Machine Vision Guided Assembly Station

# 1.0 Introduction

# 1.1 History & Background

Guided assembly stations have evolved in response to the changing demands and complexities of modern manufacturing. The concept of using technology to assist in the assembly process can be traced back to the mid-20th century when automation and robotics began to make their presence felt on the factory floor. However, the more advanced guided assembly stations we see today are the result of significant technological advancements in the latter part of the 20th century and the early 21st century.

1. Early Automation: The roots of guided assembly can be traced back to early automation, where simple machines and mechanisms were used to aid workers in repetitive assembly tasks. This early form of automation laid the groundwork for the integration of technology into assembly processes.

2. Computerization: The widespread adoption of computers in manufacturing during the 1970s and 1980s marked a significant turning point. Computers were initially used for controlling machinery, but their potential to assist human workers in assembly became evident.

3. Industrial Robotics: The development of industrial robots in the mid-20th century allowed for more precise and repetitive assembly tasks to be automated. While not direct precursors to guided assembly stations, industrial robots paved the way for a more sophisticated integration of technology into the assembly process.

4. Advancements in Human-Machine Interaction: As human-computer interaction and user interface design improved, it became feasible to develop user-friendly interfaces for assembly line workers. This laid the foundation for the visual and interactive components of guided assembly systems.

5. Emergence of IoT and Industry 4.0: The advent of the Internet of Things (IoT) and the Industry 4.0 paradigm in the early 21st century brought the concept of smart factories and interconnected systems to the forefront. Guided assembly stations fit within this framework, using sensors and data exchange to enhance the assembly process.

6. Augmented Reality and Wearable Technology: More recently, augmented reality (AR) and wearable devices have become integral components of guided assembly stations. AR glasses and devices provide workers with real-time visual instructions and feedback, enhancing their capabilities and reducing the need for extensive training.

7. Customization and Adaptability: Today's guided assembly stations are highly customizable to accommodate a wide range of assembly processes. Manufacturers can tailor these systems to suit the specific requirements of their products, making them versatile tools in various industries.

In summary, guided assembly stations have their roots in the historical development of automation, computerization, and the integration of advanced technologies into manufacturing processes. Over time, they have become increasingly sophisticated and adaptable, playing a crucial role in the pursuit of efficiency, accuracy, and quality in modern manufacturing. These systems are a product of continuous innovation and a response to the ever-evolving needs of the manufacturing industry.

Computer Vision [(ref7)](https://www.youtube.com/shorts/lQSaziJF7AA)

* Image classification
* Object localization
* Object detection
* Image segmentation

AKA “Industrial Vision”

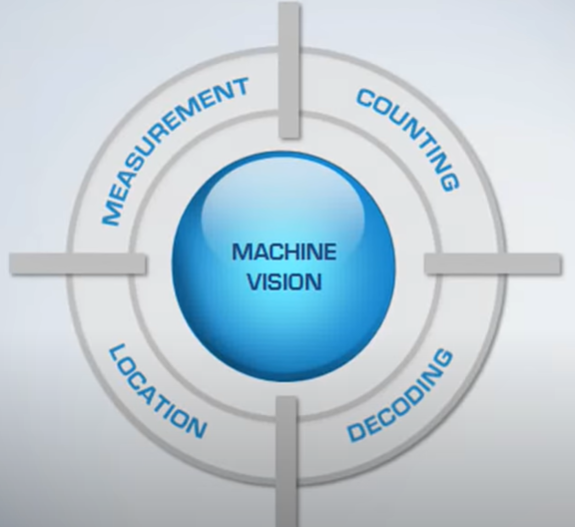
Def - Automatic extraction of information from digital images [(ref3)](https://www.youtube.com/watch?v=TTnho9-i6dI)

Manufacturers use MV because

* Faster.
* More Consistent.
* Works for longer periods.

### System Architecture

1. You have a manufacturing production line. – a steady flow of objects
2. camera or optical system trained (on the assembly line)
   1. proper lighting
   2. captures digital photographs.
   3. analyzes the images against a defined set of criteria.



### Types

#### Measurement

Automated measurement by a machine

A wrench with blue lines drawn on it

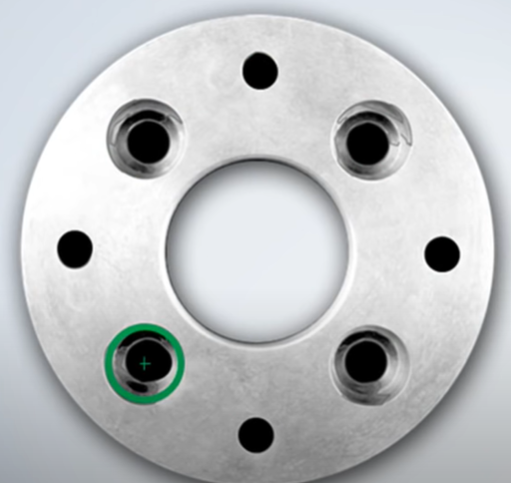
Description automatically generated A close-up of a spark plug

Description automatically generated

Spark plug Gap Measurement

#### Counting

1. means to look for a part / to look for a number of features on a part.
2. Helps to locate missing parts.
3. Ensure products are assembled properly.
4. Checking Features



Absence - Presence Detection

A group of bottles in a container

Description automatically generated

Presence inspection (quantity, missing parts)

Presence inspection is used to check the quantity or the presence/absence of parts or work on a target. There are many different types of presence inspection, such as:

* Counting bottles in cardboard boxes
* Checking the presence of manuals/accessories in packages
* Checking the presence of food labels
* Checking the presence of electronic components on PCBs
* Checking the presence of screws/washers for securing parts
* Checking the presence of adhesive application
* Checking the presence of cutting or boring work [(ref6)](https://www.keyence.com/ss/products/vision/visionbasics/use/inspection01/#:~:text=Presence%20inspection%20using%20machine%20vision,typical%20256%2Dlevel%20monochrome%20camera.)

#### Location

* to locate the position and orientation of the part
* check to specified tolerances.

#### Decoding

# 1.3 Recent Trends & Changes

Certainly, here are some recent trends and changes in guided assembly stations:

1. \*\*Integration of Augmented Reality (AR) and Virtual Reality (VR)\*\*: Guided assembly stations are increasingly incorporating AR and VR technologies. Workers can wear AR glasses or use VR headsets to receive immersive, real-time guidance and interact with digital models of the assembly process. This enhances the worker's spatial awareness and understanding of complex tasks.

2. \*\*IoT Connectivity and Data Analytics\*\*: Guided assembly stations are becoming more connected through the Internet of Things (IoT). Sensors embedded in these stations collect real-time data on assembly processes, which is then analyzed to identify areas for improvement. Predictive maintenance is also used to reduce downtime.

3. \*\*Collaborative Robots (Cobots)\*\*: Collaborative robots, or cobots, are being integrated into guided assembly stations to work alongside human operators. These robots can perform repetitive or physically demanding tasks, freeing up workers for more intricate assembly steps. Cobots are designed to be safe and easily programmable.

4. \*\*Enhanced User Interfaces\*\*: User interfaces for guided assembly stations are becoming more intuitive and user-friendly. Touchscreens, gesture recognition, and voice commands are being integrated to improve communication between workers and the system. The goal is to reduce the learning curve and make the technology accessible to a broader workforce.

5. \*\*3D Printing and Additive Manufacturing\*\*: Guided assembly stations are adapting to include 3D printing and additive manufacturing processes. These technologies allow for on-demand production of customized components, reducing lead times and enabling more agile manufacturing.

6. \*\*Remote Assistance and Collaboration\*\*: The capability for remote assistance and collaboration is becoming more common. Workers can connect with experts or colleagues in different locations for troubleshooting or real-time guidance. This is especially useful for global companies with multiple facilities.

7. \*\*Machine Learning and AI\*\*: Guided assembly stations are starting to incorporate machine learning and artificial intelligence to improve their guidance and error detection capabilities. These technologies can adapt to changing conditions and continuously optimize assembly processes.

8. \*\*Sustainability and Green Practices\*\*: There is a growing emphasis on sustainability in manufacturing, and guided assembly stations are being used to minimize waste and energy consumption. By optimizing the assembly process, manufacturers can reduce the environmental impact of production.

9. \*\*Regulatory Compliance and Quality Assurance\*\*: Guided assembly systems are aligning with increasingly stringent regulatory standards and quality control measures. These systems help ensure that products meet safety and quality requirements, reducing the risk of recalls and liability.

10. **Blockchain for Traceability**: Some industries, such as aerospace and automotive, are exploring the use of blockchain technology in guided assembly to provide a transparent and immutable record of every component and step in the assembly process. This enhances traceability and quality control.

In summary, guided assembly stations are evolving to incorporate cutting-edge technologies and adapt to changing industry demands. These trends are driven by the need for greater efficiency, improved quality, and enhanced worker capabilities, as well as the broader shift toward smart manufacturing and Industry 4.0 principles.

# 1.4 Applications

## 1.4.1 Inventory management

When it comes to inventory management, there are two main computer vision applications.

Through security camera image analysis, a computer vision algorithm can generate a very accurate estimate of the items available in the store. This is extremely valuable information for store managers, who can immediately become aware of an unusual increase in demand and react early and efficiently.

Another fairly common application is analyzing the use of shelf space to identify suboptimal configurations. In addition to discovering lost space, an algorithm of this nature can suggest better item placement. [(ref2)](https://tryolabs.com/guides/introductory-guide-computer-vision)

## 1.4.2 Manufacturing

Major problems that can occur on a manufacturing line are the breaking of machines or the production of defective components. These result in delays and significant losses in profits.

Computer vision algorithms prove to be a great means of **predictive maintenance**. By analyzing visual information (e.g., from cameras attached to robots), algorithms can identify potential trouble before it occurs. The fact that a system can anticipate that a packaging or car assembly robot will fail is a huge contribution.

The same idea applies to **defect reduction**, where the system can spot defects in components throughout the entire production line. This allows manufacturers to take action in real-time and decide what should be done to resolve the issue. Perhaps the defect is not so serious, and the process can continue, but the product is flagged in some way or redirected through a specific production path. Sometimes, however, it may be necessary to stop the production line. Of further interest is that the system can be trained, for each use case, to classify the defects by types and degrees of severity.

This is a particular case where computer vision is used to perform some actions, typically in production or manufacturing lines. In the chemical industry, machine vision systems can help with the manufacturing of products by checking the containers in the line (are they clean, empty, and free of damage?) or by checking that the final product is properly sealed. [(ref1)](https://tryolabs.com/guides/introductory-guide-computer-vision)

# 2.0 Literature Review

1. Pick-to-light (PTL)
2. FANUC

* **iRVISION camera** taking a snapshot of the screw pickup area to make sure that a screw is present, its precise location, and that no obstacles are in the way.
* It verifies this information using FANUC iRVision Inspection and **Error Proofing Software** before moving in to pick up a screw. It takes just minutes to set up an application using this FANUC iRVision Inspection system.
* **No camera calibration** is required. [(ref4)](https://www.youtube.com/watch?v=ThWwuId0Fas)
  1. Sensopart – Vision-guided screw insertion. [(ref5)](https://www.youtube.com/redirect?event=video_description&redir_token=QUFFLUhqa1pLMjA1NDh5Zkg5NC1rM3BrcFhaaG5PemVoUXxBQ3Jtc0trc3VUS1k2Rl9XUDVHU3JWSkwxRmhobnBMLWtLSUJva2JKTmNGTjdQUlBNQjVBVU9raWpxUjBmNjhYS3h3S2YwZVJ6d2tweDl6WU1KUGZSdFRseG9TRXhhVGFkbE5JWXJnNW9JWGlEVnFIVWk1SENBVQ&q=https%3A%2F%2Fwww.sensopart.com%2Fen%2Fproducts%2Fvision-sensors-systems%2Frobotic&v=dGWvsNEwTe8)
  2. TensorFlow light
  3. YOLO

He should have stated it better. TensorFlow is for machine learning training and YOLO is for object detection. For YOLO, you can use TensorFlow to train on objects and import them/configure them to be used for YOLO. YOLO takes these files (called weights) and then compares them to the camera feed and checks if they're similar. By doing so, you can detect objects and place boxes around them.

### Papers

1. [https://scholarworks.calstate.edu/downloads/xg94hx05x#:~:text=The%20system%20uses%20a%20camera,screws%20and%20reliable%20bit%20insertion.](https://scholarworks.calstate.edu/downloads/xg94hx05x" \l ":~:text=The%20system%20uses%20a%20camera,screws%20and%20reliable%20bit%20insertion.)
2. <https://blog.griddynamics.com/identifying-screws-a-practical-use-case-study-for-visual-search/>
3. <https://www.iject.org/vol2issue1/ajaypal.pdf>
4. <https://www.sciencedirect.com/science/article/pii/S2212827122000014>
5. <https://www.mdpi.com/1424-8220/22/14/5184>
6. <https://www.mdpi.com/1424-8220/23/12/5655>

<https://pab47.github.io/reports/Ezra_Ameperosa_MS_Thesis.pdf>

<https://www.diva-portal.org/smash/get/diva2:1635533/FULLTEXT01.pdf>

<https://www.mdpi.com/1424-8220/23/12/5655>

<https://www.sciencedirect.com/science/article/pii/S2212827122000014>

<https://www.iject.org/vol2issue1/ajaypal.pdf>

<https://www.mdpi.com/1424-8220/18/11/3709>

# 3.0 Objective



# Methodology/Ideas

| **Project Phase** | **Description** |
| --- | --- |
| Data Collection | Gather a large dataset of images or videos for training and testing machine vision algorithms. |
| Algorithm Development | Implement and fine-tune machine vision algorithms for screw and tool localization, presence detection, and pose estimation. Utilize libraries or frameworks like OpenCV or machine learning tools. |
| Testing and Validation | Rigorously test the system with real-world scenarios to ensure reliable performance. Iterate and refine algorithms as necessary. |
| Mechanical and Electrical Design | Collaborate with mechanical and electrical engineers to design and build the hardware components of the guided assembly station. |
| Software Development | Develop control software to manage the entire assembly process, including screwing, presence verification, and workpiece handling. |
| User Interface | Create a user interface for operators to interact with the system, monitor progress, and troubleshoot issues. |
| Documentation | Maintain detailed records of the project, including code, design documentation, and test results. |
| Safety Considerations | Ensure safety measures are in place, especially when dealing with moving parts or automation. |
| Presentation and Documentation | Prepare a comprehensive report and presentation for the final year project, outlining the problem, objectives, methods, results, and conclusions. |

This table should help you organize and plan the various aspects of your project efficiently.

1. Screw Identification

Diagrams and images

Colour masking contour

AR Tags

* 1. What is the best object detection technique for this.
  2. Dataset?
  3. Pre-requisites?
  4. Components?
  5. Literature Survey – to get some of this questions answered

1. Geoposition Tagging.
2. Screw position identification.
3. Remove the lock once all the screws are tightened.
4. Camera Mounted in the screwdriver than an over-the-system setup.
5. [(ref1)](https://tryolabs.com/guides/introductory-guide-computer-vision)
6. [(ref2)](https://tryolabs.com/guides/introductory-guide-computer-vision)
7. [(ref3)](https://www.youtube.com/watch?v=TTnho9-i6dI)
8. [(ref4)](https://www.youtube.com/watch?v=ThWwuId0Fas)
9. [(ref5)](https://www.youtube.com/redirect?event=video_description&redir_token=QUFFLUhqa1pLMjA1NDh5Zkg5NC1rM3BrcFhaaG5PemVoUXxBQ3Jtc0trc3VUS1k2Rl9XUDVHU3JWSkwxRmhobnBMLWtLSUJva2JKTmNGTjdQUlBNQjVBVU9raWpxUjBmNjhYS3h3S2YwZVJ6d2tweDl6WU1KUGZSdFRseG9TRXhhVGFkbE5JWXJnNW9JWGlEVnFIVWk1SENBVQ&q=https%3A%2F%2Fwww.sensopart.com%2Fen%2Fproducts%2Fvision-sensors-systems%2Frobotic&v=dGWvsNEwTe8)
10. [(ref6)](https://www.keyence.com/ss/products/vision/visionbasics/use/inspection01/#:~:text=Presence%20inspection%20using%20machine%20vision,typical%20256%2Dlevel%20monochrome%20camera.)
11. [(ref7)](https://www.youtube.com/shorts/lQSaziJF7AA)
12. [(ref8)](https://www.youtube.com/watch?v=fZY0i-wG20I)

# 5.0 List of Components

# 6.0 Timeline

# 6.0 Conclusion

# 7.0 References

**Proof of concept**

Camera

* Webcam
* Working, giving real-time data
* Camera Placement is fixed, Workpiece placement is fixed.

Program

* Coded to:
  1. Mark the points where screw is present.
  2. Return the coordinates of specific points.
  3. Identification of April ta

Code for tracking fast-moving objects. – for April tag – not needed now

Code to identify if the tag has entered the screw position.

April tag installation error.

Processor for the camera

Option 2

Images of the workpiece

Reference object.

Template of the image

Questions

Fixed workpiece and camera.

If yes – manual coding

If no – template matching, ML methods

**Alpha Prototype**

Camera

Light

PLC

Do I need to establish a communication between PLC and MV

If yes, why?

* Feedback

MC

Hole detection

Bounding box

Nutrunner detection

Decide the sequence – hard code.

Bounding box around the hole

Find its Centrepoint.

It has to detect that it’s a hole. And get the coordinates of the hole.

Hole parameters

Coordinates

**Process**

1. Product loaded into the conveyor belt.
2. It moves the conveyor Belt with the workpiece under the camera – and stops
3. The next task of plc should activate the camera and lighting.
4. As a result, the program runs a code and displays real-time video stream on the monitor
5. Camera detects the AR Tags on the workpiece.
6. The RPi display the pre-mapped screw coordinates of the workpiece on to the display.
7. The RPi program now shows the sequencing of screw on the display.
8. The program begins to detect position of the screwdriver using the April Tag.
9. Once the screwdriver moves closer to the screw coordinate, it activates power to the screwdriver.
10. PLC receives Torque feedback (to verify proper fastening of the screw).
11. Torque feedback is sent to the RPi from PLC as input for the sequencing code.
12. RPi verifies the torque feedback and displays “screwing successful” for respective screw.
13. RPi Displays the next Screw in the sequence. (RPi proceeds again from step 7)
14. Now the screw sequence is complete.
15. RPi takes an image of the workpiece and uses digital image processing to verify the presence of the screw.
16. If all screws are verified, display ‘all screws are in place’.
17. If a screw is absent RPi proceeds again from step 7 with only the absent screws in the sequence. (RPi proceeds again from step 15).
18. Send workpiece to the Next station.

Camera identifies the Screw holes.

Acquires the location for the hole.

Gives the sequence of screwing process.

Completes screwing process.

Identifies screws or checks for holes.

Workpiece to the next station.

PLC And MC

Right now, how CV works is

Camera is plugged into the Laptop

* Python code is run to get the data from the camera and identify the screw.

I think we need to come up with a system where:

* + Theres the master PLC
  + It moves the conveyor Belt with the workpiece under the camera – and stops
  + The next task of plc should activate the camera and lighting.
  + Object identification
  + The camera should get the instruction from an MC, preferably an RPi.
  + The RPi should have the code for the camera.
  + And it should communicate with the Master PLC system.

**Parameters**

A piece of paper with writing on it

Description automatically generated

TO DO

Jam board

Market survey - What are the tech that are currently available. Who is providing this ? – PowerPoint

Torque feedback sensor.

Pick to light.

Suggestions by chinna

Architecture diagram

System design – Chinna

Why we chose this architecture

Why not the other

Permission letter

Send to eby

Code

Pics

Ppt

synopsis