computer Science Department, COMSATS University Islamabad, Lahore. I declare that my FYP proposal is checked by my supervisor and the similarity index is ____4____% that is less than 20%, an acceptable limit by HEC. Report is attached herewith as Appendix A.

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Abstract:

This project aims to develop a real-time machine vision-based quality inspection system for small and medium enterprises. Labeling errors that occur during packaging can damage consumers' perception of quality. To meet the quality and aesthetic expectations of customers, it is important to identify labeling defects before goods reach the market. All industries are in the race of making their products more apparently and qualitatively appealing. In Pakistan, Quality Inspection responsibility is handed over to the human labor but the Production lines works on so high speed that's it is very difficult to catch minor errors in packaging by Humans so our system shall perform Machine Vision-based measures for quality assessment of the products in real-time to ensure the standard of products. Tests include identification of dirt spots, print template analysis, correct seals, torn, damaged and missing labels of packaging. The basic aim behind this project is to promote the fourth industrial revolution and Artificial Intelligence in Pakistan because our country is lacking in both. Deployment of this system will include specialized cameras, a computer with the design and implementation of industry-standard HMI.

Introduction:

Industry 4.0 pursues the goal to optimize the production output through an efficient collaboration of all components of the production process with the adoption of latest technologies like computer vision, machine learning, deep learning and automating the decision making. Cyber-physical systems, the Internet of Things and the Internet of Systems make Industry 4.0 possible and the smart factory a reality. Companies are increasingly investing on their solutions and tools to digitalize their machines, manufacturing processes and products and to intergrate all things together in a single integrated network to enhance the productivity and quality of the product and reduce cost [1]. Figure 1 illustrates the revolution in industry 4.0.

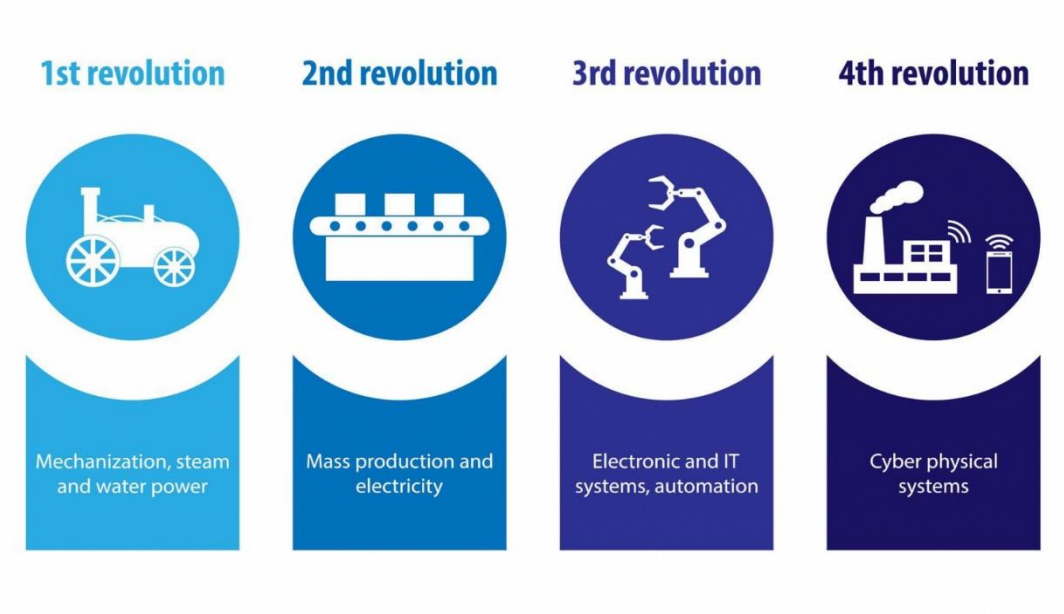

Figure 1 : Industry 4.0 revolution [2]

Consumers have raised expectations of the quality and appearance of products. Many companies perform quality inspections on their products using human labor but they are

unable to detect small errors in packaging because of the limitations of humans and the high speed of product line. For example, in the production line of a company, it gives an output of forty-two sachet per minute and there is no mechanism of checking the quality of packaging as shown in figure 2. There can be many issues in packaging like there could be dirt, seals could be damaged and labels could be missing. All these issues can damage the reputation of a company. For all these reasons, we need quality inspection tools to make our tasks easy and efficient.

Figure 2: Packaging machine [3]

In industry 3.0 humans use different tools to ensure the quality of packaging. But it still needs the help of a human to ensure the quality. Packaging lines perform the packaging of products at a very high speed. Human labor is unable to perform a quality check on every product. Industry 4.0 lets the machines work independently without the involvement of humans. Machines are itself intelligent to do all these tasks without the supervision of human at very high speed. The machine collects a lot of data and processes it at a very high speed and ensures the quality of the product by triggering actions itself.

The standards that are available for quality control of packaging material include:

- The BRC/IOP is a Global Standard devoted to packaging industries that manufacture packaging materials used in various industries. The purpose behind creating this standard was to provide a set of instructions for packaging industries that ensures consumer's safety and fulfillment of legal requirements. [4]
- Regulation (EC) No 1935/2004): The labeling, presentation and advertising shall not delude the customers. Also, packaging material's traceability should be ensured at all phases to ease control. [4]
- ISO 9001:2015 is a quality management standard that allows the production of ISO quality packaging. It also acts as a core component in operating a quality management system throughout the manufacturing process.

Other developed countries are using autonomous quality inspection tools for a long time. These tools are not fulfilling our Pakistan's industry requirement as they are specially built for their industry requirements and standards. When these technologies are integrated into our industry it becomes very expensive in terms of both time and money. Pakistani Industry

is far away from Industry 4.0 and thus or country is lagging in the race of innovation and advancement. Our basic aim is to develop a real-time vision-based quality inspection system for small and medium industries of our country. It would also be cost-effective.

Based on all these factors we want to purpose a system for quality inspection of 'packaging material ' with the help of machine vision and artificial intelligence to promote industry 4.0 and automation in our country. Our system will inspect the product packaging in real-time to ensure the quality and standard of the product by performing various tests.

- Identification of dirt spot: The system shall examine the finished product for dirt spot identification. The dirt spots can be either stains or blots on the packaging material. It will have an acceptable range according to the industrial standards, and if the dirt spot exceeds that range the system will fall in unacceptable range and thus will be rejected.
- Print template analysis as per quality standards: The system shall examine the packaging material to see if the printing is done according to the industrial quality inspection standards or not.
- Identification of faulty seals: The system shall examine the seals of the packaging sachet to see if the seals are at their positions and no seal is defective or torn.

Our target will be achieved using cameras computer and cloud technology. Cameras will capture real-time images. After capturing, it sends images to our system for further processing. Our system will perform quality inspection tests on images using intelligent computer vision and machine learning algorithms. After performing all these tests our system will show a response on HMI terminal whether the packaging quality is acceptable or not. HMI application will be of industrial standards. The resulted information would also be stored in our database for later use.

Motivation and Scope:

In other countries, modern technologies are used to ensure the quality of the packaging material. In Pakistan, there are very few industries that are using an autonomous system to inspect the quality of packaging. Most of the local industries are using human resources for quality inspection which is not enough to ensure the quality of packaging and its very time-consuming.

Our goal behind the development of this system is to promote the modern industry 4.0 concept in our country. Our system will enable local small and medium industries to check the quality measures of product packaging at low cost at high speed without any error.

The main motivation towards this project is to contribute towards the promotion of Industrial 4.0 and Artificial Intelligence in Pakistan

Related Work:

The related work section contains the data from research papers and the details of some products currently working in the industries.

To prevent the damage in packaging material a solution was proposed by Stanley Mamah.In this research work a classification system was developed to assist manufacturing engineer to detect the damages in final product [5].

Convolutional Neural Networks based solution was proposed by Mahdi Bahaghighat, Fereshteh Abedini, Arthur-Jozsef Molnar and Misak S'hoyan to prevent the damage of the bottle caps in drinks manufacturing factory. This paper focuses on the visual inspection of bottle caps in drink factories. 99% accuracy was achieved in this solution based on VGG-19 as an End-to-End deep learning approach. [6]

Optimal approaches to the quality control were proposed by Smith-spark to detect wrong information presented on labels of the Packaging of Various Products. Most of the label errors get undetected due to which the paper suggested the use of software and hardware-based systematic approach. [7]

Distributed Vision Network for Packaging Inspection was proposed by Meliones to deal with the Industrial Packaging Inspection for various products. The Independent Stations that the system had was able to do inspection tasks parallelly such as identification of products, an inspection of product tags and quality control of packaging at high speed and in less time. [8]

A Real-Time Artificial Vision by Aguilar-Torres was proposed to check the quality of the packaging of the industrial products. It performs visual inspection using Pattern Recognition techniques. [9]

Due to continuous advancements in the Internet of Things (IoT) and Sensor Networks, Industry 4.0 having a deep effect on every aspect of the industry, from logistics to quality control. The quality inspection of the products will not deal in a different section. It will be on the production line at the end. The continuous transfer of information from WSNs to the decision-making bodies is the foundation of Industry 4.0. The overall analysis of industry 4.0 on quality inspection is imperative. [10]

Some of the Quality Inspection Tools that are currently available in the market are as follows:

Cognex vision systems inspect food packaging to ensure it is correctly assembled, defect-free, and complete so that only the highest quality products reach customers. Machine vision, barcoding methods and 3d laser profilers are used in their solution. [11]

Figure 6:Cognex solution for packaging [11]

The quality inspection tool by Futec company allows to prevent,eliminate and documentation of potential printing defects. In this process the data of packaging print is compared with the master files to prevent the defects. On the basis of comparison the end product packaging is classified as acceped or rejected. Figure 3 describes the errors caught by their solutions. [12]

Figure 3: Example of detected errors by Futec tool [12]

Quality Inspection Tool by the EyeC company that provides inspection of print defects and catch artwork before they start generating losses. The machine in figure 4 below is one of their product. [13].

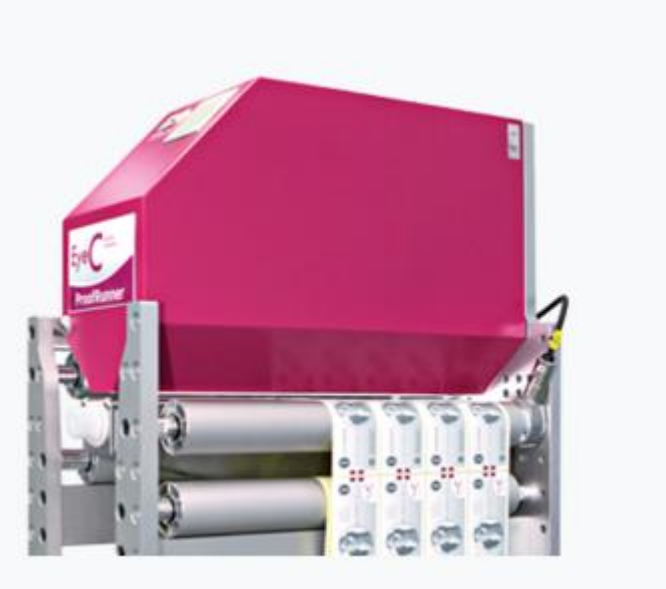

Figure 4 : A Tool by EyeC company [13]

The TriVision IML Packaging Inspector is offering quality control of packaging products that are produced using IML technologies [14].

Quality Inspection Solution by YUZEN is focusing on quality inspection and control of plastic packaging. Their main customers are in food, drug packaging, packaging industry, plastic and rubber packaging. [15]

System Architecture:

The system architecture is illustrated in figure 5. Our system shall have two cameras one for the front view of packaging and another for the back view. The cameras will send data to our computer\processing unit for further processing. The processing unit will process the data and show output results on the HCI terminal. Data will be processed by matching real-time images with sample images using a machine learning algorithm. All our processing units will be connected to a cloud and that cloud will be connected to the server, saving all the data in the database.

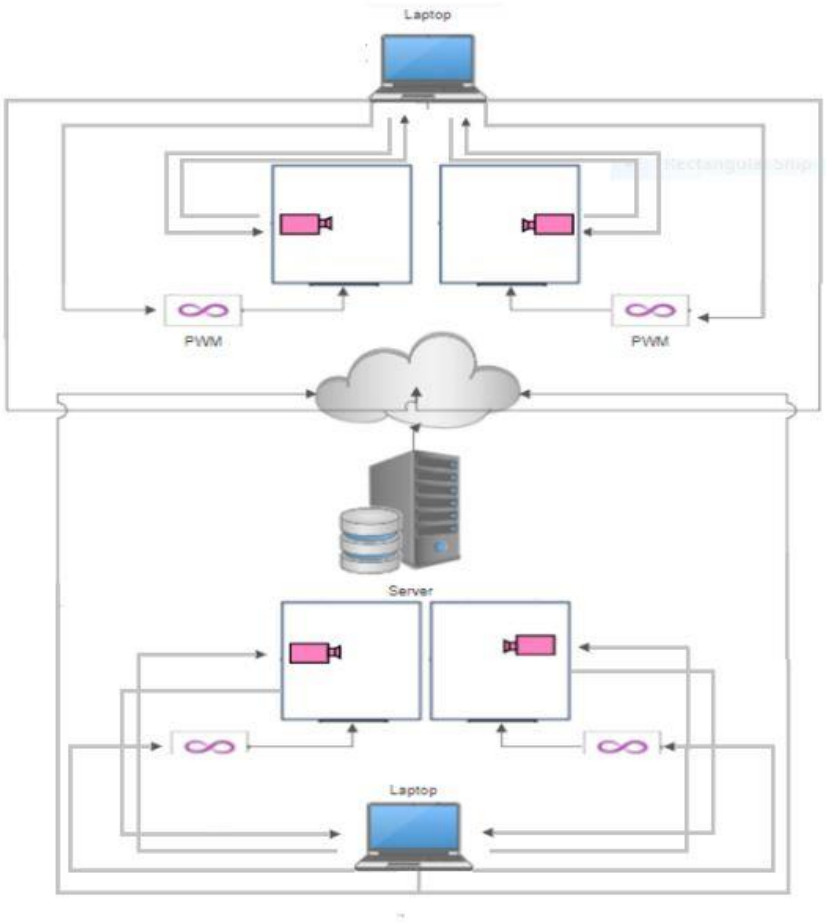

Figure 5 : System Architecture

Goals and Objectives:

- Develop a real-time Inspection of packaging material.
- Develop a module for dirt spot identification of packaging material.
- Develop a system to entertain the high speed production of products.
- Develop a system to reduce scrapping in packaging.
- Develop a module to recognize printing mistakes on the packaging.
- Efficient and accurate inspection of packaging.
- Reduce the time of the quality inspection process in packaging.
- Develop a cost-effective system

1.1 Individual Tasks:

Umer Imtiaz	Abdul Wajid	Abdul Muhib
• Packaging print template analysis model • Correct sealing inspection model	• Dirt spot detection model • Packaging print template analysis model	• Correct sealing inspection model • Dirt spot detection model

• Design • Database Integration • Synchronization of cameras with Real time environment • Testing	• Analysis • Implementation of standard HMI • Synchronization of cameras with Real time environment • Testing	• Documentation • Design of standard HMI • Synchronization of cameras with Real time environment • Testing

Gantt Chart:

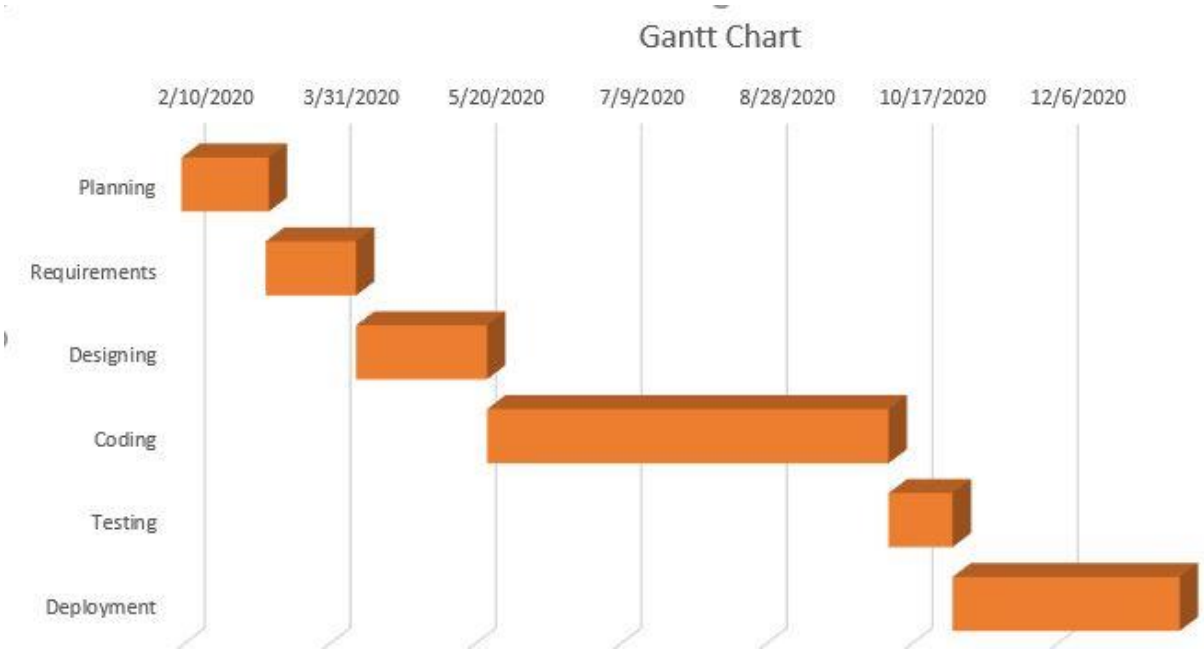

Figure 6: Gantt Chart

Tools and Technology:

- Python as core language to develop the project.
- Tensor flow library for deep learning and computer vision.
- PyCharm is used as an integrated development environment for our project.
- Tkinter framework for HMI application

References

[1] B. Marr, "Forbes," 2 sept 2018. [Online]. Available: https://www.forbes.com/sites/bernardmarr/2018/09/02/what-is-industry-4-0-heres-a-super-easy-explanation-for-anyone/#4a8444959788.

[2] Rossana, "tracesoftware," 12 Nov 2018. [Online]. Available: https://www.trace-software.com/blog/what-is-industry-4-0/.

[3] "gempackindia," [Online]. Available: https://www.gempackindia.com/form-fill-seal-machines.html.

[4] A. Cholewa-Wójcik and A. Kawecka, "PACKAGING QUALITY ASSURANCE IN SUPPLY CHAIN," in *14th International Scientific Conference*, Osijek, Croati, 2014.

[5] S. Mamah, "A Method for Damage Detection in the Packaging Materials," March 2019.

[6] M. Bahaghighat, f. Abedini, A.-J. Molnar and M. , "Vision Inspection of Bottle Caps in Drink Factories Using Convolutional Neural Networks," in *Conference: IEEE 15th International Conference on Intelligent Computer Communication and Processing (ICCP 2019)*, Romania, 2019.

[7] Smith-Spark, Katz and Wilcockson, "Optimal approaches to the quality control checking of product labels.," *International Journal of Industrial Ergonomics, 68,* pp. 118-124, 2018.

[8] Meliones, Baltas, S. P. Kammenos, Vardangalos and Kuleschow, "A distributed vision network for industrial packaging inspection," in *In International Conference on High-Performance Computing and Networking*, 2006.

[9] Aguilar-Torres, Argüelles-Cruz, A. J, Yánez-Márquez and M. A., "A real time artificial vision implementation for quality inspection of industrial products," in *In 2008 Electronics, Robotics and Automotive Mechanics Conference (CERMA'08)*, 2008.

[10] Godina, Radu, Matias and Joao, "Quality Control in the Context of Industry 4.0.," pp. 177-187, 2019.

[11] "Cognex," Cognex Solutions, [Online]. Available: https://www.cognex.com/industries/food-and-beverage.

[12] "Futec," [Online]. Available: https://www.futeceurope.com/printing-quality-control-and-process/.

[13] “EyeC "Your Vision for quality",” EyeC GmbH, [Online]. Available: https://www.eyec-inspection.com/.

[14] “IML packaging Inspector,” [Online]. Available: https://trivision.dk/iml-packaging-inspector/.

[15] “Bottle Vision System,” [Online]. Available: http://www.yuzenvision.com/products_list-6.html.