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STILL IMAGE BASED FOREIGN OBJECT DEBRIS (FOD) DETECTION SYSTEM

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Abstract

Foreign object debris (FOD) detection is an important term in the field of aviation as small sized. FOD can cause pecuniary as well as life forfeiture. Many FOD detection systems have been instigated for circumventing this menace. This paper is presenting a novel enactment of maximally stable extremal regions (MSER) detector for detecting FOD on aircraft operating surfaces. Detail analysis revealed that MSER was able to detect FODs of very small sizes like 0.6 inch × 0.6 inch with repeatability accuracy of 92%.

Keywords: Foreign object debris (FOD), Image, Maximally stable extremal regions (MSER), Safety, Aviation.

Introduction

Aviation industry, which is one of the fastest growing fields in the world, has passed more than 100 years of flying. With increasing population of the world and high flying rate, each year aviation industry is facing bigger amount of financial losses because of air crashes. Detail-investigation of these air crashes reveals many factors. One of these factors is FOD.

Efforts are in hand in almost all international airports for controlling occurrences caused by FOD. Two major systems, developed in this regard, are millimeter wave radar and electro optical system. Both these systems are recently installed at few airports of the world. In a one year airport study about FODs, it was discovered that more than 60% of the FODs were metal; nearly 18% were made up of rubber and black items made up nearly 50% of the FOD Workshop 2008 (Fig. 1).

In this paper, we propose an automated FOD detection system using electro-optical sensors. In this regard, selection of detector best suitable for small objects on runway and other operating surfaces was required. Mikolajczyk et al. (2005) studied different detectors, including Harris-affine, Hessian-affine, maximally stable extremal regions (MSER), edge-based regions, intensity extrema and salient regions. Mikolajczyk et al. (2005) recommended MSER on the basis of better results in terms of region density, region size, viewpoint change, scale change, blur and light change from other detectors. Matas et al. (2002) labelled MSER detection in single gray scale images. Evaluations by Mikolajczyk (2002) as well as Fraundorfer (2005) revealed that the MSER detector performs best on a wide range of test sequences. A comparison of affine region detectors is discussed by Mikolajczyk et al. in 2005. An affine invariant shape descriptor MSER was explained by Forss´en et al. (2007), on grey scale images, which was further explained to colour images by Forss´en (2007). MSER features are discussed by Kimmel et al. (2009) in general, and edge enhanced of MSER in particular, is discussed by Chen et al. (2011).

All these results were studied and an algorithm was devised based on MSER detection to detect FODs in successive still images respectively. Images of different operating surfaces were recorded and processed. FODs were detected with very low false alarm rate and algorithm was found to be invariant to global changes. This work is a novel implementation of MSER detector in FOD detection application.

Section I of this paper comprises proposed Algorithm, while section II describes the experimental results of the FOD detection system.

Proposed Algorithm

A. FOD detection system

A flow of complete FOD detection system was designed and shown in Fig. 2. We installed a camera for capturing clean images and periodic runway images afterwards for comparison and subsequently any FOD detection. Images will be processed in MSER based FOD detection algorithm. If any FOD is detected it will generate an audio/visual alarm at user interface. FOD database will also be maintained for references in processing and record purposes. Control Panel will be placed at control room for operating users. Lastly, each detected FOD will be recorded and database will be created for easy references.

B. MSER algorithm

Following equations show basic operations in grey scale images:

Black = less than threshold … (1)

White = equal or more than threshold … (2)

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Processing of all pixels can be computationally expensive for FOD detection. We can adjust parameters like maximum area, minimum area, stable threshold, maximum variation of image and minimum diversity. In this paper, MSER was implemented which was proposed by Matas et al. (2002). The technique was selected on the basis of better results as compared to other detectors.

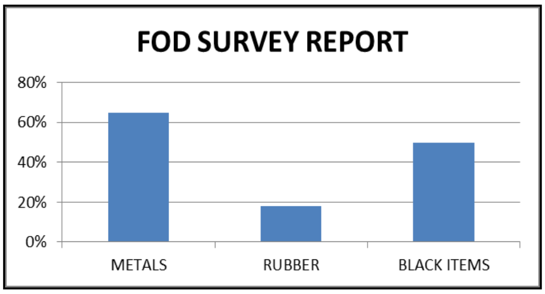

Fig. 1. FOD Survey Report

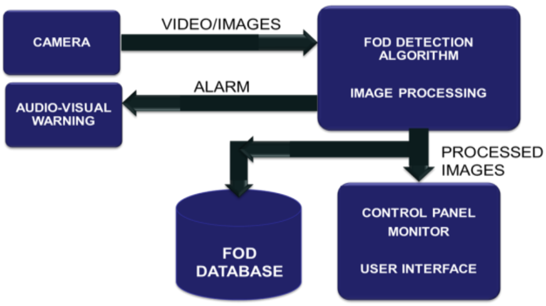

Fig. 2. Block diagram of FOD detection system

Experimental Results

For testing the algorithm Sony HD Handy Cam at resolution of “576 x 720” with 1 Megapixel was employed. Videos at different times of the day were taken. Camera was placed 30 feet from the runway and the minimum FOD size detected was 0.6 × 0.6 inch. Fig. 3 shows details of FODs used in experimentation.

A clean runway image was taken from setup defined above and is shown in Fig. 4. In the following figures, x- and y-axis show the resolution of the image. On same position another image was taken with FODs placed. Red boxes in Fig. 5 show the FODs on runway.

MSER detection technique was applied on clean background image (Fig. 4) and result obtained is shown in Fig. 6. Afterwards, MSER detection technique was applied on image containing FODs (Fig. 5) and results obtained are shown in Fig. 7.

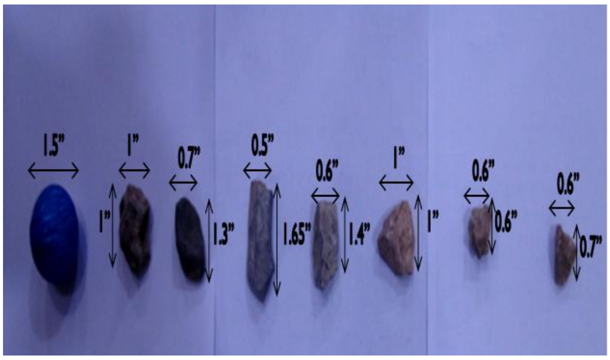

Fig. 3. Items used as FODs for experimentation

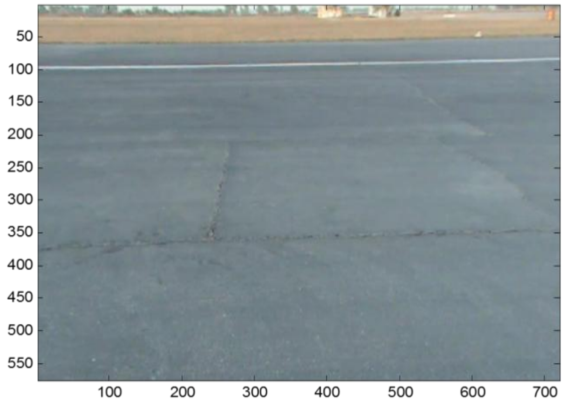

Fig. 4. Clean background images

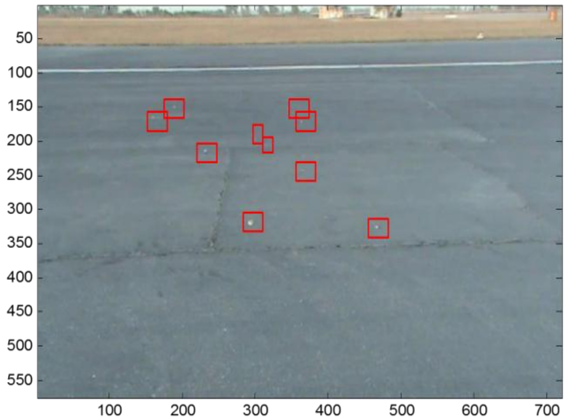

Fig. 5. Image containing FODs

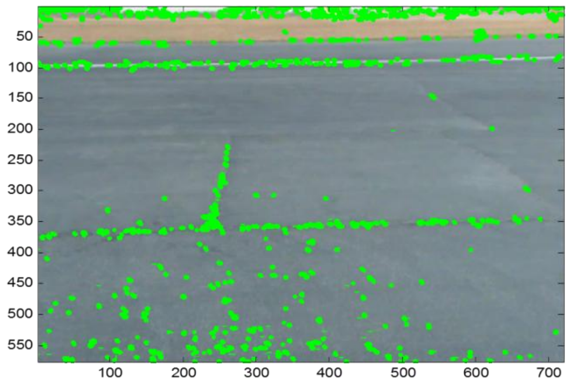

Fig. 6. MSER applied on clean background image

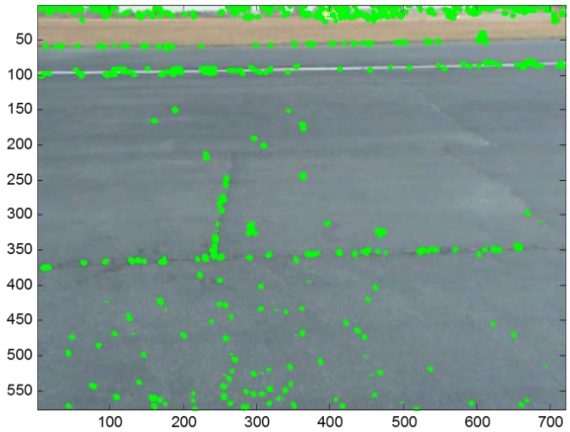

Fig. 7. MSER applied on image containing FODs

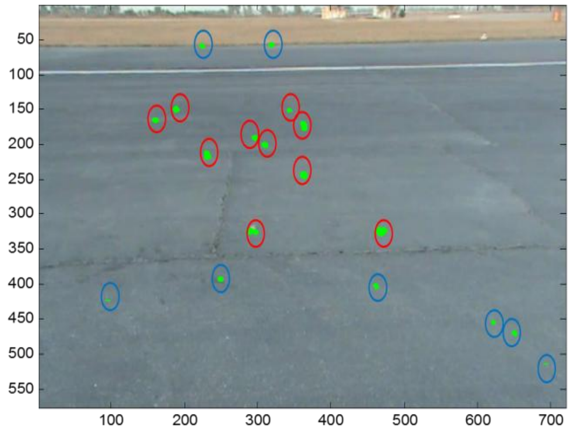

Fig. 8. Results after Center point's comparison (red circles show detected FODs, blue circles show false alarms)

Analysing MSER results on both clean and FOD containing images revealed that ellipsoids, present in both images, did not have exactly same center points and it is not possible to subtract the center points of ellipsoids in both the matrices to get the required result. To overcome this problem, center points of each ellipsoid in the second matrix were compared with the center points of all the ellipsoids in the first matrix. The result of this comparison was written in a new third matrix. This process made this technique computationally very expensive, as center points of one ellipsoid was compared with the center points of all the ellipsoids of the second matrix. All ellipsoids of second matrix unmatched with ellipsoids of first matrix were considered as FODs and plotted on clean image as shown in Fig. 4. In this way, we have a final image shown in Fig. 8.

It is evident from the results that there is still a high false alarm rate; the reason for this is the repeatability factor of MSER detection which is 92%. It means that there is 8% probability of detection of newer ellipsoids every time algorithm runs on the new image resulting in false alarms. Fig. 9 shows the pie chart of detection rate of MSER on still images containing FOD.

An experiment was carried out on 20 still frames each containing one more FOD from previous. Each time, we processed frames, we had one more detected FOD but after two frames, we got a false alarm using MSER. Fig. 10 shows the results of experiment. It can be seen total FODs detected after 20 frames came out to be 30.

Table 1 shows eight different sizes FOD used for experiments. It is clearly evident that MSER has advantage of detecting very small size FODs, which is why we recommend this detector for electro optical detection systems.

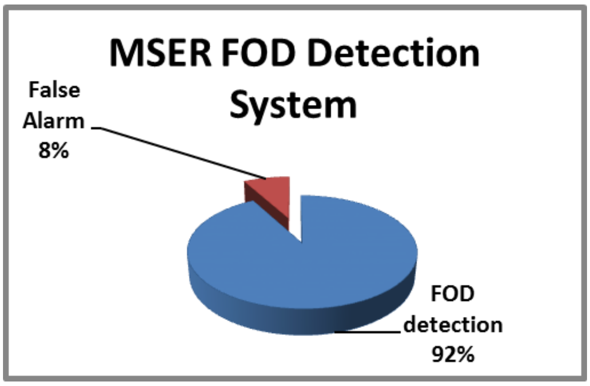

Fig. 9. PIE for MSER FOD Detection

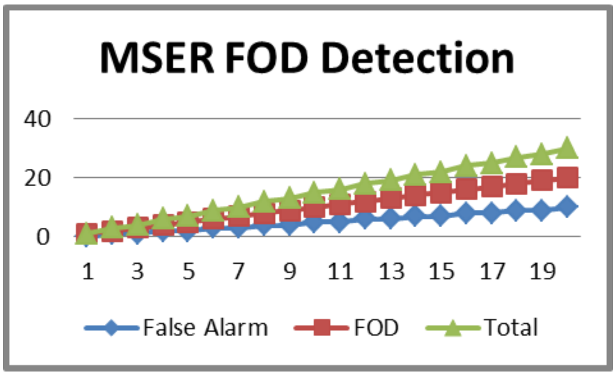

Fig. 10. MSER FOD Detection

Table 1. MSER detection results

S. No.	FOD Type	Size (inch × inch)	Result
1	Pebble	1.5 × 1.5	detected
2	Pebble	1 × 1.4	detected
3	Pebble	0.7 × 1.3	detected
4	Pebble	0.5 × 1.65	detected
5	Pebble	0.6 × 1.4	detected
6	Pebble	1 × 1	detected
7	Pebble	0.6 × 0.6	detected
8	Pebble	0.6 × 0.7	detected

Conclusion

Using the discussed methodology and algorithm, satisfactory results are obtained. Different items of different size, shape and colour are used as FODs in experiments where the minimum detected FOD size is 0.6 × 0.6 inch. Contrast of the object w.r.t. background, size, shape, height of object and weather conditions can affect the detection rate. It can be further improved by employing high resolution images and fast processing systems.

References

Fraundorfer, F. and H. Bischof. 2005. A novel performance evaluation method of local detectors on non-planar scenes. In Workshop Proc. of Conference on Computer Vision and Pattern Recognition, CVPR Workshops, pp. 33.

Matas, J., O. Chum, M. Urban and T. Pajdla. 2002. Robust wide baseline stereo from maximally stable external regions. In Proc. of British Machine Vision Conference, 384–393.

Mikolajczyk, K. and C. Schmid. 2002. An affine invariant interest point detector. In European Conference on Computer Vision. V. 1: 128-142.

Mikolajczyk, K., T. Tuytelaars, C. Schmid, A. Zisserman, J. Matas, F. Schaffalitzky, T. Kadir and L.V. Gool. 2005. A comparison of affine region detectors. *Intl. J. Computer Vision Springer Sci*. 65(1/2): 43-72.

Forss´en, P.E. 2007. Maximally stable colour regions for recognition and matching. IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR). Minneapolis, Minnesota, USA.

Forss´en, P.E. and D.G. Lowe. 2007. Shape descriptors for maximally stable extremal regions. International Conference on Computer Vision (ICCV), Rio de Janeiro, Brazil.

Workshop EUROCONTROL, 2008. Information Paper on French Study on Automatic FOD Detection Systems.

Kimmel, R., C. Zhang, A. Bronstein and M. Bronstein. 2009. Are MSER features really interesting? IEEE PAMI,

Chen, H., S.S. Tsai1, G. Schroth, D.M. Chen, R. Grzeszczuk and B. Girod. 2011. Robust text detection in natural images with edge-enhanced maximally stable extremal regions. 18th IEEE International Conference on Image Processing (ICIP), 2609-2612.