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A REVIEW ON EVALUATION OF ARTIFICIAL INTELLIGENCE AND COMPUTER VISION IN THE FOOD BUSINESS

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ABSTRACT

It is anticipated that large data would be used for active training by artificial intelligence (AI) and other emerging technologies, such as computer vision, to build operational real-time smart devices and predictive models. The phrase "computer vision and AI-driven food industry" refers to the development of using learning and vision techniques in the food business. This review sheds light on potential new computer vision and artificial intelligence (AI) methods that might help farmers with agricultural and food processing activities. This study has a global viewpoint and takes into account a variety of sustainable use cases and scenarios, including deep learning, machine learning, and machine vision. The article talks about the growing interest in using computer vision and artificial intelligence in the agricultural technology sector, which might pave the way for future sustainable food production to feed the world. This research also has significant implications for important global investments and regulations, as well as problems and solutions for integrating technology into real-time farming. The research concludes by looking at how Fourth Industrial Revolution (4.0 IR) technology, such deep learning and computer vision robots, may help to guarantee the long-term stability of the food supply.
Keywords: Artificial Intelligence, Computer Vision, Industrial Revolution and Agriculture Food Processing,

INTRODUCTION

Global speculation on food production and demand-supply chainfactors has increased in recent years. "Is it possible to deal withthis problem without further exploiting the world's resources anddamaging the environment?" is one way to address the topic.Answering these questions reveals numerous factors. Encompasses a lot of issues, such as the world's increasing population growth, the growing standard of living in emerging nations, global warming, and other environmental dangers brought on by humans throughout history. The FAO estimated that the world's population will reach 9.1 billion by 2050 **[1].** This estimate understates the need for a 70%worldwide food production increase and a nearly double increase in impoverished countries **[2].** 793 million people worldwide lack enough food to live. Intuitively, India and China are tied for first and second placed on their growing populations and economics **[3].** Modernization linearly increases environmental risks, as seen in Fig.1 C's continental green house gas emissions.

In Fig. 1D, several portfolios show the continental value-added share of GDP. Instead, data inaccuracy due to factors like rising wages in developing countries and economic disparity may lead to accurate global estimates [4]. Thus, as a vital component in the demand supply cycle, food supply will remain disputed. Selecting an effective approach from modern, sustainable ways may improve results and maintain output and demand.

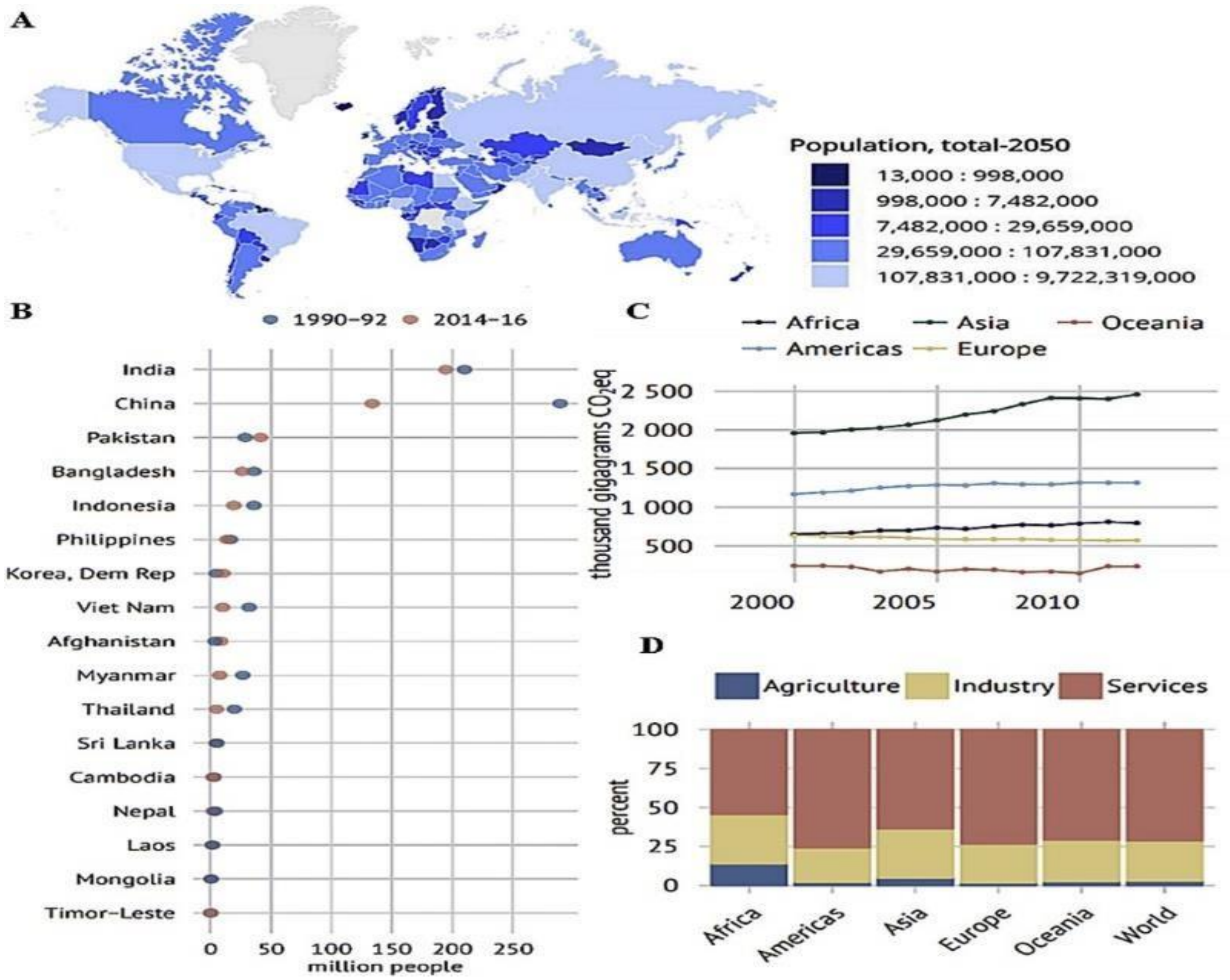

Figure 1: **Demonstrates food insecurity statistics**

Heat maps of the following topics: (A) worldwide population increase; (B) food insecurity in Asian nations; (C) greenhouse gas emissions in agriculture; and (D) value added as a percentage of GDP (2013)

Technological innovations in food production and technological food processing are now possible thanks to contemporary advancements in the food sector.

Various food types have been in demand over the last 50 years, including some unusual ones like functional meals, which have been shown to be essential to leading a healthy lifestyle [8]. In an attempt to meet consumer demand and manufacture food rapidly, the food industry developed a few food processing techniques. Innovative leaders in the modernization of the food sector used cutting-edge technologies in agricultural and food processing.

These machines were eventually superseded by intelligent machines and production lines **[9].** Can these advancements both feed the rapidly expanding population and avoid the unavoidable? With the rise in demand and the corresponding rise in technological breakthrough, it seems feasible. With the growth of 4IR technologies like artificial intelligence and computer vision robots during the last ten years, there has been a significant paradigm shift in business models and investments. In the future, these new technologies could help meet the need for a steady supply of food.

Early developments in the food business

Modern food industry developments started with simpletools and progressed to huge equipment **[10].** One of the world's highest-earning agribusiness and food processing companies, which employs technology to produce and prepare 64% of theworld's food **[11].** As time went on, every food industry sectorstarted employing cutting-edge ways to enhance efficiency andreducewaste.

A. Agricultural Aspect

The weather has always affected agriculture. Conventional techniques are used to boost agricultural productivity on 570 million farms worldwide **[13].** At the start of the 1990s, innovations entered the agriculture sector to address the declining number of farmer's and the rising brain drain in cities. A small number of researchers tested, improved, and implemented modern agricultural practices, comparable to technological research and development **[16].** With all of these initiatives, the market for contemporary agro-business investments is expanding and ushering in a new age in the ag-tech industrial sector, where agriculture and technology converge. Numerous developments early in this century changed agriculture into a platform for contemporary concerns to be addressed by advancements in automation, wireless communications, geo-satellite research, and many other sectors **[17].** Astrium-Geo, Geographical Systems (GEOSYS), Skybox Imaging, and Monitoring Agricultural Resources (MARS) satellite monitoring technologies used satellites including IKONOS, SPOT-6, RAPID EYE, and others for spectrum analysis and real-time crop vegetation index **[18, 19].** These services provide farmers, investors, firm owners, governmental authorities, and others with growth-related information. ' All these advances over the last three decades turned the traditional agricultural system into more useful modern methods. It's unclear whether these developments didn't affect the environment.

International capital investments and commerce surged due toagricultural advancements. It was obvious that this advancement would harm the environment. Agriculture's green housegas (GHG) emissions and geographic regions are depicted in Fig.1C. Under developed and food-insecure regions are affected by CO2 and other GHGs **[24].** These negative impacts demonstrate the environmental damage that yield-boosting agricultural advances may inflict.

B. The perspective of food processing

Agriculture, together with food processing and administration, may have a large influence on the food economy **[25, 26].** Due to these constraints, food processing must use technology to boost productivity, decrease waste, and fulfill customer demand **[27].** Market trends shape food processing technology, which affects the food business.

Consumer views about a food or product affect market patterns, which may be adjusted by marketing

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approaches **[28].** Time constraints, social gatherings, stress relief, and indulgence have increased modular food demand, according to Global Food Technology **[29].** Wellness and health knowledge have also boosted functional food uptake **[30].**

Emerging Technologies

A. AI Revolution

Automation has increased productivity in manufacturing and contemporary industry over the last several decades. Technology and the manufacturing industry influenced numerous other sectors **[31].** AI has outperformed humans in object identification and computer vision tasks in recent years **[32].** This dynamic seems to change as learning techniques and processing capacity improve. Automation began in the early 1800s, allowing the industrial revolution and contemporary technology **[33].** Today, automation is in every sector and growing market transactions **[34].** In the 18th century, machinery was mostly used for basic activities like wielding, turning, and repetitive duties to free up labor for more sophisticated work **[35].**

Graphics Processing Units' huge computing power makes thisinvention possible (GPU). Artificial intelligence (AI) can learn difficult tasks from enormous training sets because of the computer power that enables neural networks to simulate the human brain **[37].** Tech behemoths like Google, Microsoft, Amazon, Facebook, and Apple began their study on artificial intelligence by gathering enormous quantities of data via their services **[38,39].** Miracles began with neural networks. Google's Deep Mind technology expanded machine learning potential two years ago **[40].** In 2014, this technique proved how rapidly robots can learn complex tasks that took humans years to master.

With massive data and trainable AI, scientists, futurists, and researchers forecast the next industrial revolution **[32-34].** Google's speech recognition was enabled by" Google Brain" training data on 16,000 computers and 100 billion connections. Self-driving cars were developed by NVIDIA and Google (Esther Francis). Google's massive street view and automobile annotation data were used by NVIDIA GPUs totrain self-driving AI **[36].** In test scenarios, this AI had a 50% lower false-positive rate than human radiologists and performed well in intricate scans, where as human radiologists missed 8% **[29].** Fig.2 illustrates McKinsey and company's global institute's conceptual research on AI's priorityand potential breadth **[10].** In the next decade, the public and private sectors will grow significantly as AI startups will grow annually **[11].**

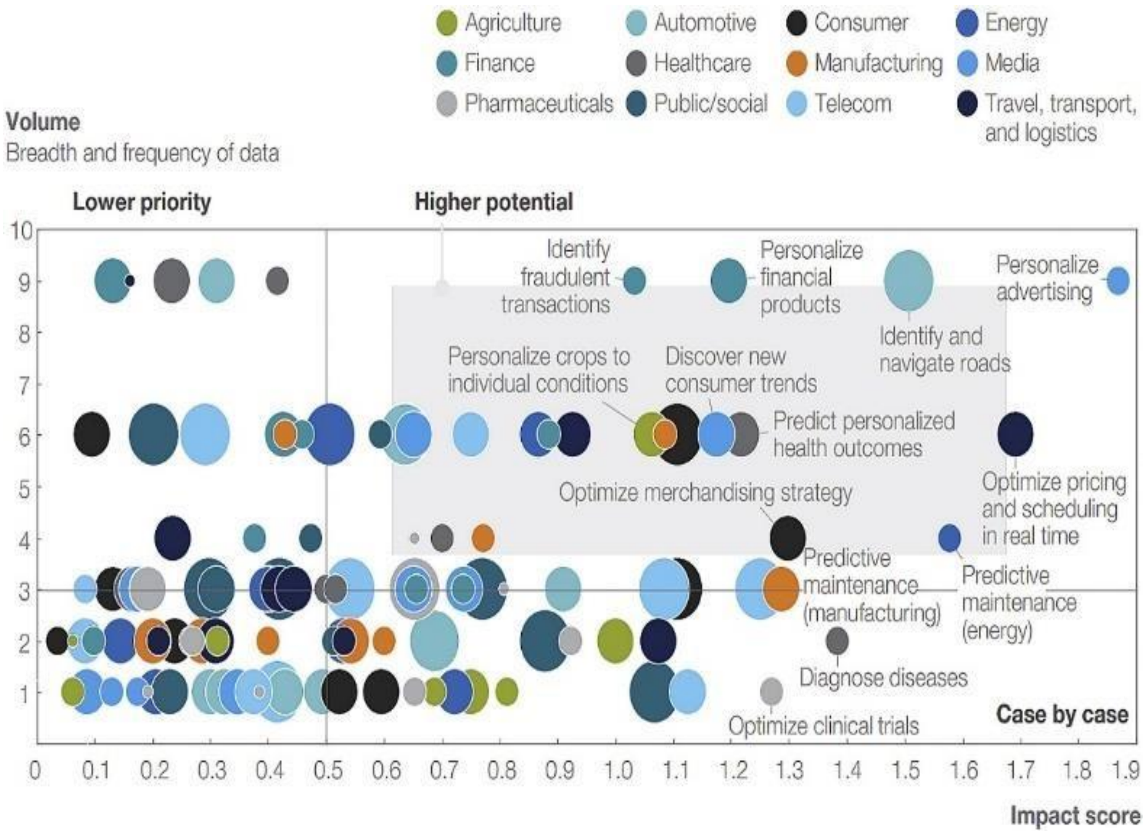


Figure 2: AI use-cases across fields

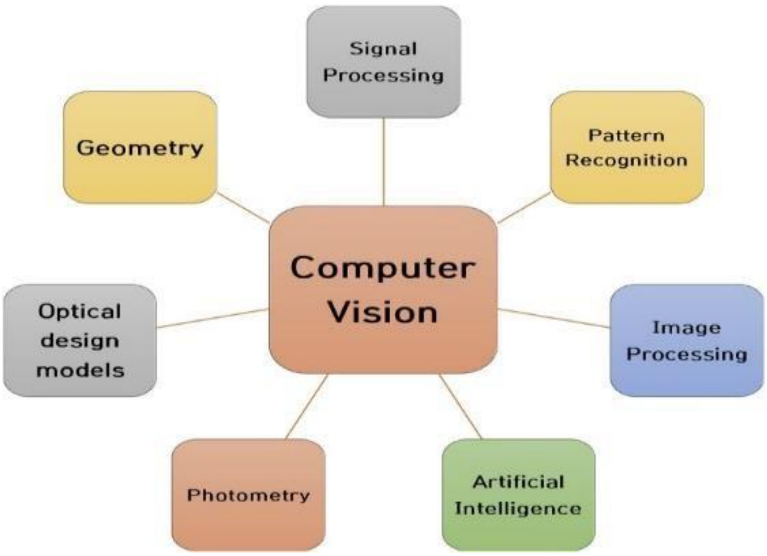


Figure 3: The various aspects of computer vision.

B. Computer Vision

In a few decades, computer vision has been used to every conceivable field, including pattern recognition, machine learning, computer graphics, 3D reconstructions, virtual reality, and augmented reality **[12].** In 2010, advanced tasks such as object recognition, self-driving vehicle navigation, face detection, fingerprint recognition, quick photo processing, and robotic navigation could be performed using computer vision **[23].** Amazing discoveries like visual simultaneous localization and mapping (SLAM), object tracking, and more were made by using line detection, feature extraction, segmentation, feature matching and tracking, optimization, and reconstruction of 3D reality **[34].** The taxonomy of computer vision and its connected fields, such as science and technology, mathematics and geometry, and physics and probability, is presented in Fig. 3. Computer vision can collect and handle large amounts of training data for AI methods like machine learning and deep learning **[25].**

AI's impact on five-year-old firms and sectors is explored in Refs.**[26].** AI and computer vision firms have penetrated every lucrative field, as seen in this infographic. Industries such as vision-based AI, healthcare, cognition, core AI, unmanned vehicles, smart robots, and more may be shown in Fig. 4 as employing 4IR technologies such as computer vision and artificial intelligence. Approximately $3.5 billion was invested in computer vision-based companies, while $7.0 billion was invested in AI machine learning businesses in the United States. The natural language processing, smart robotics, and unmanned vehicle industries, which generate over $2 billion annually, employ AI-trainable algorithms and computer vision's sensory data for autonomous navigation.

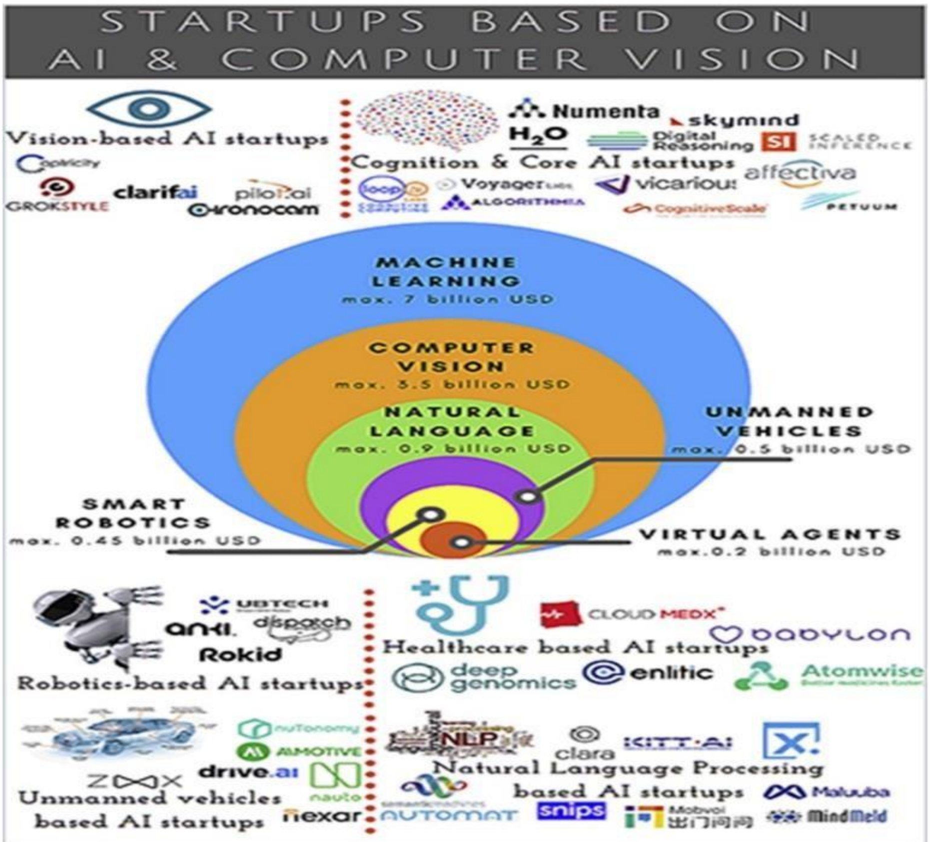


Figure 4: Numerous AI and vision startups

Food Industry/Agriculture Supported by the Fourth Industrial Revolution

A. The food industry is dominated by AI and computer vision

Experts and scientists anticipate that by 2020, AI will power several businesses **[17].** Digital data is expanding quickly, and by 2020, 44 trillion gigabytes will be generated **[8].** This enormous quantity of data and trainable AI startups, which will make it possible for innovative solutions to challenges in a variety of industries, are what will usher in the fourth industrial revolution (4.0 IR). The second industrial revolution (2.0 IR) was sparked by the development of electricity, radio, and airplanes [**4**]. The globalization and interconnectedness of computers and the internet served as the catalyst for the third industrial revolution, often known as the 3.0 IR **[12].**

Recent advancements in AI, computer vision, and Big Data have had an impact on every industry, resulting in the Fourth Industrial Revolution (4.0 IR) **[15].** AI has had a big impact on the equipment, instruments, and procedures used in the food industry. The advent of AI-driven methods and technology in agriculture and food processing has altered crop growth, cultivation, production, and processing. Famous chefs were silenced by IBM Watson's capacity to provide recipe options with similar ingredients **[28].** Computer vision image processing was made possible by AI concepts like machine learning and deep learning. Prior to 2012, image processing and computer vision were used to analyze images so that computers could understand them and reach conclusions. When machine learning and deep learning were introduced, computer vision was able to perform tasks like object identification, recognition, tracking, face recognition, and more at the pinnacle of technological advancement. Data, images, motion pictures, language patterns, etc. **[33].** Massive amounts of data were used for training and testing deep networks in a well-known competition that evaluated them against several benchmarks **[37].**

B. AI-based food processing techniques, portion

In early 2016, the Massachusetts Institute of Technology's (MITAI) system was able to evaluate the contents and nutritional values of the food that was given to it **[33].** In 2015, computers were intelligent enough to recognize food in images. These AI technologies help the food industry efficiently market its products via the use of global food trending strategies and planning. With machines that can distinguish apples from oranges and do more complex tasks like separating low-saturated fats from unsaturated high-fat ones, food processing becomes more versatile. The monitoring techniques for "Stemmer Imaging food" [**23]** for various applications are shown in Fig. 5A, and deep learning for food classification using LeNet architecture **[14]** is shown in Fig. 5B.

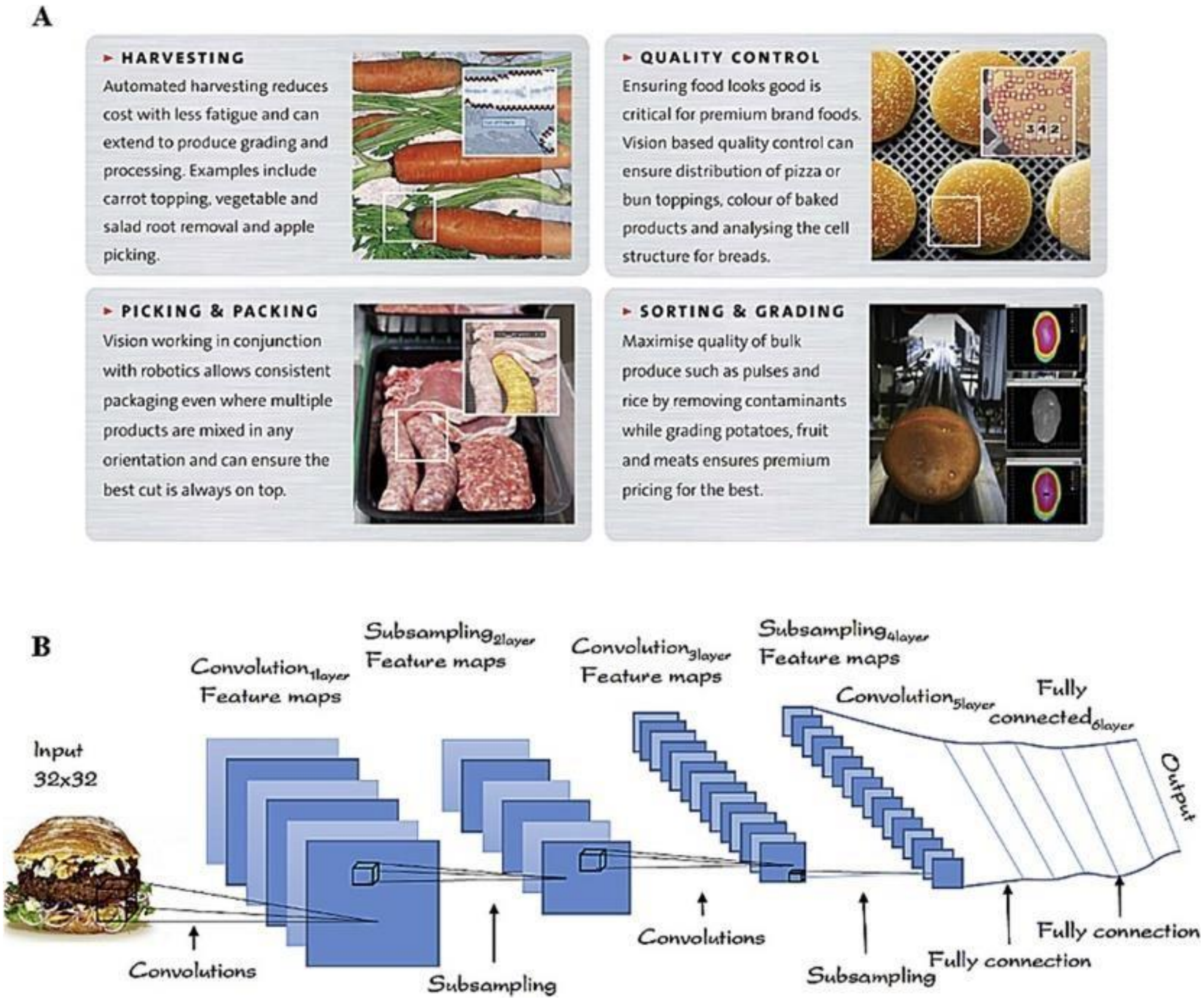


Figure 5: **A**. recognition algorithms for harvesting, picking, quality control, and sorting in the food business [93]; **B.** the LeNet deep learning architecture for food categorization, which makes use of AI and computer vision.

C. Agriculture assisted by AI and computer vision

In developed countries, where new inventions can reach the market more quickly thanks to investment in R&D, traditional methods of production have given way to more recent technological alternatives. By mapping the landscape and analyzing the data, computer vision and robotics have developed a novel approach to farming. Site-specific crop management now uses drones for crop imagery. These drones with multi-spectral sensors let farmers assess their property; decide on irrigation, and checksoil productivity in areas **[9].** Before 2010, farmers relied on satellite imagery, which took two weeks to obtain and was laborious in cloudy conditions **[25].**

Drones using multi-sensor imaging systems help farmers find fewer infrared-reflected regions in agricultural land, minimizing disease transmission **[1].** Robotics and deep learning are used to detect pesticide irrigation by assessing plant development and moving sprinklers closer and further from croplands. Some sprinkler modification tactics reduced water loss while maintaining agricultural productivity.

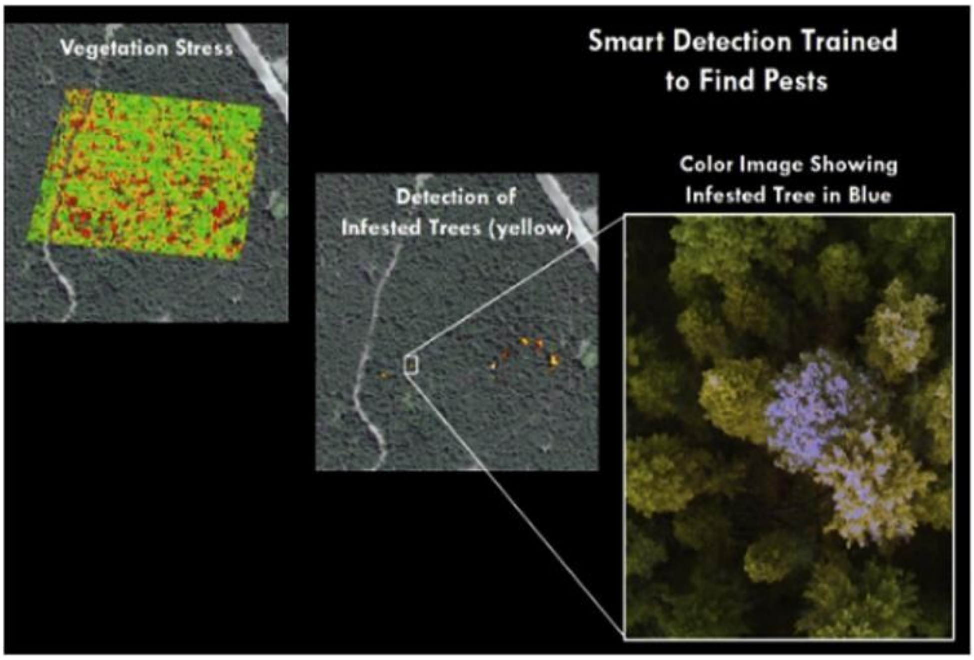
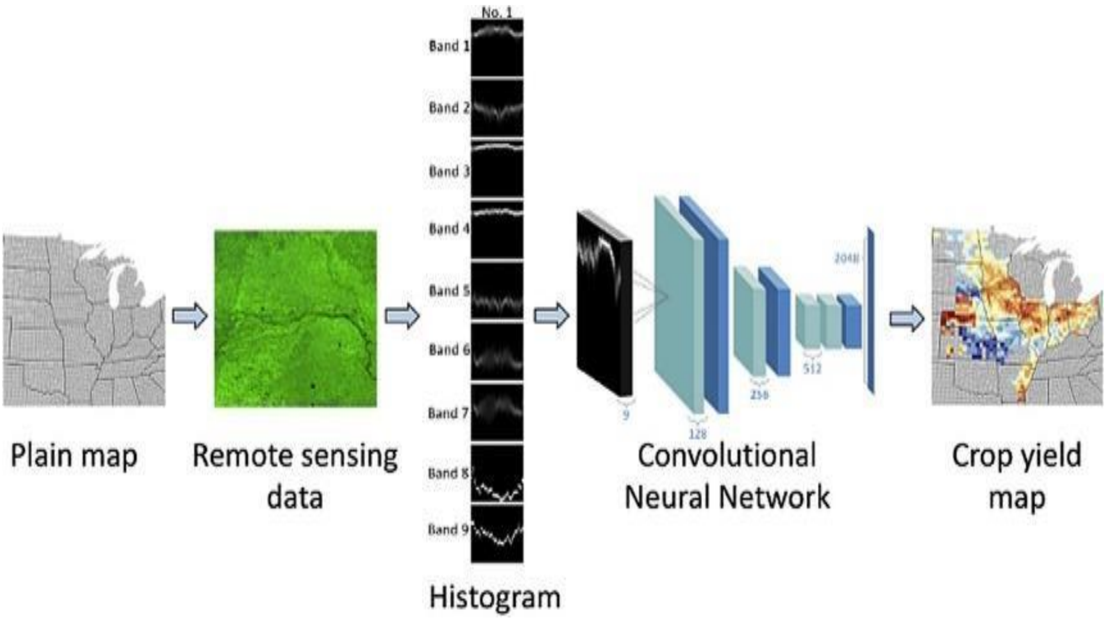


Figure 6: SLANTRANGE's Smart Detection uses Artificial intelligence to locate pests

Figure 7: SLANTRANGE's AI crop yield map detection



The concept of utilizing robots to cultivate crops, take photographs of crops, milk cows [37], and other similar activities pose the following question: can we make greater progress with artificial intelligence by leveraging all of the data we get from plants, soil, cattle, and other such topics? Machine learning and computer vision methods are being used in a variety of industries, such as agriculture, food processing, livestock, and so on, as illustrated in Figure 8. These techniques are being used by a variety of firms and startups.

Udio, an AgTech company located in California, is using artificial intelligence to optimize water irrigation in order to quadruple productivity. Their primary objective is to make use of data from agriculture, irrigation, soil, and meteorology in order to provide field-level insights and recommendations to farmers in the hopes that they may practically double their output **[23].** Trace Genomics, a firm founded in 2016, is digitizing soil in an effort to increase crop yields. This endeavor is comparable to the Water Intelligence solutions offered by Udio AgTech. How can we prevent the presence of nematodes and other pests in the soil while yet producing a nutrient-rich environment for seed growth? In contrast to conventional soil diagnostics, Trace Genomics models data from a wide variety of pathogens found in soil. Trace Genomics obtains its data by studying the microbiomes found in soil.

The problem is non-linear due to the fact that the origin of the aforementioned factors includes not only bacteria in the soil but also the environment, nutrients, fertilizers, and other factors.

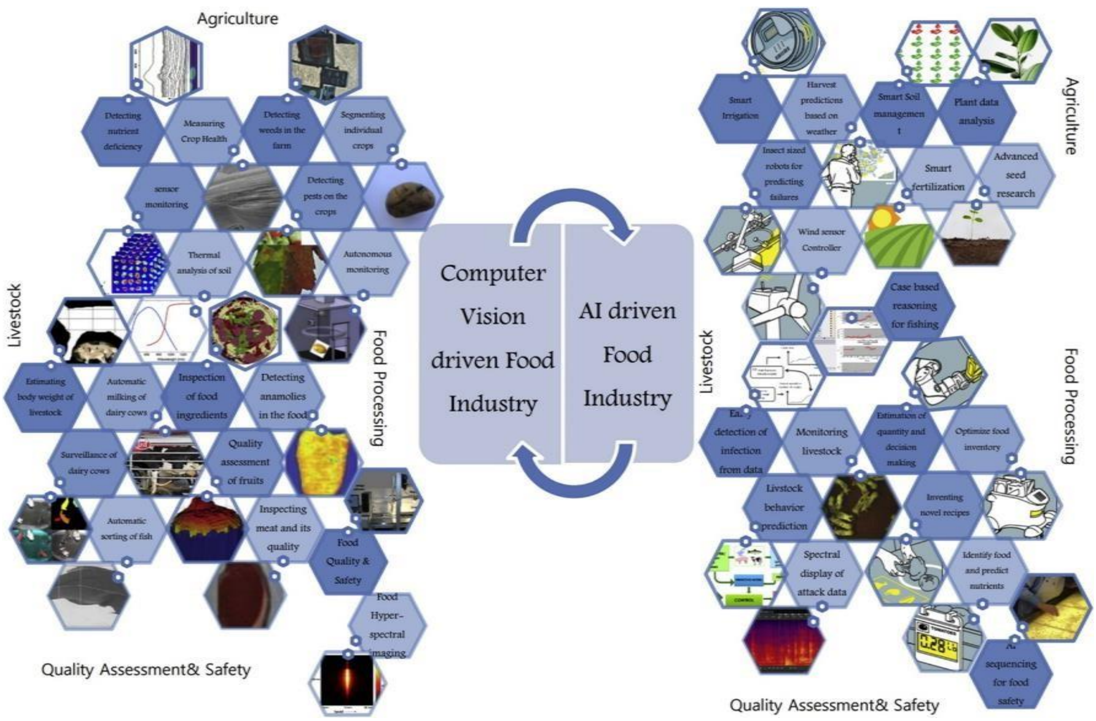


Figure 8: AI and computer vision have transformed the food sector

Investments and Prospective Applications

The ever-increasing human population has a significant impact, on a global scale, on topics such as the policies and services provided by governments. The primary challenge facing developing countries with expanding populations is finding a happy medium between rising food demand and increasing food supply. Artificial intelligence (AI) and computer vision technologies are being introduced into the food and agriculture sectors by both government agencies and private businesses in order to address specific difficulties and increase output **[13].**
By providing these countries with their respective technology, Microsoft and Google are helping to influence global economic stability. Microsoft and the International Crops Research Institute for the

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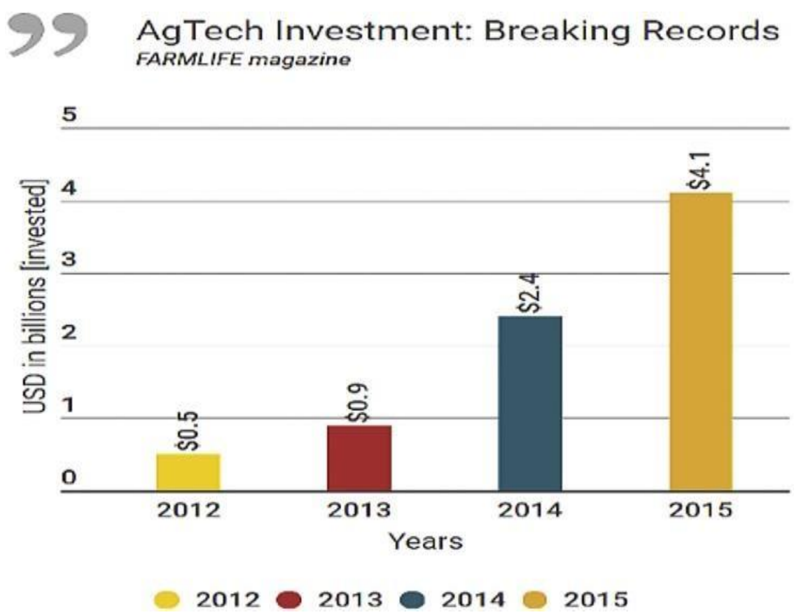
Semi-Arid Tropics (ICRISAT) of the Indian Government utilized the Microsoft Cortana Intelligent Suite to collect and analyze agricultural data using machine learning methods. This was done in collaboration with Microsoft. In order to assist farmers by means of public-private and state investments, the government of India constructed pilot sites for learning in thirteen different districts **[31].**

These pilot sites included soil analysis labs, smart irrigation schemes, and Inclusive Market-Oriented Development (IMOD) initiatives. These services construct a trained model based on the soil, water, weather forecasts, historical rainfall data, crop yields, and other data in order to provide predictions about the optimal time of year and growing season for various crops. ' During the third week of June, pilot sites informed all farmers through SMS that they were utilizing machine learning from Microsoft to monitor meteorological data and train on a variety of parameters. This strategy enabled farmers to place seeds in areas that were more likely to get rainfall, which resulted in an increase in agricultural output of 30–40%. Numerous private investors are responsible for using artificial intelligence and computer vision technologies to a task-specific agriculture advantage in order to achieve their goals. In 2015, record-breaking investments of 4.1 billion USD were made in the AgTech business (Fig. 9), prompting experts all over the globe to project that the Fourth Industrial Revolution will cause significant changes to the sector (4IR).

Figure 9: Significant AgTech investment growth



AgTech companies are using AI and vision technologies that are task-specific in order to increase yields and attain a sustainable food supply by the year 2050. A number of agtech companies, including as Ceres Imaging, Sky Squirrel Technologies, and Blue River Technologies, use drones and robots in conjunction with computer vision to take spectrum photos and analyze them. In order to identify irregularities in crop productivity and resource supply, new businesses such as centaur analytics, spensa technologies, and sencrop employ data collected from sensors.

Machine learning and computer vision are being used by startups such as cropxaquaspy, hydropoint data systems, alesca life, aero farms, bright farms, connector, farmnote, and advanced animal diagnostics to record, analyze, model, and predict yield-boosting factors in livestock and next-generation greenhouse farms with smart irrigation.

CONCLUSION

This article examines the usage of technology from the fourth industrial revolution in the context of agriculture and the food industry. Some examples of such technologies are artificial intelligence and computer vision. The current review, in particular, provides a comprehensive understanding of computer vision and intelligence methodologies that address a number of agricultural applications. These applications include food processing, applications that are based on agriculture, farming, plant data analysis, smart irrigation, and next-generation farming. In addition to this, the article places a strong focus on the core idea of making use of environmentally responsible technologies that are classified as 4 IR that are sustainable in order to assist mankind in meeting the needed food supply by the year 2050. The importance of the AgriTech industry and investments based on AI and vision technology were brought to light by referring to relevant sources using use examples. The businesses that are making use of AI and computer vision in the agricultural food industry have been scrutinized in great detail and sorted into numerous categories according to the applications they are making use of. This article provides a list of a few businesses that are not connected to the food industry or agriculture, such as animal data and next-generation farms. This research serves as a central point of access for multidisciplinary information including AI and vision-based methodologies with reference to the food and agricultural business.

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