Analysis and Recognition of Curve Type as The Basis of Object Recognition in Image

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Abstract. An object in an image when analyzed further will show the characteristics that distinguish one object with another object in an image. Characteristics that are used in object recognition in an image can be a color, shape, pattern, texture and spatial information that can be used to represent objects in the digital image. The method has recently been developed for image feature extraction on objects that share characteristics curve analysis (simple curve) and use the search feature of chain code object. This study will develop an algorithm analysis and the recognition of the type of curve as the basis for object recognition in images, with proposing addition of complex curve characteristics with maximum four branches that will be used for the process of object recognition in images. Definition of complex curve is the curve that has a point of intersection. By using some of the image of the edge detection, the algorithm was able to do the analysis and recognition of complex curve shape well.

1. Introduction

Digital image processing can be grouped into two types of activities, those are image quality repairing and image information processing. The repairing process of image quality is made to clarify the image so that the image can be viewed without any strain on the eyes and the important information contained in the image can be extracted well. While information processing contained in the image is done for an object recognition by extracting the important information contained in an image. [Marvin., Wijaya., Prijono., A, 2007].

An object in an image when analyzed further will show the characteristics that distinguish one image object with another object. Characteristics that are used in object recognition in an image can be a color, shape, pattern, texture and spatial information that can be used to represent objects in the digital image. A good characteristic is having high distinguishing, so grouping of objects based on the characteristic can be carried out quickly and with high precision.

The method has recently been developed for image feature extraction on the objects that is the curve characteristic similarity analysis and chain code using on object characteristic searching. One is the identification of patterns of squares using eight directions chain code [Ernastuti 2006]. This method successfully characterize the object in the form of plane based on a chaincode that illustrated into a histogram. However, this method has not been able to characterize the object that has the point of intersection.

Image processing research that has not been developed is Image Recognition Based On Similarity Of Curve Characteristics Invariant To Translation [Indarti D, Madenda S, Kusuma TM, Agushinta D, 2014]. In that research image characteristics are identified based on the characteristic curve obtained from the edge detection of objects in the image. Characteristic curves used in that research is the type of simple closed curves, simple curves open linear and non-linear open simple curves. The results of image recognition method presented in that research is able to recognize the precise same image based on the similarity of the characteristics of the yield curve edge detection of objects in the image even if the image has undergone a process of transformation. However, that research have not been able to identify the type of complex curve. So characteristic curves recognized are still few and limited.

Furthermore, research image recognition using characteristic curve [Indart, 2014] is applied to an object recognition on the image of ultrasound results are Segmentation Method Development and
Shape Feature Extraction Algorithm for Recognition of Breast Tumor type On Ultrasound Image [Lestari DP, 2015]. This research uses eight directions chain code to search contours tumor area. Chain code on the research is used to record the position of each pixel and calculate the number of curves forming tumor area and calculate the code occurrences probability from chain code. The number of curves and the value of the code occurrence probability can be expressed as the difference parameter between one shape of the tumor to another. Curve characteristic that is used in that research is the kind of closed and open simple curves.

Based on the research that has been done before, this research will develop an algorithm analysis and the recognition of the type of curve as the basis for object recognition in images. The image used is the image of the edge detection. Object that can be recognized is a simple object, which has point of intersection the most. This research proposes the addition of the curve characteristic which will be used for the object recognition process on an image, that is, the complex curve characteristic that has maximum four branches. Therefore, curve characteristic which will be used as the basis for object recognition in image in this research is a simple closed curve, linear open simple curves, non-linear open simple curve, the complex closed curve, complex open-linear, complex non-linear curve. By adding the curve characteristic which is used as the basis for object recognition in an image, then the characteristic exists at the object will be more, so grouping of objects based on the features can be done more precisely and accurately.

2. Related Work

2.1. Square Pattern Identification System with Chain Code Method

Method of square pattern identification system with chain code method is divided into training phases and recognition phase. In the training phase, all square image, with a variety of positions, included in the training set, further Canny edge detection method is done. By using detection result is done eight direction chain code methods. From the ranks of chain code formed created histogram. The results of the training phase observation is a pattern of squares, it has the characteristics for each $i$ odd, $Hist[i]$ has equal height or almost equal with the tolerance limit $\leq 1$ and for every $i$ is even, $Hist[i]$ has equal height or almost equal to the tolerance limit $\leq 1$. Circle pattern and the pattern of equilateral polygons have the feature for all $i$, $Hist[i]$ has equal height or nearly equal to the tolerance limit $\leq 5$. For four rectangle pattern, parallelogram, and diamond has characteristic for $i = 1, 5$, $Hist[i]$] has equal height, for $i = 2, 6$, $Hist[i]$ has equal height, for $i = 3, 7$, $Hist[i]$ has equal height, and for $i = 4, 8$, $Hist[i]$ has equal height. While in irregular sides odd and even patterns have characteristics other than those already discussed.

2.2. Image Recognition Method Based on Similarity of Invariant Curve Characteristic Toward Transformation Geometry

This method is image recognition based on similarity of curve characteristic. The curve character used in this method is simple curve, that is the curve does not have intersection. Stages of research starting from the formation of image database and image recognition. At the formation of image database stage consists of detecting the edge of the image, the curve searching phase, and the recognition curve type stage. In image recognition stage, there is a same stage as database formation until curve type recognition stage. To determine similarity between the characteristic curves in query image were compared with characteristic curve all the images stored in the database. Curve searching is performed pixel per pixel by observing 8 (eight) directions of pixels to determine the position of the next pixel. After all finished curve searching the next step is identify the type of curve that is simple closed curve, linear open simple curves, and non-linear open simple curve. The recognition of the type carried out by characteristics that exist in each curve.
3. Method

Analysis and recognition of curve type as a basic object recognition in image is divided into two stages. Those are complex and simple curves recognition. This paper just focuses on complex curve recognition, that is the curve does not have intersection, the study about simple curve has been done completely by Indarti, 2014. Analysis and recognition of complex curve stage is searching and determining of intersection, determining and searching starting point, curve searching, curve type recognition, and determining of the branch of the curve unity. In generality the algorithm of analysis and recognition of complex curve shown in flowchart at Figure 1.

3.1. Searching and Determining of Intersection

Two curves said intersect, if two curves lies in a field and have a point of fellowship, communion point is called the point of intersection. The corners formed by the intersection of two curves is the basic idea of searching and determining of the point of intersection of two curves. The angle points of all angels that will be the intersections of two curves. The corners formed by the intersection of two curves could have an angle of 90°, 45°, 22.5°, 11.25°, and so on. For an idea of searching and determining of intersection point in this research used two linear curves that intersect at an angle of 90°, 45°, and 22.5°. Here is presented a picture of the two curves intersecting at an angle of 90°, 45°, and 22.5°.

Figure 1. Flowchart algorithm of analysis and recognition of complex curve

Figure 2. the possibility of two linear curves intersect forming angle 90°
Figure 2 shows there are 10 possible positions of the two linear curves that intersect at an angle of 90°. In Figure 3, there are 18 possible positions of the two linear curves that intersect at an angle of 45°. While in Figure 4, there are 18 possible positions of the two linear curves that intersect at an angle of 22.5°. Pixels circled in the picture is the point of intersection or in other words pixels alliance of two intersecting linear curve. Pixel alliance has more than three neighbors. Neighborhoods that should be examined is the environment right and left as well as the top and bottom of the pixel alliance. The examination should be performed on each pixel on the curve.

Search pixel in an edge detection result image in the form of curves is done by tracing the first line of the first column to the first row of the last column. If the search in the first row there is not any pixel that is part of a curve, then continue with the second row of the first column, the second column and so on. For these reasons, the neighborhood that should be examined from every pixel is the environment
and the bottom right of each of the pixel. Neighborhoods investigated in the search point on this research are divided into groups. Shown in Figure 5 below.

![Figure 5 Neighbor Environmental Groups](image)

In Figure 5 (a) group 1 are neighborhoods that are in one column to the right and one column to the left, and one row up and down the rows of pixels are investigated. The number of neighbors (including pixels being investigated) in group 1 was given the name of the NoP. The first group which is most important in determining a candidate point of intersection. In Figure 4 (b) group 2 named NoP 2, Figure 4 (c) 3 groups are named NoP3, Figure 4 (d) group 4 named NoP4, and Figure 4 (e) group 5 named NoP5.

Each pixel part of the curve is checked in environment NoP, NoP2, NoP3, NoP4, and NoP5. If NoP on a pixel amounted to more than 3 then will be further checked. This is because the pixels alliance on a curve has a NoP least more than 3. If a pixel has HoP3, then checking continue to NoP2, NoP3, NoP4, and NoP5. Based on the position of the pixel alliance of two linear curves that intersect at an angle of 90°, 45°, and 22.5° can be concluded there are 10 conditions that must be met in order for a pixel becomes a cut point. 10 These conditions are shown in Table 1. Based on Table 1 a pixel cutoff point would be candidates if they meet one of the conditions.

Table 1. Type Condition At the candidates of Intersection (x, y)

| No | Case                          | Condition | Intersection      |
|----|-------------------------------|-----------|-------------------|
| 1  | For curves intersecting       | NoP > 4   | (x + 1, y)        |
|    |                               | NoP2 > 4  |                   |
|    |                               | NoP3 > 4  |                   |
| 2  |                               | NoP4 > 4  | (x, y + 1)        |
|    |                               | NoP5 > 4  |                   |
| 3  |                               | NoP2 > 4  | (x + 1, y)        |
| 4  |                               | NoP2 = 5  | (x + 2, y)        |
|    |                               | NoP4 = 5  | (x, y)            |
| 5  |                               | NoP2 ≥ 4  | (x + 1, y)        |
| 6  |                               |           | (x, y)            |
| 7  |                               |           |                   |
| 8  | For curve intercept           | NoP = 4   | (x, y + 1)        |
|    |                               | NoP > 4   |                   |
|    |                               | NoP4 ≥ 4  |                   |
| 9  |                               | NoP = 4   | (x + 1, y + 1)    |
|    |                               | NoP2 = 3  |                   |
|    |                               | NoP3 = 3  |                   |
| 10 |                               | NoP > 3   | (x, y)            |
3.2. The Recognition of Type Intersection

Type of intersection identified in this research is the point of interception to the curve that intersects, and the intersection point for the curves intersect. Intersection point is a point if it is deleted, two linear curves intersect will be divided into four linear curves. Meanwhile intercept point is point if it is deleted, two linear curves intersect will be divided into three linear curves. Examples of curves that intersect and intercept shown in Figure 6.

![Figure 6](image)

Figure 6 (a) Example curves intersect, (b) Example curves intercept

In Figure 7 (a) clearly shows the intersecting of complex curve, and (b) complex curve intercept, with the intersection point indicated by the arrow. Having obtained the intersection point, the pixels are located around the point of intersection (a pixel above and below, as well as one pixel on the right and left) is removed, it is intended that the pixels of the point of intersection is clearly visible. To determine a curve has a point of interception or intersection point type, defined a neighborhood of the point of intersection has been obtained from the previous step.

Neighborhood 1 is a neighborhood 5x5 or two pixels above and below, as well as two pixels on the right and left from intersection point. Neighborhood 2 is a neighborhood 7x7 or three pixels above and below, as well as three pixels on the right and left from intersection point. Neighborhood 3 is a neighborhood 9x9 or four pixels above and below, as well as four pixels on the right and left from intersection point. Neighborhood 4 is a neighborhood 11x11 or five pixels above and below, as well as five pixels on the right and left from intersection point. All four neighborhoods is shown in Figure 7.

![Figure 7](image)

Figure 7 Neighborhood of intersection point
(a) Neighborhood 1, (b) Neighborhood 2, (c) Neighborhood 3, (d) Neighborhood 4

A point called intercept point if the number of black pixel (pixel part of curve) in Neighborhood 1 ≤ 3 pixels, and in Neighborhood 2 ≤ 6 pixels, and in Neighborhood 3 ≤ 9 pixels, in Neighborhood 4 ≤ 12 pixels. If condition does not satisfy, a point called intersection point.

3.3. Determination of Searching Start Point

Searching complex curve is started from intersections, further to ensure that all branches of the curve traced, first determine the starting point of the search. The starting point of the search obtained by identifying the points that are in the neighborhood intersection points. Neighborhood intersection studied is one line upwards and downwards from the point of intersection with the column up and down from the point of intersection. The environment is shown in Figure 8 below.
Chronology of determining the searching starting point starts from counting the number of pixels that are in the neighborhood at the first intersection point on the original curve (not a curve that has eliminated the pixels around the point of intersection). The number of pixels in the neighborhood named NoTP3. If identified NoTP3 ≥ 1, look for the location where neighboring pixels of the intersection point by examining 8 neighbors direction. Identifying neighbors of intersection point (x, y) starting from the direction 0, followed by a direction 1, and direction 7, direction 2, direction 6, direction 3, direction 4, and the last direction 5. The layout of the 8 directions neighbor checked are shown in Figure 9 below.

On examination NoTP3 if found the existence of the pixels on the environment, then the pixel positions found are stored as the starting point of the branch curve of complex curve. Identification of neighboring pixels from one point of intersection is repeated until the conditions NoTP3 ≥ 1 are not satisfied, it means all the neighboring pixels of the first intersection point has been successfully identified. The number of searching start point characterize the number of branches on a curve.

3.4. Curve Searching
Image from edge detection result and vector from the search starting point of curve is used as a search base curve, the search of complex curve starts from the starting point of the first search at the first branch of the first curve. From that point the search is done by checking the neighboring pixel in 8 directions (the same as a check on neighbors intersection point). From the neighboring pixels, checked back the next neighboring pixels, and so on is repeated until all the pixels on the first branch forming of the first curve completely searched. Note that all of the pixels that have been traced is deleted in order to avoid repeated searches in a same curve. The search is performed until all branches traced.

3.5. Curve Type Recognition
The recognition of the curve type performed on each branch at each point of intersection. Each branch of the complex curve recognized its type, is the kind of closed curves, open curve linear, or non-linear open curve. The recognition of the curve type using the data coordinate points of the curve search results. Closed curve is a curve that has a starting point and end point coincident. To determine a branch of the closed curve investigate whether the absolute difference from the starting point and end point of the curve is equal to 0. If yes, this curve is a kind of a closed curve, if not, do further examination.
Further examination are carried out if a curve does not include the type of closed curve, which examined whether the curve is the kind of linear open or non-linear open curve. A curve is said open if the starting point and end point is not coincide. Open curve is divided into two types: linear open curve and non-linear open curve. Discussion on the recognition of the curve types described in [Indarti, 2014].

3.6. Determination of One Unity Curve Branch

After searching and recognizing of curve type at any branch of the curve, the next step is to determine which branches as an unity curve. In determining the curve unity branches used gradient calculation of each branch. Two curve branches that has an equal gradient or nearly equal, then both branches are said to be mutually connecting curve.

4. Result

Given an image is supposed as image the result of edge detection, the image shown in Figure 10. Will be Analyzed and recognition complex curve from that image.

![Image of Edge Detection Results Neighbors](image)

Figure 10. Image of Edge Detection Results Neighbors

In Figure 10 analysis and the recognition of complex curve type. In the image, there are 5 complex curves. The analysis results of the image are:

a. Coordinates (y, x) from the point of intersection and the starting point of the search:
   - Complex Curve 1: Intersection point at (740.74), and the starting point of the search is (74, 741), (73, 740), (75, 740), (74, 73)
   - Complex Curve 2: Intersection point at (508.167), and the starting point of the search is (167.509), (166, 508), (168, 508), (167, 507)
   - Complex Curve 3: Intersection point at (99.197), and the starting point of the search is (197, 100), (196, 99), (198.99), (197, 98)
   - Complex Curve 4: Intercept point at (633.251), and the starting point of the search is (252, 634), (252, 633), (250, 632)
   - Complex Curve 5: Intersection point at (406.343), and the starting point of the search is (252, 634), (252.633), (250, 632)

b. Results of type of curve recognition
Complex Curve 1 consists of three branches: Branch 1 and 2 are open non-linear curve, branch 1 is a closed curve.

Complex Curve 2 consists of four branches: The branch 2 and branch 3 is one unity curve and the branch 1 and branch 4 is one unity curve. Branch 2 and 3 are open non-linear curve, Branch 1 and 4 is an open non-linear curve.

Complex Curve 3 consists of four branches: The branch 1 and branch 4 is one unity curve and the the branch 2 and branch 3 is one unity curve. Branch 1 and 4 is an open non-linear curve, branch 2 and 3 are open non-linear curve.

Complex Curve 4 consist of three branches: The branch 2 and branch 3 is one unity curve. Branch 2 and 3 is an open-linear curve, branch 1 is an open-linear curve.

Complex Curve 5 consists of four branches: The branch 2 and 3 is one unity curve and the branch 1 and branch 4 is one unity curve. Branch 2 and 3 are an open-linear curve, branch 1 and 4 are open linear curve.

4. Conclusion
From a number of testing and analysis of the results of each algorithm devised or developed in this research, it can be concluded that the curve type analysis recognition presented in the research consists of several stages and based on the implementation of these methods obtained the following results:

- The algorithms detection and curve searching developed has been able to detect and track the complex curves.
- The curve recognition algorithm created curve can determine the type of the complex.
- The curve recognition algorithm created can define and differentiate between types of open linear and non-linear open curve.

5. Future Work
This research can be developed at recognition of the precise image or the image that has some same characteristics. Furthermore, it can also be developed in the form of the recognition of more complex objects consisting of many intersection point. Applications of this research can also be used on the recognition of the form of letters or numbers.

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