ISSN 2278-3091
Volume 8, No.1.6, 2019
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse6681.62019.pdf
https://doi.org/10.30534/ijatcse/2019/6681.62019

Comparative Study of Composite Defect and Segmentation in RGB and Lab Colour Space

[1]**Murniwati Anwar, Faizal Mustapha, Norazlin Ibrahim, Mohamed Thariq Hameed Sutan, Izhal Abd Halin, Fhynthiazien Bobby, Syed Nazrin Wan AbduRahman, Mohamad Iswady Hassim.**

[1]Universiti Kuala Lumpur Malaysia-France Institute, Malaysia, murniwati@unikl.edu.my
[2] Universiti Putra Malaysia(UPM), Malaysia, faizalms@upm.edu.my
[1]Universiti Kuala Lumpur Malaysia-France Institute, Malaysia, norazlin@unikl.edu.my
[3] Universiti Putra Malaysia(UPM), Malaysia, thariq@upm.edu.my
[4] Universiti Putra Malaysia(UPM), Malaysia, izhal@upm.edu.my
[3] Universiti Kuala Lumpur Malaysia-France Institute, Malaysia, norazlin@unikl.edu.my
[4] Universiti Kuala Lumpur Malaysia-France Institute, Malaysia, fhynthiazienb2@gmail.com
[5] Universiti Kuala Lumpur Malaysia-France Institute, Malaysia, syednazrin1995@gmail.com
2 Universiti Putra Malaysia(UPM), Malaysia, iswady@outlook.com

ABSTRACT

Composite material has the advantage where it has been used in manufacturing electric vehicle and aerospace components due to the stiffness, hardness and lightness of the material. However, because of the anisotropy of the composite material, the inspection of material is still become a challenge. Active thermography has been applied as one of non-destructive tools to test, assess and identify composite fibre defects. In this project a low-resolution infrared camera is used to measure composite defect using active thermography method. The infrared images taken were then converted into RGB and Lab Colour Space. Image filtering and enhancement were then utilized and finally using circle detection algorithm to determine the number of defects on composite material. A comparison was done on segmentation between RGB and Lab colour spaces and determine which colour space that could produce optimum result by identifying the maximum total of actual defects. Simulation depth defect of a glass fibre reinforced polymer (CFRP) with different depth and diameter of defects is used as the sample testing.

Key words: Thermograph technology, quality assessment, fibre composite defects, Low-resolution Infrared camera, RGB, LAB colour space.

1.INTRODUCTION

In recent years shows a growth of usage of composite material in many areas such as building, transportation and aerospace has increase. This is due to the material has great properties where with a proper combination of materials, it could produce a new material that has the characteristics of stronger, lighter and harder that metals. However, composite material exposes to defect and damage due such as cracks and delamination internally due to the anisotropy of the material.

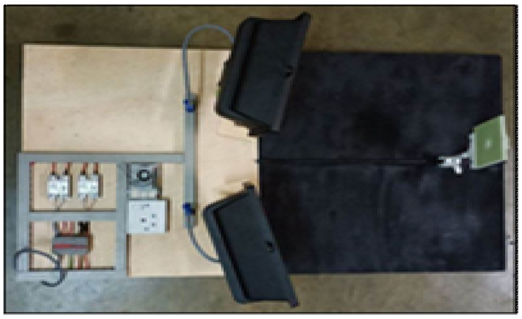
Active thermography is one of the non-destructive testing techniques that is reliable in detecting internal defects underneath the material surface that are not visible to human eyesight. This technique identifies the defects by measuring the transient temperature of the material by using the thermal camera and visualize the transient heat of the material by capturing its images in variation type of colours that indicate the material surface temperature. The type of processing techniques also depends on the techniques of taken image and type of defects. Thermography has been used vastly in various application from medical such as to detect variety type of cancers [1][2][3], in bridge and building maintenance [4][5][6], in monitoring pipe and underwater monitoring. [7][8]. Material defects research not only on composite material but also other material such as metal, aluminium, foam and other [9][10].

Several well-known active thermography techniques are flash or pulse thermography, pulse phase thermography and lock-in thermography. These techniques have been used in research to detect defects on composite fibre. [11] [12] [13] [14] [15]

Image processing has become important where it can be implemented in various field to interpret images and videos and further use for detection of object of interest automatically. Several researches on images such as classifying brain damage, skin cancer and others[16][17][18], and with algorithms to enhance different type of images taken [19][20]. Several researches analyse image by analysing light intensity of the image using histogram [21][22][23]

Most of the testing equipment and research utilized a high-resolution camera to increase accuracy and enhance the defected area.

Several camera resolutions used in the research were 640x512 and 320x256[24] [25][26] .This project applied a low-resolution infrared camera. However, this leads to a low contrast image where the defects are barely seen. Colour segmentation is one of the methods to capture the details of interest of an object. It has been used in several studies on various fields to detect objects for example in detecting skin colour, object from an aerial image as well as detecting any object in chessboard. [27][28][29]



An RGB colour space is a mixture of three premier colours which are red, green, and blue additive while Lab colour space is derived from the CIE XYZ tristimulus values. The Lab space consists of L as the lightness or brightness layer while a and b are the direction of an along the red-green axis, and layer 'b' along the blue-yellow axis. Figure 1 show Lab colour space

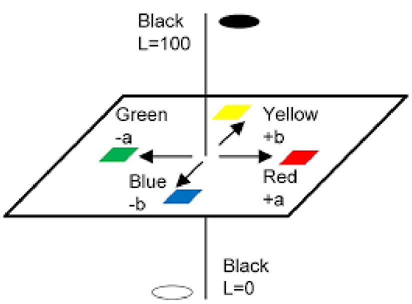


Figure 1: Lab colour space retrieved from [30]

It is important to ensure the setup parameters for this project is at optimum level. The proper optimization parameters setup will reduce the noise on the thermal image output. Light angle, heating duration were the important parameters. Image segmentation was carried out using colour segmentation which were RGB and Lab colour space. The suitable threshold value of every colour in the two-colour space was selected to capture the defected area. Morphological methods were required to reduce the noise and enhance the defected area, and finally identify round object automatically using round or circle object detection algorithm.

2. EXPERIMENT SET-UP

The defected sample is an artificial defect made of 5mm thickness of GRFP that has eight defects that are represented in a circular flat bottom holes created at the back side of the sample with different sizes and depths as in Figure 2.

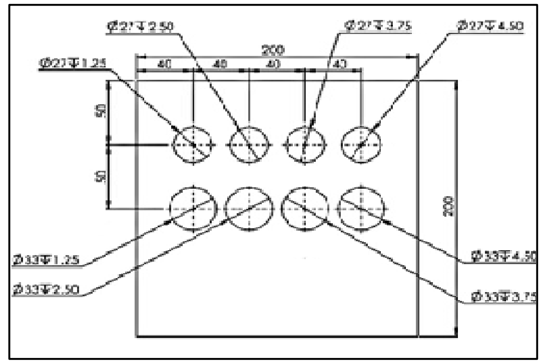


Figure 2: Architecture of circular flat bottom holes artificial defect

The setup of the experiment is as in Figure 3 below where camera FLIR lepton with resolution of 160x120 pixels was used as well as two external heat sources from halogen lamps at 1Kwatt. The system implemented Flash active thermography. In the experiment, both lamps were located at the angle of 30° facing to the surface of the test sample to have an equilibrium heat diffusion.

Figure 3: Front view of thermography setup

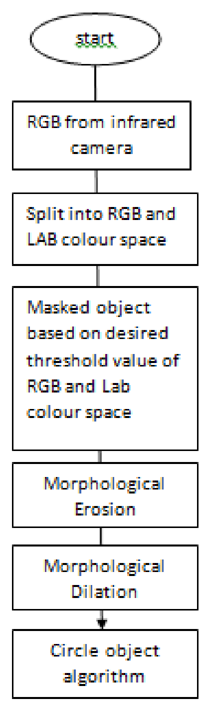


Figure 4: Image Processing Flowchart

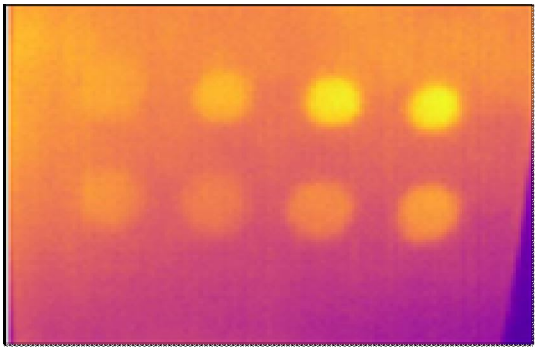


Figure 5: RGB image

The sample will undergo cooling process after the heating process to ensure the heat dissipates to the material before it captures the thermal image of the material. The initial image taken was in RGB colour as in Figure 5. Then, the colour is converted to Lab colour space and further analysis were done to identify defects.

3. IMAGE PRE-PROCESSING

Image processing includes segmentation which were performed by using MATLAB. **Figure 4** displays the flowchart of image processing and segmentation for this research. **Figure 6 to 7** show RGB-based segmentation and Lab-based threshold value selected. The threshold value for each colour in each different colour space was selected to a value where only defected area could be chosen and the background noise to be minimised. For RGB colour space, the Red colour threshold selected is from 0 to 255, Green threshold is taken from 150 to 255 while for Blue, the threshold remains from 0 to 80. As for Lab colour space, L threshold was selected from 75 to 90, 'a' colour from -25 to 60 while 'b' is from -60 to 90.

The results of both Lab and RBG colour segmentation were compared as in Figure 8. In terms of segmentation result comparison, Lab produced a better result where all eight defects were detected with less background noise compared to RGB colour segmentation which contained more background noise.

In order to reduce the sounding noise and enlarge the defects, morphological process is required where it starts from erosion and continues with dilation. The output of dilation and erosion is at Figure 9 shows that some of noise were removed and the sizes of defects were enlarged. Defects are represented in a circle or round object. The circle detection search on the image is set within the search radius of 14 to 20. This value is suitable for the sizes of the defect Figure 10 shows the final result by using circle detections algorithm. Form the result shown that all eight defects were automatically detected both on RGB and Lab colour segmentation output even though in RGB colour space, the circle shaped defected areas were attached together with the surrounding noise.

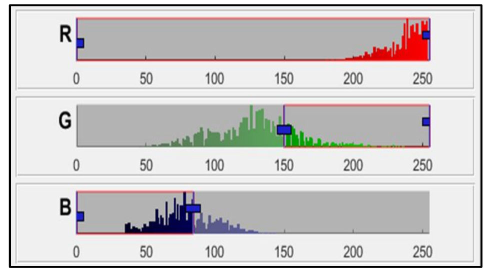


Figure 6: RGB threshold

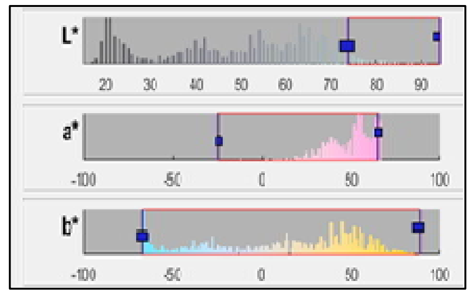


Figure 7: LAB color threshold

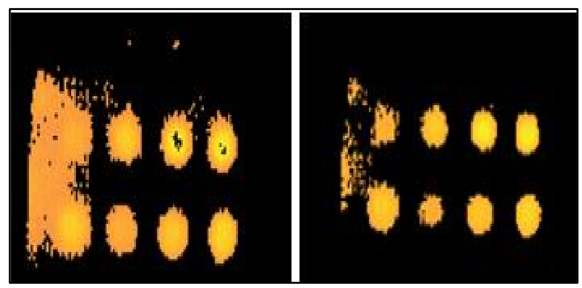


Figure 8: Result of colour segmentation for RGB (left) and Lab (Right)

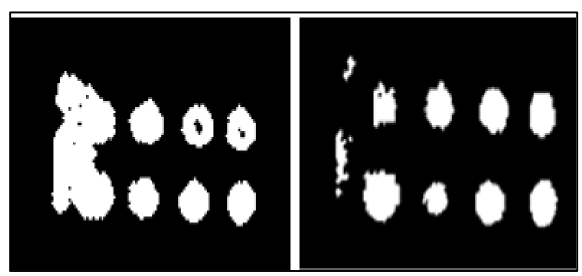


Figure 9: After Morpological for RGB (left) and Lab(Right)

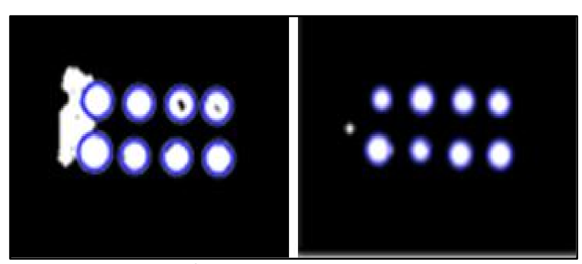


Figure 10: After round/circle detection algorithm

4. CONCLUSION

Thermography can be used in an application of detecting composite defects. However, using a low-resolution infrared camera did affected the images taken. Together with optimised parameter setting on the apparatus, the noise was reduced. Proper image segmentation and image enhancement were required to detect the composite defects. One of the suggestions is using colour space segmentation. RGB and Lab colour space were selected to for colour segmentation. Subsequently, morphological operation erosion, dilation and circle detection were implemented to identify and detect composite defects. By using RGB and Lab colour, all defects were detected. However, from the result showed that Lab colour space produce less noise compared to RGB colour space.

APPENDIX

Appendixes, if needed, appear before the acknowledgment.

ACKNOWLEDGEMENT

This research was supported/partially supported by Universiti Kuala Lumpur Malaysia-France Institute. We are thankful to our colleagues who provided expertise that greatly assisted the research, although they may not agree with all the interpretations provided in this paper.

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