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# COMPARATIVE STUDY OF IMAGE MATCHING ALGORITHMS

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Image matching is an important task to be performed for the correspondence problem. The distinction between different matching primitives is probably the most prominent difference between the various matching algorithms. The primitives fall into two broad categories: either windows composed of grey values or features extracted in each image a priori are used in the actual matching step. The resulting algorithm usually called: Area Based Matching (ABM), and Feature Based Matching (FBM) respectively. In this paper, the comparative study of these two algorithms has been done which results with one best optimal method i.e. Feature Based Matching. FBM procedures widely used in pattern recognition and computer vision & fine increasing interest also in photogrammetry.

Keywords: Correspondence, Orientation of Edges, Convergence, Versatility.

## 1. Introduction

The matching problem is also referred to as the correspondence problem. This paper represents some of the comparative points of Matching and after this comparative study, some distinct points with an interest operator for matching are described. The interest operator is optimal for selecting points which promise high matching accuracy, for selecting corners with arbitrary number and orientation of edges or centers of discs, circles or rings. From the n' into n" possible pairs of points only a few are pairs of corresponding points. In this step a preliminary list of candidate pairs is built, which is based on the similarity of the points [1].

## 2. Basic Concepts

Image Matching exemplifies two fundamental problems of image matching.

a) Ambiguous solutions may occur, if image matching is tackled using only local information.

b) Good approximations are needed.

In most of the image matching algorithms, parameters like translation, rotation, scaling and perspective invariance must often be taken into account. Moreover, the input to different sensors at the same time or input to same sensor at different times will always result in occluded output, and matching an occluded image is always been a challenging task[4]. For quick and reliable object recognition, the kind of feature to be used for matching and criterion for best matching must be known. For this, the comparative study is done which results with one optimal method i.e. Feature based matching. Number of parameters has been discussed which helps in resulting with Feature Extraction. In FBM, Local features are points, edges and lines, and regions. Larger (global) features are called structures. Global features are usually composed of different local features. Besides the attributes of local features, relations between these local features are introduced to characterize global features.

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## 3. Comparative Study

| Parameters | Area based Matching | Feature Based Matching |
|---|---|---|
| Matching Strategy | In ABM, each point to be matched is the center of a small window of pixels in a reference image and this window is statistically compared with equally sized windows of pixels in other images. | In FBM, instead of matching all pixels in an image, only selected points with certain features are to be matched. |
| Convergence, Speed & Versatility | ABM is being observed with less Convergence, speed and versatility as compared to FBM. | FBM is superior to image Correlation with respect to speed & versatility and is superior to LSM with respect to range of convergence, speed and versatility. |
| Initial Estimates | ABM usually requires very good initial values for the unknown parameters. | FBM does not require very precise initial estimates. |

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| Parameters | Area based Matching | Feature Based Matching |
|---|---|---|
| Sensitivity | LSM has a very small radius of convergence. Even though it is greater for cross correlation, the similarity condition has to be fulfilled. | Feature based matching techniques are less sensitive with respect to the quality of approximate values. |
| Occlusions | ABM is sensitive with respect to occlusions. | FBM techniques are also less sensitive with respect to occlusions because the mathematical model needs not necessarily to be fulfilled exactly. |

The above points of comparative study explain that the feature based correspondence method is the optimal one.

## 4. Concept of Feature Based Matching

1. To select distinct points in the images separately.
2. The points are selected using a so-called interest operator.
3. Building up a preliminary list of candidate pairs of corresponding points assuming a similarity measure.
4. Finding the final list of point pairs consistent with an object model.

### 4.1. Selecting Distinct Points with an Interest Operator

In FBM Instead of matching all pixels in an image, only selected points with certain features are to be matched. The selection principle should fulfill the following requirements:

Distinctness: The points should be distinct, i.e. be different from neighbouring points e.g. points on edges should not be selected if the epipolar geometry constraint is not used; also points in flat areas should not be selected. MORAVEC's and HANNAH's operators follow this aim: MORAVEC's operator (1977) searches for points with the largest minimum variance of gray level differences in 4 directions, while HANNAH's operator (1974) searches for points where the autocorrelation function of the gray level function is steep in all directions.

Invariance: The selection as well as the selected position should be invariant with respect to the expected geometric and radiometric distortions. This besides the distinctness, probably is the most important requirement. The degree of invariance directly influences the precision and the reliability of the matching.

Stability: The selected points should be expected to appear in the other images. Thus the selection should be robust with respect to noise. In image sequence analysis the selected points should appear in long sequences of consecutive frames.

Interpretability: The selection principle should be interpretable in some sense, e.g. looking for edges, corners or other simple but labeled features. This requirement is not essential from an engineering point of view, but may be essential if the interest operator is used for image analysis.

Seldomness: Whereas distinctness guarantees local separability of points seldomness aims at global separability. This is essential in images with partially repetitive patterns. In order to avoid confusion elements of repetitive patterns should

## 5. Feature Extraction

In Feature based matching, features are extracted in each image individually prior to matching them. Local features are points, edges and lines, and regions. Larger (global) features are called structures. Global features are usually composed of different local features.

### 5.1. Point Extracton

The point features are usually extracted by local operators, often called "interest" operators. Some interest operators are listed below:

1. The operator of Moravec detects points with high grey level variances.
2. Luhmann and Ehlers used a grid-like feature extraction without contrast-depending thresholding to obtain a homogeneous distribution of the features.
3. Dreschler developed an interest operator based on the principal and Gaussian curvatures and the angle of the principal direction of the intensity function.

— Compute the grey level gradients of the image gx, gy by using an edge operator (e.g. Prewitt or Sobel).

For a 3X3 mask gx and gy are computed by using the equations:

gx = (z7 + z8 + z9) – (z1 + z2 + z3), and

gy = (z3 + z6 + z9) – (z1 + z4 + z7).

Where, zi is the value of coefficients of the above mask.

| | | |
|---|---|---|
| Z1 | Z2 | Z3 |
| Z4 | Z5 | Z6 |
| Z7 | Z8 | Z9 |

— Compute the elements of the normal matrix N

$$N = \begin{bmatrix} \Sigma g_x^2 & \Sigma g_x g_y \\ \Sigma g_x g_y & \Sigma g_y^2 \end{bmatrix}$$

— Estimate two criteria within a small window, e.g. 7x7

a) weight w, relates to the size of the error ellipse,

$w = \frac{\det N}{trN}$ with

proportional to contrast

det N = determinant of N;

tr N= trace of N.

b) roundness q, relates to the shape of the error ellipse, i.e. the length of the semi major and semi minor ellipse axes

$q = \frac{4 \det N}{tr^2 N}$; $0 < q < 1$

Threshold criteria

— w(x, y) = w(x, y) if g(x, y) > = q min and w(x, y) >= wmin otherwise

w (x, y) = 0

— Non-maxima suppression by using w (x,y) within window size

— Estimation of accurate point coordinates

5. Hannah uses an operator that selects points with steep autocorrelation function of the grey levels in all directions (conceptually similar to Foerstner)

### 5.2. Edge Extraction

Edges can be extracted from operators that detect edges. Two of the most known are:

- Gradient operators, which is based on the calculation of the local intensity gradient with the use of a mask usually with odd dimensions.
- The zero-crossings of the Laplacian, which are inflection points of the intensity function f(x, y).

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} = 0$$

The Laplacian is based on second-order derivatives, thus is highly sensitive to noise and therefore is combined with a smoothing operation, e.g. convolution with a Gaussian filter, and is called "Laplacian of a Gaussian" (LoG).

### 5.3. Region Extraction

This extraction of regions starts with the detection of some very "homogeneous regions" of the image, e.g. regions with intensity variations below a certain threshold, and are then maximally grown but only to the extent that they remain sufficiently homogeneous.

The multi-patch process based on the relative geometry works as follows.

1. Three patches are chosen in the first image. A search is conducted in the candidate list of each of the three patches for a combination of candidates that form a triangle of similar size, shape and orientation to the patches in the first image.
2. If no suitable set of candidates can be found, one of the patches in step 1 is replaced, and step 2 is repeated.
3. Steps 2 and 3 are repeated until suitable triangles are formed.
4. With the first two successfully matched patches, other patches are processed in turn from the first image, with the candidate list being compared as in step 2 to find the one with the correct geometry.
5. The triangles are compared by the orientation and length of their edges, and are regarded as similar if edge orientation is approximately 5°.

## 6. CONCLUSIONS

The feature based matching method is the optimal method for image matching problem and it supports the least squares matching algorithm by providing reliable and accurate approximate values if necessary. The precision of this FBM procedure has been shown to be appr. 1/3 of a pixel in case the centre of the selected windows is used as feature points and the images show enough texture. The ability of the interest operator to find and accurately locate corners with arbitrary number and orientation of edges or lines need further investigation, specifically for supporting image analysis.

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