Similarity Measure Using Hausdorff Distance in 2D Shape Recognition System

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***Abstract*—Shape plays an important role for human to recognize an object. Shape can be recognized easily by human regardless of size, rotation or translation. In this paper a shape recognition system is presented. In this research, authors investigate late improves in shape analysis and shape recognition issues with a concentrate on significant highlights of a shape. In the proposed method, the first stage is an edge detection method based on fuzzy cellular automata. In the second stage, shapes were clustered based on the differences of degree of each angle. Finally Hausdorff method is used for determining the rate of similarities. Simulation results demonstrate the system invariance to rotation, translation and scale.**

Keywords-component; Edge detection, Fuzzy cellular Automata, Hausdorff method

I. INTRODUCTION

Shape is an important feature in identifying object. Recently, there has been increasing interest in the shape recognition area [1-4]. Studies demonstrated that image similarity is essential for the identification of objects[4, 5]. The structure of an overall purpose artificial system effective at recognizing arbitrarily complex 3-Dl objects without human intervention continues to be a negotiable task in computer vision. The whole picture that objects within the project scope on our retinas changes as our position changes with regards to the objects. In lifestyle 3D objects is usually recognized regardless of the variability in object appearance brought on by the pose from the object according to the viewer. You will need to understand the way the visual system represents the objects internally, while countering the consequences belonging to the viewing conditions, and associating the several two dimension images originating through the same three dimension object.

Although several features of object shapes are utilized by the visual object recognition, the initial requirements resulting from shape categorization increase the risk for comprehension of its underlying system very complicated in contrast to that relating to other features of objects[6]. The majority of the existing methods [7-9] for pattern recognition through optical correlation happen to be developed for 2D objects, which may have played important roles in several applications for instance detection, recognition, and classifying with the images. Nevertheless the intensity shapes from those algorithms only support the gray scale data, and lose the peak distribution information belonging to the object. Particularly for those objects, which have a similar shape and various heights, it is nearly impossible to differentiate them by observing the two dimentionintensity images. However, other theorists have argued for viewpoint invariance in shape detection. Viewpoint-invariance hypothesis suppose that objects might be recognized from unfamiliar or inexperienced viewpoints.

In the first thing individuals proposed technique is the side detection. In this task, an advantage detection method is used to look for shape's edge. In these studies we applied a good sharp edge detection algorithm which can be proposed by Meybodi . Then some important characteristic including variety of angles and degree of every angle will extract through the input object. Then each object is going to be clustered base on mentioned characteristics. In the end, similarity rate is determined depending on Hausdorff method [10, 11].The remainder of the article is organized the following: In next section, a background studies of our tasks are presented. In section 3 a new technique is proposed. In section 4, the simulation results are presented. Section 5 contains the conclusions.

II. PRELIMINARIES

A. Cellular Automata

Cellular Automata (CA) are discrete systems. CA behavior seemingly depending on local relations. A cellular automaton is made up of grid of cells; all of them is within the finite variety of state [12, 13]. In CA, plenty of time can also be discrete, and the condition of a cell can be often a function of the prior states of their neighbor cells. A uniform rule is utilized to each and every cell and its particular neighbours and every time that it is used, the newest states of cells are created [14].

B. Cellular Learning Automata

The Cellular Learning Automaton (CLA) can be a mathematical function for implementing dynamics of an complex system which contains numerous simple components. In reality, CLA can be a CA through which all cell comes with a minumum of one learning automata (LA). The LA includes a finite pair of actions as well as goal is to understand which action within this set is the perfect action. Like CA, you will find there's uniform local rule placed on the cell and depending on this rule the chosen action gets an incentive or perhaps a penalty. If the learning method is selected properly, the iterative procedure for interacting using the environment can lead to collection of the suitable action in each and every cell [15].

C. Fuzzy Cellular Automata

Fuzzy Cellular Automaton (FCA) is often a cellular automaton where fuzzy logic is utilized towards the states of cells and transition functions. There are several explanation for FCA [16]. In FCA, the states of cells are linguistic variables along with the transition procedure are fuzzy rules. The linguistic variables are determined according to our understanding of the problem. The following state of every cell is dependent upon transition function. The existing state of every cell its particular neighbours would be the input arguments with the transition procedure. The transition function can be a uniform fuzzy function that takes the membership values with the neighbor cells and calculates the valuation on Membership from the next state. The membership values of linguistic variables which represent the State of cells are employed to present the evolution of FCA throughout the process. The group of neighbor cells is uniform and fixed throughout the process.

III. PROPOSED METHOD

The proposed method can be performed in three phases as follows:

Phase 1: Pre-processing.

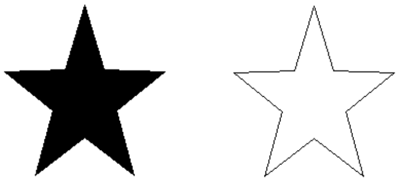
In the first step, input shape has been extracted by edge detection algorithm which is proposed in reference [12]. For the edge detection the following steps will be conducted.

For having a high quality edge, in the first step, variance feature is used to detect the initial edges of original image. After that in the second step, power function is used to remove the information of background which is not belonging to the image's edges. The mentioned power function is defined as below:

$$F(i,j) = \sqrt{I(i,j)^{c}}, c \succ 2 \qquad (1)$$

As it clear in the above equation, value of C for all pixels is higher than 2, whereas some pixel need more than others and vice versa. To adjust the exact value of C for each pixel, a fuzzy cellular automaton is utilized. Finally in the last stage to detect the high quality edge, cellular learning automata is applied. For more information see reference [12].

Presented algorithm in the initial stage used of statistic characteristic of their object for primary edge detection that induces adaptively because of this algorithm whatsoever internal shape. Along at the second stage FCA and CLA [12]. Figure 1 shows the input shape pre and post edge detection.



(a) (b)

Figure 1. a) Input shape b) Edge detection

Phase 2: Feature extraction

After detecting the shape's edge, algorithm goes through the edges and the angle (θ) between three adjacent pixels is determined as follow:

$$\theta = arccos \frac{\vec{r_1}.\vec{r_2}}{\left\|\vec{r_1}\right\|\left\|\vec{r_2}\right\|} ? \qquad 2)$$

Subject to:

$$r_1 = |x_1 - x_2| i + |y_1 - y_2| j$$
$$r_2 = |x_2 - x_3| i + |y_2 - y_3| j$$

Where x_1, x_2 x_3 are three sequential pixels on the shape. All angles for a specified shape are saved in the array list. The distance between two sequential angles is calculated as the length of side. Now, all shape with same number of angles is put in the same cluster.

Phase 3: Similarity

To measure the similarity of two shapes in the same cluster, we proposed the following steps:

1. Calculating the center of each 2D object
2. Re-scale object to set objects size.
3. Align w.r.t. position the two objects at corresponding centroids.
4. Rotate orientation to align w.r.t

After performing the above steps, Hausdorff method will be applied to measure the distance of two shapes. The Hausdorff distance $\vec{h}(A,B)$ is defined as the lowest upper bound (supremum) over all points in A of the distances to $B : \vec{h}(A,B) = \sup_{a \in A} \inf_{b \in B} d(a,b)$ with $d(a,b)$ the underlying distance, for example the Euclidean distance L_2 . The Hausdorff distance H(A,B) is the maximum of $\vec{h}(A,B)$ and $\vec{h}(A,B) : H(A,B) = \max\{\vec{d}(A,B), \vec{d}(B,A)\}$.

After finding the distance between two shapes, the following properties apply to all shapes A,B and C.

1. (Nonnegativity) $d(A,B) \geq 0$
2. (Identity) $d(A,A) \geq 0$ for all shapes A.
3. (Uniqueness) $d(A,B) = 0$ implies A=B.
4. (Strong Triangle inequality) $d(A,B) + d(A,C) \geq d(B,C)$.
5. (Triangle inequality) $d(A,B) + d(B,C) \geq d(A,C)$

Properties (2) and (5) do not imply symmetry. Similarity measures for partial matching, giving a small distance *d(A,B)* if a part of A matches apart of B, in general do not obey the triangle inequality. After finding the distance between two shapes, the following properties apply to all shapes A,B and C.

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The whole process of the proposed method is shown in Figure 2.

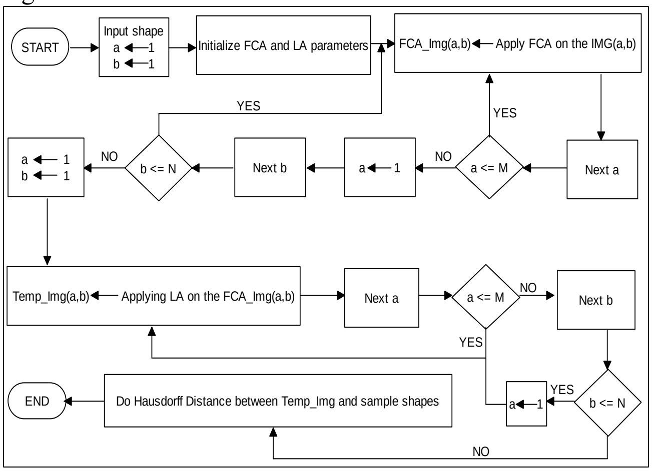

Figure 2. Overview of the Proposed Method

VI. Simulation Results

In this section, we examine the real performance of the proposed scheme by performing some experiments. In the first experiment, four test images (Figure 3(a,b,c,d)) have been recognized by proposed method. An existing shape Fig 3 (e) was used for comparison. Table 1 represents the similarity rate between inputting shapes and test shape.

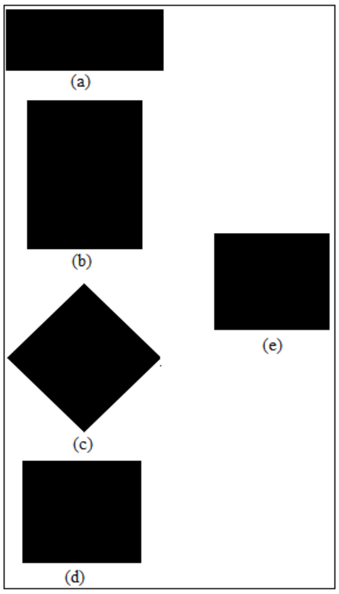

Figure 3. (a),(b),(c),(d) input shapes, (e) existing shape

TABLE 1. Similarity Measure

	Figure 3(a)	Figure 3(b)	Figure 3(c)	Figure 3(d)
Figure 2(e)	71 %	73 %	96%	96 %

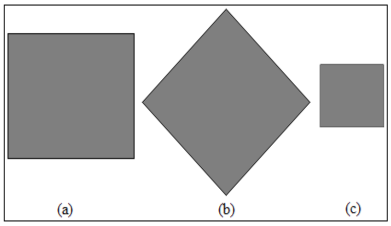

Figure 4. (a) main shape, (b) Figure 3a with 45 degree rotation, (c) Figure 3a with 50% resize

TABLE 2. The similarity rate between shapes in Figure5 and Figure 6

	Figure6a	Figure6b	Figure6c	Figure6d
Figure 5a	0	0	78%	0
Figure 5b	91%	0	0	0
Figure 5c	68%	0	0	0
Figure 5d	0	74%	0	0
Figure 5e	70%	0	0	0
Figure 5f	0	0	81%	0
Figure 5g	0	0	0	%64
Figure 5h	0	73%	0	0
Figure 5i	63%	0	0	0
Figure 5j	0	82%	0	0
Figure 5k	0	0	66%	0
Figure 5L	0	0	0	61%

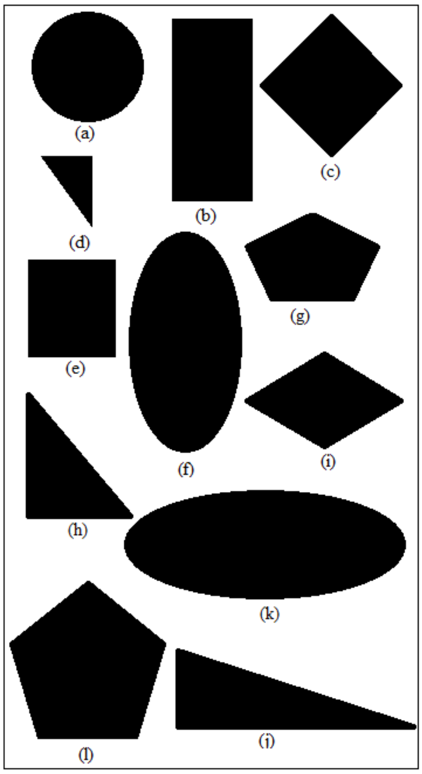

Figure 5. Sample images

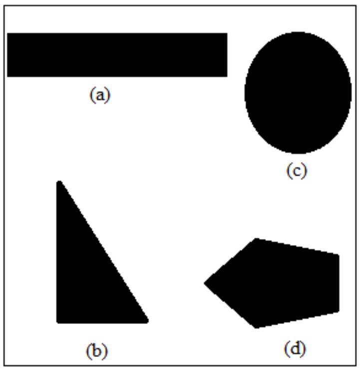

Figure 6. Test images

IV. CONCLUSION

In this paper a new method based on FCA, feature extraction and Hausdorff method is proposed. This method using FCA because of its ability to determining the thin and clear edge. Number of angle and degree of each angle are determined and shapes with the same number of angles have been put in the same cluster. In the final stage of the proposed method Hausdorff method is employed to explain the distance between to shapes in the same cluster. Simulation results shows the proposed method is resist against rotation and resize.

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