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Pilot Assistive Safe Landing Site Detection System, an Experimentation Using Fuzzy C Mean Clustering

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Abstract: *In a situation of emergency landing of an aircraft, finding a safe landing-site is vital to the survival of the passengers and the pilot. Conventionally the emergency landing-site is visually selected by the pilot by looking at the terrain through the cockpit. This is a required, fundamental skill acquired in the flight training program. However, many external environmental factors, i.e., fog, rain, illumination, etc., can significantly affect human vision so that the decision of choosing the optimal landing-site greatly depends on the pilot's flight experience–the most significant internal factor–which can vary a lot among different pilots. An automatic pilot assistive safe landing-site detection system is proposed for aircraft emergency landing. The system automatically processes the aircraft mounted camera images and provides options for suitable landing areas. The pilot then makes the final decision by choosing from among them.*

Keywords: *dehaze, hough transform, canny edge detection, fuzzy c-means,*

I. Introduction

Emergency landing is an unplanned event in response to emergency situations. If, as is usually the case, there is no airstrip or airfield that can be reached by the unpowered aircraft, a crash landing or ditching has to be carried out. Identifying a safe landing-site is critical to the survival of passengers and crew.[1]

Conventionally the emergency landing-site is visually selected by the pilot looking at the terrain through the cockpit. This is a required , fundamental skill acquired in flight training program. However, many external environmental factors, that is, fog, rain, illumination etc... can significantly affect human vision so that the decision of choosing the optimal landing site greatly depends on the pilot's flight experience–the most significant internal factor which can vary a lot among different pilots.

The contributions of the present paper consists of the following:

1) A delicate automatic safe landing-site detection mechanism is developed by seamlessly combining some existing image-processing and analysis techniques.
2) A hierarchical elastic horizon detection algorithm to identify the ground in the aerial image so that the camera is relieved from the limitation of looking straight down to the ground.
3) The efficiency of the system is improved by applying the canny edge detector.
4) A fuzzy C-mean clustering operation is done to identify smooth regions.
5) Visualization of the smooth regions to make it convenient for the pilot to choose from.

At the end, the pilot makes the final decision by confirming one of the candidates, by considering other factors such as wind speed and wind direction. etc. There are only very few designs proposed on this topic based on image processing.

II. System Architecture

The proposed safe landing-site detection system consists of eight main modules as shown in fig 1. In the first module, images are acquired by aircraft mounted cameras. Each camera looks in a specific direction that covers a portion of the region in front of the airplane. Multi-spectrum sensors are preferred to obtain complementary information. In second module, the separate images that are acquired at the same time instant are registered and stitched together to form a larger panorama image that covers the full FOV in front of the airplane. In the third module, if the images are captured under poor illumination or weather conditions, we make use of the image enhancement method to ameliorate the effect of environmental factors and to improve the contrast and sharpness of the images. The first three modules are necessary for getting high-quality images and directly affect the performance of the subsequent modules.[1]

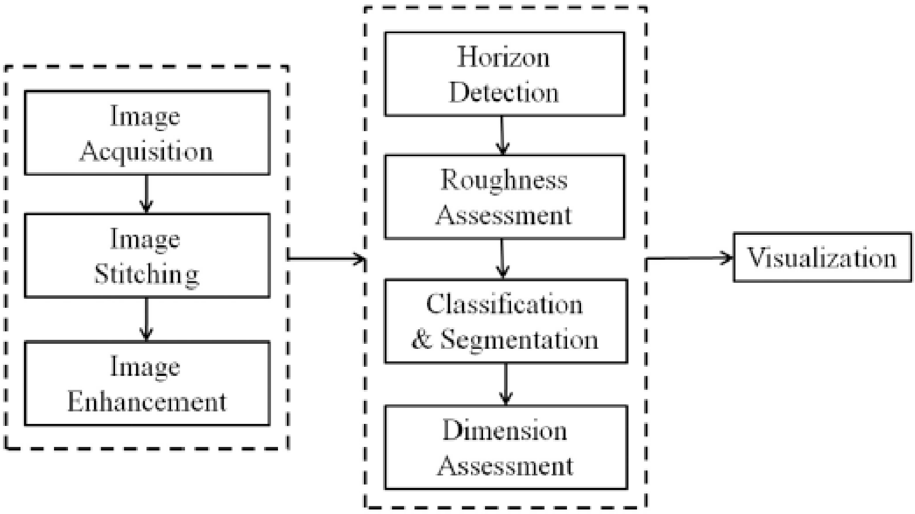

Fig.1: System Architecture

1. Horizon Detection

A hierarchical elastic horizon detection algorithm is proposed to provide a robust and efficient way to determine the horizon in the images. First of all the original image is blurred by low pass filter. A dehaze operation can be performed so that all the fine edges are ignored and only the strongest bounds remain. Secondly a canny edge detector is used to find major bounds. After finding the strongest peaks in the image , hough transform is used to find the horizon by joining these strong peaks.[1,2]

2. Roughness Assessment

The Canny edge detector is an efficient tool for computing the sharpness of edges, which is, from smoothest to sharpest, quantified to the range from 0 to 255. This method is applied at the beginning of the roughness assessment module. To characterize the difference, the map is first divided into non overlapping blocks. We define the cumulative hazard strength (CHS) of each block as;

$$CHS_B = \sum_{P \in B} H(ES_P) \quad (1)$$

$$H(ES_P) = \begin{cases} 1 & ES_p > T \\ 0 & ES_p \leq T \end{cases} \quad (2)$$

where ES_P is the edge strength of each pixel p in block B, and H( ) is the hazard-indicator function. If ES_P is greater than the pre-specified safeness threshold T, then the pixel p is considered hazardous, and the CHS of block B, CHS_B , is incremented by 1. In contrast, if ES_P is no greater than T, then the pixel p is considered safe, and CHS_B remains the same. The block size (BS) in the unit of pixels is adaptively determined based on the height of the camera.[1,2]

3. Classification and Segmentation

The classification module utilizes the Fuzzy c-mean clustering method to classify the CHS of each block into a number of clusters. For example, if the number of clusters is specified as seven, the clusters can be interpreted as “very rough”, “rough”, “moderate rough”, “median”, “moderate smooth”, “ smooth” and “ very smooth”. Regions with similar roughness measure is merged or region growing is done and those regions with different roughness measures are specified using different color as shown in fig 2 . Only the less rough areas are considered as a suitable choice.[3]

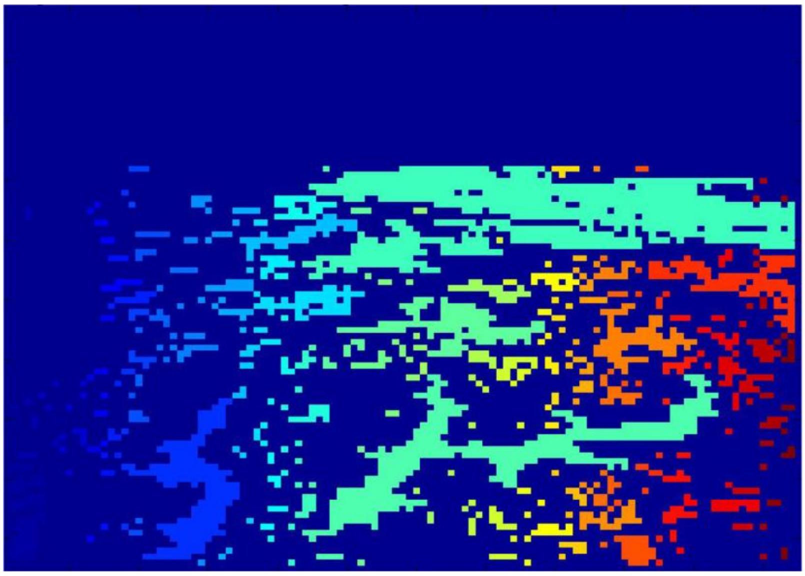

Fig 2: Clustering

4. Dimension Assessment

After the above steps, potential landing-sites are obtained. In this module we measure their realistic dimensions and determine which are qualified to be candidate landing-sites. The realistic dimensionality of each potential landing-site is measured by converting its size from the image coordinate system to the realistic world coordinate. For experimental purpose , dimension in pixel area can be found out.

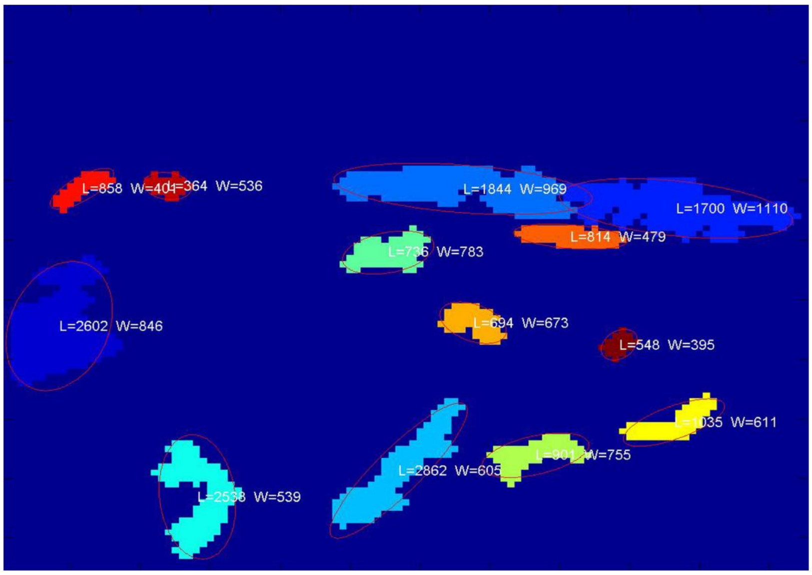

Fig 3: Dimension Assessment

5. Visualization

The visualization module is designed to highlight, at most, the five largest safe landing-site candidates on the human-machine interface for the pilot's final decision, though the system may detect more than five safe landing-sites. If the system provides the pilot with all the possible choices, he may get confused when seeing too many recommended areas on the screen, and the time cost of making a decision is very critical under the emergency situation. Therefore, only up to five largest candidate landing-sites are visualized on the human-machine interface and labeled with preference indices.

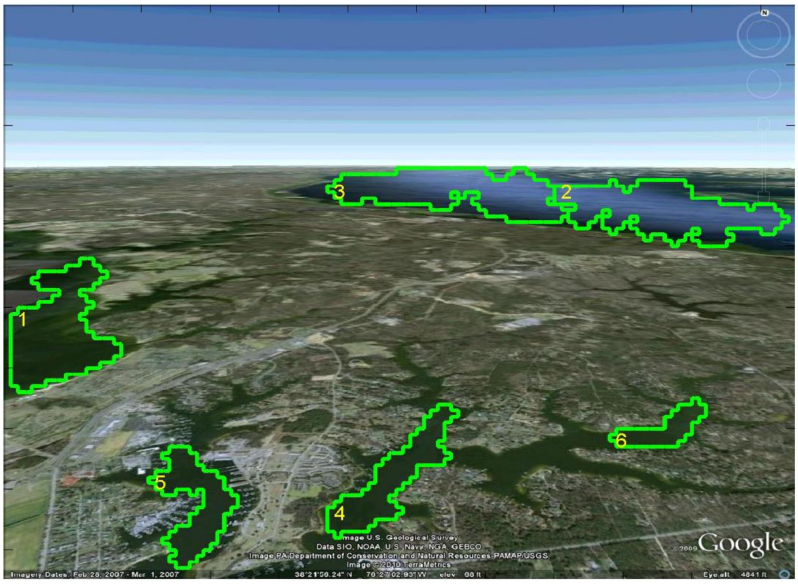

Fig 4: Visualization

III. Fuzzy C Mean Clustering

In fuzzy clustering (also referred to as soft clustering), data elements can belong to more than one cluster, and associated with each element is a set of membership levels. These indicate the strength of the association between that data element and a particular cluster. Fuzzy clustering is a process of assigning these membership levels, and then using them to assign data elements to one or more clusters.[1,4]

One of the most widely used fuzzy clustering algorithms is the Fuzzy C Mean (FCM) algorithm. The FCM algorithm attempts to partition a finite collection of n elements. X={$"x1 \ldots \ldots xn"$} into a collection of c

fuzzy clusters with respect to some given criterion. Given a finite set of data, the algorithm returns a list of c cluster centres C= {$\{c_1 \ldots \ldots c_c\}$ and a partition matrix W=$w_{i,j} \in [0,1], i = 1, \ldots, c$, where each

element w_{ij} tells the degree to which element x_i belongs to cluster c_j. Like the k-means algorithm, the FCM aims to minimize an objective function. The standard function is:

$$\frac{1}{\sum_j \left(\frac{d(center_k, x)}{d(center_j, x)}\right)^{\frac{2}{m-1}}} \qquad (4)$$

In fuzzy clustering, every point has a degree of belonging to clusters, as in fuzzy logic, rather than belonging completely to just one cluster. Thus, points on the edge of a cluster, may be in the cluster to a lesser degree than points in the centre of cluster.

IV. Results And Discussions

The system described above is implemented using Matlab and the result was successfully obtained. Instead of working on the real time images from aircraft mounted camera, experiments were performed on Photoshop edited Google Earth images.

V. Conclusion

The paper presents an automatic pilot assistive safe landing-site detection system for robust, reliable, and efficient emergency landing. The proposed system makes up for the limitations of human eyes, assists the pilot to find safe landing-sites, and more importantly, saves time for the pilot to devote to other necessary actions under emergency conditions.

To meet the practical needs a criterion to set the threshold of the roughness value for evaluation has to be found and a LIDAR system can be used along with the proposed system to obtain higher accuracy on the hazard level information of the surface.

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