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IDENTIFICATION OF DEFECTS IN ALUMINUM PROFILES USING VISION-BASED SYSTEM

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Machine Vision, Image Processing, RGB Color Segmentation, Gray Scale, Rice, Canny Edge Detection, Aluminium Fabrication

ABSTRACT
Aluminum manufacturing is one of the leading industries in Sri Lanka, and many companies are engaged in the manufacture of aluminum extrusions for a wide range of applications, such as windows, doors, shopfront, curtain walls. The extrusion of aluminum is a mechanism by which aluminum alloy is turned into metal. Due to workforce constraints for the quality control process, the anodizing and powder coating plant received aluminum profiles with defects from the extrusion factory. This operation leads to a loss of around 2.8 million anodizing materials each month. This research intends to develop and construct a vision-based framework to detect defects in aluminum extrusion processes. The goal of this analysis is to classify defects on aluminum profiles as a potential solution. The findings have been confirmed that the device has established air bubble identification, oil patch identification, pigeon poo detection for many more effective trials.

INTRODUCTION

Aluminum is known as an alloy and commonly used in numerous fields such as the manufacture of automobiles, building industry, oil, fuel, transport, and medicine. The construction industry plays an essential role in any developing country, promoting the core human needs that are required for socioeconomic development (Karimet al., 2012). The Association of Aluminum states that in the 19th century, aluminum was found more valuable and valuable than silver or gold[1-2]. Aluminum extrusion is a process used to transform aluminum alloy into items of direct cross-sectional shape for a wide range of applications. Companies producing aluminum conduct aluminum extrusions to build and assemble a wide variety of items, such as bars, doors, and curtain walls.

Use with a surface coating of aluminum oxide was considered to be susceptible to corrosion and abrasion on the skin of aluminum during the extrusion process. Layers vary from 0.1-1.0 mm thick and are usually translucent, but maybe painted. The billet is the starting stock for extrusion service in the Aluminum extrusion process [3]. The extrusion billet may be a hollow or solid shape, usually cylindrical, which is the length charged into the nozzle of the extrusion device. It's also made of a wider alloyed aluminum base, regarded as a log. Aluminum extrusion is a method used to transform aluminum alloy into goods with a simple cross-sectional design and a broad range of uses. This procedure has several phases, including the preparation of raw materials, the extrusion stage, and the anodizing system. Figure 1 indicates the process of the items being manufactured from aluminum.

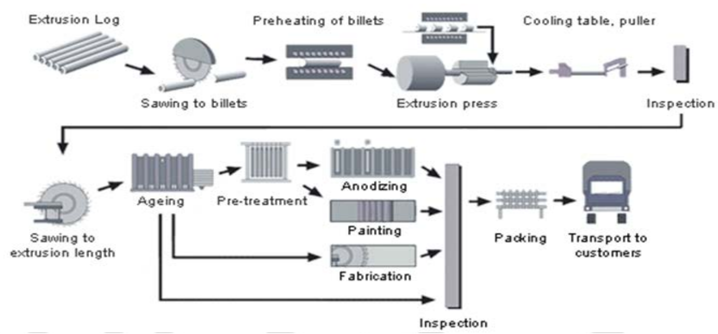

Figure 1. Production Process Flow

Human examination of aluminum profiles is exhausting and may cause eye exhaustion, as well as becoming susceptible to mistakes in sorting due to the actions of various individuals. Owing to a shortage of manpower for quality control service, anodizing and powder coating plants provided profiles of defects from the Extrusion factory. Despite this, companies waste a minimum of 2,8 million anodizing products for a month (Figure 2).This research seeks to offer a potential alternative for constructing an aluminum profile handling bench and detecting flaws on the aluminum profile utilizing computer vision techniques.

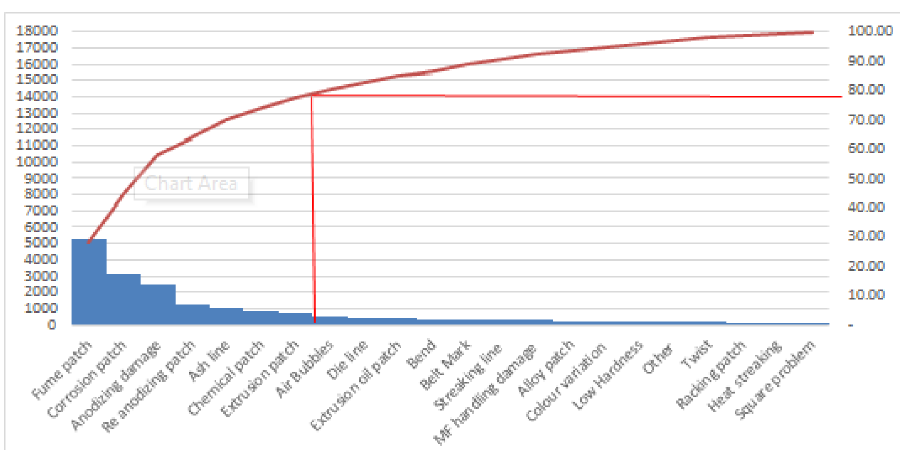

Figure 2. Anodizing Rejects of Fabrication Industry

Literature Review

Industrial monitoring plays a very important role in maintaining performance. Any inspection procedures need significant skill and flexibility in communication. Human beings are considered prone to make errors, so they are sluggish and not consistent. The visual inspection practices have been streamlined due to the requirements of 100 percent testing, good efficiency, low production costs, and documentation of the defect rates that arise in the manufacturing processes. A robust design, flexibility, and verified accuracy findings found when it comes to surface inspection are accessible devices with the surface vision system.

SMARTVIEW. AMETEK SURFACE VISION

The SmartView solution family has become synonymous with offering detailed testing, effective detection of faults, precise recognition and visualization, meeting the needs of manufacturers and converters in several different industries across the globe. SmartView, AMETEK Surface Vision offers full visual integration for the SmartView framework by offering optimized solutions for cloud monitoring or event capture, surface texture calculation, screen width calculation, automated video capturing and recovery, detailed ranking, and judgment processing, and device reclaiming. Using the integrated camera systems, together with state-of-the-art technologies and equipment, we can catch defective images from multiple inspection angles to include unrivaled real-time surface detection, monitoring, measurement, reporting, and classification.

AUTOMATED METAL SURFACE INSPECTION THROUGH MACHINE VISION

Through this process, visual testing is automatic on metal surfaces. Originally, updated grey-level co-occurrence matrices of metal artifacts are used for viewing details on metal surfaces. Third, the moment of variation and the entropy of the gray level matrices co-occurring are obtained as properties of metal surfaces. Finally, the features of the inspecting artifacts are then compared with the specified confidence duration to test whether or not the inspecting metal is defective. In the experiments, many combinations of relative locations were tested between two positioning pixels and feature descriptors to decide the right one.

RELATED WORKS

Ruofeng and Yunbo are engaged in a deep learning-based study on aluminum profile surface defects recognition technology. They demonstrated that the network's efficiency in the identification of surface defects in aluminum profiles was high [4].Neuhauser and his research team propose an approach for the classification and detection of surface defects, whereby a simple camera records the extruded profiles during production, and neural network architecture distinguishes between immaculate surfaces and surfaces that contain a variety of common defects. According to their results, Classification accuracies of 0.98 and a mean average precision of 0.47 in the detection setting were achieved while training on a data set containing 813 images[5].

Methodology

The detection of multiple defects on different types of aluminum profiles is a problem in the aluminum manufacturing field. Intelligent image processing is a tool for the identification of various types of defects in aluminum profiles. This research focuses mainly on creating a potential profile handling bench configuration and review of the features and creating an algorithm to identify defects on aluminum profiles.

DESIGN OF MACHINE VISION SYSTEM

Development of the machine vision device to identify the rejections during the extrusion step as follows, the software layout, as illustrated in Figure 3. The device devoted to continuous on-line monitoring as centered on a feedback loop, resulting in a notification regarding the possible process anomalies produced by the product's examination of malfunctioning defects. The camera is the tracking system's principal module.

The precision of image calculation depends on the scale of the region of examination defined on the surface of an object. An Important factor in the inspection process of the Web camera [6-7] to ensure adequate lighting conditions within the area of observation. The Halogen illuminator and the Pulse Driven illuminator were the origins selected for implementation. To control reflection on a bright surface by adjusting or transferring the main light or raising the lux level across the surface. Pulse - Dimmable Light is a specific device of lighting that can monitor the lux amount on the panel [5].

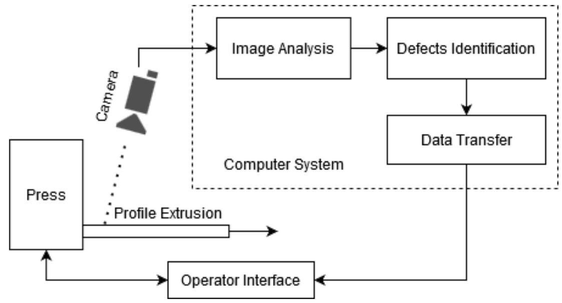

Figure 3. Proposed Machine Vision System

CALCULATING REQUIRED RESOLUTION FOR CAMERA

The detail is defined byresolution in an image.The shorter the focal length ofthe lens, the field of vision is larger.Most lenses tend to display bent, blurred barrel images thatcompress the picture at the edges more than around 90 degrees.

$$Resolution\ = 2\left(\frac{Object\ Size}{Size\ of\ the\ detail\ to\ be\ inspected2}\right)^2$$

Object size = Largest profile
Size of the detail to be inspected = Minimum size of the defect
$Resolution\ = 2x\ (250\ mm\ x\ 250\ mm)/(0.25\ mm\ x\ 0.25\ mm)$
$Resolution\ = 2{,}000{,}000\ pixel$

CALCULATING MAGNIFICATION ON CAMERA

$\boldsymbol{H_i = Distance\ between\ lens\ to\ sensor\ /\ Height\ of\ the\ image}$
$\boldsymbol{H_o = Distance\ between\ aluminum\ profile\ and\ lens\ /\ Height\ of\ the\ object}$
$According\ to\ camera\ specification\ (Raspberry\ Pi)$
D_i – $Length\ of\ the\ sensor\ (3.6\ mm)$
D_o – $Length\ of\ the\ object\ (250\ mm)$
$Magnification = (Hi\ )/Ho = (Di\ )/Do$
$M = (\ 3.76\ mm)/(250\ mm)$
$M = 0.015$

IMAGE PRE-PROCESSING, AUGMENTATION AND CLASSIFICATION PROCESS

The first phase needed for pre-processing after loading the dataset. This is a color image that transforms into a gray picture and equalizes all images to match the lighting condition to determine whether there are defects on the surface of the aluminum profile. As the images contain noise, noise must be removed using filter and smoothing techniques to recognize and cope with the defects [8-9]. The target image is compared with the sample image, and the ROI exists if their gray level gap exceeds.

Due to the environmental factors, the grab images have noise and may have mixed with motion-blurred; at the same time, the profile runs at high speed, so it is difficult to detect edge for Image defects. To satisfy the device specifications of real-time, image smoothing is first done by means of a filter, and then the process of edge detection is employed by choosing the appropriate threshold to obtain the binary image and then using cluster analysis to locate defects that contain the smallest region to quickly and effectively realize image segmentation. Using special functions, if there is any zoom range, image rotation, and image shifted vertically or horizontally to increase the level of accuracy on detecting defects [10-12]. This is necessary to extract features on images that are defective. The aluminum surface inspection method has to properly identify defects according to the origin of the defects. Neural network methodsare used for the defect classification.

Image Processing Toolbox [13] offers a robust collection of common reference algorithms and software frameworks for image processing, study, simulation, and creation of the algorithms. Image segmentation, image stabilization, noise reduction, graphical transformations, image capture, and 3D image analysis may be made. Image processing Toolbox Applications simplify those workflows in image processing. The toolbox will segment image data interactively, compare image processing strategies, and batch process broad data sets. Visualization functions and applications enable to explore pictures, 3D dimensions, and videos; change contrast; build histograms; and control interest regions.

In a single image, there are about (32x32) 1,024 pixels. But here can separate it from the original image after a defect is identified. And then,the system starts classifying the defect from the Neural Network for that chosen region. Usually,six defect features decide the output nodes of the neural network six, respectively. The neural network comprises of three layers.Figure 4 illustrates the flow chart of the defect detection algorithm

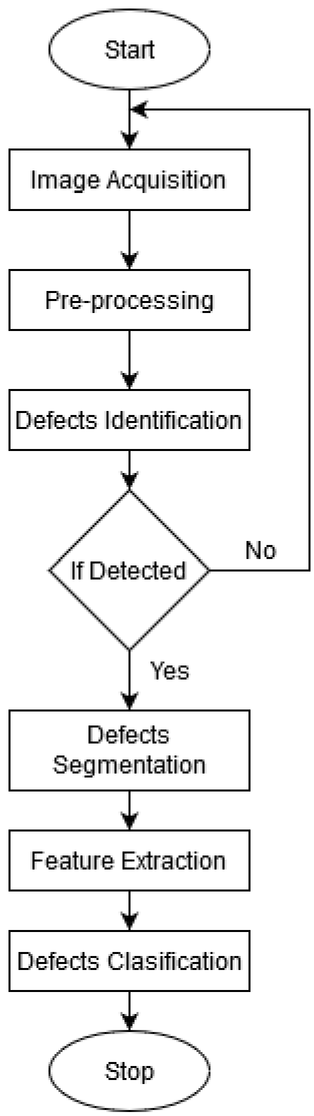

Figure 4. Defects Detection Algorithm

RESULTS

In this experimental system, thegenerated air bubble was identified.This algorithm is powerful enough to identify95 percent of defects in aluminum profiles.Figures 5, 8, and 11 illustrate the source image, and Figures 6, 9, and 12 depict object detection after the application of the algorithm. At each test run, Figures 7, 10, and13 represent the histogram of the respective source pictures.A canny edge detection algorithm wasused to detect fault edges.In test 1, air bubbles are counted and note that 54 objects have been identified for the source image of test 1. According to the histogram, the gray level was varied between 75-120 ranges.

TEST 1: AIR BUBBLE DETECTION IN EXPERIMENT AND RESULT

Figure 5. Source Image on Test 1

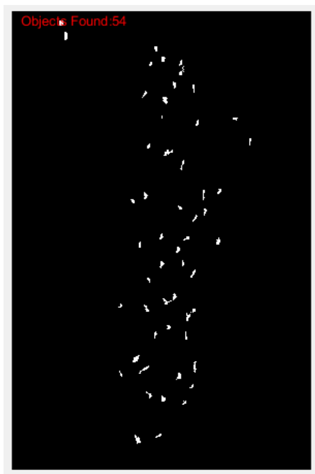

Figure 6: Defects Identifies on Test 1

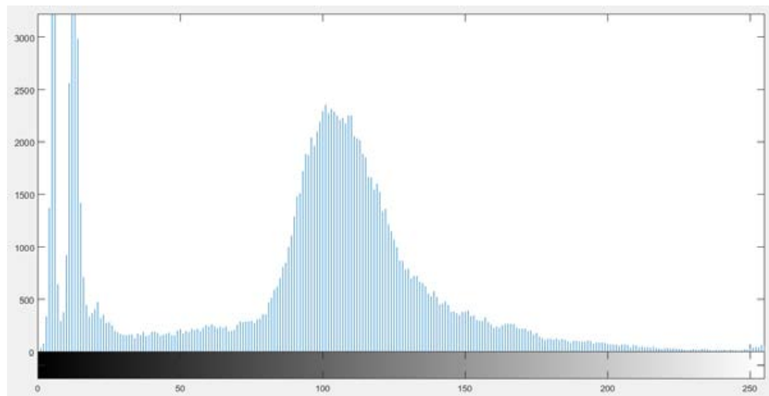

Figure 7: Histogram of Source Image on Test 1

TEST 2: OIL PATCH DETECTION IN EXPERIMENT AND RESULT

Canny Edge identification was used in the second experiment, and the oilpatch variability was observed from the 200-230 gray level range according to the histogram.Threshold values are set belowthe amount of gray required.The threshold value, in this case,was 200-250 observed.

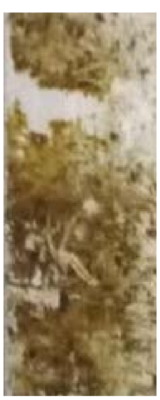

Figure 8: Source Image on Test 2

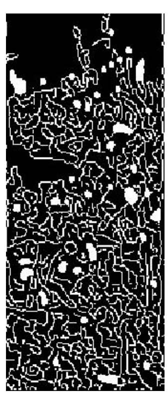

Figure 9: Defects Identifies on Test 2

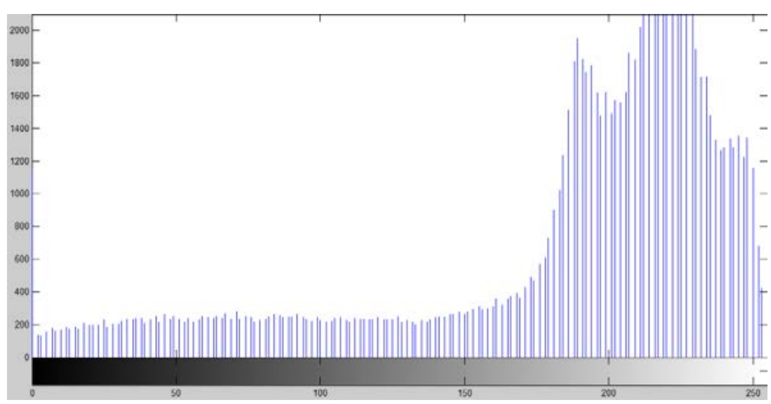

Figure 10: Histogram of Source Image on Test 2

TEST 3: PIGEON POO DETECTION IN EXPERIMENT AND RESULT

Figure 11: Source Image on Test 3

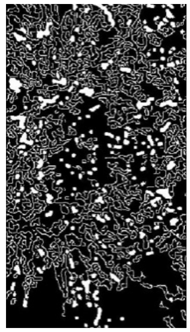

Figure 12: Defects Identifies in Test 3

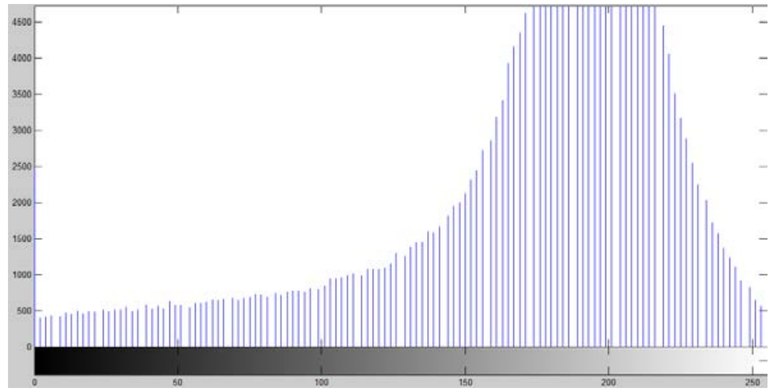

Figure 13: Histogram of Source Image on Test 3

Histogram suggested that gray level variation 160-220 was identified as pigeon poo patches.Table 1 depicts the gray level variation for three trials on the above mentioned defects. Test 3 also used canny edge detection and color segmentation algorithm.

Table 1. Results for Three Trials

Type of Defect	Histogram Variation		
	Trial 1	Trial 2	Trial 3
Air Bubble	75-120	70-130	85-125
Oil Patches	200-230	210-225	195-215
Pigeon Poo	160-220	155-225	150-220

Conclusion

The analysis was done for three tests, and, according tothe study results,better success was reported for three defects.

The histogram helps to classifyprofile faults for each image.Default artifacts were counted for each item,and each flaw was specified by object size.The Canny Edge detection was effectively usedto identify the edges of the defects.

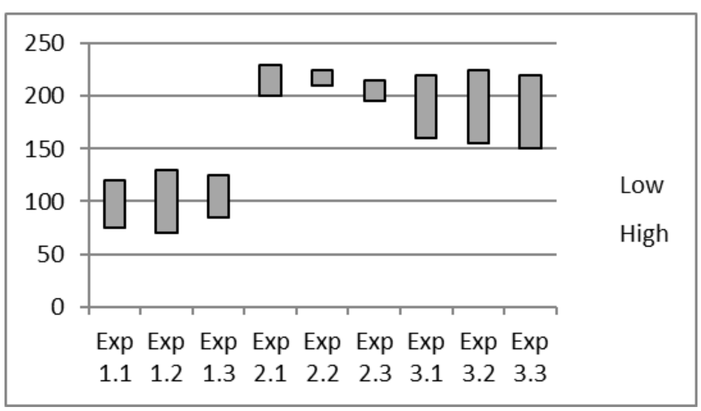

Figure 14. Comparison of Results on Three Trials

Figure 13 illustrates the comparison of three trials and observes that average threshold values for Test 1 are 76-125, Test 2 is 201-225, and Test 3 is 155-221.According to the graph, test 3 and test threshold values overlap, due for this reason, the color segmentation algorithm was used on test 3 along with the threshold value between 155-221.

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