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Centerline Extraction: A Review

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Abstract

There are a lot of methods for centerline extractions have been proposed due of its application in the different fields, and it was facilitated deal with various formats whether 2D or 3D. These methods are varies from each other because of the differences in strategies. In this paper, we presented a survey to highlight on some of these methods that used to extract the centerline.

Keywords: Centerline Extraction, Skeleton, Road Detection, Vessel Extraction.

1. INTRODUCTION

Centreline is a geometric shape, the first introduced in the 60's by Blum [2], it's also refer to medial, symmetric axis or skeleton.Where each points on the centreline is at the same distance from at least two points on the boundary [4], where the original shape can be reconstructed from its centerline (skeleton) [5]. Show figure (1) [16].

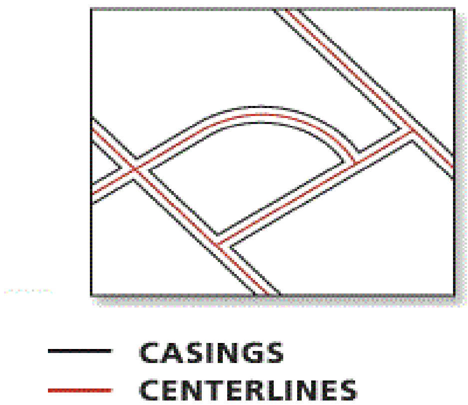

Figure 1: Example of Centerline.

Centerline Extracting is a major stage in a lot of applications such as: medicine, virtual engineering, architectural [2], computer vision [1], and geospatial applications [3].

There are two ways to extract the centerline: semi-automatic and fully automatic, The first method requires user interaction to prescribe central seed points in advance, and the other does not require; modern researches trying to develop semi-automatic method because it does not suitable for real-time applications [6].

2.CENTRELINE EXTRACTION

Centerline extraction is a hard task, the difficulty is about how to determining width of tubular shapes [15], as well as, the process of roads detection from their centerline hampered by the existence of buildings, trees and shadows [9].

A paper published by ParagChaudhuri [11] give a simple, efficient algorithm for centerline extraction for 3D objects depending on the distance from boundary, the first step is a hierarchical subdivision the object into cubical blocks which no more subdivision for the blocks that inside or outside the object and the stop parameter for subdivision the other blocks define by the user; the next step is calculate the distance from boundary for each block to determine centeral blocks.Finally, compute the centerline using Dijkstra's algorithm from source central block to destination central block responding to the user queries.

Guangxiang [13] introduces a fast centreline extraction algorithm for 3D virtual colonoscopy based on distance mapping algorithm. This method contains four steps: colon segmentation from other data by using threshold and branch detecting; compute 3D Euclidean distance transform algorithm from every voxel to the colon boundary by a proposed method Bidirectional Distance Adjustion (BDA) algorithm, where it is uses (10,14,17) metrix in order to increase computation speed; apply a new boundary voxels cutting (BVC) technique by expand the maximum center voxel until the set of connected voxels is reached; and then isolate all others that is not in the set to speed-up Dijkstra shortest path algorithm in the next step.Finally use Dijkstra algorithm to generate the centreline where source and destination defined by the user. This algorithm designed for clinical applications.

Hassouna [10] give a robust centerline extraction method for 2D and 3D connected graph using level sets. The first step is calculating the distance transform (D) to determine most of the central points (Ps). Secondly, spread a slow front wave (T1) from each central point (Ps) with speed (D^β) that suitable with its Euclidean distance from the boundary for some ($0 \leq \beta \leq 1$). Thirdly, using level sets of (T1) to solve nonlinear partial differential equation which it manage the motion of the front. Fourthly, propagate a fast front wave (T2) from central points (Ps) with a speed (e^(α*D)) that it's much faster than non-central ones. Finally, tracking the extreme points and ends with (Ps) or ends on an already extracted path for the purpose of extracting centerlines. This method is robust against noise because the small branches are removed by a preset threshold operation without the influence on the remainder of the centerilne.

Khaleel [12] presented a method to tracking the coronary artery vessels depending on extraction of their centerline for both 2D and 3D angiograms. This method based on intensity value of new gravity equations and it's consists the following phases: angiogram segmentation using recursive data structure technique which partition image into four equal parts, count the number of points (NoP) in each segment; then compare the (NoP) in each part with a threshold value if (NoP≥T) the partition is divided again or pass it to next phase, where (T) value is set by the user, after this, compute the center of gravity (COG) where the partition is also division or else a center of gravity (CoG) point is calculated using two proposed mathematical equations (Eq. (1) and Eq. (2)):

$$Xcog = \frac{\sum_{i=x1}^{x2} \sum_{j=y1}^{y2} (i * g(i,j))}{\sum_{i=x1}^{x2} \sum_{j=y1}^{y2} g(i,j)} \qquad (1)$$

$$Ycog = \frac{\sum_{i=x1}^{x2} \sum_{j=y1}^{y2} (j * g(i,j))}{\sum_{i=x1}^{x2} \sum_{j=y1}^{y2} g(i,j)} \qquad (2)$$

"Where Xocg is the x-coordinate of a (CoG) point and Ycog is the y-coordinate of the (CoG). x1 and x2 are the limits of a partition in the x-axis, y1 and y2 are the limits of the partition in the y-axis, and g is the intensity value of pixels". and finally, linking the center of gravity (COG) points.

A paper published by Xiangyun [9] give a multistep and multi-features automatic method to extract road centerlines from LiDAR points after categorized it into ground class and nonground class. This method involves three basic steps: mean shift, tensor voting and Hough transform (MTH). Firstly, apply spatial clustering to detect the road's center points based on multiple features by using an adaptive mean shift. Secondly, using stick tensor voting to improve the eminent linear features. Thirdly, apply weighted Hough transform to detect the primary arc of the road centerline, the completeness and the accuracy of road network that extraction are 81.7% and 88.4% respectively.

Li Zhang [1] proposed a method to extract centerline for color edge detection depending on the gradient information of color images, this method includes the following stages: firstly, use sobel gradient operator and color image to get pseudo-color edges by compared the differential value of point in horizontal and vertical direction and take each larger difference component value as a new R, G, B. Secondly, do high-frequency filter to intensify pseudo-color image. Thirdly, apply Otsu threshold method to get a binary image with most of edge information, de-noise image and extract the four connectivity of binary image. Finally, use Hessian matrix to get centerline by calculate eigenvalue and eigenvector to find out whether the point on the centerline or not.

Chinnathevar [6] presented an automatic method for road detection from their centerline, this method contains four steps: segmentation of road area using adaptive global thresholding, apply closing morphological operation extract the connected component from road region, then remove non-road pixels by using opening morphological operation and finally, apply thinning morphological operation to get road centerline. The average performance of completeness, correctness, and quality for different images are 90%, 96%, and 87%, sequentially.

Zelang [7] presented an accrue road centerline extraction method based on Gaussian mixture model (GMM) and subspace constraint mean shift (SCMS), this method include three steps: firstly, image partition into multiple segments using (GMM) to implement image clustering, Secondly, extraction the approximate initial road centerlines from the main axis of each ellipsoid of Gaussian, Finally, normalization of initial road centerline using (SCMS) to provide precise road centerline. performance result showed that using both of (GMM) and (SCMS) provided a low computational and accuracy compare with using (SCMS) only; and the completeness, correctness and quality was 96.94, 97.74 and 94.82, respectively.

Ural [8] proposed a method for extracting the road centerline information from remote sensing image, that used multiple data like orthophotos and LiDAR point clouds for extracting features. The first phase is the preprocessing stage to facilitate data analysis, then use orthophotos data to distinguish road surface using support vector machine and use 3D LiDAR data cloud to distinguish buildings and trees, after this, extraction of the medial axis using thinning morphological operation to reconstruct road surface, and then estimate the noisy of the centerline by applying simplification process.

Jianhua [14] propose method for road centerline extraction based on predefined seed points. The first step is link the seed points by extraction the initial road parts using geodesic method. Secondly, compute a road probability depending on these coarse road parts, apply a threshold operation to split the aerial image into two categories: road and non-road. After that, generate kernel density estimation (KDE) map using the road part image and (KDE), then using mean shift method to extract precise of central road positions. Finally, use geodesic method again to link seed points.

3. CONCLUSIONS

In this paper we introduced variety of centerline extraction methods, and we concluded that the extraction of the centerlines is a main step in many applications that need for accurate measurements of length or better understood and handled for complicated shapes, where it can be reconstructed original topology for objects from their centerlines and it's reduces the processing time for big shapes. Also extract centerline methods differ from each other depending on application, dimensions of the shape, resolution, and methods of image processing.

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