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An Approach for Image Matching Based on ACO Fuzzyfication

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Abstract—*Ant Colony Optimization (ACO) is an optimization algorithm inspired by the natural behavior of ant species that ants deposit pheromone on the ground for foraging. In this paper ant colony optimization is introduced for matching different pattern images. The proposed ACO based image matching approach establishes a pheromone matrix that represents the intensity values at each pixel position of the image, according to the movements of a number of ants which are dispatched to move on the image. Intensity threshold value has been set for computing two mean values i.e Mean Above Threshold (MAT) and Mean Below Threshold (MBT). The proposed ACO based image matching approach also takes the advantage of rule based fuzzy in determining the best matching rate.*

Keywords: *Image matching, Ant colony optimization, Rule based fuzzy.*

1. INTRODUCTION

Over the last few decades the volume of interest, research, development of computer vision systems has increased. Nowadays they appear to be important in every spear of life, ranging from the medical application to environmental science. With the advancement of the digital image processing techniques. Image matching is highly configurable and applicable to a vast number of different applications that require the functionality of searching and identifying matching images. The image matching problem, also known as the correspondence problem [13] is one of the most challenging research task in the computer vision. The basic principle of matching is searching the whole pixel set space for the right area which is identical to the given template image [14]. The matching problem can be defined as the establishment of the correspondence between features extracted from two or more images of the same scene. To solve such problems a wider search space may be required that may dramatically impact the numerical computation cost and thus the overall complexity of the algorithm. In computer vision, analysis of symmetry has been a long-standing problem, and is attractive as a way of representing images for many reasons. In particular, symmetries are a potentially stable and robust feature of an image, yet, when considered at multiple scales and locations, symmetries can also be quite descriptive.

The main contribution of this paper is to provide an approach for image matching based on ant colony optimization with fuzzy. The paper is organized as follows: Section I presents an overview of ACO and Fuzzy Logic. Section I is divided into subsection from A to F defining ACO, Fuzzy Logic, Membership functions, Representation of membership function, Fuzzy inference system and Mamdani Fuzzy models. Section II describes proposed methodology with subsection A as proposed method and B as proposed algorithm. Section III shows the experimental results and Section IV is conclusion of our proposed work.

2. ACO AND FUZZY LOGIC:

A. ACO

Swarm intelligence is a relatively new approach to problem solving that takes inspiration from the social behaviors of insects and of other animals. [10][12]

Ant colony optimization (ACO) takes inspiration from the foraging behavior of some ant species. These ants deposit pheromone on the ground in order to mark some favorable path that should be followed by other members of the colony. Ant colony optimization exploits a similar mechanism for solving optimization problems [8]. In the natural world, ants (initially) wander randomly, and upon finding food return to their colony while laying down pheromone trails. If other ants find such a path, they are likely not to keep travelling at random, but to instead follow the trail, returning and reinforcing it if they eventually find food. Thus, when one ant finds a good (i.e., short) path from the colony to a food source, other ants are more likely to follow that path, and positive feedback eventually leads to all the ants' following a single path. The idea of the ant colony algorithm is to mimic this behavior with "simulated ants" walking around the graph representing the problem to solve.

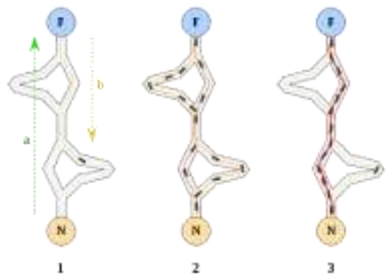


Figure 1. Behavior of Ant system [9]

The original idea comes from observing the exploitation of food resources among ants, in which ants' individually limited cognitive abilities have collectively been able to find the shortest path between a food source and the nest. 1. The first ant finds the food source (F), via any way (a), then returns to the nest (N), leaving behind a trail pheromone (b) 2. Ants indiscriminately follow four possible ways, but the strengthening of the runway makes it more attractive as the shortest route. 3. Ants take the shortest route; long portions of other ways lose their trail pheromones [7] [9].

B. Fuzzy Logic

Fuzzy logic is a mathematical approach to solve problems. In classical logic, an object takes on a value of either 0 or 1. In fuzzy logic, a statement can assume any real value between 0 and 1, representing the degree to which an element belong to given set. In terms of gait recognition, it is complicated to distinguish the person due to the slight variation of gait feature and similar type of physical structure. Therefore the concept of fuzzy logic is able to categorize or recognize the person on an extracted feature of gait. The FIS system has designed with the membership range value 0 to 1, if the membership value is nearer to 0 then cannot recognize the person and membership value is closer to 1 then recognize the person

C. Membership Function

Membership function is a curve that defines how each point in the input space is mapped to a membership value between 0 to1. Mathematically it is defined as shown in equation (1).

$$A = \{(x, \mu_A(x)) \mid x \in X\} \quad (1)$$

Where x is an element in X and $\mu_A(x)$ is the membership function of set A which defines the membership of fuzzy set A in the universe of discourse, X [5].

D. Representation of membership function

There are many types of membership function depend on the base set. If base set consist of many value then piecewise linear membership function is preferred. Their computability is simple and efficient. Mostly they are:

1. Triangular membership function.
2. Trapezoidal function.
3. Normalized Gaussian function.
4. Sigmoidal function.
5. Bell function.

The membership functions are defined as trapezoidal membership functions for all input variables. it is defined by four parameters, x (a, b, c, d). A trapezoidal function formally described in equation (2).

$$\mu_A(x) = \begin{cases} 0, & for\ x < a \\ \frac{x-a}{b-a}, & for\ a \le x \le b \\ 1, & for\ b \le x \le c \\ \frac{d-x}{d-c}, & c \le x \le d \end{cases} \quad (2)$$

E. Fuzzy inference system

Fuzzy inference system is capable to map between in puts to output using fuzzy logic. The mapping provides the decision on the basis of input. the process of fuzzy inference involves all the process i.e. Membership function, logical operations, fuzzification, defuzzification and if–then rules. Fuzzy inference systems have been applied successfully in fields such as automatic control, data classification, decision analysis, expert system [5]. Basically, fuzzy inference system consists of five functional blocks as shown in fig.2

A rule base containing a number of fuzzy if –then rules;

- A database which defines the membership functions of fuzzy sets used in the fuzzy rules;
- A decision making unit which perform inference operation on the rules.
- A fuzzification interface which transforms the crisp inputs in to degree of match with linguistic values;
- A defuzzification interface which transform the fuzzy results on the interface in to a crisp output

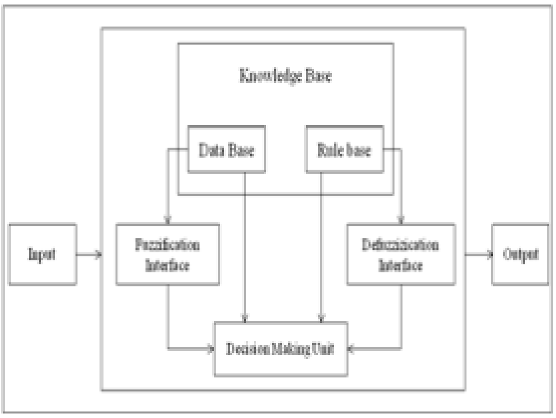


Fig 2. Fuzzy Inference System [5].

F. Mamdani Fuzzy models

Mamdani's fuzzy inference method is the most commonly seen fuzzy methodology. It expects the output membership functions to be fuzzy sets. After the aggregation process, there is a fuzzy set for each output variable that needs defuzzification. it enhances the efficiency of the defuzzification process because it greatly simplifies the computation required, which finds the centroid of a two dimensional function. In many cases it is much more efficient [5].

2. PROPOSED METHODOLOGY

A. Proposed Method:

In this section, we present an ACO based with fuzzy algorithm for image matching. The algorithm is based on the pheromone table. The architecture of our proposed work is shown in figure 3.

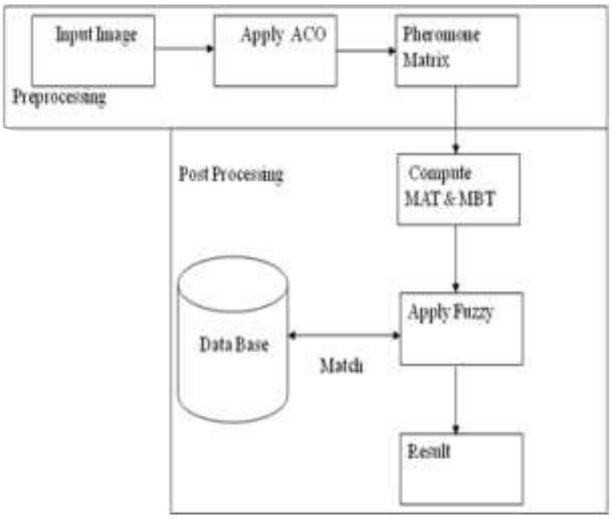


Figure 3. Block Architecture of Proposed Work.

Our proposed work is divided into two blocks that is preprocessing and post processing. In first block preprocessing, an image is input in our system that is designed using matlab2011b. Then ACO is applied over inputted image to compute pheromone matrix which is used for further analysis. The second block post processing consists of three main modules. The first module compute mean values i.e MAT (mean above threshold) and MBT (mean below threshold) which is based on pheromone image intensity matrix. Here pheromone matrix gives the intensity value of an image. After computing two mean values, these mean values have been input into fuzzy inference system for finding better matching results. FIS compare and produces result with the database values according to the following fuzzy rules:

- If (ACO 1 is Yes) and (ACO 2 is Yes)
  Then (match is Excellent) (1)
- If (ACO 1 is No) and (ACO 2 is Yes)
  Then (match is Average) (1)
- If (ACO is Yes) and (ACO is No)
  Then (match is Average) (1)
- If (ACO1 is No) and (ACO 2 is No)
  Then (match is No match) (1)
- If (ACO 1 is No) and (ACO 2 is No)
  Then (match is No match) (0)
- If (ACO 1 is Yes) and (ACO 2 is Yes)
  Then (match is excellent) (0)
- If (ACO 1 is No) and (ACO 2 is Yes)
  Then (match is Average) (0)
- If (ACO 1 is Yes) and (ACO 2 is No)
  Then (match is Average) (0)

Here ACO1 and ACO2 represents two mean values i.e. MAT and MBT.Our fuzzy system is based on mamdani membership function to obtain better results. Output of the fuzzy module is stored in database. This process is repeated for further original images and query image to obtain better results.

B. Proposed Algorithm:

- Input an image
- Apply ACO on input image
- Compute Pheromone matrix of an image
- Compute two mean values MAT (Mean Above Threshold) and MBT (Mean Below Threshold).
- Input MAT and MBT into fuzzy inference system.
- Stored output data from fuzzy into database.
- Input query image and apply steps 2 to 5 on input query image.
- Match query image with stored images at step 6.
- Desired result after step 8 achieved.

3. EXPERIMENTAL RESULTS AND ANALYSIS:

The proposed algorithm is implemented on Matlab R2011a.We have taken 15 images for analysis of our proposed work. Analysis of our proposed work is divided into two phases.

Phase I Analysis:

First Phase is matching of stored images with same query images. In phase 1, we first stored value of 8 images in the database by applying the proposed Algorithm. Here, same 8 images are used as query images as shown in table I for analysis.

Table I. Matching Result of Phase I Analysis, E (Excellent) G (Good), A (Average) and P (Poor)

	A1	A2	A3	B1	B2	C1	C2	C3
A1	E	P	P	P	P	A	G	A
A2	P	G	G	G	G	P	P	P
A3	P	G	E	G	E	P	P	A
B1	A	G	G	E	G	A	P	A
B2	P	G	G	G	E	P	P	A
C1	A	P	P	A	P	E	G	G
C2	G	P	P	P	P	G	E	P
C3	G	A	G	A	A	A	P	E

In phase I analysis, we have computed Average Excellent Match Rate (AEMR) and Average False Excellent Match Rate (AFEMR). In our proposed research work, result analysis of image matching is divided into four categories. (E) Excellent (G) good (A) average and (P) poor.

Table I reveals that out of 8 query images, 7 images have excellent match, with AEMR of 87.5%. Query image B2 has mismatch with stored images A3 and average false excellent match is 12.5%

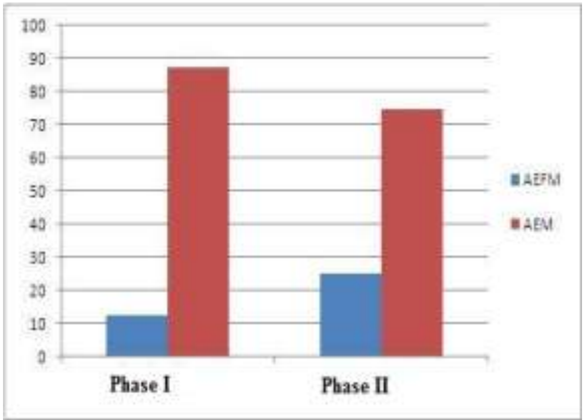
Phase II Analysis:

The second phase of result analysis is based on same stored original images with different query images as shown in table II. Here we have taken seven query images.

Table II. Matching Result of Phase II Analysis, E (Excellent) G (Good), A (Average) and P (Poor)

	D1	D2	D3	D4	E1	E2	E3
A1	G	G	P	A	A	A	A
A2	P	P	P	P	P	P	P
A3	P	P	P	P	P	A	P
B1	A	P	P	P	P	A	A
B2	A	P	P	P	P	A	P
C1	A	A	P	A	A	G	E
C2	A	A	A	A	G	P	G
C3	A	A	P	P	P	E	A

In this testing we find average false excellent match of 25% because E2 have excellent (E) mismatch with C3 and E3 have excellent (E) mismatch with C1. This shows that if we have less false match, then we have higher true match rate. The table I show that we have excellent match rate of 75% because we get false match rate of 25%. So, overall excellent efficiency is 75%



Graph 1. Shows comparison of two phase analysis.

Graph 1 shows the comparison of two type of analysis done in our proposed work. Here X axis represents two type of testing that is one testing is of original images stored in database with same as query image(phase1)and second testing is between original images and different query images(phase2).Y axis represents the efficiency in percentage. The blue legend AEFM defines Average Excellent False Match and Red Legend AEM defines Average Excellent Match.

4. CONCLUSION

In this paper, we have proposed an approach for image matching using ACO with fuzzy. As we have done two types of testing for matching images. In first testing that is matching of original images with same as query images gives an efficiency of 87.5%. In second phase of testing, matching of original images with different query images gives an efficiency of 75%. We have concluded that our proposed work has given an average accuracy of 75%.

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