iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** III **Month of publication:** March 2017

DOI: http://doi.org/10.22214/ijraset.2017.3063

www.ijraset.com
IC Value: 45.98
Volume 5 Issue III, March 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Automation Detection, Localiation and Classification Mission for Unmanned Aerial Vehicles

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***Abstract-Image Processing is processing using mathematical for which the input is an image, and the output is a set of parameters related to the image. Importance and necessity of digital image processing stems from two principal application areas: the first being the improvement of pictorial information for human interpretation and the second being the processing of the available image for an autonomous machine perception. Image processing has increasing relevance in today's digital world as it can be used to manipulate all sorts of digital images and videos. Image processing finds applications in medicine, security, and robotics. From the aerodynamic structure to self-driven unmanned aerial vehicles, the technology in designing planes has escalated in the last few years. Autonomous aircrafts with human payload have still not been achieved. Even though autonomous navigation is implemented in most flights today, a pilot is necessity for takeoff and landing. The proposed work intends to automate this process and eliminate the need of a pilot. This shall remove the factor of human error and reduce accidents. The current work also presents the development of software that process the images to extract the color, alphanumeric, shape, orientation and the GPS coordinates of the image*.**

I. INTRODUCTION

This work presents the implementation of autonomous take-off and landing system using image processing, to automate the entire flight process. Most flights today make use of autonomous navigation while the airplane is airborne but still require a pilot for takeoff and landing. Although the technology in designing planes has improved in the last few years, autonomous aircrafts with human payload has still not been implemented. By eliminating the need of a pilot, the margin for human error will be reduced and air travel can become even safer. To achieve this, we will process the images that are taken from the camera mounted on the airplane. In this, mathematical operations are applied to the input image and the output is the parameters necessary for navigation. Importance of the processing of the digital image captured is for two reasons: the improvement of pictorial information for interpretation and for an autonomous machine perception. The main components of the image that will be analyzed are Shape, Alphanumeric, Orientation and Color Recognition. Each component of the image is to be coded with a particular instruction. Once the components have been extracted, the instruction will be read from each component. These instructions will then be relayed back to the mission planner present in the flight system of the plane. The mission planner will use the instructions obtained to autonomously guide the plane during takeoff and landing. In such a way, the pilot will be completely removed from the flight navigation process and the process will become streamlined and precise. However, in case of a failure of the system an override option will still be provided so that the pilots can take control of the plane in an emergency situation.

II. DETAILED DESIGN OVERVIEW

Design provides an in depth description of the working and implementation of each module. The system needs to be deployed on each aircraft to help navigate during takeoff and landing. A data center can be installed on only a few aircrafts, but it shall increase processing time as it requires transfer of images and controls between each aircraft and the data center. The present work make use of a system that has very low requirements and can be integrated with the Mission Planner deployed on each aircraft, eliminating the need of a remote data center.

A. Alphanumeric Character Recognition

The image is converted to a binary image to obtain black background with the character in white is depicted in fig 1. It is passed into

Volume 5 Issue III, March 2017
ISSN: 2321-9653

Tesseract, the OCR engine. Based on the confidence level of the Tesseract output, the image is rotated until a high <what is the threshold> confidence is reached. This gives the correct character as the output and the local orientation of the character with respect to the image.

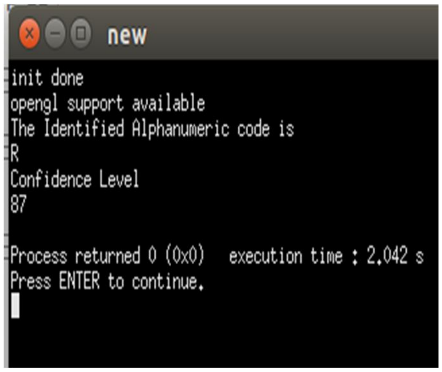

Fig 1: Alphanumeric Character Recognition

B. Shape Recognition

All targets are represented using standard geometric shapes such as rectangle, square, and circle characteristics like number of sides, angle between sides, relation between sides, relation between angles are used to classify them. Angles are calculated by using the cosine formula. Contours in the image are detected and characteristics are extracted. Convex contour of three sides would be a triangle, four sides with angles of 90 degrees between each would be a rectangle. Pentagon, hexagon, heptagon, and, octagon are detected in a similar manner. Cross and star do not satisfy the convexity condition. Circles are detected using the Hough Circles function shown in fig 2.

Fig 2: Shape Identification

C. Localization

The Contours found in the split RGB images are mapped to the original image by masking and merging all contours. The image containing the mapped mask is subjected to K-means clustering. The cluster count is set to 4 so that the background, target shape, alphanumeric within the target and target outline, arranged in decreasing order of sizes respectively, are obtained. Now the smallest cluster - outline and background are dropped. Out of the remaining the smaller one is the alphanumeric and the larger one is the target shape are indicated in fig 3 and fig 4.

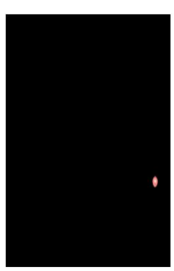

Fig 3: Mapped Image

Fig 4: ROI Orientation

Volume 5 Issue III, March 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

To successfully complete the ADLC task, the UAV will need to be able to acquire GPS and compass data for the image being taken. This was to be done without adding much weight or expenses to the UAV/Project. To do this, the team has come up with a custom algorithm implemented in python that intercepts and reads the stream of MAVLINK messages being sent to the GCS. The message acquisition is done through a serial to USB device connected to the ODROID and the TX pin of the secondary serial port on the Pixhawk. The code scans through all the messages being sent and saves the message with the required set of data into the buffer; then the GPS data (latitude and longitude) and compass data (orientation in degrees is extracted).

D. Color Identification

The adjacent diagram color values are scattered due non-uniform illumination, and camera optics. Hence clustering them is the best approach before finding the color of target and alphanumeric. After clustering the largest cluster indicates the object. The second largest cluster indicates the alphanumeric color. Other clusters indicate the background. The color of a cluster is found by obtaining the pixel values of the center of each cluster. Based on the HSV properties the colors are identified. These are mentioned in fig 5 and fig 6. One disadvantage of this approach is if the color of alphanumeric and background are same then color of the alphanumeric can be misinterpreted.

Fig 5: Detected as White

Fig 6: Detected as Red

III. MODULE CODES PREPROCESSING

All images are passed through this phase to determine whether they contain a target sign board or not. Target images are segmented and each component is sent to a different section of the code.

```
void pre_processing()
//resize image to half it's original size
image = pyrDown(image)
//apply fast Non-Local Means to remove noise
image = fastNLMeans(image)
//split into RGB components
split[3] = split(image)
for( i = 0 ; i  < 3 ; i++ )
if( findContours(split[i]) == True )
Check if contour has child contour and arcLength>60
If true, map onto original image
Else, reject image
Take age with ROI and apply K-means for segmentation, separate background, target board and alphanumeric character.
Convert shape to binary and send to shape_detect()
Send alphanumeric character to ocr()
Obtain RGB values of colors and sent to rgb_to_lab for both colors
```

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Obtain metadata from image and send to gps() and orient()

Since all targets are standard geometric shapes such as rectangle, square, and circle characteristics like number of sides, angle between sides, relation between sides, relation between angles are used to classify them. Angles are calculated by using the cosine formula.

float error (ideal, detected)
return abs(ideal - detected)
void shape_detect ( )
Check if it's a circle *// Hough Circle Transform*
/ unknown center and radius in a given range */*
if (circle)
shape = "Circle"
else
find edges *// Canny edge detector*
edge_count = size(vector)
angles[i] = cos(angle between adjacent edges)
for (each shape)
/ shape has ideal edge count and ideal cosine of angles*/* param1 = error(ideal_count, edge_count)
for (each angle i)
param2 = error(ideal_cos, angles[i])
param3 = param1 * 0.4 + param2 * 0.6if param3 is minimum
shape = "ideal shape"print shape
Return

The image is converted to a binary image to obtain black background with the character in white. It is passed into Tesseract, the OCR engine.

float delta (lab1, lab2)
return delta(lab1, lab2)
void rgb_to_lab (image)
obtain r,g,b values from pixel
convert to lab
void closest (float l, float a, float b)
/ Store LAB values and names of standard colors */*
for (each standard color i)
deltas[i] = delta(lab_standard, lab_current)
index = min (deltas)
print " Color[index] "
Return

The color of a cluster is found by obtaining the pixel values of the center of each cluster. Based on the HSV properties the colors are identified.

min_conf = 80
void ocr (image)
// set angle to 360 degrees with 4 degrees interval
confs, al_num = tesseract (image)
while (alnum lies in 0-9 , a-z, A-Z if (confs[i] > min_conf and other confs)
print al_num
break;   retur

The autopilot in each aircraft provides the coordinates, elevation, yaw and pitch of the plane. These are encrypted in the metadata of each image and are used to find the exact location of each signboard.

void gps(double x, double y, float elevation, float yaw, float pitch)
// x is latitude and y is longitude

Volume 5 Issue III, March 2017
ISSN: 2321-9653

double new_x, new_y
new_x = x + yaw; new_y = y + elevation + pitch

IV. RESULTS AND ANALYSIS

The system is evaluated based on six criteria. It includes
Obtaining Target Image, Alphanumeric Character Detection, Shape Detection, Shape color, alphanumeric character Color, Orientation of alphanumeric character on the target board. For a series of images tested, the system gives nearly accurate results are shown in fig 7 and fig 8. Alphanumeric isn't identified because the number format is different.

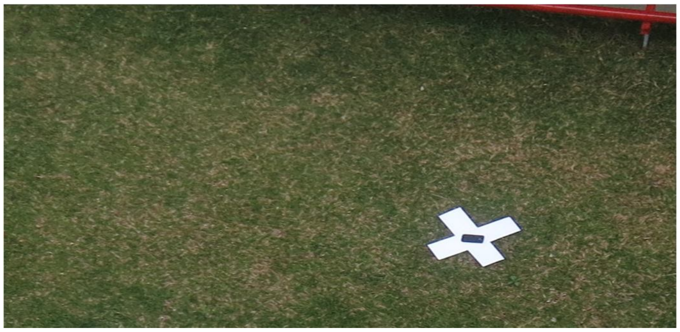

Fig 7: Shape is Cross

Fig 8: Shape is Circle

V. CONCLUSION

The proposed software process the images to extract the color, alphanumeric, shape, orientation and the GPS coordinates. The analysis of this information can then be used to guide the plane for an automatic takeoff and landing. In addition, the program is also capable of rejecting images without target boards and decode target information with appreciable accuracy. Using the test images to mimic those on the airport runway, it is observed that the system designed can identify the required components correctly with accuracy of 94%. The accuracy can be improved using a learning data set of images.

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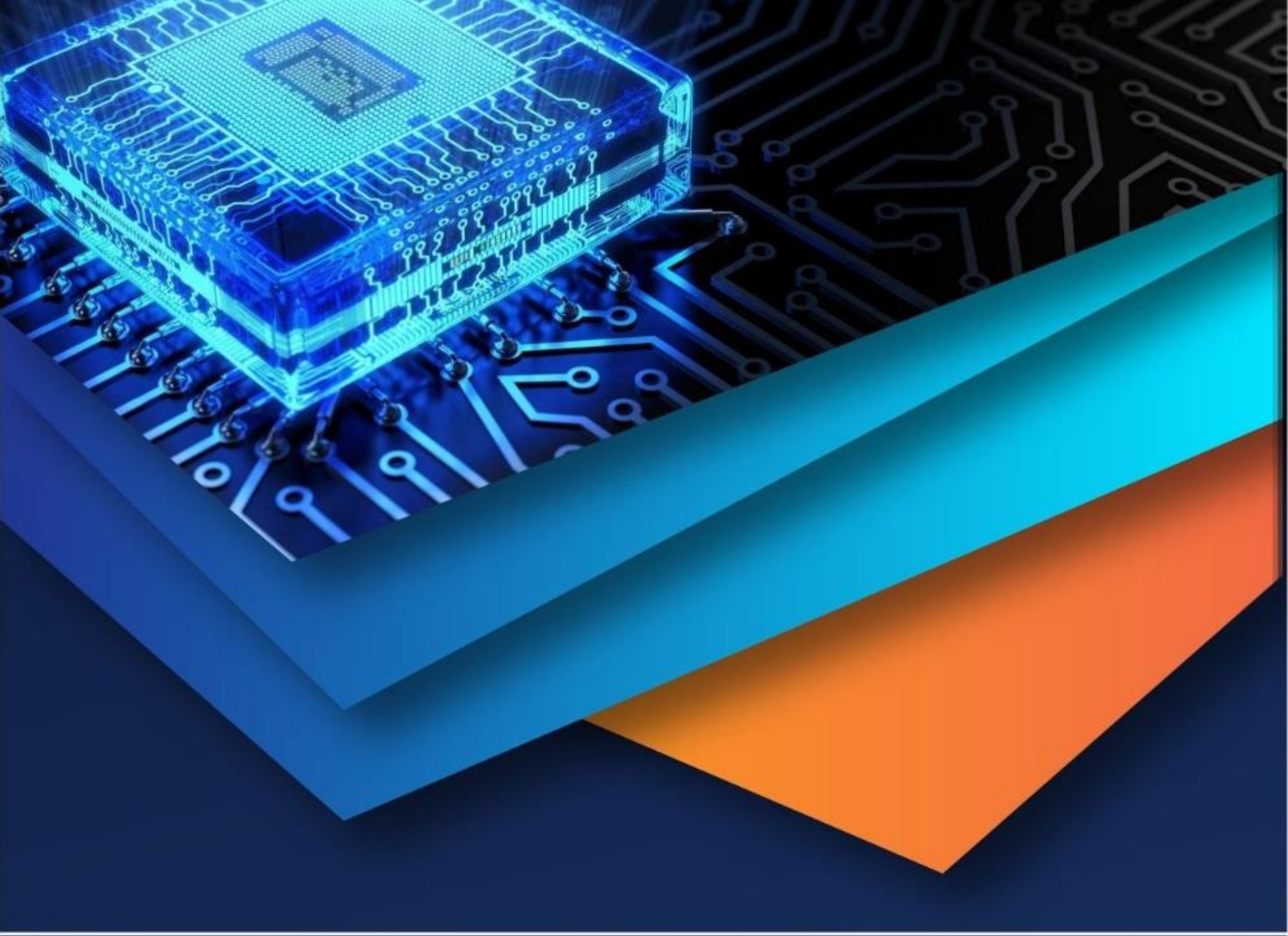

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