VISION BASED AUTONOMOUS NAVIGATION OF MICRO AIR VEHICLE

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Abstract- The *appearance variation cue captures the variation in texture* in a single image. Obstacle avoidance is based on the assumption that there is less variation when the camera is at very close to an obstacle.

This system proposes a procedure to improve the navigation when the building has detailed texture, since the existing system cannot detect the wall as an obstacle. The process of indoor navigation is optimized by extracting the image features such as texture of the building. Sensitivity can be improved with the help of using Black & White Camera instead of colour cameras.

Key words – UAV, MAV, Ornithoptor, Corner detection, Image registration and Obstacle detection.

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I. INTRODUCTION

An Unmanned Aerial Vehicle or Unmanned Air Vehicle (UAV), generally known as a "Drone" is an aircraft without a human being as a pilot on board. It is autonomously controlled by computers in the vehicle or with the help of controls, or pilot on the ground station or in another vehicle parked at distance location. UAV's are invented essentially to reduce the human interface needed for its maneuvering and throughout missions. UAVs were simple as remotely controllable aircraft, but the process independent maneuvering is increasingly being employed. They are mainly deployed for military purposes, but also used in a small but increasing number of civil applications. UAVs are often chosen for missions that are too dull, dirty, or unsafe for manned aircraft. A Micro Air Vehicle or micro aerial vehicle (MAV) is a class of unmanned aerial vehicles (UAV) that has a size constraint and may be autonomous. MAV refer to a new breed of aircrafts that are considerably smaller than all flying vehicles available today. Although small, it is required to carry a surveillance camera, means of control and of image transmission. The small aircraft allows remote inspection of hazardous environments difficult to get to for the ground vehicles. Initially MAVs have been built as a hobby, such as for contests and for aerial photography.

An Ornithoptor or Flapping wing UAV is a kind of MAV that flies by flapping its wings. This kind of UAV uses wing for generating lift power which operates like wings of a bird. Designers seek to imitate the flapping-wing flight of birds, bats, and insects. Though machines may be different in form, they are usually built on the same scale as these flying creatures. This MAV flies like normal humming bird, which assures stealthy behavior of the MAV. The camera it carries will help the MAV to navigate through the environment and it can get detailed and clear information about the target environment. But the use of normal RGB image from the camera can be used for the navigation of the MAV through the environment. But use of black and white cameras will improve the sensitivity and the performance of the MAV. Obstacles which are present in the environment or in the path of MAV will be detected with the processing of image through corner detection and then by image registration.

II. CORNER DETECTION

A corner can be defined as a point, for which there are two principal and dissimilar edge information in a local region of the point. Corner detection is a method used in computer vision systems to extract some of the features and infer the contents of an image. It is primarily used for recognizing a particular object in an image. The method corner detection is commonly used in motion detection, image registration, video tracking or motion tracking, alignment methods of an image like homography and fundamental matrix, building up a panorama image, 3D reconstruction and modelling and object recognition. Corners are image locations that have large intensity changes in more than one direction. That is shifting of sample point will result in large change in image intensity.

Whereas in an edge, the shifting of sample point will not result in change the intensity value so that it can be shifted in along the edge of an image. In simple words, an edge is a sharp change in image brightness, and a corner can be defined as the intersection of two edges. This intersection point of two edges in an image is simply called as an interest point. An interest point is a point in an image which has a well-defined position and can be vigorously detected.

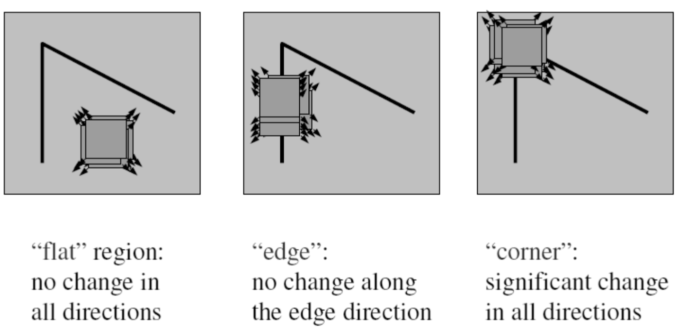

Figure.1

This means that an interest point can be a corner but it can also, an isolated point of local intensity which can be high or low, line endings, or a point on a curve where the curvature is locally maximal. Generally corner detectors are not especially robust and it repeatedly requires expert supervision or huge redundancies introduced to avoid the effect of individual errors from dominating the recognition task. Determining the quality of a corner detector is its ability to detect the same corner in a number of similar images, under the situation of different light illumination, rotation, translation and other transforming methods. A simple straightforward approach for the method of corner detection in images is using correlation, but this gets very computationally complex and suboptimal.

A. Harris Corner detection:

The Harris corner detector is the most popular and accepted interest point detector due to its strong invariance to scale & rotation, illumination variation and image noise. Harris corner detector is basically works on the local auto-correlation function of a signal, where the local auto-correlation function measures the local changes of the signal with patches shifted by a small amount in different directions. The predecessor of the Harris detector was presented by Moravec, where it refers to the shifting of the patches. Harris detection method is an improved one of Moravec's detection method. Moravec's corner detector functions by considering a local window in the image, and determining the average changes of image intensity that result from shifting the window by a small amount in various directions. Harris corner detector is based on the local auto-correlation function of a signal which measures the local changes of the signal with patches shifted by a small amount in different directions.

An another approach which is frequently used is based on a method proposed by Harris and Stephens, which in turn is an improvement of a method of Moravec corner detection. Since the Moravec corner detection considers only 45 degree of angles whereas Harris corner detection detects in all directions. Harris detector is proved for its more accuracy in differentiating between edges and corners.

$$c(x,y) = [\Delta x \quad \Delta y] \begin{bmatrix} \sum_W \left(I_x(x_i,y_i)\right)^2 & \sum_W I_x(x_i,y_i)\, I_y(x_i,y_i) \\ \sum_W I_x(x_i,y_i)\, I_y(x_i,y_i) & \sum_W \left(I_y(x_i,y_i)\right)^2 \end{bmatrix} \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix} = [\Delta x \quad \Delta y]\, C(x,y) \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix}$$

Let a & b are the eigen values of C(x,y). Then there are three cases to be considered:

1. If both eigen values are small, so that the local auto-correlation function is flat (i.e., little change in c(x, y) in any direction), the windowed image region is of approximately constant intensity.

2. If anyone of the eigen value is high and the other low, so the local auto-correlation function is ridge shaped, then only local shifts along one direction (along the ridge) cause little alteration in c(x, y) and considerable change in the orthogonal direction; this indicates an edge.

3. If both eigen values are high, thus the local auto-correlation function is sharply peaked, then it shifts in any direction consequently it results in a significant increase; this indicates a corner.

Improved Harris detected as similar as Harris operator, but the average anti-noise factors of the improved Harris detector were higher than those of the original detector. Therefore, it has a certain improvement indeed.

A. *SUSAN's Corner detection:*

The word SUSAN is an acronym standing for Smallest Univalue Segment Assimilating Nucleus. For feature detection, SUSAN detector places a circular mask over the pixel to be tested (the nucleus). If the brightness of each pixel within a mask is compared with the brightness of that mask's nucleus then an area of the mask can be defined which has the same (or similar) brightness as the nucleus. For corner detection, two steps are to be used further. Firstly, the centroid of the SUSAN detector is found. An appropriate corner will have the centroid far from nucleus. In the second step, it insists that all points on the line from the nucleus through the centroid out to the edge of the mask are in the SUSAN.

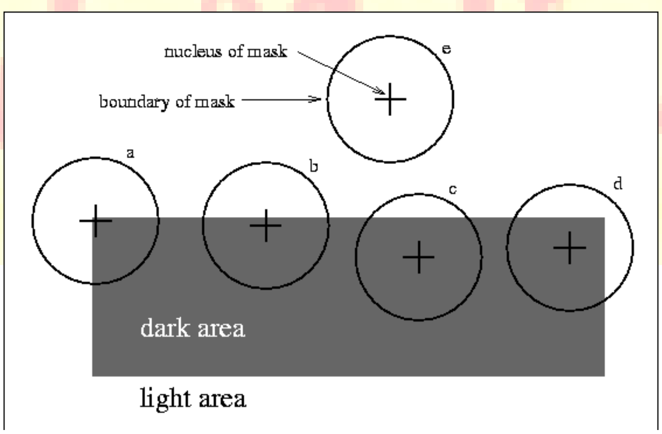

Figure.2

Corner detection based on SUSAN method falls under the three categories.

1. In flat regions the SUSAN has similar area to the template
2. At edges the SUSAN area is about half the template area
3. At corners the SUSAN area is smaller than half the template area.

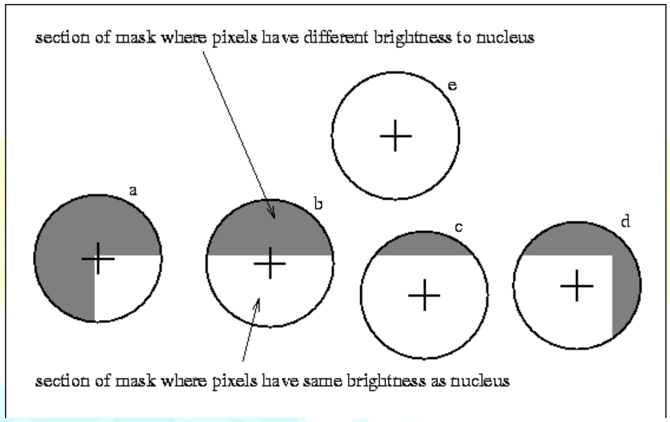

Figure.3

III. IMAGE REGISTRATION

Image registration is the simple process of transforming different sets of data into one. The data may be of multiple photographs, data from different sensors or from different times or from different viewpoints. The image registration process is one of the most important tasks when integrating and analyzing information from a number of sources. This is a key-stage in image fusion, detection of changes, super-resolution imaging and in the process of building image information systems between others. It is the process of estimating an optimal transformation between two images. Sometimes it is also known as Spatial Normalization. Some of the applications of image registration are video stabilization, video compression, image mosaicking, motion correction, stereo matching, and structure from motion. The basic steps which are involved in the image registration are feature detection, matching, mapping and function design, and image re-sampling and transformation.

The application of image registration process falls under the following categories.

1. Different viewpoints (multi-view analysis): Images of the same scene are acquired from different viewpoints. The aim is to gain larger a 2D view or a 3D representation of the scanned scene.

2. Different times (multi-temporal analysis): Images of the same scene are acquired at different times, often on regular basis, and possibly under different conditions. The aim is to find and evaluate changes in the scene which appeared between the consecutive image acquisitions.
3. Different sensors (multimodal analysis): Images of the same scene are acquired by different sensors. The aim is to integrate the information obtained from different source streams to gain more complex and detailed scene representation.

The methodology for the process of image registration has the following steps.

i. Feature detection: Salient and distinctive objects are manually or, preferably, automatically detected. For further processing, these features can be represented by their point representatives (centers of gravity, line endings, distinctive points), which are called control points (CPs) in the literature.
ii. Feature matching: In this step, the correspondence between the features detected in the sensed image and those detected in the reference image is established. Various feature descriptors and similarity measures along with spatial relationships among the features are used for that purpose.
iii. Transform model estimation: The type and parameters of the so-called mapping functions, aligning the sensed image with the reference image, are estimated. The parameters of the mapping functions are computed by means of the established feature correspondence.
iv. Image re-sampling and transformation: The sensed image is transformed by means of the mapping functions. Image values in non-integer coordinates are computed by the appropriate interpolation technique.

IV. OBSTACLE DETECTION

The obstacle from the environment is detected with the help of the following steps. They are, Image Subtraction, Hole Filling, Thresholding and Detection.

A. *Image Subtraction:*

Image subtraction or pixel subtraction is a process whereby the digital numeric value of one pixel or whole image is subtracted from another image. This is primarily done for one of two reasons – leveling uneven sections of an image such as half an image having a shadow on it, or detecting changes between two images. This detection of changes can be used to tell if something in the image moved. This is commonly used in fields such as astrophotography to assist with the computerized search for asteroids in which the target is moving and would be in one place in one image, and another from an image after some times and where using this technique would make the fixed stars in the background disappear leaving only the target.

B. *Hole Filling:*

Creating accurate models of real environments is a nontrivial task for which traditional modelling techniques are inappropriate. In these situations, the use of laser rangefinders seems attractive due to its relative independence of the sampled geometry and short acquisition time. The problem of filling holes in range data can essentially be divided into two sub-problems: identifying the holes and finding appropriate parameterizations that allow the reconstruction of the missing parts using the available data.

C. Thresholding:

Thresholding is the simplest method of image segmentation. To make segmentation more robust, the threshold should be automatically selected by the system. Knowledge about the objects such as intensity characteristics of the objects, sizes of the objects, fractions of an image occupied by the objects, number of different types of objects appearing in an image, the application and the environment should be used to choose the threshold automatically. From a grayscale image, thresholding can be used to create binary images. Colour images can also be thresholded. One approach is to assign a separate threshold for each RGB components of the image and combine them with logical AND operation. This resembles the way of camera works and how the data is stored in the computer, but it does not match to the way that people identify the colours. Thresholding process is categorized as Histogram shape based methods, clustering based, entropy based, object attribute based, spatial based and local methods.

V. COLCLUTION

Here we are proposing a method for finding the obstacle present in the environment. The obstacle is found with the help of feature extraction rather than using optical flow and cue. The image captured from the camera which is present at the front end of the MAV is processed through these steps for finding the obstacle present in its path and the environment. The input image can be processed as normal RGB colour image or as grey scale image. The first step is to find the corners and edges present in the image. The image is then undergone for image registration process in which the entire corner processed image is combined as same as environment as a whole image for detecting the obstacles. The obstacle is detected in this image with the help of various processes. The obstacle present in the environment is detected and the MAV is made to maneuver without hitting on the obstacle.

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