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IMAGE PROCESSING COMPUTER VISION FOR CRACK DETECTION OF AIRCRAFT SURFACE

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Abstract: The goal of this paper is to disclose a library of image enhancement and comprehension algorithms that have been developed to improve and recognize surface flaws from remote live imagery of an aircraft surface. Improved remote visual inspection could allow the inspector to undertake the essential visual examination on an aircraft in a safe, timely, and accurate manner. CIMP sends high-resolution, real-time stereoscopic pictures of the aircraft crown to an inspector at a console. The inspector examines the images for surface problems using computer augmentation and intelligence. We will discuss many image enhancing methods as well as an inspector's interface for emphasizing surface cracks, scratches, lightning strikes, and corrosion in live imagery in this paper. Surface-specific image enhancement techniques emphasize image features that are unique to the surface.

I. INTRODUCTION

Visual examination is by far the most used approach for inspecting the surface of an aircraft. However, the current practice of checking aircraft bodies from the ground raises safety concerns for the inspector, is time consuming, and ineffectual at times owing to inspector weariness or boredom. Enhanced remote visual inspection could allow the inspector to execute the needed visual analysis in a safe, timely, and accurate manner. The Crown Inspection Mobile Platform (CIMP) is a prototype aircraft-capable mobile robot created at Carnegie Mellon University in Pittsburgh. CIMP sends high-resolution, real-time stereoscopic pictures of the aircraft crown to an inspector at a console. The inspector examines the images for surface problems using computer improvement and intelligence.

In this paper, we will look upon

II. BACKGROUND

The Carnegie Mellon University-developed Automated Non-Destructive Inspection (ANDI) robot successfully showed a robot's movement, manipulation, and navigational skills on an aircraft surface. ANDI was outfitted with a sensor package that included an eddy current probe and four remote navigation cameras [3]. The cameras were good for viewing broad visual features, but not good enough for thorough visual assessment due to poor optical or electronic quality. However, because the focus was on mobility and navigation, the importance of collecting valuable inspection data was overlooked. Following the initial demonstration of ANDI, the next step was to create a sensor package for CIMP that would provide relevant inspection data, as well as the creation of a Graphical User Interface (GUI) and an image enhancement and understanding library.

III. SENSOR PACKAGE

A typical heavy inspection check consists of 90% visual examination and 10% NDI inspection. With this in mind, the CIMP sensor package was developed to carry remote vision cameras and lighting equipment at first, with the potential of adding NDI technology later. A stereoscopic pair of inspection cameras, a dynamic lighting array with two fixed floodlights and a rotating directed light source, and two proprioceptive navigational cameras are all included in the sensor package. The inspectional cameras produce a narrow, 3.5x magnified image of the aircraft's surface that is of excellent quality. These cameras have a technically correct imaging setup that delivers natural, easy-to-view stereoscopic pictures of the aircraft surface. The navigational and proprioceptive cameras provide a stereoscopic wide angle picture of CIMP in relation to the environment.

IV. INSPECTION CONSOLE

A. Hardware

The inspector uses a hand-held remote-control unit to regulate CIMP's movements, lighting array in the sensor package, and switching between inspection and navigational cameras. Two principal monitors and their accompanying devices make up the modern inspection console. The first is a monitor that shows live, flicker-free stereoscopic imagery of either

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the inspection or navigational camera pair with full spatial and temporal resolution per eye. The second is a Silicon Graphics Indy workstation with a graphical user interface (GUI) that displays a single channel of the selected camera pair while simultaneously serving as an interface to the image processing algorithms. The Indy workstation's present limitation is its ability to only display live monochrome video images on the GUI. Similarly, but with more force

B. Software

The Intelligent Inspection Window is a GUI developed by Carnegie Mellon University's Department of Electrical and Computer Engineering, Robotics Institute, School of Computer Science, Pittsburgh, PA (IIW). The IIW serves a number of purposes. It acts as an operational interface and output display unit to the image enhancement and understanding algorithms that are tied to menus and buttons on IIW. It displays live monoscopic or still stereoscopic video imagery on a part of its canvas called the display screen; it acts as an operational interface and output display unit to the image enhancement and understanding algorithms that are tied to menus and buttons on IIW. It will also include features for storing multimedia records of surface faults in the future. The IIW is shown in Figure 3b. VI. ENHANCEMENT OF MONOSCOPIC IMAGES.

Monoscopic Enhancement algorithms bring out details in the current live image on the IIW's display panel. Three monoscopic organisms are described.

A. High Frequency Emphasis

A high-pass spatial filtering operation is followed by the addition of a fraction of the low frequency components back to the filtered image for high frequency emphasis. The sensitivity parameter under the inspector's control controls the gain of the high-pass filter. Because scratches, cracks, and corrosion texture occur frequently, this approach is very useful in highlighting them [1]. Note how lines form on the enlarged photos in Figure 4, drawing attention to scratches and cracks. Due to a lack of inherent detail, many live photographs suffer from low contrast, which is compounded by extremely diffuse lighting. Scratches, cracks, and rust texturing, for example, are nearly imperceptible to the human eye. These characteristics are frequently overlooked by high-frequency analysis.

B. Sharpening by Differentiation

On the input image, sharpening executes an edge detection procedure. To create the edge picture, we employ a stochastic gradient filter convolved with the input image. The absolute value at each pixel is thresholded to identify edges in the filtered image [1]. Based on the value of the GUI sensitivity slide bar and the statistics of the image intensity histogram, a variable threshold algorithm determines the threshold value. Figure 6 shows how the sharpened image highlights cracks and scratches.

C. Adaptive Histogram Equalization

Proposed method and other global histogram modification techniques alter image pixels based on overall image statistics. However, enhancing detail across a smaller area is frequently required (for example, in a rectangle containing a small crack). Normally, a global histogram normalization approach does not accomplish this local enhancement. This is due to the fact that the total number of pixels in such a small area has minimal effect on the global numbers that drive the latter transformation. The adaptive histogram equalisation approach proposes a solution to this problem by devising transformation functions based on pixel intensity statistics in the vicinity of each pixel in the live image [1].
As a result, adaptive histogram equalisation requires masking, which entails choosing a local area centred on the data.

VII. STEREOSCOPIC IMAGE ENHANCEMENT

On the IIW, two stereoscopic image augmentation methods were employed.
They are as follows:
1. Emphasis on stereoscopic high frequency
2. High-frequency augmented-stereoscopic emphasis (artificial augmentation of natural stereoscopic information content) [1].

These methods collect the left and right pictures matching to the current image displayed on the IIW by sampling the input video sources. The recorded images are individually processed and shown on the IIW display screen using the defined methodology. This screen is stereoscopically viewed by the inspector using active eyewear that is synchronised with the display. The IIW includes two sliding bars for adjusting the horizontal and vertical discrepancies between the displayed left and right frames. The inspector can comfortably read the data by moving the slide bars to the desired level.

A. Stereoscopic high-frequency emphasis

On the left and right input frames, the stereoscopic high-frequency emphasis algorithm consists of a histogram equalisation followed by a high frequency emphasis operation. On the IIW display, the output frames are presented. Prior to high-frequency emphasis, histogram equalisation is used to roughly balance the intensity distribution of the left and right frames, which may change due to differences in lighting conditions, apertures, and other factors between the two

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physical cameras. The left and right stereoscopic high-frequency accentuated images are shown in Figure 8. It's worth noting that several of the features indicated in one image aren't present in the other. Despite the histogram equalisation step, this could be due to occlusion or differing intensity distributions. When they stereoscopically perceive a scene with these unique qualities, they.

B. Augmented-Stereoscopic high-frequency emphasis

Exaggerated stereoscopic picture of a natural stereoscopic pair achieved by modifying the natural disparity vector field can be defined as augmented-stereoscopic imagery. Because it can make features stand out against a background by modifying the relevant disparity maps in a complicated scene, augmented-stereoscopic imagery can be a strong visualisation approach. There are four functional phases in the Augmented-stereoscopic high-frequency emphasis method. The left and right frames are histogram equalised and processed through a high-frequency emphasis procedure to locate the high-frequency material, similar to the stereoscopic high-frequency emphasis technique. The left and right high pass filtered frames are thresholded to generate the left and right binary feature maps in the third step. The final step is to.

VIII. IMAGE UNDERSTANDING

Image properties such as spatial high frequencies are emphasised by enhancement techniques. Surface faults on aeroplanes, such as cracks and surface corrosion, are inherently high-frequency, hence adding augmentation algorithms to imaging highlights these defects. Normal features like as scratches, rivet heads, paint cracks and transitions, discolouration, grime, and so on are also included in the collection of accentuated features due to their high frequency [2]. As a result, separating the skin flaws from the typical features is left to the inspector's judgement, which is a product of talent and experience. The purpose of the image understanding algorithm is to merge image enhancement and the complicated human interpretation process into a single programme module to some extent. The ability of an object to detect surface imperfections.

IX. CURRENT WORK IN IMAGE UNDERSTANDING ALGORITHMS

Surface flaws on aircraft are classified according to their 2D and 3D characteristics. Surface corrosion, for example, has roughness that is visible as a 2D feature, whereas a surface dent or a subsurface corrosion area has a change in local surface curvature that is visible as a 3D feature. In order to analyse and recognise surface faults, a comprehensive image understanding algorithm must take into account both types of features. The image understanding algorithm extracts 2D and 3D information from a range map generated by an active vision sensor and a mix of live imagery displayed on the IIW. A multi-resolution, multi-orientation wavelet framework is used to extract the 2D edges and texture from live images. Edges are interesting because they point in different directions.

X. CONCLUSION

Our research is focused on determining the feasibility and benefits of remote visual examination of aircraft surfaces. The CIMP has been built to test this concept, as well as a prototype mobile robot that contains a remote imaging system, a GUI-based inspection console, and a library of image enhancement and interpretation algorithms that facilitate remote visual inspection.

It has been proved that the remote live stereoscopic system produces imagery of sufficient visual quality for aeroplane inspectors to accept it as a substitute for direct visual inspection. The efforts in the creation of picture enhancement and understanding algorithms are described in this study. As a result, co-operative inspection by persons and computers, where an algorithm could be applied.

REFERENCES

[1] Gonzalez and Woods, Digital Image Processing.
[2] W.T. Shepherd, "Human factors in aircraft maintenance and inspection", Conference on aging aircraft and structural airworthiness.
[3] M. Siegel, P. Gunatilake, and G. Podnar, Instrumentation and Measurement Magazine, Vol. 1, No.1, March,1998.
[4] A survey on Packrat Parser by Prof. S.K. Purve

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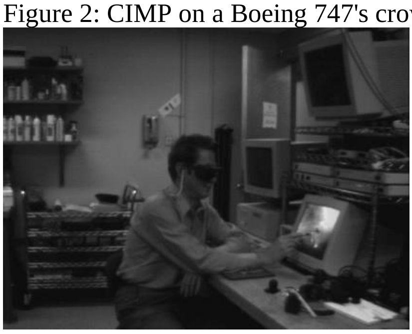
Figure 1 shows ANDI on a plane's surface.

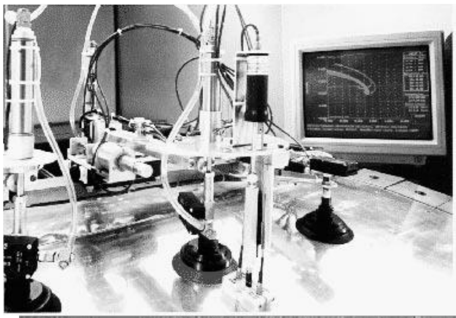
Figure 2: CIMP on a Boeing 747's crown.

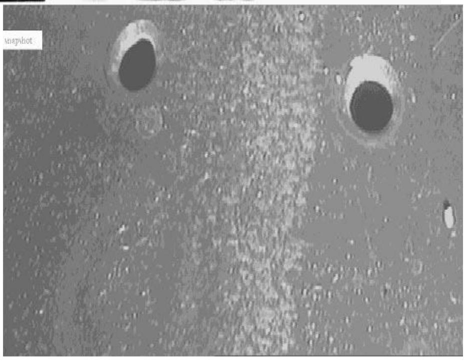


Remote Live Video Station (Fig. 3a).

An inspector at the Remote Live Video Station (Fig. 3b).

Figure 3c Inspection Window with Intelligence (IIW).





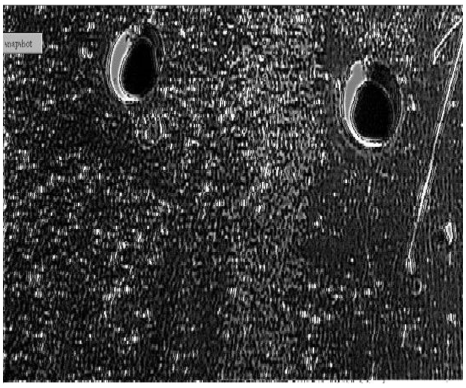
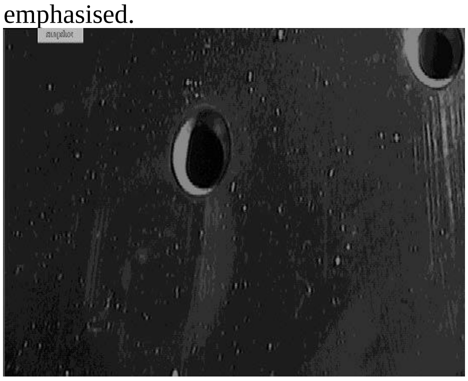


Figure 4 shows a live image of an inspection surface (top) and a high-frequency accentuated image of the same surface (bottom) (bottom). When using high-frequency emphasis, cracks, scratches, and texture are emphasised.



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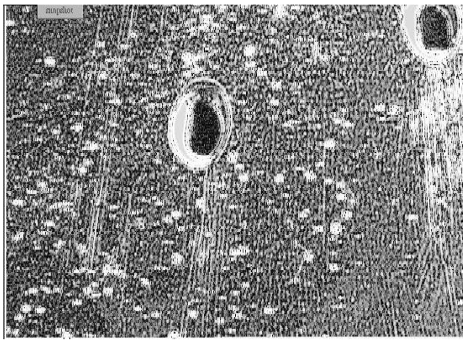


In the histogram equalised, high-frequency emphasis operation, a live image of a low contrast inspection surface (top) and its histogram equalised, high-frequency emphasised contrast image are highlighted.

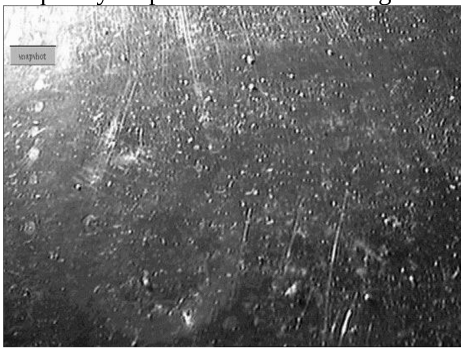


Figure 6 shows a live view of an inspection surface (on the left) and its sharpened image (on the right) (bottom). The sharpened image emphasises cracks and scratches.

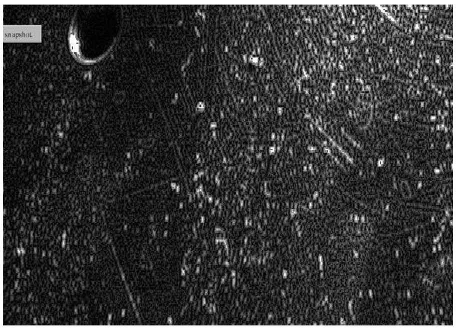
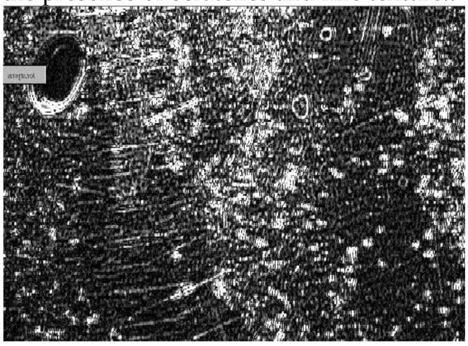


Figure 7 shows a live image of a low-contrast inspection surface (top) and an adaptive histogram equalised image of the same size (bottom). In the enhanced image, note the presence of scratches and fine texture..



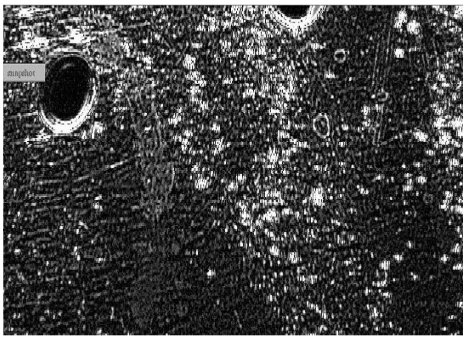


Fig. 8: High-frequency accentuated pictures on the left (top) and right (bottom). These images are viewed in stereoscopic mode by the inspector.

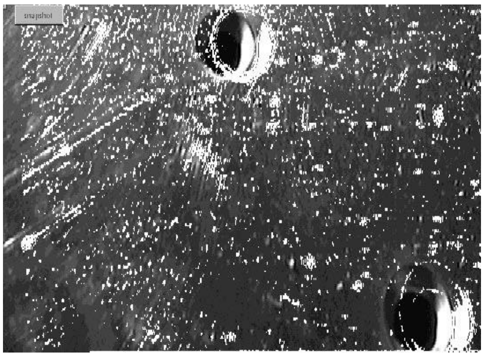


Fig. 9: High-frequency augmented-stereo pictures on the left (top) and right (bottom). The highlights are highlighted. The augmented-stereoscopic effect is created by the displacement of the emphasised components in the photographs.