Scaling of Color Image using B-spline Curves

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ABSTRACT

This paper presents representation techniques as the image can be represented in Cubic B-splines that are used to represent the curvilinear features of an image. The algorithm is devised to convert a raster image into vector image. The algorithm first detects the curvilinear features of the image, then based on the curvilinear edges and feature attributes it constructs a triangulation, and finally iteratively optimizes the vertex color attributes and updates the triangulation. The results of the used techniques are presented. Compared with existing vector representation technique this method provides advantages for various image operations. This method is useful to vectorize the images of fonts, logos, blueprints and maps.

Keywords

Image processing, subdivision surfaces, curvilinear features, mesh generation, graphics primitives.

1. INTRODUCTION

The techniques used in the image representation are raster graphics and vector graphics. Raster graphics uses pixels which stores the gray/color value for representing images. Vector graphics use object like curves and surfaces to represent the image. The major difference is that raster image pixels do not retain their appearance as the size increases and it becomes blurry. The processing of the associated attribute data may be cumbersome if large amount of data exists as raster images may reflect only one attribute or characteristics. The vector graphics representation is flexible, compact and resolution independent. It provides many image editing processes like image based on objects[1].

There are various graphics primitives for representing an image like curves, lines and polygon. It supports linear or radial color gradients of images[2],[3],[4] and surface patches such as quad-mesh based parametric surfaces describing smoothly varying color[5]. Some graphics editing softwares like Adobe Illustrator and CorelDraw has adopted the vector graphics representation for creating the images. But available techniques for vector image representation having problems because of complexity in color or intensity changes in images. Images with smoothly shaded regions or curvilinear features of arbitrary shapes and orientation or complicated topology was unable to represent with accuracy with the available techniques.

By observing the above results of vector image representation this paper presents a vector representation that is able to properly approximate raster image and their curvilinear features as well. The graphics primitive cubic B-splines are used for curvilinear feature representation and a triangular mesh based subdivision surface for image representation.

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This paper describes as follows. Section 3. Propose a method for subdivision surface based representation for image. Section 4.Presents an algorithm for polygon detection using edge detection (boundary of the image). Section 5. Provides method for B-spline curve fitting. Section 6. Provides method for color modeling and Section 7. Provides experimental results and implementation.

2. RELATED WORK

There are various techniques which are used for raster image to vector image conversion. Depending on the method used for vector representation they are defined as follows. Techniques based on the decomposition of the region. Polygonal image decomposition[6] extracts feature edges of an image and apply Delaunay triangulation on the vertices of the feature edges to yield triangles that tile the image and merges it into polygons depending on some perceptual grouping criteria. M. Froumentin[7] proposed a method to decompose an image into regions having relatively same color and for each region the boundary is fitted by a NURBS curve and the interior color is specified by Delaunay triangulation. Automatic region Detection and conversion[8] detects smooth regions and cubic spline curves are used for fitting the boundaries. The flat color or linear or circular gradients are used for filling the interior color and relative plane color variation is assumed for above implementation. Tian Xia[9]proposed method to decompose an image into a set of non-overlapping region, each of which is parameterized as a triangular Bezier patch with curved boundaries aligning with image features. Image with complicated geometry and smoothly varying color distribution was efficiently represented by the above method, but the continuity between the patches was difficult to control here.

Triangles are very flexible for any arrangement so thetriangle is good for geometric representation and it is found very useful in computer vision and image processing operations like medical imaging[10],[11], motion track and compensation[12],[13], feature detection[14], image and video compression[15],[16], and image registration. D. Su and P.Willis[17] proposed a pixel level triangulation method in which all pixels are connected in order forming a quadrilateral mesh and then each quad is split into two triangles by inserting one of the two diagonals.

In computer graphics bicubic patches are commonly used for better representing smoothly varying colors. B. Price and w. Barrett[18] useda collection of rectangular bicubic Bezier patches to represent an image. The representation accuracy is improved by refining patches with local greedy strategy, which leads to many tiny patches.

3. USING SURFACE SUBDIVISION-BASED IMAGE REPRESENTATION

Here some notations are introduced which are used for image description. A point u ϵ S^5 And it is denoted as S^5=(x, y, R, G, B) where as first two components (x, y) denotes the Cartesian coordinates of the image x-y - plane and the components (R, G, B) denotes RGB channels of color. The two operation LOC and COLOR over S^2Representation of the image is defined as LOCATION (x, y, R,G, B) ->(x, y) denotes each pint in S^5And COLOR: (x, y, R, G, B) -> (R, G, B) gives the color value from S^5 [19].

3.1 Curvilinear Feature Representation

The curvilinear features are denoted by a collection of curvilinear edges. Each curvilinear edge is smooth curve. Uniform cubic periodic B-spline curve is used to define the curvilinear features of the image. The curvilinear features are detected from the image and these curvilinear features are represented by B-spline curves[20].

3.2 Reducing the Resolution of Image

The resolution of the input raster image is reduced for processing further and detecting edges and boundaries which is used for the representation of B-Spline curve.

4. POLYGON DETECTION

Polygons in the input image are identified using color quantization, median filtering and region tracing. Region tracing is performed on the binary image which givesan array of coordinated outline of each shape. This shape, then sampled at different frequencies to obtain the vertices that can be used to represent the image as a set of colored polygons. The optimal amount of position sampled highly depends on the resolution and complexity of the original image so the resolution of the original image is reduced in the Section III. The number of control points used to specify the polygon can be updated to increase the accuracy of results. The optimal number of control points can be easily found out through trial and error.

5. B-SPLINE CURVE FITTING

The cubic B-spline curve fitting works well to approximate curve trace. The B-spline curve is explained as.

$$P(t) = \sum_{i=0}^{n} P_i \, N_{i,k}(t)$$

Where (P_i : i=0, 1,… n) are the control points, K is the order of the polynomial segments of the B-spline curve. Order means that the curve is made up of piecewise (k pieces) polynomial segments of degree k-1.

$N_{i,k}(t)$ is normalized B-spline blending function with order k and $\{t_i$: i=0, 1… n+k$\}$ knot sequence. Fig. 1 shows the cubic B-spline curve.

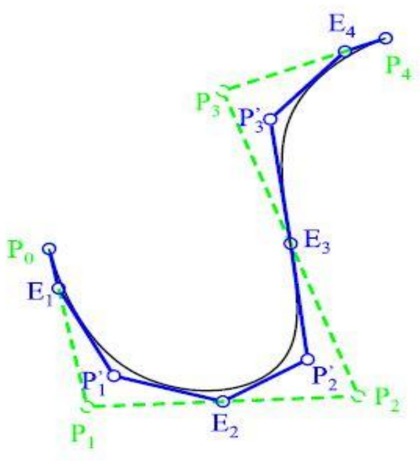


Fig. 1. A special cubic B-spline curve corresponds to an initial polyline (in green) and refined polyline (in blue).

The curve is fitted in increasingly larger segment of polygon to maintain the square error threshold, then the curve is saved and the new curve is starting from the end of the previous curve till the whole polygon is covered.

This phase involves the curvilinear feature extraction and curve fitting. Here, for determining the curvilinear feature edge detection is used and after that the curvilinear feature are considered for curve fitting. The cubic B-spline curve is used for representing the curvilinear features. The method in [21] is used to locate the corners in each curvilinear edge. The points where two curvilinear edge intersects are treated as corners.

The B-spline curve fitting has already generated one polyline for each feature curve , so another one is created by offsetting the first one along the normal direction by a certain distance. Fig.[2]a. Input image, b. Edge image c. Curvilinear feature by B-spline curve.

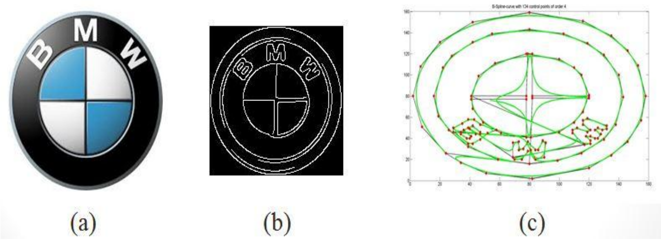


Fig. 2. Results of representing image using B-spline curves. (a). Input image. (b). Curvilinear features (c). B-spline representation of curvilinear features.

6. COLOR FILLING

There are various ways to determine the color for the given vertices. The one way is to take the original color from the input image COLOR(U) = G(LOC(U)), but this color scheme does not lead to the best solution so the color of given vertex is considered from original image also the color of pixels beside that control point in the original image is considered for color filling in vector image. The region where two or more different color region meets is filled by averaging that different color. Fig. 3 shows the color filling in the region where two different colors meet.

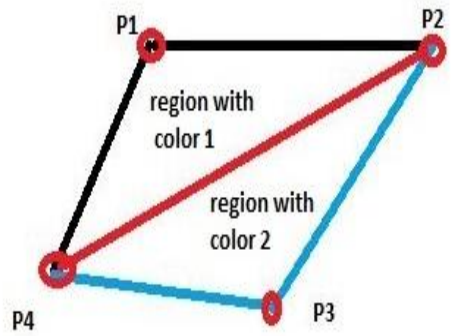


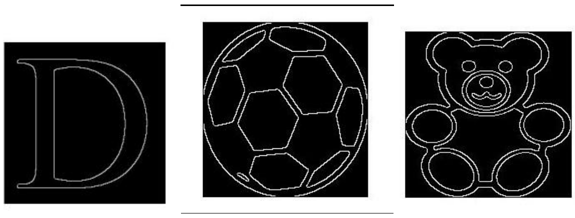
Fig. 3. Here P1, P2, P3 and P4 are the control points and two triangles shows the region with two different colors. The middle red line shows where the average of two different colors is to be filled.

7. EXPERIMENTS

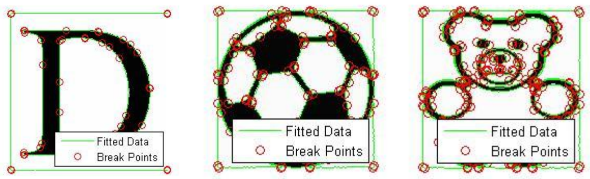
The method is implemented using MATLAB. The experimental results are shown in respective section. Fig. 6 shows the experimental results for different image using the proposed method.

(a)

(b)



(c)



(d)

(e)

Fig. 4. Vectorization results of black and white images (a) input raster image. (b) Reduced raster image. (c) Edge image used for control point detection. (d) B-spline curve fitting. (e) Vector image which is stored in a scalable graphics format (SVG).

The method described in section VI is used for color filling in the vector image. The results for color image vectorization is shown in fig. 5.

(a)

(b)

(c)

(d)

(e)

Fig. 5. Vectorization results of color images (a) input raster image. (b) Reduced raster image. (c) Edge image used for control point detection. (d) B-spline curve fitting. (e) Vector image which is stored in a scalable graphics format (SVG).

8. CONCLUSIONS

An image vectorization method is proposed here. The curvilinear curves are designed with special cubic B-spline curves. The proposed representation has flexibility in defining complicated contents of images also capable of modeling different sharp and semi-sharp edges in a compact way. Also results better than than the base paper is expected by using the proposed method.

Since, the proposed system uses B-spline curve forrepresenting the curvilinear feature, the futureworkshould concentrate on the other curve fitting techniques for increasing the accuracy of finalresults.

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