# A Framework for Optimum Contour Detection

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***Abstract*— The importance of contour detection have been acknowledged by researchers worldwide, and indeed dozens of methods have been introduced. However there is no single method suit with various conditions of digital images. Most of the time, a tedious work to select best method from dozens is required only to derive the most appropriate objects contour from a digital image. Once an object contour is recognized, further image analysis process can be computed efficiently. This condition is in contrast with human visual perception which employs contour detection as a preliminary process with minimal energy consumption before conducting exhaustive visual analysis. Therefore this research aims to develop a framework to automatically detecting optimum object contour by selecting the best method for each condition of input image. Efficient energy consumption will be achieved by applying mechanism based on multi criteria decision making.**

***Keywords*— Contour detection, Edge detection, Image analysis, Multi criteria decision making**

## I. INTRODUCTION

Visual perception becomes an interesting topic to research recently due to the development of information technology and the Internet which incorporate visual technology massively. Nowadays it is common to see varied devices which are equipped with camera or other visual-related facilities such as GPS (Global Positioning System), Multimedia Player, and Image Gallery. Therefore the growth of visual data increases exponentially both in sizes of data that require much bigger storage, as well as in the quality of data due to the increasing resolution of recent devices. Beside opening chances to explore broader data, this condition becomes a burden to computation. Bigger size of data means the computation to analyze data would demand more time consumption, while higher resolution means more aspects must be incorporated into the computation, thus algorithm complexity would increase as well.

Researchers have been recognizing human visual perception as a superb example to conduct visual data analysis (Nixon & Aguado, 2008), hence a strategy to deal with the above condition is by mimicking how human analyzing visual data. Clinical evidence proves that human capability to develop perception on contour is a vital component towards objects recognition (Papari & Petkov, 2011), it means the absence of contour perception would make a patient completely unable to recognize object. Thus contour detection becomes a vital process for visual data analysis particularly for object recognition. Researchers have indeed found that contour detection become an important component for many image analysis processes such as medical image analysis, gesture recognition, and land use analysis based on satellite photo. Since then many methods on detecting contour have been proposed up to now (Papari & Petkov, 2011; Verma et al. 2011; Somkantha et al, 2011; Koren & Yitzhaky, 2006; Becerikli & Karan, 2005). However recent applications of computer vision show the immaturity of contour detection especially to support further image analysis processes. Instead of simplifying the content of image, varied methods for contour detection often disrupt or even destroy the structure of image objects. Evidence show that false object recognition is often produced by image analysis due to poor contour detection (Rodriguez & Shah, 2007; Somkantha et al, 2011; Tong, 2014; Amirgaliyev et al, 2014). Therefore it is important to measure the quality of contour resulted from detection methods before it is supplied to further image analysis processes. This research aims to formulate a framework for contour quality measurement in order to find the most accurate contour detection given a set of natural images.

## II. RELATED WORK

There have been tremendous efforts to research contour detection, and lots of methods have been proposed in this field. Researchers have widely known that contour of objects contained in digital image can traditionally be derived from the first-order derivative of the image with regard to edge as computed using Equation 1.

$$\nabla I = \left(\frac{\partial I}{\partial x}, \frac{\partial I}{\partial y}\right) \qquad (1)$$

Implementation of Equation 1 however restricts vast variation of neighboring pixels which potentially affect the formation of contour. Therefore researchers have proposed other approach based on convolution such as Roberts (1963), Sobel (1970) and Prewitt (1970) which fulfill Equation 2, with $k$ is the kernel being convolved to the input image $I$ to obtain its first-order derivative.

$$\nabla I = kI \qquad (2)$$

Experiments however show that this approach encounters difficulties to derive edges of the object in natural images particularly in the noisy condition. Later, researchers proposed mechanisms that still survive in noisy image such as Laplacian of Gaussian (LOG) (Marr & Hildreth, 1980) and Canny (1986). Different with first-order derivative method, this approach rather detects zero-crossing of second–order derivative to obtain object contour. Even though this approach performs better than the previous, however experiments show that this approach encounter difficulties to respond on vast variety of natural image condition, especially one with spurious edges and texture image.

The condition above drive the researchers to propose many other different approaches to detect object contour. Some incorporate even artificial intelligence in their mechanism such as Becerikli and Karan (2005) that propose fuzzy-based edge detection system, and Verma et al (2011) that propose edge detection based on novel bacterial foraging technique. Testing results however show that the performances of both methods are indifferent to the previous proposed methods such as Canny, LOG, Sobel etc. Meanwhile the approach proposed by Rodriguez and Shah (2007) to segment human in crowded scenes assumes that human is isotropic, therefore the proposed method is initialized with a set of posture silhouette. The results however still deliver low accuracy. Other approach proposed by Somkantha et al (2011) presents different mechanism to detect object contour. The method employs edge following algorithm that expands snake-like mechanism based on intensity gradient and texture gradient features. The experimental results show that this approach derives only an object boundary despite the existence of many objects contained in digital image. Besides, this approach depends greatly on the formation of initial model that must be located correctly. Hence the approach is prone to error since it has to follow edge magnitude and edge map in order to develop object contour in which the value of edge magnitude sometimes is very weak for noisy image.

Due to varied natural image condition spanning from noisy and spurious edge to texture image which deliver complexities for contour detection, a group of researchers in this field then afford to measure the quality of derived contour. It was started by Yitzhaky and Peli (2003) and then followed by Koren and Yitzhaky (2006) which propose objective evaluation on the result of edge detection in order to define best parameter selection supplied to certain edge detection method. This research however is not sensitive enough to deal with noisy and texture image. Other approach to measure contour such as conducted by Wang et al (2006) depends a lot on manual ground truth, therefore its applicability is questionable since different natural image would require different ground truth. Recently Gimenez et al (2014) propose a set of measurement to evaluate contour quality namely equilibrium index and entropy index. This method employs statistical approach based on Kolmogorov-Smirnov to measure the quality of edge map. However this approach has not considered the use of contour in term of edge presentation particularly to represent object existed in the image for further analysis processes. Therefore further development is still required to produce good contour definition which is useful for image analysis processes.

## III. Framework Development

The research employs a quantitative approach to identify the best parameter for contour quality evaluation. Schematic diagram of research design is given in Figure 2. In this research there are four main stages required to complete as follows:

### A. Data Collection

This stage aims to collect data set which represents a wide variety of natural images. It is important to notice that the image being collected shall present a dominant foreground objects. Therefore images which have no dominant objects such as satellite photos are excluded from data set.

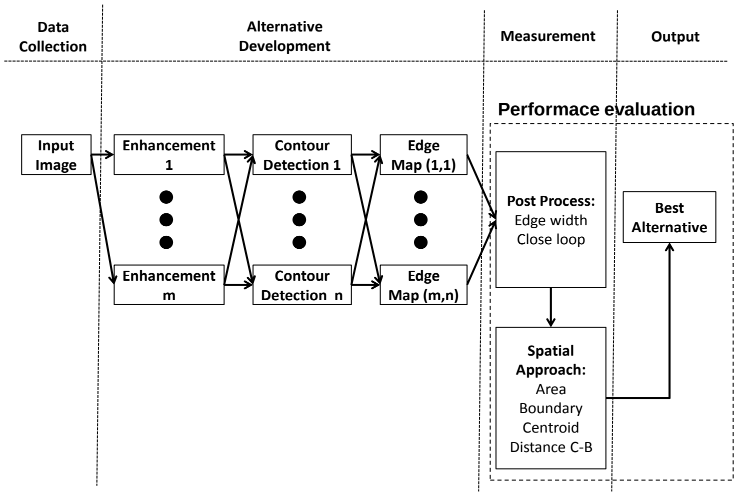



Fig. 1 Developed framework for fully automatic contour extraction

### B. Alternatives Development

This stage aims to collect and organize as many as possible alternative processes to detect contour of the object contained in digital images. The processes are composed by the combination of image enhancement and contour detection. Therefore, if there exist *m* enhancement and *n* contour detection, there would be *m x n* alternative processes to form the edge map that will produce *m x n* edge map.

### C. Measurement

This stage aims to measure the performance of each edge map formulated in the previous stages. Two main processes are held to enable performance measurement i.e. post-detection process and evaluation process based on spatial approach. The former is intended to facilitate the latter process by enhancing the presentation of contour in term of edge width and closure, while the latter is the evaluation towards contour quality. It is held using a set of testing parameters based on spatial approach such as contour area, boundary, centroid, and the distance between centroid and boundary.

### *D. Output Selection*

This stage becomes the conclusion of the measurement. It is settled by selecting the best contour quality based on a set of testing parameters described in the previous stage. By recognizing which edge map contain the best contour quality, the best alternative process to detect contour for that image could easily be defined.

### *E. Performance Evaluation*

This stage aims to measure the accuracy of certain testing parameters defined in the Measurement stage. It is held by modifying a set of testing parameters, and then each performance of testing parameter is measured in term of two aspects i.e. its accuracy to obtain best contour and its reliability to handle different condition of natural images. At the end of this stage, the best testing parameter would be defined based on accuracy and reliability measurements.

*1) Contour attributes:* Contour attributes are defined as a set of parameters which represent the characteristics of contour. Acquisition of contour attributes is held by computing edge map using spatial approach. Currently some parameters have been defined to compose contour attributes namely number of edge, number of non-edge object, edge length, non-edge area, non-edge boundary, non-edge centroid, and distance between centroid to boundary. The research aims to define the best parameters composing contour attributes. Here the term best parameters mean the parameters that deliver most significant impact to the measurement of contour quality. The mechanism to select the best parameters which represent contour attributes is held together with the definition of parameters weight given in the next research instrument.

*2) Parameters weight:* Parameters weight defines the role of each contour attribute to measure contour quality. Therefore it would be assigned to each parameter composing contour attributes. To obtain the best parameters weight, an iterative mechanism based on multi criteria decision making such as weighted sum model (WSM) or weighted product model (WPM) is employed to measure the quality and to match the result with pre-defined contour quality. Assuming that WSM is utilized to compute parameters weight, the mechanism would fulfil Equation 3, with Q denotes contour quality, w denotes the weight for each parameter p.

$$Q = \sum_{i=1}^{n} w_i p_i \qquad (3)$$

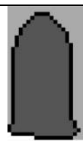
It should be noted that computation in Equation 3 requires no ground truth to define the best parameters weight. Here the definition of parameters weight becomes a pre-defined contour quality measurement.

*3) Accuracy & Reliability:* Accuracy and reliability becomes the last instrument to employ in this research. The intention of these instruments is to disclose the performance of weighted contour attributes defined by the previous instruments. Here accuracy deals with correct decision made by weighted contour attributes to measure contour quality and more importantly to define the best contour detection mechanism for any given natural images. Meanwhile reliability means the defined weighted contour attributes still produce good measurement when it has to process varied condition of digital image.

## IV. Experiment

Preliminary experiment has been conducted to a set of digital images such as shown in Table 1 column 2. The input data is obtained from the image of some cultural heritage sites. It is important to note rich noises existed in the input image which form disturbing pattern to the object. Meanwhile the result is given in the same table column 3. Although qualitative measurement on the quality of edge derived from the proposed algorithm has not been carried out, however experimental results show there always edges representing objects contained in every image and no open edges produced by the proposed algorithm. This is a promising output from the preliminary experiment.

TABLE I
EXPERIMENTAL RESULTS

| Index | Input Image | Output |
|---|---|---|
| Data 1 |  |  |
| Data 2 |  |  |
| Data 3 |  |  |
| Data 4 |  |  |
| Data 5 |  |  |

## V. Discussion

Measuring contour quality is a growing recent interest in contour detection research because of many factors such as vary digital image conditions, plenty methods have been proposed in this field, and more importantly significant role of contour detection to support many processes in the field of image analysis and image understanding. This research follows Papari and Petkov (2011) which assumes that there exist plenty available methods for contour detection having capability of handling different condition of natural images. However due to more varied conditions of natural images, it is extremely difficult (if we do not want to mention impossible) to find the correct method without putting a great deal of efforts to extract the contour of the object from natural images such as shown by many experimental results (Rodriguez & Shah, 2007; Somkantha et al, 2011; Tong, 2014; Amirgaliyev et al, 2014). Therefore it is important to develop method to automatically selecting best contour detection.

Here we argue that certain parameters derived from spatial approach would have significant role to measure contour quality, hence they would be useful to settle this task. These parameters would disclose the characteristic of contour and thus they become contour attributes. Each contour attribute would affect differently to measure contour quality, hence a weight is assigned for each attribute. Computing the attributes together with their weight in iterative fashioned utilizing multi criteria decision making as formulated in Equation 3 would reveal most significant attributes for contour measurement. The work in this research include extending Gimenez at al (2014) by formulating automatic mechanism to select best contour detection method for each given natural image.

## VI. Conclusions

The applications of image processing and computer vision have been noted capable of improving human life quality. Researchers have even believed that image processing and computer vision become the complement of human visual perception, as each carry its own superiorities and benefits (Nixon & Aguado, 2008). Therefore researchers have been developing many methods in the field of image processing and computer vision since the early age of computer, particularly in the field of image understanding. Amid the conviction that computer would help people in understanding visual data, many research outcomes disclose the difficulties and complexities to process visual data due to its discrete nature while in reality any objects recorded in an image are not discrete. They somehow correlated physically. The complexities of any algorithm developed for image understanding come from the necessities to locate and classify discrete data in term of a set of pixels contained in digital image to follow their physical nature. Hence, up to now it is difficult to mention any application which successfully establishes automatic image understanding. If there is successful application, usually it becomes confidential and used for high priority businesses such as US forensics.

Meanwhile human visual perception has been noted superior for image understanding. However it is not designed to process tons of visual data. On the other hand, overwhelming information through visual data is supplied by different parties originated from Internet and mobile communities. Therefore implementing human visual cognition to computer vision becomes the focus of this research. Since it is clinically proven that human visual cognition is mainly based on the perception of object contour (Papari & Petkov, 2011), developing adaptive contour detection which recognizes local condition of natural image would enable automatic analysis on tons of visual data existed today.

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