APPLYING IMAGE PROCESSING TECHNOLOGY IN AVIATION TO DETECT FOREIGN OBJECT DEBRIS (FOD)

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Abstract: The goal of the algorithms developed in this paper is the real-time detection of randomly shaped FODs damaging the airport runway, the surveillance zone used by the camera. This is achieved based on the results provided by subtraction. The detection of object objects is accomplished using the subtraction algorithm. In a follow-up development approach, the results provided by the multilayered pixel classifier are analyzed at the regional level to distinguish between the new object and the removed object. This allows the detection of static objects without predictable data. Furthermore, it shows that the results provided by the regional analysis can be used to improve the quality of the cảnh nền models, thus significantly improving the detection results. Background detection was used to monitor the landing area's runway area safety. Monitoring techniques will be used to improve the accuracy of FOD (Foreign Object Debris) objects moving or appearing on the runway.

Keywords: Background Subtraction, Subtraction Algorithm, FOD, Foreign Object Debris in Runway, Aviation Safety.

I. INTRODUCTION

In the course of its implementation, the main research methods used here are research from scientific journals, documents related to digital image processing, ICAO standards on the Internet and books. in Vietnamese, the research process is also based on the practical experience of the experts, the teachers studied, the published scientific papers. The system is capable of approximating the number of FOD objects as well as the location and area of the object. Good processing time, sort time after the object falls into the control area, the system will alert. This will help the collection of ground monitoring staff deployed quickly. Efficient, contributing to ensuring safety in aviation.

II. DANGER OF FOD IN AVIATION SECTOR

FODs can cause significant problems at the airport - even the smallest debris can cause major hazards to airport safety. Although FOD monitoring and elimination methods have been implemented, many of the FOD-related losses are recorded annually. This study introduces a simulation system that enables FOD detection and localizes FOD numbers and distinguishes FOD from aircraft, thereby providing appropriate audio warnings. As a practical matter, this topic will increase the safety of airport operations while maintaining the efficiency of air navigation. Therefore, this simulation system will create a premise for research and application in the future, thereby increasing domestic content, reducing the cost compared to existing systems. FOD can cause serious injury to airport personnel or carriers or damage to equipment. Types of damage that may occur include: the tire being entered into the engine or trapped in the mechanism affecting the flight. FOD comes from many sources, complicating the efforts to maintain the operation of the airport safely. FOD can be created from staff, airport infrastructure (sidewalks, lights and signage), environments (wildlife, snow, ice, materials, steel) Airports (airplanes, airport operation vehicles, maintenance equipment, aircraft service equipment and construction equipment).

FOD can collect both above and below ground support equipment stored or displayed on the airport airport, especially in the access area. Then jet can blow FOD to staff or plane. Airplane engine start-ups can also create on the runway an FOD appearing when the aircraft moves from a relatively large runway to a smaller freeway. The engine blows out any dirt and material from the contiguous area to the runway. In addition, the outboard motors of the four-engine aircraft can blow debris from the edge of the runway and the landing areas of the runway, where it tends to accumulate, back toward the center of the runway. . FOD is more common when the airport starts construction activities. FOD may also be more common in winter conditions, as the aging pavement infrastructure may be affected by weather (freezing and ice melting) and begin to crack or break. Wind can blow away debris, such as sand or plastic bags, from relatively unimportant areas of the airspace. Rainwater and drainage systems can mud, gravel and other small objects along the runway. Awareness of weather-related FODs helps builders design barriers and other structures in a logical way.

Fig 1. Plane crash by FOD

III. BACKGROUND SUBTRACTION METHOD

Today, subtraction is a widely used concept for detecting moving objects from video and even extends to video taken from cameras. In the last two decades, several algorithms have been developed to improve the subtraction algorithm, the subtraction algorithm used in various important applications, such as visual monitoring, sports video analysis, etc. A background pattern can change over time.

Case 1:

When a new background object is added to the background, it is clear that the number of objects in the object increases.

Case 2:

When an existing background object is removed, it creates an empty space with a pixel distribution that is not equal to the current background, and therefore introduces a new background object that does not actually exist.

Case 3:

The migration of existing background objects can be understood as a combination of the two. An existing background object will be removed from its current location (Case 2) and placed in another location (Case 1) and will make a difference in the two new objects.

Classify Background Model:

$$f_t(x,y) = I * h = \iint_{\mathbb{R}^2} I_t(x-a, y-b)h(a,b)dadb \quad (1)$$

Where h is the spatial filter mask [11], I_t (x, y) is a pixel in coordinates (x, y) with a gray level value of t = 0,1 ... in the gray scale of the image. The filter responds to every point (x, y) $\in R^2$, and in the still image state, the background and surroundings are easily classified. The Stauffer-Grimson estimate with the method for h = δ0,0 [11] is the Dirac measurement at the root, in the case of $I * \delta_{0,0} = I$, base on the estimated raw pixel data.

Detection Object:

Where (Th) is the user defined threshold. The main limitation of this approach is that it uses a single threshold for all pixel models although some pixels may have more variations than other pixels. Therefore, methods that provide a method for measuring the difference for each pixel are preferable. The pixel modeling algorithm as a probability density function divides a new pixel from the object whenever $p(I_t^c|B_t^c) < T^c = n^{\varphi^c}$ for any channel c. The threshold T^c is proportional to the estimated variance, φ^c, to ensure that the pixel is classified as object only when it is outside the observed normal range.

$$|I_t(x,y) - B_t(x,y)| > Th \text{ (Threshold)} \quad (2)$$

Discrepancies between frames are the easiest model of the subtraction algorithm. The nature is to take the frame before and then subtract the current frame. In case the pixel value for a pixel exceeds the threshold value, that particular pixel is treated as part of the moving object. Time differences are significantly adaptable to a group of volatile environments

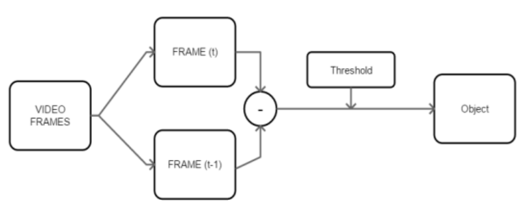

Fig 2. Block diagram of background subtraction

For a grayscale image, 0 represents the black value and 255 represents the white value, Measurement noise is equal to the standard deviation σ (n), we can determine the signal-to-noise ratio (SNR) as follows [10]:

$$SNR = \frac{\sigma(u)}{\sigma(n)} \qquad (3)$$

Where σ (u) is defined as the empirical standard deviation of u,

$$\sigma(u) = \left(\frac{1}{|I|}\sum_{i\in I}(u(i) - \bar{u})^2\right)^{\frac{1}{2}} \qquad (4)$$

And $\bar{u} = \frac{1}{|I|}\sum_{i\in I} u(i)$ is the gray mean. The standard deviation of the noise can be either empirical measurements or calculated when noise and parameter models are known. [11] A good quality image will have a standard deviation of about 60. The best way to test the effect of noise on a standard digital image is to add a white gaussian noise. Most applications using background subtraction are interested in identifying background objects. As such, labeling of connection components is almost always done to identify blobs at the object level. In comparative study, it examined the threshold areas that could improve the blobs identified in a front mask. Morphological arrangement is used to fill in the gaps and small voids while the threshold is used to remove unnecessary blobs. There are two contradictory approaches to updating the background model. In the unconditional update each pixel in the background model is updated, while conditional updating only the pixels that have been determined from the background (as indicated by the nearest object mask) are updated. date. In addition, it eliminates shadowing issues because valid foreground objects will not be integrated into the background model. The danger of conditional updating is that an incorrectly-defined object pixel is constantly being misclassified because the background model will never adapt to it. When using conditional updates, specific application experiments may be required to ensure that background objects persist over a long period of time in combination with the background model.

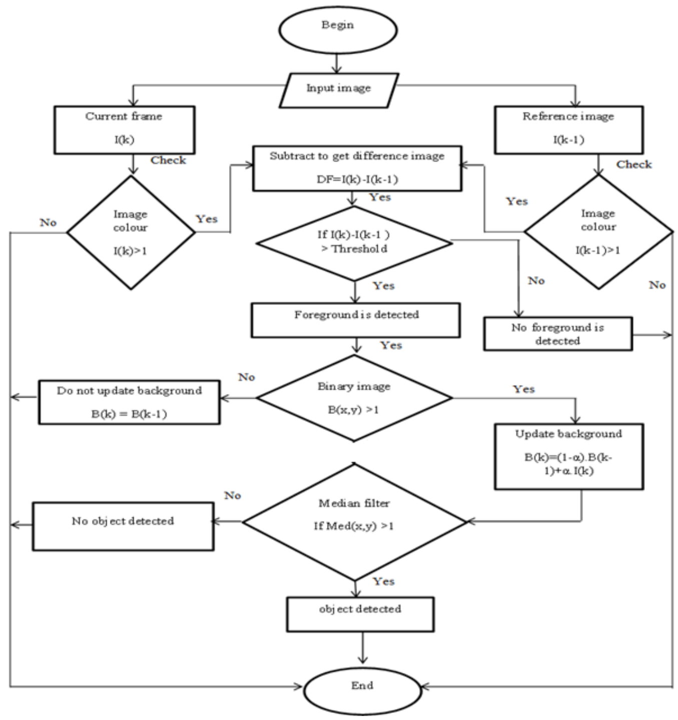

Fig 3. Flow chart of detection FOD method

IV. SIMULATION PROGRAM

In this paper uses background subtraction algorithm to detect FOD in the monitoring area. The demonstration system was set up to implement the proposed system in MATLAB software. Here the reference image is initialized and then the subtraction of the current frame is made. And after subtracting both frames, the minus image is displayed on the screen. The pictures below show the reference image, the current image, the subtracted image, the blob object and the convolution mask. In matlab, the initialization of the webcam is done and it will be photographed. That image is subtracted from the reference image. The background subtraction extracts the background from all incoming frames, which is subtracted from the next frame and compared against the background. If larger than the background threshold, it assumes that the current image otherwise it is the background.

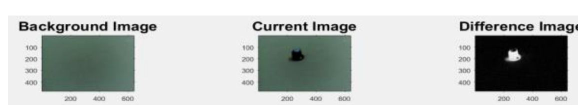

Fig 4. Show difference Image after subtract

Fig 5. Modeling assumption

Table 1. Parameters modeling

Resolutions	Height of camera	Distance from camera to Runway	Area surveillance
640x480	20cm	23cm	25cm x 20cm = 500 cm^2
1920x1080	h	d	$\frac{(m+n).l}{2}$

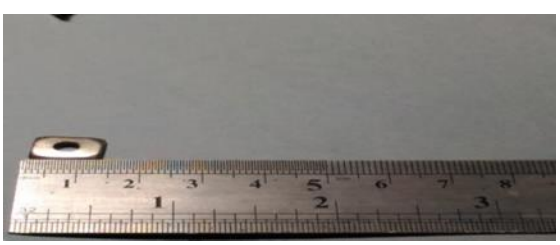

Fig 6. Size of FOD

Fig 7. Detection multi-Objects

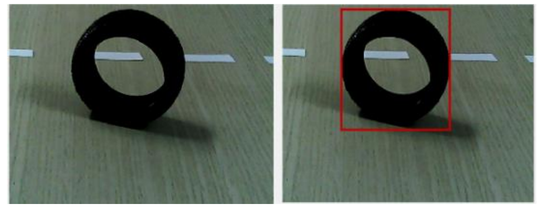

Fig 8. Detection tire

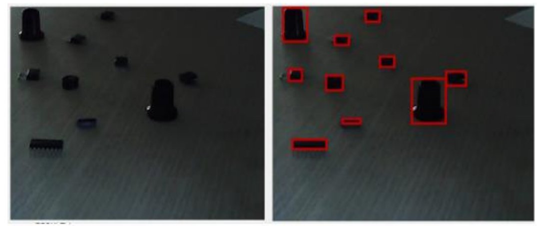

Fig 9. Detection multi-objects in dim light

V. CONCLUSION

This paper dealt with the problem of detecting exotic objects FOD in monitoring. In particular, objects of interest have two different properties: moving objects and static objects are added to the runway. Algorithm subtraction has been proposed to solve the above problems by combining some image enhancement methods as well as updating the underlying platform model. Method suggested was thoroughly evaluated in terms of convergence, the processing time and the result segment that identifies objects from FOD and locate as well as physical quantity estimation FOD appear. The main advantages of this approach were observed by the evaluation of the results provided by the analysis of sequences with different characteristics (lighting, noise, size ...). This theme will make for an extremely important prerequisite in choosing direction image processing to solve the problems detected in the air FOD object instead of using radio waves.

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