Feature Based Multi View Image Registration by Detecting the Feature with Fuzzy Logic for Corner Detection

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Abstract- This paper aim to Present accurate feature base registration by detecting the feature with Fuzzy logic for corner detection. Image registration is process used to match two or more partially overlapping image taken for example at different times ,from different sensors, or from different viewpoints and stitch these image into one panoramic image comprising whole scene. It is a fundamental image processing technique very useful in integrating information from different sensors, finding changes in image taken at different time, inferring three-dimensional information from stereo images and recognizing model-based objects. The paper presents a corner detection algorithm for feature detection which employs such fuzzy reasoning. The robustness of the proposed algorithm is compared to well-known conventional Harris corner detectors and its performance is also tested over a noise image.

Keywords- *Registration, Harris corner detector, Fuzzy Corner Detector, Normalized cross correlation, Transformation function design, Image Transformation and re-sampling.*

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I. Introduction

Image Registration is the spatial alignment of corresponding images of the same scene acquired from different times, views, and sensors. In general, registration methods can be divided into two categories: 1) area-based methods, and 2) feature-based methods. Area-based methods use the pixel intensity of corresponding region in which the similarity measure is key factor for registration accuracy. In contrast, feature-based methods use points, curves, lines, branches, and regions. The critical point of feature-based methods is to extract correct correspondent features between two or more images. Normally, feature-based methods consist of four steps [24].

A. *Feature extraction*
Common, but distinctive objects are considered features, such as points, edges, curves, lines, branches, and regions.

B. *Feature matching*
Using features from the previous step, the common features between the reference image and the sensed image are matched. Registration accuracy depends on the correctness of feature matching. To improve the matching quality, outlier removal techniques are normally integrated.

C. *Transformation Estimation*
Parameters of the mapping function are estimated using the matched features, and the sensed image is then transformed using the estimated transformation.

D. *Image re-Sampling*
The transformed image is finally re-sampled.

II. Feature Extraction

Any salient and distinctive objects or features like closed-boundary regions, edges, contours, line intersections, corners, etc. are detected using the various feature detectors. For further processing, these features can be represented by their point representatives centre of gravity, line endings, distinctive points which are called control points (CPs).For feature detection corner detection method is used because corner is important feature. It is defined as inter section of two edges. Corner contain more information compare to another feature and it detection process is easy compare to another feature [18].

A *Harris Corner Detection*
Harris corner detector is based on the auto correlation function of the signal. The basic idea of this detector is we find whether point shows significant change in all direction or not. If yes then point is marked as a corner point [5]. To do this second moment matrix and corner function is calculated [5, 6]. If both of the Eigen values of the second moment matrix are large and nearly equal than that point are considered as the corner point [5] (see Figure 1). The Harris corner detector is invariant to translation, rotation and illumination change [6]. This detector is most repetitive and most informative. The disadvantage of this detector is it is not invariant to large scale change [7]. Harris detector detects the L-junctions and points with the higher curvature along with the corner points [7]. Here we find the second moment matrix which requires finding the gradients of an image which is sensitive to noise and computationally expensive.
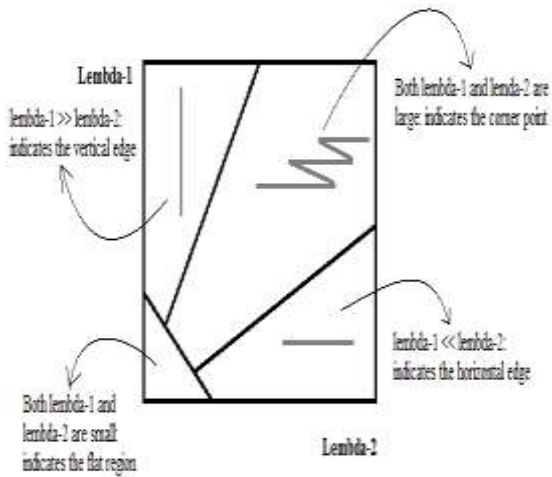
Figure 1: Classification of points using Eigen values of the second moment matrix

B   *Fuzzy Logic for Corner Detection*

Data from natural images are always imprecise and noisy due to inherent uncertainties that may arise from the imaging process (such as defocusing, wide variations of illuminations, etc.). As a result, precise localization and detection of corners become difficult under such imperfect situations. On the other hand, Fuzzy systems are well known for efficiently handling of impreciseness and incompleteness [13, 14, and 15] due to imperfection of data [16].

Fuzzy System:

The fuzzy system is simple to implement and still fast in computation if it is compared to some existing fuzzy methods [25, 26]. Also, it can be easily extended to detect other features. In the proposed approach, the fuzzy rules are applied to a set of pixels belonging to a rectangular N x N window (usually 3x3 pixels), where the gray-level differences between the centre pixel and its surrounding pixels are computed and stored within matrix E as follows:

$$E=\begin{bmatrix} P_{m,n} - P_{m-1,n-1} & P_{m,n} - P_{m-1,n} & P_{mn} - P_{m-1,n+1} \\ P_{m,n} - P_{m,n-1} & 0 & P_{m,n} - P_{m,n+1} \\ P_{m,n} - P_{m+1,n-1} & P_{m,n} - P_{m+1,n} & P_{m,n} - P_{m+1,n+1} \end{bmatrix}$$
$$(1)$$

Where m and n represent the coordinates of the central pixel. If the neighbourhood is a homogenous region, then E contains values near zero. In the case of corners, the matrix E possesses a specific configuration depending on the corner type. These divide E in two connected regions, one with positive (pixel type A) and another with negative (pixel type B) difference values (see Figure 1). The reasoning structure

uses two different types of rules: the THEN-rules and the ELSE-rules (don't care conditions) respectively. Each THEN-rule includes a determined pixel configuration as antecedent and only one pixel as consequent. Antecedents are related to a corner existence test and the consequent to its presence or absence. The rule-base gathers many fuzzy rules (THEN-rules) and only one ELSE-rule (i.e. do-not-care rule). Therefore only relevant rules (i.e. configurations) are formulated as THEN-rules while other not important configurations may be handled as a group of ELSE-rules. The set of THEN-rules lies on the very core of the algorithm. The rules must deliver successful structure detection, i.e. corners in this case, while still cancelling other inconsistencies such as noise. Such tradeoffs may be solved by using a reduced set of rules (configurations) which in turn represent the minimum number in order to coherently detect the structure as it is required by a given application. Such procedure allows dealing with noisy pixels or imprecision.
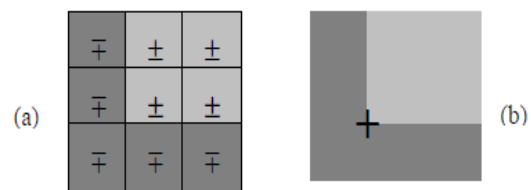

Fig 2. Region shaping with respect to gray level differences: (a) the resulting template and (b) the real corner that originates the template.

The proposed corner detector considers twelve THEN-rules that represent the same number of possible corner configurations and only one ELSE-rule as it is graphically explained by Fig. 5. It may be also possible to consider some other corner configurations. However it may reduce the algorithm's ability to deal with noise or uncertainty [26,27].
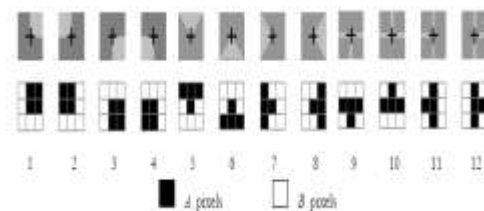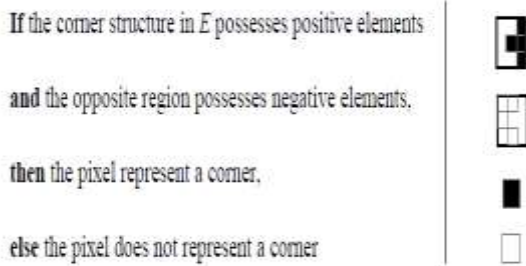

Fig 3. Different corner cases to be considered for building the fuzzy rules. The image region containing the corner is shown in the upper section while the resulting 3x3 template is shown below each case.

Despite using a reduced rule base, the performance in the detection process can be considered acceptable when it is compared to other algorithms solving the same task. Each rule has the following form:

If the corner structure in E possesses positive elements

and the opposite region possesses negative elements.

then the pixel represent a corner,

else the pixel does not represent a corner

The principle can be explained as follows: If one region of the neighbourhood, according to any of the twelve cases, contains positive/negative differences with respect to the center pixel, and if any other region contains the opposite (negative/positive) differences with respect to the center pixel, then the center pixel is a corner. The procedure can be considered as the evaluation of each one of the 12 different THEN-rules (configurations), yielding two auxiliary matrices E^p and E^n as follows:

$$E^p (i,j) = \begin{cases} 1 \ if \ E(i,j) \le t_h \\ 0 \qquad\quad else \end{cases}$$

$$E^n (i,j) = \begin{cases} 1 \quad if \ E(i,j) > t_h \\ 0 \qquad\qquad else \end{cases} \qquad (2)$$

For all the elements of E^p being ones, and

$$E^p (i,j) = \begin{cases} 1 \ if \ E(i,j) \ge -t_h \\ 0 \qquad\qquad else \end{cases}$$

$$E^n (i,j) = \begin{cases} 1 \quad if \ E(i,j) < -t_h \\ 0 \qquad\qquad else \end{cases} \qquad (3)$$

For all the elements of E^n being ones is a threshold that controls the sensitivity of the considered differences. Typical values for th normally fall into the interval (5-35). The lowest value of 5 would yield a higher detector's sensitivity which may detect a great number of corners corresponding to noisy intensity changes which are commonly found in images. On the other hand, a maximum value of 35 would detect corners matching to a significant difference between several objects in the structure, i.e. object whose pixels may be considered as being connected. Although the selection of the best value for th clearly depends on the particular application, a good compromise can be obtained by taking a value on approximately half the overall interval, i.e. 20th. The membership values μ_c (m,n) (where $c = 1, 2, K, 12$) are computed depending on the corner types (see Fig. 5). According to such values represent the antecedents of each employed THEN-rule. They can be calculated as follows:

$$\mu_c (m,n) = \frac{1}{20} max \left[\left(\sum_{ije A} E^p (i,j) \right) \cdot \left(\sum_{ije B} E^n (i,j) \right), \left(\sum_{ije B} E^p (i,j) \right) \cdot \left(\sum_{ije A} E^n (i,j) \right) \right]$$

(4)

considers a normalization factor equal to 20 which represents the maximum possible value,i.e. the highest product of the multiplication among the pixels between E^p and E^n . Hence, the membership value $\mu_c(m,n)$ falls between 0 and 1.above Eq.(5)can be considered as the numerical member implementation of the generic rule previously defined by Eq. 2. If Rule 1 (case 1) is considered as an example, the expressions corresponding to Eq. (6) would thus be:

$$\sum_{ije A} E^p (i,j) = E^p (1,2) + E^p(1,3) + E^p(2,2) + E^p(2,3) \qquad (5)$$

$$\sum_{ije B} E^n (i,j) = E^n (1,1) + E^n(2,1) + E^n(3,1) + E^n(3,2) + E^n(3,3) \qquad (6)$$

$$\sum_{ije B} E^p (i,j) = E^p (1,1) + E^p(2,1) + E^p(3,1) + E^p(3,2) + E^p(3,3) \qquad (7)$$

$$\sum_{ije B} E^n (i,j) = E^n (1,2) + E^n(1,3) + E^n(2,2) + E^n(2,3) \qquad (8)$$

Analogously to above equation, membership values μ_2 (i, j)... μ_{12} (i, j) for other rules (cases) can be calculated. Finally, the 12 fuzzy rules can be added into a single fuzzy value using the **max** (maximum) operator. The final fuzzy value represents the linguistic meaning of cornerness yielding:

$$\mu_{cornerness} (m,n) = max (\mu_1 (m,n), \mu_2 (m,n),.......\mu_{12}(m,n)) \qquad (9)$$

The pixels whose value $\mu_{cornerness}(m,n)$ are near to one, belong to a feature similar to a corner, while values near to zero would represent any other feature.

III.   Feature Matching

Once the features from the reference and sensed image are detected the very next step is to find the correspondence between the detected features. In feature matching step, our goal is to find that which feature of the reference image is corresponding to which feature of the sensed image.
A. *Normalized cross correlation method*

The classical representative of the feature matching methods is the normalized CC. This measure of similarity is

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computed for window pairs from the sensed and reference images and its maximum is searched [15]. The window pairs for which the maximum is achieved are set as the corresponding ones. Although the CC based registration can exactly align mutually translated images only, it can also be successfully applied when slight rotation and scaling are present. There are generalized versions of CC for geometrically more deformed images. They compute the CC for each assumed geometric transformation of the sensed image window and are able to handle even more complicated geometric deformations than the translation-usually the similarity transform. The computational load, however, grows very fast with the increase of the transformation complexity. Recently big interest in the area of multimodal registration has been paid to the correlation ratio based methods. In opposite to classical CC, this similarity measure can handle intensity differences between images due to the usage of different sensors-multimodal images. It supposes that intensity dependence can be represented by some function[24,4].

Two main drawbacks of the correlation-like methods are the flatness of the similarity measure maxima (due to the self-similarity of the images) and high computational complexity. The maximum can be sharpened by pre-processing or by using the edge or vector correlation. Despite the limitations mentioned above, the correlation like registration methods are still often in use, particularly thanks to their easy hardware implementation, which makes them useful for real-time applications[24].

IV.   Transformation Function Design

Once the set of matched feature (CPs) is obtained, our next task is to select the transformation function or also called as mapping function. Sometimes the RANSAC (Random Sample Consensus) [18] or MDSAC [4] (which is advancement of the RANSAC) algorithms are used to remove the outliers present after the matching step and hence robustness of the algorithm is increases. Outliers are the falsely matched feature. If outliers are not removed it might affect the overall accuracy of the algorithm. After removing the falsely matched feature's pair, the available final set of CPs are called as pruned CPs[24].

Once the feature correspondence has been established the mapping function is constructed. It should able to transform the sensed image to overlay it over the reference image. One should choose the type of mapping function (see Figure 5) and then one has to find the parameters of the selected mapping function. The selection of the mapping function depends on the geometric deformation of the sensed image. In special situations when the geometric deformation is partially known, e.g. when there exists a model for the distortion caused by the acquisition device and/or the scene

geometry, the pre-correction based on the inverse of the deformation can be performed. Models of mapping functions can be divided into two broad categories according to the amount of image data they use as their support. Global models use all CPs for calculating one set of the mapping function parameters valid for the entire image. The local mapping functions treat the image as a composition of patches and the function parameters depend on the location of their support in the image[24].

A   *Global mapping models*

The simplest and rapidly used global mapping model is similarity transform. This model consists of scale, rotation and translation. This mapping model can be solved by using two pairs of CPs. This model preserves the angles and curvatures and hence it is also called as shape-preserving mapping model. This model is also called as rigid planner transform.

Slightly more general and linear model is affine transform. This mapping model is used to convert the parallelogram into a square. This mapping model can be solved by using three pairs of CPs. The affine transformation is generally used in multi view image registration where we assume that the distance of the camera is large as compared to the scanned scene. This model exactly describes the deformation of a flat scene photographed by a pin-hole camera having its optical axis is perpendicular to the scene [18].

$$u = a_0 + a_1 X + a_2 Y \quad (10)$$

$$v = b_0 + b_1 X + b_2 Y \quad (11)$$

B   *Local mapping model*

The global mapping function cannot be used when the image is deformed locally. This is the very often in case of the medical image registration. The least square method averages out the local geometric distortion equally over the whole image which is not desirable. Local areas of the image should be registered with the available information about the local geometric distortion keep in mind [24].

V.   Image Transformation and Re-sampling

The mapping functions constructed during the previous step are used to transform the sensed image and thus to register the images. The transformation can be realized in a forward or backward manner. Each pixel from the sensed image can be directly transformed using the estimated mapping functions. This approach, called a forward method,

is complicated to implement, as it can produce holes and/or overlaps in the output image (due to the discretization and rounding). Hence, the backward approach is usually chosen.

The registered image data from the sensed image are determined using the coordinates of the target pixel (the same coordinate system as of the reference image) and the inverse of the estimated mapping function. The image interpolation takes place in the sensed image on the regular grid. In this way neither holes nor overlaps can occur in the output image [24].

VI. Result of Registration Algorithm

To perform registration in first step of feature detection consider two image
1. Saved image 2. Data image

A. *Result of registration Algorithm by Detecting the Feature with Harris Corner Detector.*
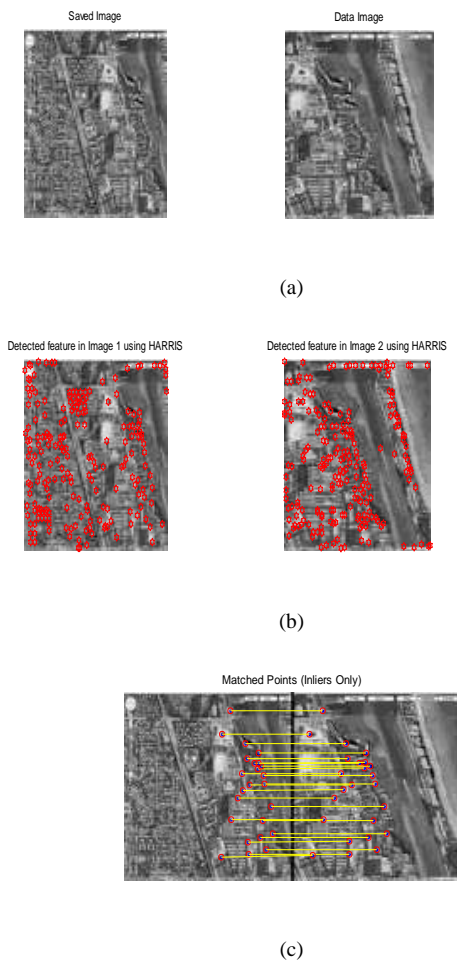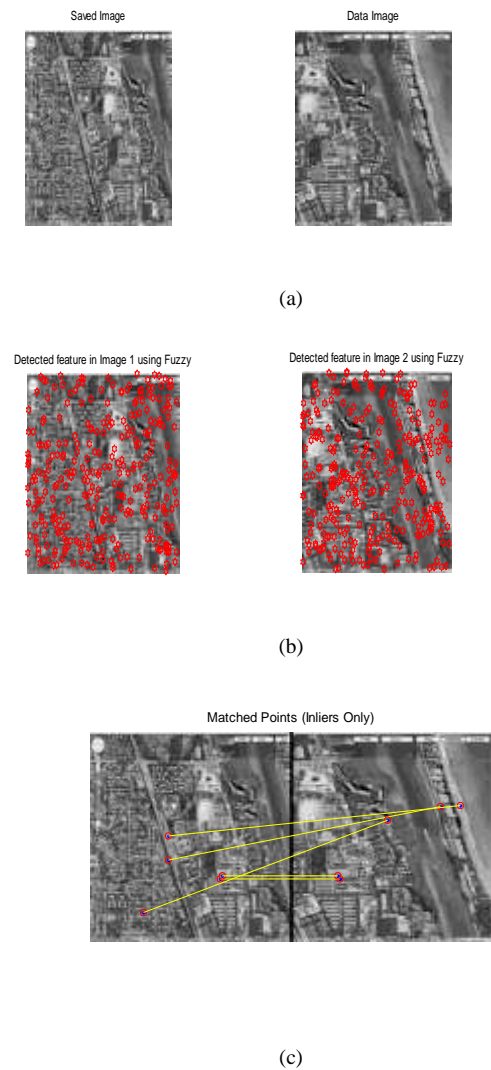

(a)

(b)

(c)

(d)

Figure (a): Original Save and Data Image,   Figure (b): The Feature with Harris Corner Detector in Save and Data Image,Figure (c): Feature Matching in Save and Data Image Figure (d): Registered Image (Image Transformation Function Design and   Re-Sampling
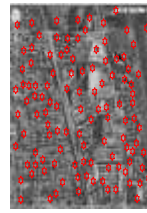
B. *Result of registration Algorithm by Detecting the Feature with Fuzzy Corner Detector:*
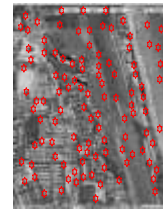

(a)

(b)

(c)

Registered Image

(d)

Detected feature in Image 1 using HARRIS   Detected feature in Image 2 using HARRIS
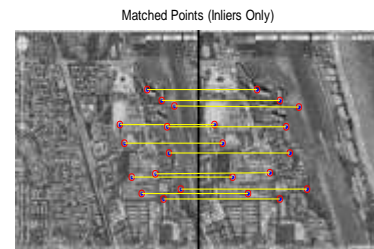

(b)

Figure (a): Original Save and Data Image . Figure (b): The Feature with Fuzzy Logic for Corner Detector in Save and Data Image. Figure(c): Feature Matching in Save and Data Image. Figure (d): Registered Image (Image Transformation Function Design and Re-Sampling)

Table 1: Comparison Table of Both Registration Algorithms

Method Used For Detect Feature In Registration Algorithm	PSNR	MSE	MAXERR	Time Required To Complete Registration
Harries Corner	11.1616	4.9765	255	8.20Sec
Fuzzy Corner logic	12.4373	3.7098	242	89.76Sec

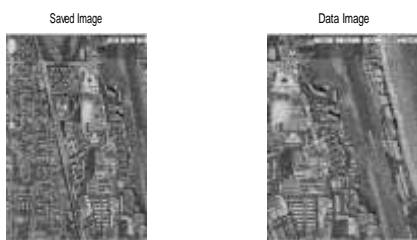Matched Points (Inliers Only)

(c)

Registered Image

(d)

Figure (a): Noisy Original Save and Data Image (salt paper noise). Figure (b): The Feature Detected With Harris Corner Detector in Save and Data Image in case of noise. Figure(c): Feature Matching in Save and Data Image in case of Noise. Figure (d): Registered Image in case of noise (Image Transformation Function Design and Re-Sampling).

B   *Result of Registration algorithm by detecting feature with Fuzzy corner logic In Case Of Noisy Image.*

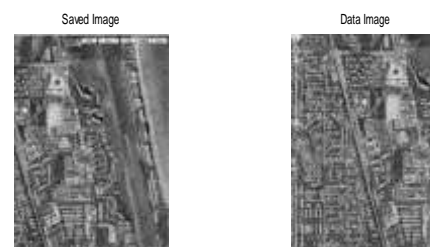## VII.   Result of Registration Algorithm In Case Of Noisy Image

In case of some atmospheric condition some noise is add in scene image .So we check the result of registration in case of add salt paper noise in save and data image

A   *Result of Registration Algorithm by detecting Feature with Harries Corner Detector In Case Of Noisy Image*

Saved Image   Data Image

(a)

Saved Image   Data Image

(a)

(b)

Matched Points (Inliers Only)

(c)

Registered Image

(d)

Figure (a): Noisy Original Save and Data Image (salt paper noise), Figure (b): The Feature With Fuzzy Corner Detector in Save and Data Image in case of noise, Figure(c): Feature Matching in Save and Data Image in case of Noise, Figure (d): Registered Image in case of noise (Image Transformation Function Design and Re-Sampling)

Table 2: Comparison Table of Registration Algorithm In Case Of Noise

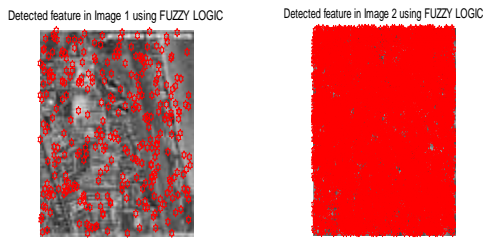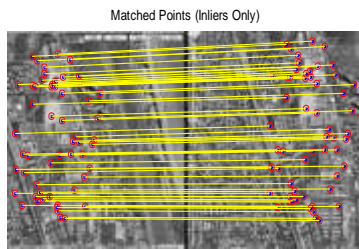| Method Used For Detect Feature In Registration Algorithm	PSNR	MSE	MAXERR	Time Required To Complete Registration
Harries Corner	12.6	3.49	250	6.332Sec
Fuzzy Corner logic	13.4	2.922	255	68.19Sec

VIII. Conclusions

In an attempt to overcome the drawbacks of Harris corner detection algorithm like poor accuracy to detect the corner in complex location and also miss certain true corner. Fuzzy Logic for corner detector have great noise proof ability and able to detect corner at complex location and less probability to miss certain true corner. Also it has higher PSNR and low MSE values compare to Harris corner detector.

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