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The area image recognition technology based on its multi domain feature

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Abstract
Area image recognition technology based on multi domain feature is growing very fast recently. Firstly, spatial structures, spatial reasoning, spatial representation has been developed with mathematical morphology greatly in image and area cognition. Secondly, spatial and transform domain recognition technology has developed many arithmetic in area image recognition. Thirdly, Quantum Computing and Random Matrix Transformation had been used in area recognition technology in their own feature. Fourthly, Fractal geometry theory had been applied in image segment technology widely and greatly. The paper analyzes these technologies and their features, meanwhile discusses the application of math software: Maple. In the end, the paper gives some proposes in area recognition technology, especially in UAV applications.
Keywords: *spatial reasoning, transform, quantum computing, random matrix, fractal geometry, the theory of group, Maple*

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I. INTRODUCTION

In many applications, the image recognition(and the image segmentation) is foundational technology [1][2][3]. There are some examples:

In the UAV system, the scene captured by the airborne camera should be real time analyzed, the area image recognition is important to detect and locate target, identify target, and track target. Then it can realize autonomous flight, precise landing, and so on[4][5].

In the intelligent vehicles, the road scene map is processed usually using image semantic segmentation technology, and the area recognition technology is core solution for the problem of environmental awareness [6][7].

According to the design principle of the image recognition, it is mainly divided into image segmentation methods based on threshold, edge, region, graph theory, and so on [8]. In classical computer vision technology, this is technology of image segmented. To emphasize its real time feature, and for the fast recognition are mainly realized by the area recognition in segmented images technology, the paper emphasis the technology image segmentation technology using in real time recognition ,and call it is the area recognition technology.

In images segmentation technology, it is very import to detect boundary of image, and to find association edge elements of image, and to search an approximate location [9][10]. Some classical methods include: the hough method for curve detection [11][12], edge following as graph searching[13][14], dynamic programming[15], and contour following method[16], and so on.

Recently, area image recognition technology based on multi domain feature is growing very fast recently.

In spatial reasoning, and so on; the spatial structures, spatial reasoning, spatial representation has been developed with mathematical morphology greatly in image and area cognition[17][18].

In spatial and transform domain recognition technology has developed many arithmetic in area image recognition[19][20].

Meanwhile, Quantum Computing [21] and Random Matrix Transformation [22] had been used in area recognition technology in their own feature.

Fractal geometry theory [23][24][25] had been applied in image segment technology widely and greatly. And the theory of group has been used in image enhancement and mirror recognition [26].

The paper analyzes these technologies and compares their features.

II. Spatial Reasoning in image and area recognition

Spatial reasoning is an abstract from the quantitative details of image, and finds a way to mimic the knowledge of human being.

There are many researches and applications in spatial reasoning.

The main content in spatial reasoning[27]:

1) Topological interpretations

Table.1 Classic applications in spatial reasoning

applications	fields
A similarity measure between spatial configurations.	natural language, robot,
logical structure detection	Documentimage analysis
Image segments	Robot

To ones normal sense, the topology of image is math basis of transforming. It is also useful for one to recognize area image.

The operator of topology of image can be analyzed by the normal modal language S4.The formulas of S4 and their intended meaning is shown in Table.2 [28].

Table.2 The formulas of S4 and their intended meaning

Formula	Interpretation
$\top$	The universe
$\bot$	The empty region
$\neg\varphi$	The complement of a region
$\varphi\wedge\psi$	Intersections of the regions φ and ψ
$\varphi\vee\psi$	Union of the regions φ and ψ
$\Box\varphi$	Interior of the region φ
$\Diamond\varphi$	closure of the region φ

The important theorem includes:

① Homeomorphism implies total topo-bisimulation.

② Corollary

③ Various (bi-)simulations transfer logical information across topological spaces

2)The modal analysis of space: space logic

Elementary geometry defines space construction: the parallelism, convexity, triangle, and so on. The vector theory of shape gives a mathematical morphology. In the modal analysis, the tight connection between modal frames and topological spaces explains the locality and in-variance. And space logic can give some interesting results about space structure of image, for example, Stone' s famous construction is homeomorphic to the Cantor space, it is compact, metric, 0-dimensional, and dense-in-itself[29].

3) The meteorology and image segmentation method

Meteorology is used in a topological space, and it is often used in interpretations of signatures of topological primitives, and explains some key mathematical questions concerning them.

In mathematical morphology, the image segmentation is defined by that the image is divided into several groups of pixels with specific semantics visually in the form of assigning category labels to pixels domain, and give the category of each region.

The normal image segmentation methods include[30]:

The threshold-based image segmentation method, it is mainly based on the calculated threshold of the image pixels. Then the image pixels are assigned to appropriate categories.

Image segmentation algorithm based on edge detection. It calculated the gray value of pixels in different semantic edge parts of the image , and find the region which the the gray value changed relatively large, and so on.

The region-based segmentation method. Region is a similar image pixel sets with different concept, it includes region growth method and region domain splitting and merging method.

The image segmentation method based on graph theory it is to construct the weighted indirect graph represents the information of the image. And then, the graph is divided into different sub-graphs.

The code demo of area recognition using spatial reasoning and morphology is lying in many website, the IRIS , Matlab ,and so on.The light ends produced by cracking reaction are removed in the stripper column. The off -gas from the stripper is sent to the fuel gas, but flared if it is under high pressure[3]. And the paraffins and olefins in the column bottom stream are fed to the linear alkyl benzene alkylation unit. In order to recover enough heat from the bottom stream, it is necessary by passing where the paraffin stream is heated [3].

III. Spatial and Transform Domain Image Feature

3.1Image fusion

The spatial and transform domain image feature is often used in image recognition using image fusion method, and multitask recognition and learning problem.

The image fusion collects more sceneinformation using two or more different images. Some spatial and transform domain image fusion methods may be used in area recognition are shown in Table.3[31].

Table.3 Some spatial and transform domain image fusion methods

Applications	Authors	Methods used
MS,PAN image fusion.	Y Kim et al	MTF,SPCA
Medical diagnosis	Azzawi A et al	ICA,WT
Medical diagnosis	Vijayarajan R,Muttan S	Pixels,PCA

It has many applications in remote sensing, medical imaging, medical diagnosis, robotics, surveillance, and image enhancements.

3.2 Multitask Learning

In some applications, the area recognition should consider the depth, reshading, surface estimation, key point and edge detection. There are many researches in these fields. For example, the MulT, it is based on the Swin transformer model, The MulT architecture is shown in Fig.1.

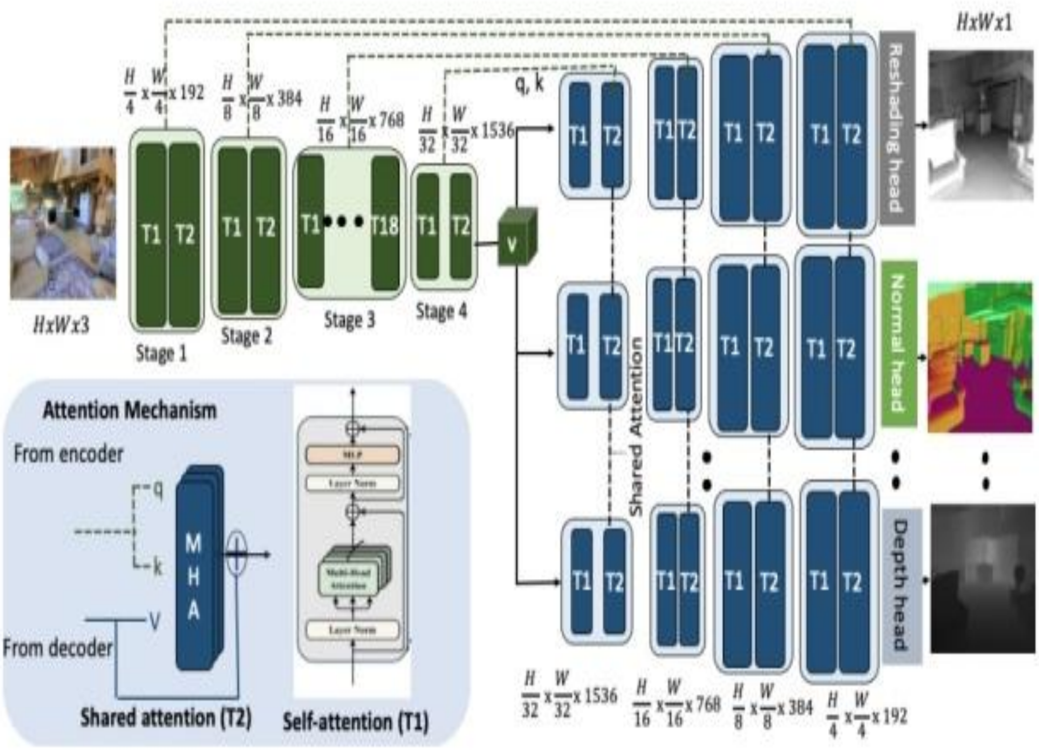

Figure1： The architecture of MulT[32]

IV. Quantum computing and random matrix transformations in Image Processing

4.1 Quantum computing

The Comparison of image processing by classical and quantum computers is shown in Fig.2.And it may be used in very fast area recognition.

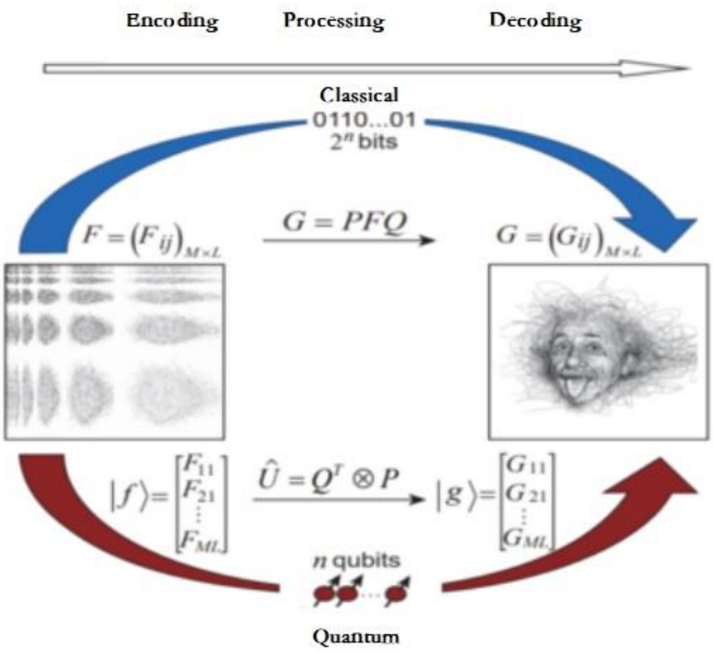

Fig.2 Comparison of image processing by classical and quantum computers[33]

In quantum computing in image recognition, there are two novel computation enhancement methods:

① Quantum computation-based quantum Fourier transforms

② Parallel computation-based modified data parallel algorithm.

These methods can be applied in the enhanced image and image recovery.
The enhanced image is displayed along with the image histogram and statistical values.
Image recovery is accomplished by extracting the binary data.

4.2 Random Matrix Transformation

The random matrix transformation is often used in Image hiding, encoding ,and area recognition image technology, and so on. The area recognition using encoding method, the random matrix transformation is important method[34].
Singular value decomposition can be used in feature decomposition.
It divides the original data matrix into three matrices, of which U and V are orthogonal matrices. Its main steps are shown in equation (1),(2),(3) [34].

$$A = U_1 \times B^* V_1^T \quad \text{.........(1)}$$

$$B = U_2 \times A \times V_2^T \quad \text{.........(2)}$$

$$A = (U_1 \times U_2) \times \Lambda \times (V_2^T \times V_1^T) \quad \text{.........(3)}$$

Here, the kernel norm of matrix minimization is usually solved as formula (4): [34]

$$\min_{W \in R^{m \times n}} rank(X) \qquad s.t. A(X) = b \quad \text{.........(4)}$$

V. Fractal geometry theory and image recognition

5.1 Fractal geometry theory

Fractal theory is a very active branch of modern mathematics and nonlinear dynamic research[35][36]. It is a kind of scientific methods and theories to explore complexity, the non-smooth and irregular phenomena in nature and nonlinear systems. The self-similarity and scale in-variance are two basic characteristics of fractal[37] [38].
All things in the world can be divided into two categories. One is natural bodies: mountains, rivers, rocks and trees, the other is artificial objects: houses, roads, wheels, tables and chairs, etc. For artificial objects, they can mostly use straight lines, cones, balls, cubes. It is not so simple for natural objects to be described by figures in classical Euclidean geometry.
Generally, fractal has the following five characteristics[39]

① Fractal sets have scale details at any small scale, or they have fine structure.

② Fractal sets are irregular, and their whole and local parts cannot be described by traditional geometric language. They are neither the locus of points that meet certain conditions, nor the solution set of some simple equations.

③ Fractal sets have some form of self-similarity, which may be approximate self-similarity or statistical self-similarity that meets the definition of fractal,

④ The "fractal dimension" defined in some way is usually greater than the topological dimension of F;

⑤ Its definition is often very simple or recursive.

The definition and algorithm of shape dimension include Hausdorff dimension, box dimension, similarity dimension, correlation dimension, information dimension, spectral dimension, Minkowski-Bouligand dimension and fractal Brownian motion dimension, etc [40].

It can be calculated by Square covering method, Cuboid covering method, Morphological expansion body covering method, interval tree method, and so on.

5.2 Segment approach for image recognition

1) Based on wavelet analysis and division. The general steps of image segmentation method based on shape theory are[41] :

A. the original image is enhanced to obtain high contrast.

B. Wavelet decomposition to obtain the texture features of the image.

C. Calculate the branch dimension of different regions of the image to obtain the fractal characteristics of the image.

D. Threshold segmentation is performed according to the texture and fractal characteristics of the image.

E. Get segmentation results

2) The general process of image segmentation algorithm based on fractal theory and neural network can be divided into the following steps[42]:

A. image enhancement

B. Calculate various fractal characteristic values

C. Training neural network using eigenvalues

D. Obtaining fractal feature topological distribution of original image using neural network

E. Get split knot

3) Other arithmetic

The common point of image segmentation algorithms based on fractal theory is that they use the fractal characteristics of each pixel in the image to segment the image. The differences can be summarized as the following three points[43].

① Different algorithms are used to calculate fractal values

② Different image prepossessing methods before calculating fractal value

③ Different techniques are used to segment the image according to the feature value after obtaining the fractal feature

VI. Maple in area recognition

In the paper, some technologies are reviewed. In Table.4, the challenge and potential development of these technologies in the area recognition are discussed.

In UAV applications, the combination of UAV and AI can reduce the cost and complete more complex tasks. For the UAV system, the scene captured by the airborne camera is effectively and real-time analyzed, the area recognition is the core step for UAV to realize autonomous flight, precise landing and other functions. Therefore, to detect and locate the target, accurately identify the target, and track the target in real time in UAV applications [45].

So, the technologies based on multi domain feature shown in Table.4 may be concerned.

Table.4 the challenge and potential development of some area recognition technologies

technology	challenge	Potential development
spatial reasoning	Region morphology	morphology ,math image segmentation
Spatial and Transform Domain	Fusion and multitask	Simultaneous parallel of region recognition
Quantum computing	High-speed identification	Safety and high capacity
Random Matrix Transformation	Encoding recognition	Feature decomposition.
Fractal geometry theory	Area recognition	natural recognition

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