The Future of Machine Vision in Industries- A systematic review

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Abstract. The Machine vision is the substitution of the human visual sense and judgment capabilities with a video camera and computer to perform an inspection task. It is the automatic acquisition and analysis of images to obtain desired data for controlling or evaluating a specific part or activity. Inspection of components using machine vision technologies provides solution for quality and process control. Now a days, Industry has huge demand for productivity improvement with the implementation of computer control automation. Machine vision reduces the scrap production due to non-conformity by controlling the manufacturing process through machine vision and to prevent the value addition for scrap product in subsequent stage of manufacturing process. The factory vision based industrial robot change the traditional way of mechanical assembly, quality control of product and rapid manufacturing. The various applications of machine vision technologies are automotive pharmaceutical, food and beverage, electronics, packages, and process control.

Keywords: Video measurement, design application industrial, image processing, computer vision, rapid manufacturing, Automatic Inspection, Machine vision, Distance measurement, stereo camera, disparity maps.

1. Introduction

According to the Automated Imaging Association (AIA), machine vision encompasses all industrial and non-industrial applications in which a combination of hardware and software provides operational guidance to devices in the execution of their functions based on the capture and processing of images. Though industrial computer vision uses many of the same algorithms and approaches as academic/educational and governmental/military applications of computer vision, constraints are different [1]. Machine Vision is the knowledge and approaches used to provide image-based automatic examination for quality control, process control, and robot guidance. Basically, machine vision is used for optical gauging, quality assurance, sorting, part assembly inspection, presence and absence and controlling the manufacturing process [2]. Liquid automatic filling technology used in the coke factories, petroleum, etc. At the time of filling some dangerous liquids like acids, there will be a serious cause to humans. If we use machine vision instead of human then there will be having advantage to humans [3]. A machine vision system is an integration of
optical technology, computer technology and it’s a basic understanding of visual capability of human and analysis. It having remarkable advantages like accuracy, consistency. Most of the electronic companies uses machine vision technology to restrict the defect products ratio. Therefore there is no need to inspect the manufactured parts [4] as shown in Figure 1.

Figure 1. Flow chart of machine vision

2. Applications of Machine vision

2.1 Packaging inspection

It is very crucial for the pharmaceutical companies to count capsules before placing them into containers. The key feature for this solution involves using computer vision to check whether the capsules formed are broken or in good condition. The pc vision based system also implemented to a pc which performs the counting function if the capsule is seemed to be defective, this information then sends a signal to the counting functioning, and at the time of shipping it helps to remove the possibility of defective medical capsules [5].

2.2 Reading barcodes

Reading and identifying the hundreds or thousands of barcodes per day is not an easy task for humans and simply cannot do. For example, electronic devices like mobiles and cell phones requires very smaller and smaller printed circuit boards or PCBs. By doing this task manufacturers are pressured and they cannot produce higher volumes of PCBs forever growing tech market. For that the process known as "penalization". In this process the number of identical circuit boards are printed on a large panel and then each and every circuit is separated by machine for the final testing, in order to inspect every board, however, a machine vision based technology called Panels can was developed to read barcodes-These are known as unique identifiers of each circuit that is present on PCN panel [5].

2.3 3D Vision Inspection

A machine vision inspection system contains a Dalsa Genie Nano camera which is been used in an industries production line to undertake tasks, Humans can struggle sometimes. In this case, the system uses high-resolution images used to build up a full 3d model of components and connector pins. A product pass through the manufacturing plant, the machine vision system takes multiple scans of images of different
angles to produce a 3D model, these images, This allow the system to identify if connector pins on circuitry are faulty which could have disastrous effects later down the production line[5].

2.4 Object detection

The objective is to locate or detect whether an object of interest is present or absent in a given image. The example is whether an egg tray or an ice tray is placed in a refrigerator. The vision system simply identifies the parts by virtue of a "golden image" or a pattern that has been pertained which it uses to compare it with the real time images from the camera [6].

2.5 Measurement

As the name suggests involves an object dimensions to be accurately determined. This is done by locating certain points on an image and measuring geometrical dimensions like distance, radius, diameter, etc. Example of such applications are measuring the inner diameter of an engine cylinder bore [6].

2.6 Healthcare

Scanning, surgical navigation and skin cancer detection are some of the examples of Machine vision in healthcare industry [7].

2.7 Logistics

Automated Data Capture (ADC)or Automated Inspection(AI) are important process in logistics for verification and control of the product list of these terms refers to automatically identifying objects, collecting data about them, entering them directly into computer systems. QR codes, bar codes and RFIDs are some of the examples of ADC [7].

2.8 Automotive

Dimensional gazing is a method in production process in automotive and machine vision helps by calculating the distance between points or geometric positions on an object and determines whether these measurements meet specifications. Machine vision allows robotic guidance which is needed to place parts onto a vehicle during the body- in-white stage of the assembly process. Presence-absence checking is also assisted by machine vision solutions in automotive plants [7].

3. How machine vision can help humans

Machine vision is widely recognized as being used within automation and production lines. Using machine vision systems allows a system to reduce human involvement in a variety of processes [8]. Correct use of machine vision systems helps not only significantly improve productivity but also delivers greater accuracy of work output by identifying defects prior to customer receipt. Due to machine vision being implemented in industries such as conveyors, they can be integrated for use in a hazardous place or clean spaces that could cause a human to become contaminated or injured. It also improves product quality as well as saves the time and cost. This helps to stop faulty products ever making it to the end-user and causing negative publicity [8].

4. Image processing in machine vision

The digital data coming from the hardware can be analyzed by using image processing algorithms. There are three main steps in image processing in machine vision:

- Pre-processing: preprocessing consists of noise removal and contrast enhancing.
- Image recognition
  - Segmentation: A threshold is applied and the edges of the image is determined in the process.
Feature Extraction: Size, color, length, shape or combination of these features can be extracted in this process.

Imaging methods emerging methods are designed to provide fast, efficient image analysis under interpretations of images. Some of these are:

- Conventional 2D light imaging: this is the most common technique in machine vision to capture details of object under analysis. 2D light imaging is limited by the wavelength of light that can be detected, this technique is not suitable for some applications police stuff some of key differentials in the technique our frame rate, resolution, monochromatic color systems [9].

- Multispectral Imaging: in this image data that ranges across the electromagnetic spectrum is used to create images. This type of imaging provides visual information behind the limited range of and human eye under visible light that includes ultraviolet and infrared Spectra. This is mainly developed for military applications I'm at least based imaging systems were developed with multi spectral imaging to detect features for mapping such as coastal lines and vegetation. Multispectral imaging is employed in many different areas that includes artwork, documentation and mainly landmine detection [9].

- Hyperspectral Imaging: Hyperspectral Imaging provides an even more in depth analysis of an object spectral fingerprint to form a 3D hyperspectral data cube by utilizing the vast portion of the electromagnetic spectrum. There are four ways one of these systems can sample the hyperspectral cube: spectral scanning, spatial scanning, and snapshot amazing, spatial- spectral scanning. This imaging has been used in molecular biology, oil exploration, surveillance and physics [9].

- 3D Machine vision Techniques: The 3D machine vision techniques are Laster triangulation, time-of-flight, stereo vision, and structured light. This systems require a larger degree of complexity and processing power then their 2D counterparts, they help to provide more in -depth analytical data in areas where 2D imaging falls less.
  i. Dimension and space management
  ii. Detection of surface and assembly defects
  iii. Measuring features such as angles, shapes, holes, and curves
  iv. Object scanning/digitization
  v. Robot Guidance
  vi. Verification against 3D CAD models [9]

- Line Scan Imaging: Line scan imaging build up an image at a time using a linear array with a very high degree of precision. A line scanning camera uses a single light sensitive pixels that scan a moving object on a conveyor belt at a very high frequency, capturing multiple "slices" of an image. Line scanning is just used in product development and QA application. It is used to cylindrical objects, Distortion, which would be produced by area scanning techniques, is limited as the line scanning camera or sensor recorded the same optical position across the entire cylinder [10].

5. Why 3D machine vision is better than 2D?

2D machine vision is a great tool for many applications, but it has some fundamental problems. 2D cameras only see the world in the flat images as shown in figure 2. This means we can't inspect objects as they actually as they measure them as you could expect to be able to. It also means that you inspection software needs to apply complex algorithms to try and guess what an object may look like in a single image. For example, darker shiny surfaces will not show up clearly and so they will lack detail. Lack of contrast poses a problem.

The important point about 3D is that virtue of being able to capture the extra third dimension data reliable, because 3D Machine vision systems are immune to the environmental factors adversely affecting 2D systems the aspects of lighting, contrast, distance to the object is better than compared to two dimensional image processing, working in 3D is indeed more time, processor and the software intensive
please stop 3D algorithms and software tools mean that 3D Machine vision systems are now more than capable of keeping up with production line throughout the requirements [11] as shown in figure 3.

Figure 2. Two dimensional image for machine vision

Figure 3. Three dimensional image for machine vision

6. Machine Vision for Quality Control and rapid manufacturing

Machine Vision stands behind many great advances in industrial automation. One of the most prominent achievements is the field of quality control. By adding Machine vision based automated systems offer an effective solution for quality and process control, adding values to inspection operations to enhance it productivity, the accuracy of the manufacturing process, reduction of operational cost. These automated systems includes a camera looking at a production line that capture images which are then are algorithmically compared do a predefined image in order to detect defective objects please stop the application has found major adoption for the detention of imperfections, joint metric inspection geometric inspections, packing control, product classifications, surface finish inspection, colour under texture analysis [12].
These can be analysis through the computer vision based working also:

**Accuracy**
It helps to ensure a higher grade of accuracy within the accepted tolerance in every manufacturing process. Even on a specific equipment such as a magnifying glass, delicate materials even in the detection of bacteria for medical equipment [12].

**Repeatability**
Machine Vision driven systems conduct monotonous tasks more effectively. Implementation of fully automated system definitely speed up the production time as the machine needs no time for think its accuracy and repeatability is for great [12].

**Reduced costs**
An automatic machine vision system provides tangible economic benefits play stop manufacturing companies do not require working personnel to manually perform control of manufacturing products, allowing them to concentrate on more important work. The cost of small human mistakes can sometimes be valuable at billions of dollars and mission vision helps to avoid it [12].

*Method of machine vision:*
In the machine vision there are different methods one of that is stereo vision system in this after collecting of images from two different cameras (one from Reference camera other is side camera) the pattern of its particular image is matched. Two Logitech C310 USB webcam is used to measurement of distance as shown in figure 4. It is used to identify the distance measurement of a person is worked by a cameras. With the computers after making disparity maps from the visible patterns of the camera it may helped to identify the matching of pattern [13].

![Figure 4. Collecting of two image pattern](image)

It Show the inner components of a standard stereo vision system. It observed that the axes and image planes are composed of a parallel system when a stereo- camera whose camera planes are properly aligned and lens disturbances are completely measured and analysed [14]. The estimation of the height of tress and vegetation near the base poles to the depth map is inversely proportional to the disparity map [15].

**7. Convolution Neural Network used at machine vision**

The convolution neural network (CNN) is work more accurately and depth of success in field of high level applications. It is known as convolution neurons with in it. The convolutional is a normal neural networks this used to convolution instead normal multiplication of matrices in one of the layers. CNN is work like step by step process to defined number of convolutions are made at same time to batch of linear activations. In the second stage each and every activation is expected with an activation function is not linear. The step is called polling stage for the objective of modifying output of each layer [16] is shown in figure 5. In every case the grouping helps to make the representation almost invariant for small translations.
of the entry, if we translate the entry by a small amount, the values of most of the grouped outputs do not change [17].

8. Report of Machine vision

The global machine vision market size validate at 12.29 billion in 2020 and is expected and expanded at a compound annual growth rate (CAGR) of 6.9% from 2021-2028. The increasing demand for quality inspection and automation in different industrial verticals is likely to drive the market for machine vision [18] are shown in figure 6.

![Figure 6. Machine vision market size mapping](Source:www.grandviewresearch)

9. Conclusion

Machine vision is used for industrial and non-industrial applications which will gives us accuracy, repeatability, and reduced costs etc. It also helps us to give exact and best productivity, by using latest technology like industry 4.0. By using of that technology and image classification we can detect the particular object in a different application of machine vision. The data will be classified in a particular pattern, it is used to validate the objects in the industries, it helps to determine and detect the product and validate the rapid manufacturing; the CNN (convolutional neural network) acts a major role to define the image data set from input layer to next layer. The process helps to define the different image from different directions of the conveyer line. The technology of using machine vision is rapidly growing as per the grand view research from 2017-2028. The machine vision is going to implement at different industries like automotive, pharmaceuticals & chemicals, electronics & semiconductors pulp and paper, printing and labelling, food and beverages, glass and metal, postal and logistics, others. Through this review, we try to reveal various confounding factors that have become barriers to the prevention of musculoskeletal diseases, and try to systematically solve these barriers. Various factors that have a significant impact on
causing musculoskeletal diseases have been discovered, such as posture, strength, frequency, and working hours.

Conflict of Interest
None to report.

References
[1] Introduction to machine vision (A guide to automating process & quality improvements)/ pg.no:3, written by Vision Drive Natick. https://www.assemblymag.com/ext/resources/White_Papers/Sep16/Introduction-to-Machine-Vision.pdf
[2] S. Sathiyamoorthy. Project scientist IV, NHHID, Anna University, Tamil Nadu, India/ International Journal of Research in Engineering and Technology. ISSN: 2321-7308
[3] Machine Vision, H. Golnabi, A. Asadpour. Institute of Water and Energy, Sharif University of Technology, Tehran, Iran Plasma Physics Research Center, Islamic Azad University, Tehran, Iran
[4] Lim DC, Yun SY, Jung BY, Hong CK (2001) Optical inspection method of lead frame using mathematical morphology. Opt mechatronic systems II, Proc SPIE. 4564:107–114
[5] Writer/Full Stack Developer/STEM Ambassador/ Articles on 10 Examples of using Machine Vision in Manufacturing. https://www.devteam.space/blog/10-examples-of-using-machine-vision-in-manufacturing/
[6] Raghava Kashyapa. 7 common machine vision Applications in manufacturing. https://qualitastech.com/7-common-applications-of-machine-vision-in-manufacturing/
[7] Al Multiple/ Machine vision in 2021: In Depth Guide by Cem Dilmegani on January 1, 2021 in what are machine vision use cases/applications areas? https://research.amitlelcome.com/machine-vision/amp/
[8] L/A/C CONVEYORS & AUTOMATION News, Robotics By: Gemma/December 11, 2019. https://www.laconveyors.co.uk/machine-vision-systems-provided/
[9] AZO MATERIALS/ Methods used to provide Imaging-Based Automatic Inspection and Analysis by Reginald Davey/ Feb 14, 2020. https://www.azom.com/article.aspx?ArticleID=18988
[10] STEMMER IMAGEING/ Member of Primepulse/ Introduction to Machine Vision- Aguid to automating process& quality. https://www.stemmer-imaging.com/en-gb/knowledge-base/cameras-line-scan-technology/
[11] blog of ZiVID/Machine Vision Written by Henrik Schumann-Olsen/2021-10-27/https://blog.zivid.com/3d-machine-vision-vs-2d
[12] blog of Softengi/ computer Vision for Quality Control written by: Sergiy Tikhonov(Head of BA)/ 2021 https://softengi.com/blog/computer-vision-for-quality-control/
[13] Kerim kursat cevik/ Akdeniz University/36 publications/ 126citations/ Conference :2019 3rd International symposium on multidisciplinary studies and innovation Technologies/ At: Ankara, Turkey / DoI: 10/1109 /IsmsIT.2019.8932817/
[14] M. Soyaslan. Stereo kamera sisteminde ayardirlik haritalari yardimiyla nesne vzakhklarinin tespit edilmesi", Sakarya university journal of science, vol. 20, pp.111-119, 2016.
[15] L. Chung- Hee and K. Dongyoung. Dense Disparity map-based pedestrian Detection for intelligent vehicle, IEEE international conference on Intelligent Transportation Engineering, pp.1015 - 1018, 2017
[16] Universidad Autonoma de Ciudad Jurez @alumnos.uacj.mx http://www.uacj.mx/Paginas/Default.aspx
[17] I. Good fellow, Y. Bengio and A. Courville. Deep learning MIT press. http://www.deeplearningbook.org/2016
[18] Grand view Research/ Machine vision market size/ published Date: Apr, 2021/Base year for Estimate:2020, Repot ID:GVR-1-68038-842-8/ Format: Electronic(pdf)/ Historical Data: 2017-2019/ Number of pages:154. https://www.grandviewresearch.com/industry-analysis/machine-vision-market