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Food Quality Assurance using Artificial Intelligence: A Review Paper

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Abstract -*In this article, we will look at how Artificial Intelligence has entered the food business and how it has affected the food security assurance department. This review article will look at several AI technologies that have been utilized to provide high-quality products to customers. As people have gained knowledge over the years, their requirements have increased and to fulfil them who AI (Artificial Intelligence) is being brought into the picture will be clear through this paper. AI works more efficient as compared to a human when it comes to specification and uniformity. Now a day's right from formation of micro-organisms, bacteria, Quality to Size of the cookie and no. of Chocó-chips on them everything is being closely monitored by the Food Associates and to ensure these AI has been brought into the scenario and it has helped a lot by increasing efficiency and decreasing the overall cost of the food product. Using a Ketchup production unit as an example, we will show how ML (Machine Learning), DL (Deep Learning), NLP (Natural Language Program), Computer Vision, and Robotics (a subset of AI) are used to produce high-quality food items. This will let other industries deploy and realize the benefits of AI in their manufacturing units.*

Key Words: **Artificial Intelligence, Machine Learning (ML), Deep Learning (DL), Computer Vision, Robotics, Food Industry, Algorithm, Prediction.**

1. INTRODUCTION

The food business is one of the most rapidly growing industries. We began by selling homemade products at clients' homes and have now expanded to huge companies that generate tons of food every day. With growth comes the need to maintain quality and other parameters independent of product demand or any other reason. All of this cannot be accomplished by either a human or a computer alone, therefore machines and humans must collaborate to reach this goal; this collaboration is known as artificial intelligence. The main reason for using artificial intelligence in the food industry is that it can function as both a robot and a person at the same time. With the help of artificial intelligence, the best output can be obtained by taking into account all of the factors such as raw material quality, environmental temperature, fermentation, and bacterial development in the product when obtaining the final items.

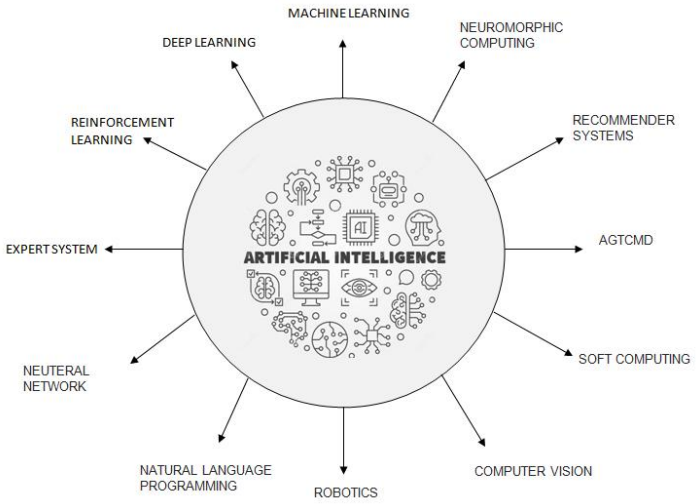

Fig-1 Branches of AI

AI is a huge technology in and of itself. Fig. 1 shows some of the branches of Artificial Intelligence which have been invented according to the requirements of the industry ML is one of the most frequently utilized fields of AI, as it is employed in almost every industry. It has greatly simplified the process of data analysis. DL is just the next stage in the evolution of ML, and it is utilized for massive data analysis in image processing, speech recognition, object identification, and other disciplines. It has recently gained acceptance in the disciplines of food science and engineering. When it comes to computer vision, it takes digital images and videos as input and makes a decision after scanning all of the perimeters. NLP and Robotics is the most important of all. A robot is a mechanism, particularly one that can be programmed by a computer that is capable of carrying out a complicated set of tasks automatically. An external control device can lead a robot, or the control can be incorporated within the robot. NLP, or Natural Language Programming, as the name implies, aids in the accomplishment of AI by the use of natural language that is readily changed and understood by laypeople.

From the standpoint of the food industry, machine learning, deep learning, robotics, and computer vision are commonly used in the four Ps of the food industry: picking, processing, packaging, and palletizing. Through this article we will discuss how at each and every level AI is used and its benefits as compared to traditional methods. This article uses a Ketchup production unit as an example to demonstrate how AI is or may be applied in each phase of the 4Ps.

2. LITERATURE REVIEW

According to [1,] using the approach outlined in this paper to evaluate the appearance quality and differentiate the grade of the specification can result in a highly accurate rate, which must have a beneficial impact on peanut production and industry growth. Table III shows the results of the neural network judging method on grains of different specifications. In the table, 100 (97+2A+1P) signifies that there are 100 grains in this grade, 97 of which are the same as the number obtained by hand, +2A represents two worm-eaten grains classified as D, and +1H represents one normal seed labelled as P. The study analyses the image processing approach used in assessing the quality of peanut kernels; several amplitudes of the output designs are created using national standard data.

Here in [2], we note that the data can come from agriculture, food processing/manufacturing, supply chain, traceability, or consumers. Sensors are sites of data collection on the Internet of Things, but views posted on social media platforms are the source of data from the customers. Data processing is now usually done from remote sites utilizing high-performance computers, which is referred to as "cloud computing." The information gathered about the system may be used to make judgments on how to improve the activities' performance or make appropriate recommendations.

In paper [3], a strong yet easy technique is presented for detecting dairy products that include or do not contain non-dairy additives (NDA), as well as distinguishing organic from non-organic food items, leveraging neural networks trained with acoustic frequency responses. Although the hypothesis is evaluated on butter samples, the approach may also be applied to other dairy products. While this approach of trial and error would take a long time to arrive at a decision, an artificial intelligence (AI) algorithm may be used to extract high-level characteristics of a material's reaction to a variety of frequencies and compare them across various materials

The use of 4.0 industrial revolution technologies such as computer vision and artificial intelligence in agriculture and the food sector is described in the study [4]. The current review, in particular, provides a clear understanding of computer vision and intelligence methodologies that are applied to a variety of agricultural applications, including food processing, agriculture-based applications, farming, plant data analysis, smart irrigation, and next-generation farming. In addition, the article focuses on the fundamental concept of employing sustainable 4 IR technologies to ensure that humankind has enough food by 2050 while being ecologically friendly. The importance of the AgriTech industry, as well as investments based on AI and vision technologies, was addressed with relevant sources and use-cases.

A virtualization approach for the food manufacturing process has been proposed in [5], which is backed by a cloud platform. The virtualization's heart is a set of intelligent algorithms (ANNs) that use NIR spectrometry data from samples to assess organoleptic attributes. The virtualization technique has been used to the cheese production process as a case study. The key agents (quality manager, tasters, tasting organizers, quality inspector) collaborate and exchange information from various points using the cloud ICatador platform, and instrumental data is systematically incorporated.

To replace manual grading, a machine vision-based approach is employed in [6], which requires both hardware and software to assess product quality. Depending on the product we grade, hardware such as a camera, conveyer belt, light sensors, and speed control sensors are required. The characteristics of the obtained pictures are retrieved, and the images are pre-processed using image processing techniques. In several industries, the grading procedure is increasingly developed to determine the quality of items. Finally, the appropriate Artificial Intelligence model is employed for categorization and to analyse the approximate value of the quality detection. Artificial intelligence is mostly employed in agricultural products.

3. PROPOSED METHODOLOGY

Some people enjoy it with burgers, while others prefer it with fried noodles; in fact, tomato ketchup has become an essential element of our diet. According to a poll, the average American consumes 71 pounds of ketchup per year, indicating the size of the industry. With an expanding market, it is critical to ensure that quality is maintained at the same cost, which is hard to do using traditional methods. But, thanks to artificial intelligence, this has become a piece of cake. We will demonstrate how AI is utilized at each and every stage of manufacturing and packing Ketchup, from a tomato seed to a bottle of rich and fresh ketchup, using the suggested technique. Each stage (Picking, Processing, Packaging and Palletizing) is discussed, as well as how Machine Learning, Deep Learning, Computer Vision and Robotics are used in these processes.

3.1 Picking:

3.1.1 Prediction of best quality of Crop:

As we all Know best tomatoes are chosen for manufacturing tomato ketchup. It is very important to select the best seed for it, out of the tons of samples which are brought into the factory, only those dark red in color are selected .For these purpose we need to select the perfect seed for it .So machine learning plays a role to select the best seed among variety of available seeds for growing tomatoes by observing their Rate of growth, need of water, Sweetness and Sourness Factor etc. .For this Purpose ML uses the algorithm data Collection and Classification .With the help of data collection we can collect

the information about variety of seed and classify them into different group according to their ability to grow best tomatoes.

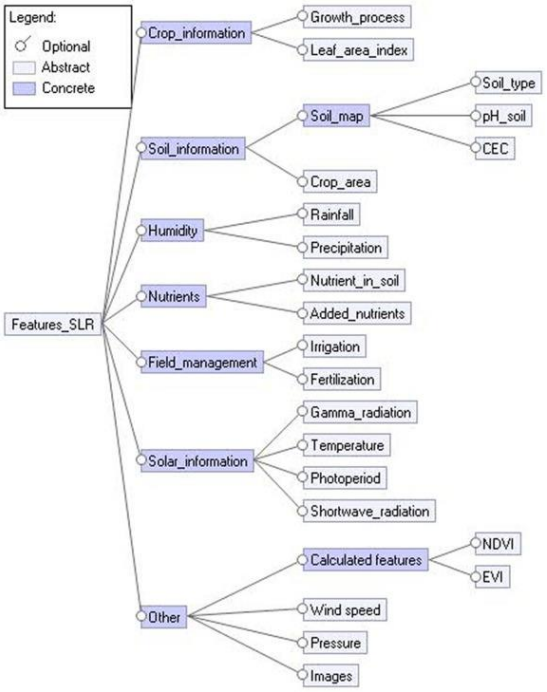

Fig-2 Machine Learning Perimeters Used in crop Prediction

Fig. 2 depicts all of the perimeters evaluated in predicting crop production. All of these perimeters are gathered for each quality of seed, and predictions are made using Linear Regression/Logistic regression/K-mean clustering. This is considered the beginning phase of the project, as it occurs prior to the establishment of the ketchup production factory. Before installing a manufacturing unit, a similar linear regression is used to forecast the optimum placement for the unit, taking into account parameters such as market, location, transportation facilities, and so on. With these forecasts, the company's entire profit is projected based on many parameters, which is impossible to do manually.

3.1.2 Computer Vision in Picking:

Firstly, the tomatoes are being harvested and washed. Once they are cleaned, they pass through a convey belt where they have to pass through a scanner. This scanner uses the concept of Computer vision to ensure the quality check of the tomatoes before they are passed on for the next step. All the raw/rotten /under size tomatoes are filtered out using Computer vision. The algorithm is used in such a way that it scans all criteria like diameter, color, discoloration due to bacterial impact, if any one of them gives a false Judgement for a tomato it is being thrown away. Earlier to carry out this task a large about of labor and time was invested eventually increasing the cost of production. In the same way all the raw materials are scanned using Computer vision to ensure quality of ketchup.

Fig-3 Computer Vision in Picking

3.2 Processing:

3.2.1 Deep Learning in Processing of Tomato ketchup:

One of the most extensively produced and consumed agricultural items is the tomato Harvesting, sorting, and grading of fruits are the primary functions of these systems, while calibrations are performed to determine characteristics such as color and size as well as mass, shape, and flaws. So, the development of an effective fruit identification and mass estimate system is essential for the creation of a fully automated farming and packaging pipeline. Object detection, categorization, and analysis are the three key phases in this method.

A few of the most common picture pre-processing methods used in the processing of the ketchup includes the color processing of the final outcome i.e., the sauce itself. Imaging's segmentation is one of the most significant elements in image processing since it decides whether image analysis is concentrated on the target sample or not. Similarly, regression prediction models based on both 2-D and 3-D picture characteristics were used to estimate tomato fruit mass from volume. Using multiple artificial intelligence methods, we used the connection between 2-D size and mass of tomato fruit to derive the physical link between these characteristics. These techniques were trained and evaluated on the output from the geometry module (estimated dimensions) to estimate the final mass using the tomato dataset.

For e.g., Feature extraction backbone network, region proposal network (RPN) to generate anchors, and an FCN running parallel to fully connected networks that output instance-wise semantic masking and target detection with classification outputs are shown in the figure below as a complete framework for the Mask-RCNN.

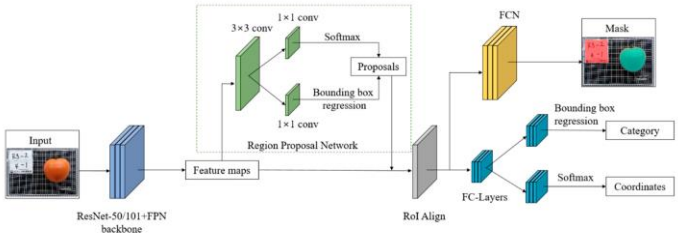

Fig-4 Process of Computer Vision at Machine level

3.2.2Computer vision in Processing Tomato Ketchup:

As soon as the highest quality tomatoes and other materials have been acquired, they are combined and processed into a final product. A computer vision system is used to monitor the slurry and its temperature to determine the temperature, mixing speed, and time of adding a component. Prior to this, the worker had to manually check all the perimeters, which may lead to over processing of the ketchup, ruining the entire batch, and costing the company money.

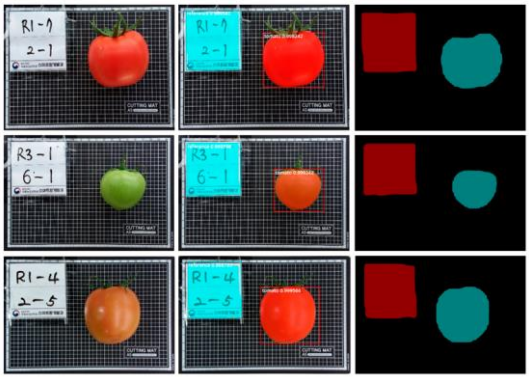

Fig-5 Computer vision at processing Level

Because color and density are important factors in ketchup, machine vision closely monitors the color and density of the ketchup as it is heated and processed. This reduces the laborious work of testing each batch of ketchup and making the necessary calculations. This Machine Vision output is also utilized as an input in Deep Learning to predict the time necessary to make the perfect decision.

3.3 Packing and Palletizing:

3.3.1 Computer vision in Packaging:

Once the tomatoes have been converted into ketchup, the next step is to package and palletize it. In the packaging industry, computer vision is crucial. After cleaning and filling the bottles with fresh ketchup, it is necessary to check if all of the bottles are full and clean, and this task is performed by Computer Vision / Machine Vision. A camera, combined with a sensor, is used to capture the digital picture. Fig 6 shows how a bottle of ketchup that has not been properly filled is removed from the convey belt before the cap is applied. As a result, Machine Vision is used to ensure consistency and precision.

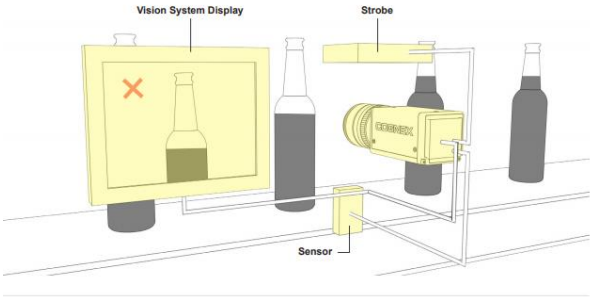

Fig-7 Computer vision scanning and eliminating bottles which are not filled up to the mark

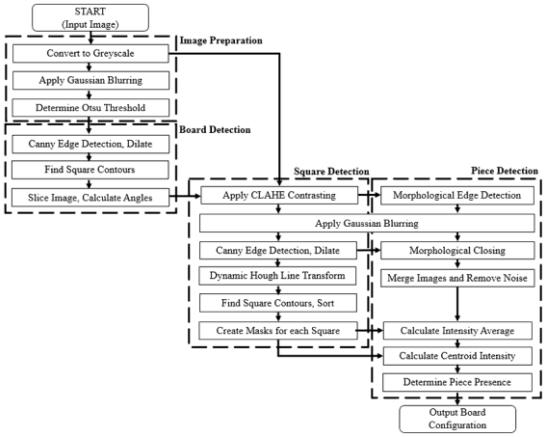

Fig-8 Process of Computer vision

Caps are placed and sealed on the bottles and again Computer Vision starts doing its work i.e., to check the bottles are sealed properly and are perfect to be palletized. Same mechanism of Computer vision is also implemented here; Fig. 8 shows the flow chart of the process followed by computer vision. All the bottles which are not sealed are eliminated and remaining is send forward where a robotic unit places a sticker on each bottle.

3.3.2Robotics in Palletizing:

Before Palletizing, a robot verifies and prints the price, as well as the production and expiration dates, on the sticker. The robotic unit obtains this information based on the date it was produced and its contents. A robotic arm then picks 12 bottles and places them in a box, which is then packaged and stacked on a pallet using a fully automated Robot. The robot places 100 boxes on a pallet, shrink wraps them, and stores them in warehouses; from there, they are transported in accordance with the requirements. A robot maintains track of all the pallets based on their production dates and selects them when it is time to send them. Packing and palletizing such large and fragile items requires a lot of human labor and time, lowering productivity and raising total production costs. There is also the possibility of human mistake, but with robots, precision and error-free goods are guaranteed.

Fig-9 Robots performing the process of Palletizing

4. COMPARATIVE ANALYSIS

The line graph in Chart .1depicts how Artificial Intelligence has affected the Food Industry's Market and Profit. Profitability began to decline about 2005, owing to the high cost of installing AI. However, once it is operational, the profit doubles. Furthermore, there has been a significant increase in profit from 2010 to 2020, since AI delivers long-term profit despite the fact that its installation is pricey. The future forecast, which can be obtained using ML, as mentioned that this number would increase with time.

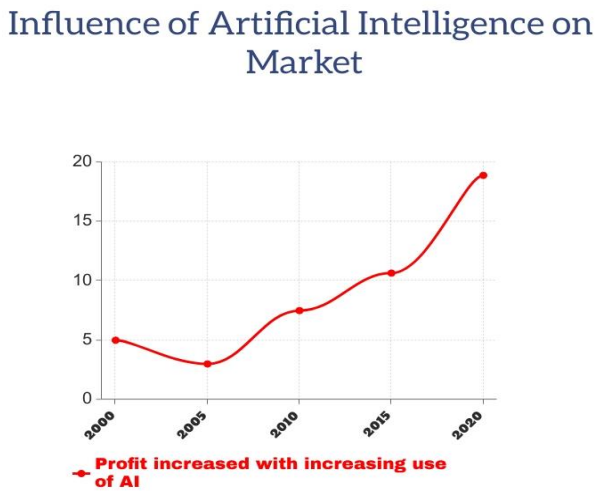

Chart-1 Profit Increase as a Result of using AI

Fig. 10 demonstrates the region's development rate in the usage of AI and computer vision in the Food & Beverage sector. Southern and South Eastern Asia, as well as Australia, has experienced rapid expansion. The Western and North Western area, which encompasses North America, South America, and the same section of Europe, has also witnessed moderate development. While Africa and certain parts of Asia have had poor growth. However, many parts of North America and Asia are either devoid of AI or have experienced a minimal increase in AI in the Food and Beverage Industry.

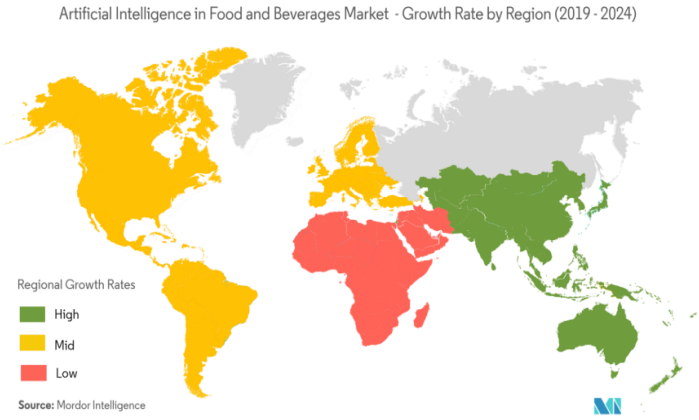

Fig-10 Growth of AI around the world

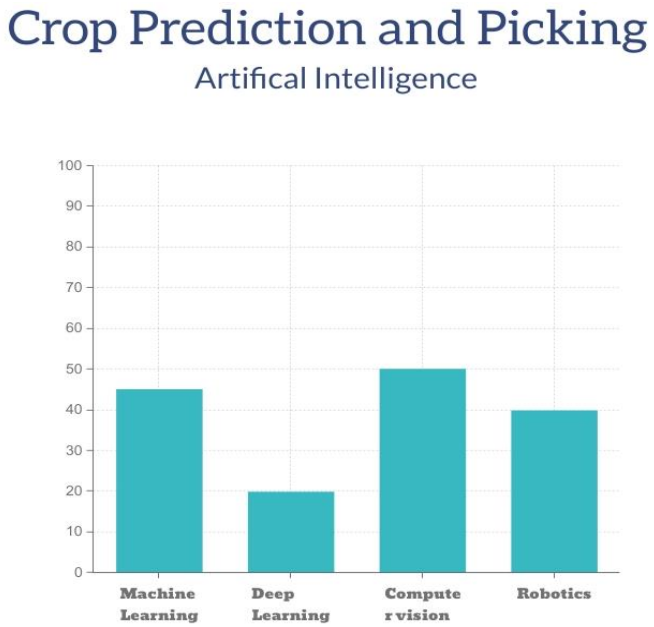

Chart-2 Comparing Different Branched of AI used in Crop Prediction and Picking

According to the graphical analysis of Chart 2, computer vision and machine learning are heavily employed in crop prediction and picking. When it comes to predicting anything, Machine Learning is required, whereas Computer Vision ensures that the best quality tomatoes are used in ketchup production to provide the best quality ketchup. In this case, ML and CV aid in food quality assurance.

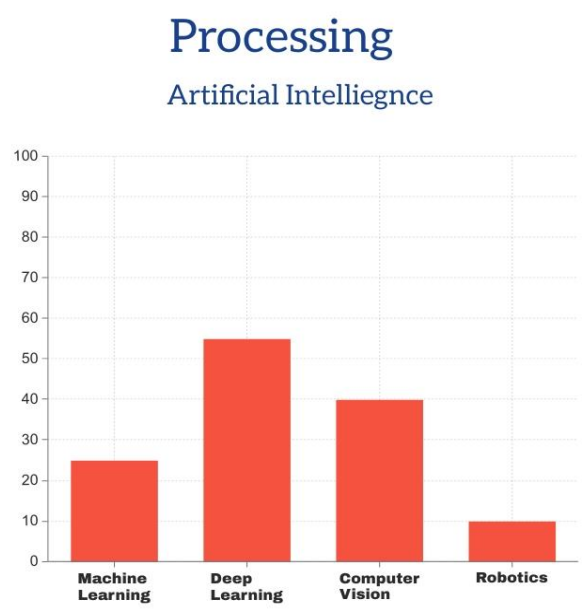

Chart-3 Comparing Different Branched of AI used in Processing

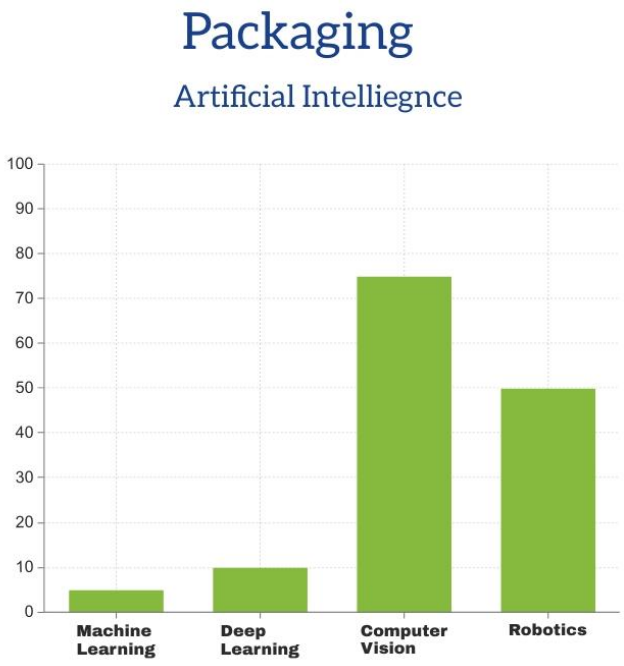

Chart-4 Comparing Different Branched of AI used in Packaging

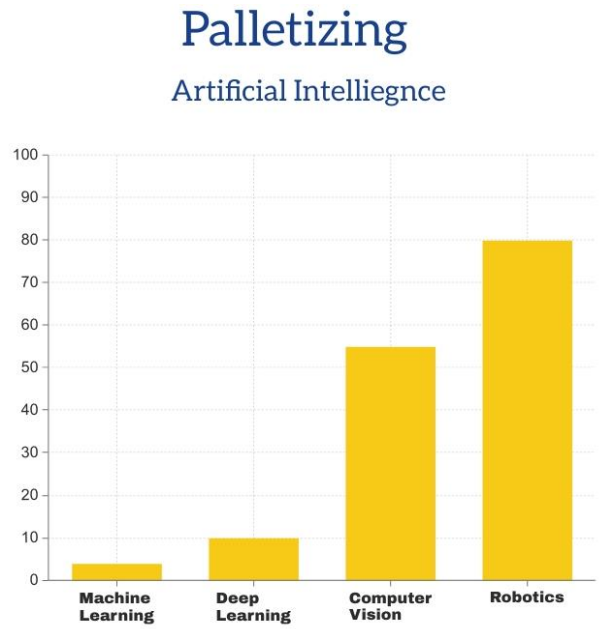

Chart-5 Comparing Different Branched of AI used in Palletizing

The data used to generate Chart. 3 clearly show that Deep Learning is critical when it comes to turning tomatoes into ketchup. As we all know, deep learning is insufficient without machine learning, thus it plays an important role here as well. At this stage, computer vision is mostly employed to ensure the colour of the ketchup, which is equally crucial, and so plays a key role after DL. Because this stage is focused on analysis, robots are rarely employed.

The packaging sector is represented by the bar graph in Chart 4. When it comes to packaging, computer vision is significant. Computer vision aids in ensuring the quality of a product by determining if it is up to standard. The packaging industry is incomplete without computer vision since employing a person here would take a long time and reduce manufacturing speed.

The data in Chart 5 show that when it comes to palletizing, robotics is widely employed. To avoid any type of human mistake, 80 percent of the duties performed in this stage are done by robots. Not only in the food sector, but also in others. Robots completely control the palletizing section. Secondly, computer vision is employed, although ML and DL are only used to estimate the amount of material needed to palletize the items, as well as the production and expiration dates.

5. CONCLUSION

In today's society, we cannot fathom mass-producing a product without the use of artificial intelligence. ML, DL, Computer vision, Robotics, NLP, etc. there are many subsets of AI which being used in food industry to deliver best quality of product. It has become an integral element of food

quality assurance since it is efficient in every manner. AI is a human-machine partnership that has taken manufacturing and quality assurance to the next level. AI ensures precise, low-cost, sanitary, efficient, large-scale, high-quality production. When it comes to decision making, AI can operate autonomously without the need for human intervention. However, many sectors and procedures are still deprived of the benefits of AI; once completely adopted, it will undoubtedly help us realize the ideal of totally automated manufacturing that can be operated with a single click.

6. REFERENCES

[1] H. Zhong-zhi, L. Yan-zhao, L. Jing and Z. You-gang, "Quality Grade-Testing of Peanut Based on Image Processing," 2010 Third International Conference on Information and Computing, 2010, pp. 333-336, DOI: 10.1109/ICIC.2010.270.

[2] N. N. Misra, Y. Dixit, A. Al-Mallahi, M. S. Bhullar, R. Upadhyay and A. Martynenko, "IoT, big data and artificial intelligence in agriculture and food industry," in IEEE Internet of Things Journal, DOI: 10.1109/JIOT.2020.2998584.

[3] Gokce Iymen, Gizem Tanriver, Yusuf Ziya Hayirlioglu, Onur Ergen, Artificial intelligence-based identification of butter variations as a model study for detecting food adulteration, Innovative Food Science & Emerging Technologies, Volume 66,2020,102527, ISSN 14668564, https://doi.org/10.1016/j.ifset.2020.102527.

[4] Vijay Kakani, Van Huan Nguyen, Basivi Praveen Kumar, Hakil Kim, Visweswara Rao Pasupuleti, A critical review on computer vision and artificial intelligence in food industry, Journal of Agriculture and Food the Research, Volume 2, 2020, 100033, ISSN 2666-1543, https://doi.org/10.1016/j.jafr.2020.100033.

[5] J. A. García-Esteban, B. Curto, V. Moreno, I. González-Martín, I. Revilla and A. Vivar-Quintana, "A digitalization strategy for quality control in food industry based on Artificial Intelligence techniques," 2018 IEEE 16th International Conference on Industrial Informatics (INDIN), 2018, pp. 221-226, DOI: 10.1109/INDIN.2018.8471994.

[6] N. Elakkiya, S. Karthikeyan and T. Ravi, "Survey of Grading Process for Agricultural Foods by Using Artificial Intelligence Technique," 2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA), 2018, pp. 1834-1838, DOI: 0.1109/ICECA.2018.8474663.

[7] Lili Zhu, Petros Spachos, Erica Pensini, Konstantinos N. Plataniotis, "Deep learning and machine vision for food processing: A survey,Current Research in Food Science",Volume 4,2021,Pages 233-249,ISSN 2665-9271,https://doi.org/10.1016/j.crfs.2021.03.009.

[8] Vijay Kakani, Van Huan Nguyen, Basivi Praveen Kumar, Hakil Kim, Visweswara Rao Pasupuleti, "A critical review on computer vision and artificial intelligence in food industry", Journal of Agriculture and Food Research, Volume 2, 2020, 100033, ISSN 2666-1543,https://doi.org/10.1016/j.jafr.2020.100033.