International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 7 Issue 4, April - 2023, Pages: 29-35

Specialized Machine Vision Applications for Quality Control and Safety at ALUMIL Aluminum Industry S.A

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Abstract— *This paper presents three machine vision applications developed by ALUMIL Aluminum Industry S.A for its specific needs. The first application performs checks on the eccentricity of holes and the diameter of aluminum angles. The second application ensures the straightness of small aluminum bars, while the third application detects and locates moving mechanical parts and loads in the workspace for the safety of workers. These machine vision systems are in the experimental stage and their accuracy and reliability are being studied, increasing efficiency and safety in the production process. The article discusses the technical details and performance of each application, highlighting their importance in the aluminum industry.*

Keywords— Machine Vision, Quality Control, Safety

1. INTRODUCTION

Over the past few decades, the aluminum industry has experienced significant growth and development, driven by advancements in technology and a growing demand for lightweight and durable materials. As a result, the industry has faced new challenges in terms of maintaining quality control and ensuring the safety of workers in an increasingly complex manufacturing process. One of the key challenges faced by the aluminum industry is maintaining the required level of accuracy and precision in the manufacturing process. The use of advanced machine vision systems has emerged as a promising solution to this challenge, offering a range of benefits over traditional methods of quality control and inspection. Machine vision systems use advanced algorithms and image processing techniques to analyze high-resolution images and detect any deviations from the required specifications. This allows manufacturers to identify and rectify issues promptly, improving the quality of the final product. In addition, machine vision applications can reduce the time and resources required for quality control and inspection, increasing efficiency and productivity in the manufacturing process [1].

This paper presents three machine vision applications that have been developed specifically for use in the aluminum industry. The first machine vision application presented in this paper is designed to check the eccentricity of holes and the diameter of aluminum angles. This system uses high-resolution images and advanced image processing techniques to identify any deviations in the diameter of holes or eccentricity of angles accurately. This level of precision ensures that the final product meets the required specifications and maintains its structural integrity, making it safe and reliable for use in various applications [2].

The second application ensures the straightness of aluminum bars. This system utilizes laser technology to measure the straightness of aluminum bars accurately. Any deviation from the required straightness is detected by the system, and corrective measures are taken promptly to rectify any issues. This system is crucial in ensuring that the aluminum bars meet the required specifications, which is vital for their use in various applications.

The third application is designed to detect and locate moving mechanical parts and loads in the workspace, ensuring the safety of workers. This system uses advanced algorithms to analyze video footage captured by multiple cameras strategically placed in the workspace. Any moving parts or loads are detected and located in real-time, and warnings are issued promptly to the workers, preventing potential accidents [3].

The paper discusses the technical details and performance of each system, highlighting their importance in the aluminum industry. Additionally, the paper discusses the potential future developments of machine vision application in the aluminum industry and their implications for the industry.

2. MACHINE VISION APPLICATIONS

2.1 Alumil Hole Inspection For Corner Joints

The problem of eccentric holes in mechanical corners sometimes occurs during their production (hand-drilling). This results in randomly generated mechanical corners with eccentric holes being placed in the same basket as centered ones. At the input of the robotic system, the operator always visually checks the centering of each hole in parts A/B of the corners before placing them on the feed tape. The operator's visual check requires great attention since mechanical corners are placed next to each other, making it impossible for the human eye to see the differences. Moreover, corners with eccentric holes that pass to the next stages of the system, such as the press station and the screwdriver station, will cause vital mechanical equipment damage, rendering the machine out of operation until repaired. Alumil Hole Inspection For Corner Joints is an auxiliary hole recognition and inspection program. It was designed and developed to solve the problem of difficult visual recognition of the eccentric hole, ensuring the correct supply of parts A/B and the smooth operation of the robotic system of mechanical corners. It can be placed at the input-feed of the robotic system through special support [4].

The solution to this problem is the Alumil Hole Inspection For Corner Joints program, which is an auxiliary system that recognizes and inspects the holes. The program was designed to ensure the correct supply of parts A/B and the smooth operation of the robotic system of mechanical corners. It can be placed at the input-feed of the robotic system through a special support, and it helps to prevent damage to the equipment and downtime. The operator will be able to control the sampling of each hole or every hole during the placement of the corners on the feed film through a screen.

Through the screen, the operator will be able to check the hole, or each hole, during the placement of the corners on the feed film. The system provides precision detection and control of the hole with an accuracy of 0.1 mm. It is a plug-and-play system that does not require any special equipment or knowledge from the operator. The system is expandable and does not involve complex parameterization. Furthermore, it is user-friendly for the operator to use [5].

The code is used for detecting a circle in a video feed captured by a camera. It calculates the distance between the center of the circle and the red line for x and y and compares the x and y coordinates of the center of the circle with the line_x and line_y respectively. It displays the direction of the center of the circle from the line on the frame along with the distance in mm. It also displays the diameter of the circle in mm. The code also prints out messages if the circle is detected to be in a certain direction relative to the center of the frame.

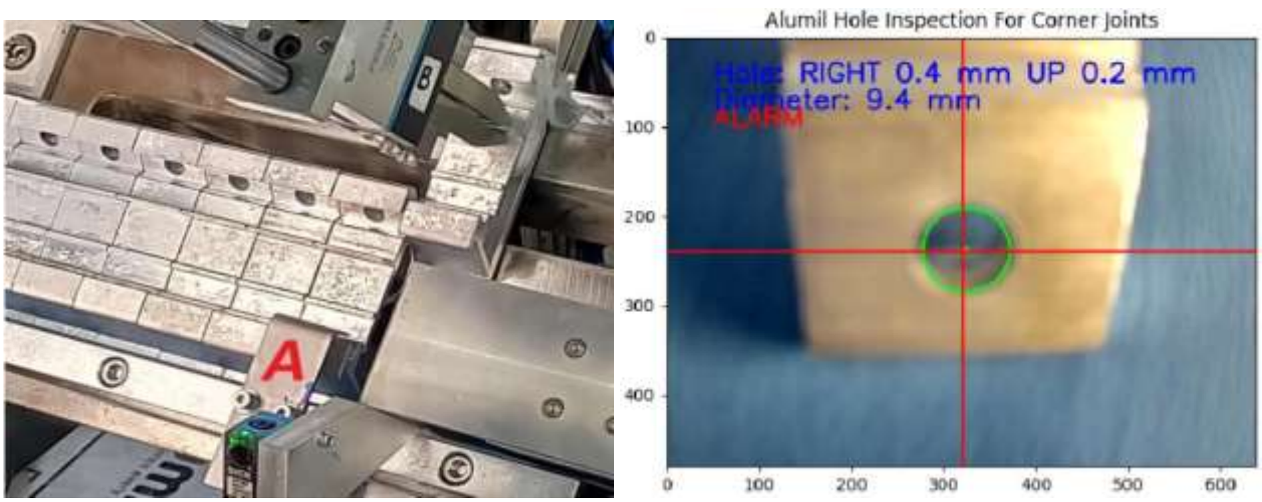

Fig 1. The input of mechanical corners (left). The application checks the hole (right).

From the experiments conducted, it was found that there was smooth accuracy under constraints. The system was tested on 50 angles passing by, with each taking 5 seconds, one after the other. Out of the 50 angles that were mixed, 25 were good and the other 25 had problems with eccentric holes. The system had a very good real-time response of around 1 second, resulting in the immediate display of the measurement result on the screen when an aluminum angle was in front of it. In terms of accuracy, it managed to detect 31 of the 50 angles, while the rest were displayed with incorrect results. This was due to the lighting in the space where the experiment was conducted, as it was a factory space. As with any vision system, the biggest problem is lighting [6].

In image 2 on the left, we see that the system detects the center of the hole to be shifted to the left. This is correct, but the diameter is wrong as it should be 8.20 mm. This is because when the aluminum angle is shifted, the ambient light reflects onto it, causing the camera to perceive a different circle outline from the pixels of the image. In image 2 on the right, we see that the diameter of the hole is correctly detected as 8.20 mm, and it is also correctly detected that the center of the hole is shifted upward by 0.8 mm from the coordinates of the screen. In image 3 on the left, we see that the system correctly detected that the center of

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the hole is shifted downward and to the left by 2.2 mm and 0.6 mm, respectively, but the diameter of the hole is wrong at 8.6 mm instead of 8.20 mm, which is also due to lighting. In image 3 on the right, we see an intermediate state in which the diameter of the hole is correctly identified at 8.20 mm, but it shows that the center of the hole is "OK!" even though it is shifted upward by 0.4 mm and to the left by 0.2 mm. These issues are mainly due to lighting and will be considered in future experiments.

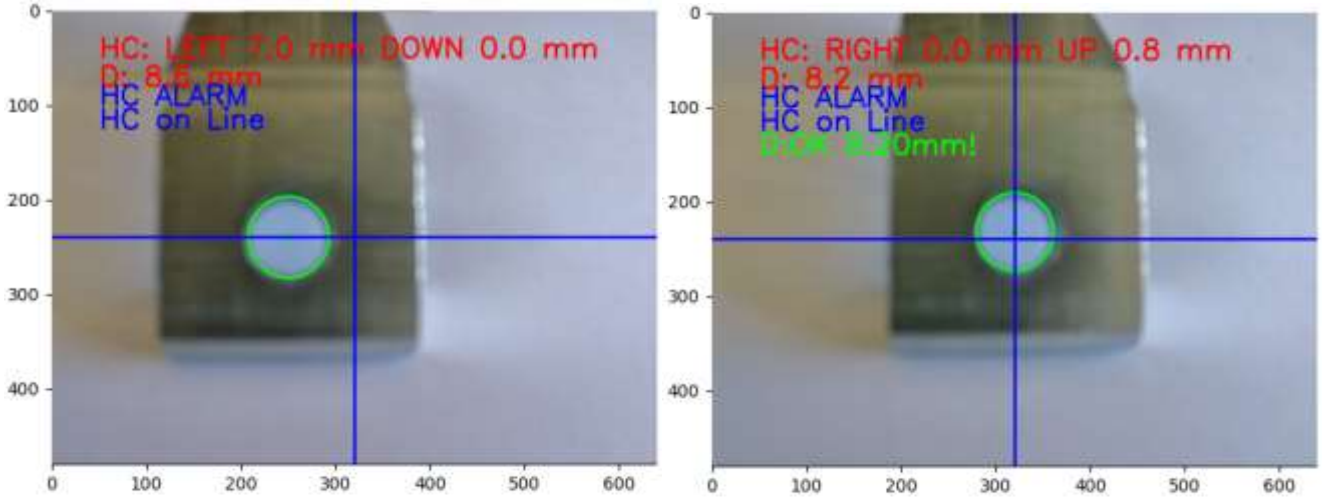

Fig 2. The application detects that the center of the hole is displaced (left). The center of the hole is not at the center, but the diameter of the hole is correct (right).

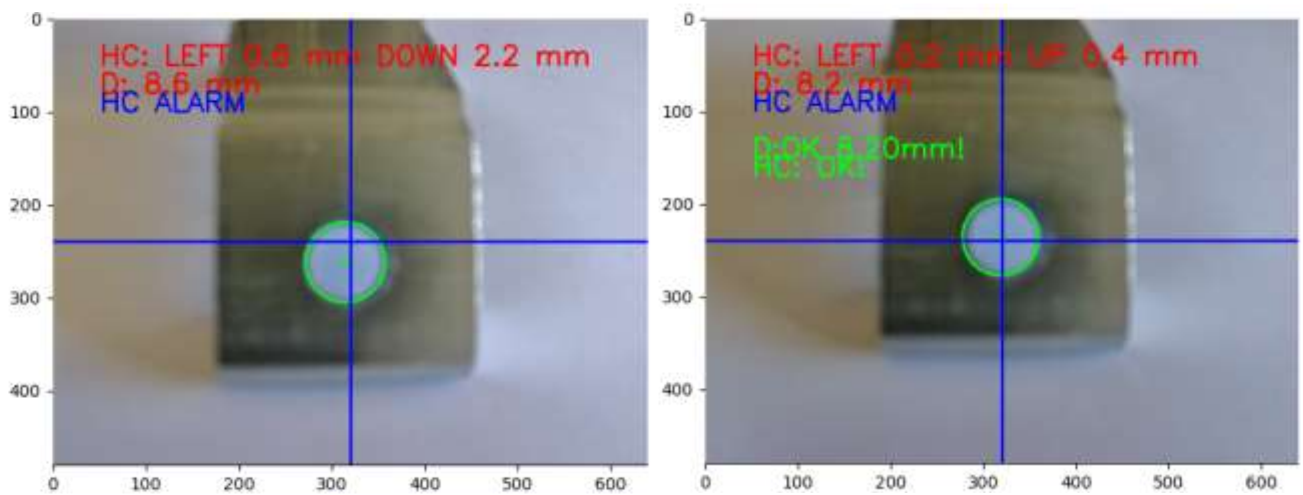

Fig 3. The application detects that the center of the hole is displaced, and the diameter is false (left). The center of the hole is not at the center, but the diameter of the hole is correct (right).

2.2 Alumil Straightness Orientation Measure

For the purposes of dimensional quality control, it is advisable to perform the control using a real-time autonomous system. We present the experimental system Alumil Straightness Orientation Measure Version 01, which allows for the control of profile straightness. It can be placed on a linear axis to scan each side. It uses a simple camera aligned in front of the profile and in real-time (live) extracts the deviation in degrees of the profile's side in comparison to the imaginary red horizontal line of the image. Below we can see the two cases of straightness control. In the first case, each pixel of the lower side of the profile is parallel to the corresponding pixel of the imaginary red line, resulting in an OK Angle of 0.00 degrees. In the second case, we can see the pixels of the left side of the profile deviating from the imaginary red line, resulting in a NOT OK Angle of 1.05 degrees. The system is capable of detecting with high accuracy, specifically 0.1 mm. It is also very easy to use since it's a plug-and-play system that doesn't require any special equipment or expertise from the operator. Additionally, the system is scalable and doesn't involve complicated settings. Moreover, it's designed to be user-friendly for the operator [7].

This code uses specific library to detect the orientation of straight lines in real-time video frames captured by a webcam. Then initializes a video capture object using the first available camera. The code continuously reads frames from the camera, flips them horizontally, and applies various image processing techniques to detect edges and lines using Canny edge detection and Hough line detection, respectively. A red line is drawn on the frame to indicate the desired orientation of the straight lines. The code calculates the slope and angle of each detected line and checks whether it falls within a certain range of angles with respect to the horizontal orientation. If the angle is within the desired range, the code overlays a green "OK" label on the frame, indicating that the orientation is acceptable. Otherwise, a red "NOT OK" label is displayed. The code also displays the angle value on the frame for reference.

Fig 4. Detection of profile with correct straightness (left). Detection of profile with an angle (right).

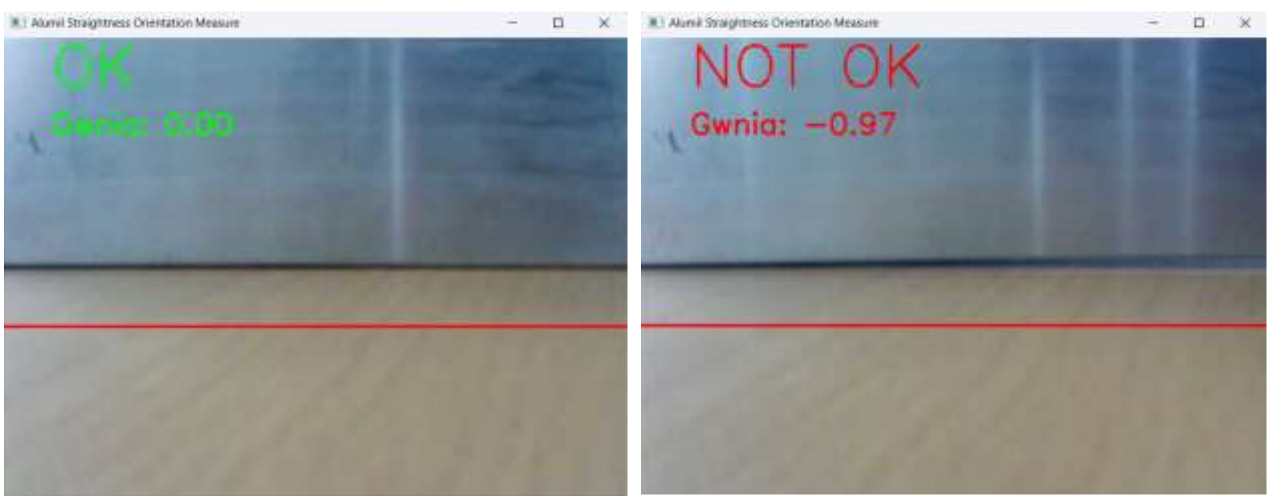

Fig 5. Detection of profile with correct straightness (left). Detection of profile with an angle (right).

From the experiments that were conducted, it was found that there was smooth accuracy under constraints. The system was tested on 10 profiles of length 30cm. Out of the 10 profiles, 5 had straightness issues while the other 5 profiles were good. The system had very good real-time response of about 1 second, resulting in the immediate display of the measurement result on the screen. In terms of accuracy, it managed to correctly detect 4 out of the 10 profiles, while the remaining ones appeared with incorrect results. This, as in the previous application we presented, was due to the lighting in the space where the experiment was conducted, as it was a factory space [8].

2.3 Alumil Change Detection and Localization System for Working Environment

The safety of employees at Alumil, as well as in all industrial environments, is necessary and must be taken seriously. A common risk for workers is the possibility of injury from moving parts and loads. To prevent this, it is important for workers to be trained in safe work practices, to use protective equipment, and to faithfully follow safety regulations in the workplace. Additionally, there must be proper design and suitable equipment, such as barriers and disposable protective materials, for the safety of workers from moving parts and loads. This system contributes to the safety of Alumil workers as well as other industrial fields [9].

The Alumil Change Detection and Localization System for Working Environment uses machine vision and image processing techniques and all that is needed is a camera connected to the production or work machine machine. It can be installed at various critical points in production such as corridors, cutting machines, etc. where workers are present, to alert them through high-frequency sound and virtual ALERT signaling of the danger of moving objects in the area. It is Plug and Play without special equipment, has a real-time system response of 1", is compact and user friendly. The system was tested at 3 production points where it was successful. In addition to displaying the necessary information on the screen, the system produces a high-frequency sound that can be perceived from a distance and can draw someone's attention to it.

The application uses specific library to capture live video from a camera and detect changes in the environment relative to a reference frame. The script first sets up the video capture and then waits for the user to press the 'r' key to capture the reference frame. The script then enters a loop where it captures frames from the video stream and compares them to the reference frame using various image processing techniques such as grayscale conversion, absolute difference, and contour detection. If a significant change is detected, the script alerts the user by drawing a bounding box around the area of change and displaying a warning message.

In this case, the results were the illumination of the environment. Additionally, the shadows created by objects that were illuminated caused the system to incorrectly perceive an object or the absence of an object or a change in an object when there was nothing there. In image 6, on the left, we see the beginning when the crane is stationary and, on the right, we see that the system detects it when it is moving, displaying the corresponding message and sound.

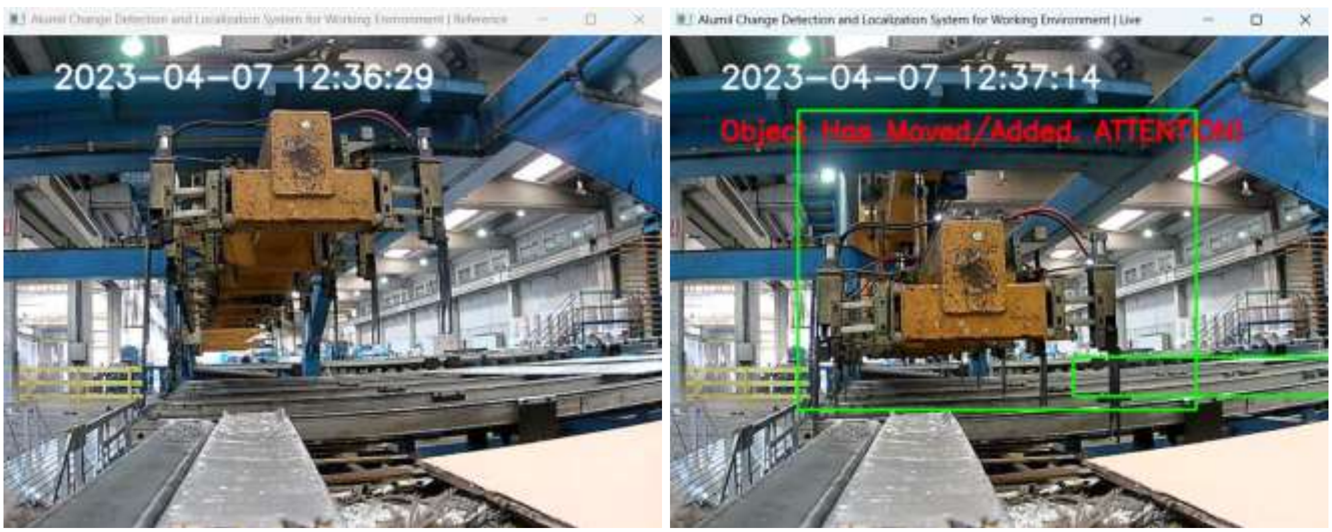

Fig 6. Motion detection of a crane.

3. Future work

The problem of detection and accuracy in machine vision systems presented earlier was largely due to the lighting conditions of the environment. In further tests, efforts will be made to control the lighting to give the systems better results. It is well-known that lighting can affect the quality of images captured by cameras, and this is particularly important in computer vision systems where accuracy is essential. By controlling the lighting conditions, we can ensure that the systems are working optimally and delivering the highest quality results possible. This will not only improve the performance of the systems but also make them more reliable for use in a variety of applications [10].

In addition to controlling the lighting conditions, future work to address the problem of detection and accuracy in machine vision applications could also include improvements in algorithm development. One approach could be to incorporate machine learning techniques that allow the system to learn from its mistakes and continuously improve its performance. This could involve training the system on a larger dataset to increase its accuracy and incorporating feedback mechanisms that allow it to adapt to new and changing environments. Another potential solution could involve the use of multiple sensors and cameras to capture a more complete picture of the environment. By combining data from multiple sources, the system could more accurately detect and track objects, even in challenging lighting conditions. This approach would require significant computational resources, but with advances in hardware and processing power, it could become a viable option in the near future.

4. CONCLUSION

In this paper, we demonstrate the successful development of three machine vision applications by ALUMIL Aluminum Industry S.A to meet their specific needs. The first system checks the eccentricity of holes and the diameter of aluminum angles, ensuring the quality of the products. The second system checks the straightness of small aluminum bars, ensuring that they meet the desired specifications. The third system detects and locates moving mechanical parts and loads, preventing workplace accidents and injuries. Although these machine vision applications are in the experimental stage, they have already shown promising results. Further studies are being conducted to assess their accuracy and reliability, as well as to optimize their performance.

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