A Review on 2d, 2.5d and 3d Image visualization Techniques

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***Abstract*— Image enhancement is a crucial step in the image processing. This step reveals some important features or points that yield to further processing of the image, such that, a result can be given based on these features or points that are enhanced. This paper presents a survey on 2d, 2.5 and its extension 3d processing techniques which clearly details the internal points of an image. This survey is mainly based on the primary filters pioneered by Dr. E.G. Rajan, G-filters. These filters transform the image in many ways. 2d processing uses a simple mask to transform an image. In contrast to 2d which can be extended to 2.5d, by the use of rectangular grid such that we can process the same 2d in a 2.5d, such that more feature points can be extracted out of image. The same concept is extended to 3d where the same image is processed through hexagonal grid. Results using various grid types are presented and compared.**

***Keywords*— Image Enhancement, 2d, 2.5d, 3d, G-Filters, Rectangular Grid.**

I. INTRODUCTION

Morphology[1] based processing of digital images has remained a subject of interest for many years. In particular, several researchers have developed various algorithms using the combinations of morphology based concepts. Such a processing mainly relies on the shape of the image. These operations are applied using a structuring element over the given input image and delivers an output image which is of the same size of the input image. Basic morphological operations are dilation and erosion, where the former adds and the later removes the pixels over the object boundaries. Fig. 1 shows the original image and the result of dilation and erosion.

It can be clearly understood that morphological image processing is a set of non-linear operations, which are operated over the image that relates to the shape of the image, which rely only on the relative ordering of the pixel values but not on the numerical values. It can be observed from figure 1 that such simple morphological processing does not clearly reveal the internal structure. Hence, edge detection is the main problem in medical image analysis and is now widely investigated.

(a)

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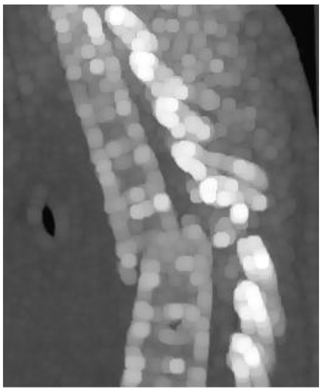
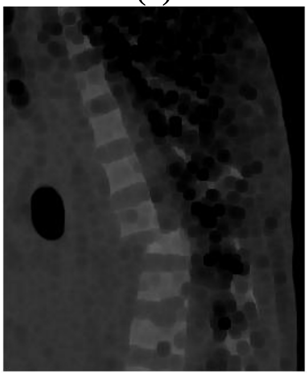


(b)



(c)

Fig. 1 Result of erosion and dilation. (a) original image (courtesy : www.auntminnie.com) (b) result of dilation (c) result of erosion

Edges in an image reveal the object boundaries which aid the user in calibration, recognition etc. From a low level perspective, boundaries in an image can be viewed as the lines that separate the regions of an image. Such lines form the outlines of the objects and also represent marks on the surfaces. Various techniques exist in the literature such as employing small masks over the image to identify the first and second derivative [2] of the image. Example of such masks is Roberts, Sobel, Prewitt, and Laplacian. These concentrate on edge enhancement having smoothing as a side effect. Hence, thresholding is applied after smoothing to identify the edges. These techniques are noise sensitive and are easier to implement.

This paper is organized as follows. Section II clearly discusses about 2D processing techniques, analysis and results. Section III elaborates about 2.5 d processing techniques paving way to 3d processing, analysis and results.

II. 2D Processing Techniques

A. Skeletonization

Iterative and Non iterative are the two approaches of skeletonization[3], where in the former divides the the image into sequential or parallel way by removing the edge pixels iteratively until one pixel remains and the laters directly skeletons the image without dividing. Morphological skeletons are defined by morphological opening and also by means of hit or miss transform. Fig. 2 shows the result of skeletonization using 2d processing techniques.

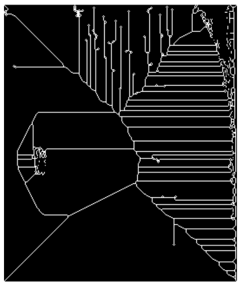


Fig. 2 Result of conventional 2d skeletonization over the image shown in Fig 1 (a)

It can be observed from figure 2 that the result of skeletonization using 2d processing does not reveal the internal structure and also not the external boundary of the object. Hence it is proposed to use 2.5d processing inorder to accurately extract the skeleton of the object.

B. Canny Edge Detector

Edge detection with a low error rate is vital and the operator must accurately localize the center of the edge. The major goal of edge detection is to considerably reduce the image data, in turn preserving the morphological properties of the image for further analysis[5]. Canny edge detector is a multistage detector. The intensity of gradients is computed based on the derivative of Gaussian. This reduces the noise present in the image, thus by reducing the edge size to 1-pixel curves.

The canny edge detection algorithm consists of five steps. They are Smoothing, Computation of gradients, Non-maximum suppression, Double thresholding, Tracking of edges by hysteresis. Smoothing is achieved by applying a Gaussian filter and the result of the smoothing is shown in fig. 3.

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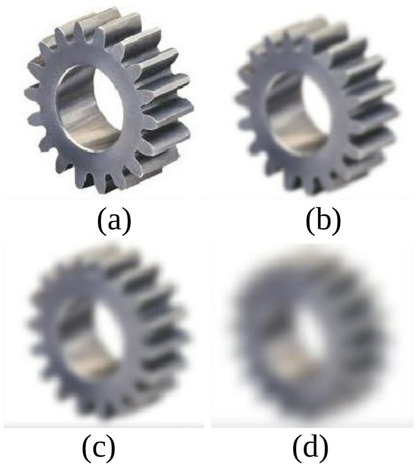

Fig. 3 Result of Gaussian smoothing. (a) Original Image (Courtesy : www.tradekorea.com), (b) Gaussian smoothing with $\sigma = 2$, (c) Gaussian smoothing with $\sigma = 4$, (d) Gaussian smoothing with $\sigma = 8$.

The next step is computation of gradients. The gradients are computed in both x and y directions. This process is normally done using sobel operator. Figure 4 shows the output of sobel operator using the original image in Fig. 3(a).

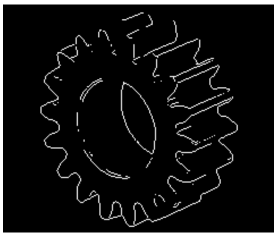

Fig. 4 Result of Sobel Operator.

The next step is non maximum suppression which is used to convert the edges that are blurred into edges that are short this can be achieved by retaining local maxima only. The next step is double thresholding which is used to detect fake edges that are due to the noise or colour variations in the image hence double thresholding is used to reduce such variations and are followed by tracking of edges using high hysteresis fig. 5 shows the final output of canny.

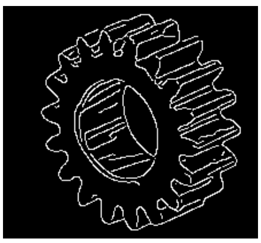

Fig. 5 Result of Canny Edge Detection.

It can be observed from fig. 5 that the result of canny edge detection is more accurate when compared to the other edge detection operators. The edges can be clearly identified using canny edge detector. Deokeoo Lee et. al proposed a two thirds power law for 2d surface[39-40] reconstruction. This law extarcts the spectral information that is useful in defining an optimal sampling rate of the surface, reflecting various circular patterns that are required for surface reconstruction. Gang Zeng et. al proposed a new approach of surface reconstruction from multiple images. It is proposed to use 3D stereo data to constrct 2D images. Such an integration of 3D and 2D data provided accurate points which are also called as feature points which aid in surface reconstruction[41]. Now in the next section we try to extend this concept to 2.5d where various skeletonization and edge detection techniques were discussed in details mentioning their pros and cons.

III. 2.5D and 3D Image Processing Techniques

It is already discussed that skeletons are compact representations for which mathematical analysis can be done. Skeletonization gives an overview of the shape of the object. It is clear from figure 2 that skeletonization in 2d does not reveal the actual structure of the object but in 2.5d it clearly delienates the structure. A skeleton is a subset of the foreground object that verifies some properties like homotopy, thinness and medialness. These are built using voronii diagrams. The skeleton must be homotopic thin and medial in relation to the representation. C-flourad etal suggested block by block skeletonisation using the above properties . The suggested method observed to preserve the global and local properties blocking the artifacts in the skeletonisation[4].

An another approach in skeletonisation is thinning . Thinning is repetitive reduction process which removes layer by layer until the resultant skeleton remains . Thinning algorithm that are available for 2d processing are efficient and extract topological kernels and medial lines where in the former gives the set of points relating to the object [6].

Thinning is a technique that is used for producing images having skeleton like structures. These

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images are formed in such a way that they preserve the topological properties. Most of these algorithms are processed using orthogonal grids, but it is also possible to use hexagonal grids which are also called as triangular lattices. The main advantage of having hexagonal grids over the existing orthogonal grid is that each pixel in the hexagonal grid is surrounded by neighbors which are equidistant, resulting in less ambiguity in the structure connectivity and also in better angular resolution when compared to that of the rectangular type[7-8].

There are basically two approaches in hexagonal sampled images acquisition. The existing conventional devices acquire only square sampled images. So, image acquisition can be done only through software where in the square image is manipulated to produce a hexagonally sampled image. Another approach is to use a hardware that is particularly designed for this purpose. Manipulation of data that is sampled on one lattice in order to produce data that exists on a different lattice is called as resampling. Assuming this to the current context, the required image is to be sampled on a hexagonal lattice while the orignal data is on square lattice.

Figure 6 shows the method used by Hartman[31] which uses hexagonal lattice and the pixels are of triangular shape. The construction process is as follows.

The square pixels that are adjacent vertically are average for generation of individual triangular pixels. It is observed that the resulting pixel produce triangles having base angles 63.4o and 53.2o. It is concluded from this discussion that square to hexagonal conversion is an affine relationship between these lattice points which is illustrated in figure 2.5b, which means that when rectangular images are skewed then form hexagonal images. It can be observed that the result of such skewing process results in a hexagon which is elongated in an oblique direction. The importance of such a resulting hexagonal shape is that it does not exhibit any rotational symmetry[9].

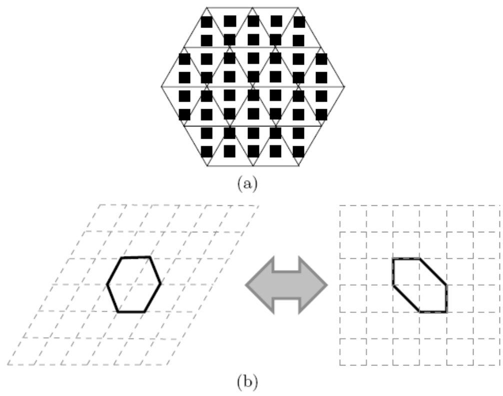

Fig. 2.5. Hexagonal resampling schemes of (a) Hartman and Tanimoto (1984) (b)Watson and Ahumada (1989).

Fig. 6 Hexagonal lattice (a) Hartman and (b) Watson [31]

Various features can be extracted from a three dimensional image. One those is volumetric features. These volumetric features comprise various other sub features like edge. 3-D edges are of two kinds, one, the intersection of two planes or surfaces, other, boundary that separates two regions having varying intensities. The former is called volumetric edge and the latter is called superficial edge[10]. This was further generalized using symmetric gradient operator[11]. An overview of different types of point detectors is presented. Different properties are defined using local feature detector[12]. Curve skeletons are the representation of the 3D objects. These are represented in the form of 1D representation of a 3D object. Its main application include virtual navigation, reduced model formulation, improvement in visualisation, animation etc. Various algorithms exists in the literature but it is still not clear in describing the methodologies in extraction of a skeleton which are robust[13,17]. Various shape features can be extracted from a skeleton. Skeleton of a three dimensional mesh is a feature and is generally used for describing the shape of an object. A novel approach for skeletal extraction using Multi-Dimensional Scaling (MDS) transformation is proposed by Sun et al.[14]. The first step is to straighten the folded branch and perform segmentation using the feature points. This algorithm is shown to be simple and invariant in terms of pose and other model components[14].

It is clear from the above discussion that skeleton is a lower dimensional descriptor of an object. The formation of a skeleton is based on the type of

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application. An object recognition recognition algorithm if so uses a skeleton as a feature then it extracts only the shape features and then computes the similarity between the query image over the existing images. In the case of a surface reconstruction algorithm, it uses skeletons to compute the detailed geometry inforamtion. This reduces the error in reconstruction. Wan-Chun Ma et al. [15] proposed a practical approach for extracting skeletons using Radial Basis Functions (RBF) kernels. It is observed that the skeletons that are formed using this approach are similar to human perception of skeletons[15].

Extracting a skeleton which is having a curve is very difficult. Oscar Kin-Chung Au et al. has presented an extraction method which is simple and robust for skeletal extraction. This method is based on mesh contraction. The basis for this method is laplacian smoothing. the object is reduced or perfomed contraction using this smoothing technique. Then it is converted into a curve while preserving the original structure[16].

Processing of 3-D images is achieved by using 3D masks. Such masks are called as 3D convex polyhedrons which are used as structuring elements for processing and extracting various features from the three dimensional objects. G.Ramesh Chandra et al. proposed various algorithms for generation such polyhedrons using an array of cells and constructred 256 convex polyhedrons using 3 x 3 x 3 neighborhood structure[18].

No such mathematical framework exists for the generation of such masks which are used for processing of 3D images. A mathematical framework was introdcued and is used to generate structuring elements by using geometric filters. Based on these G-filters various number of polyhedrons are developed[19-20].

Dakaifan et al proposed a new approach for skeletonisation. Using minimum cost existing arc skeletonisation algorithms results in noisy boundaries which are based on blums transform. A new branch is repetitively added for each iteration from the root voxel to the farthest voxel resulting in skeleton of the image. The cost of the path is reduced using minimum cost geodesic path[32].

Existing arc skeletonization algorithms using the priciple of Blum's transform[34] results in unnecessary branches leading to artifacts. Surface and curve or arc skeletonization is the two types of skeletonization methods for 3d objects where the former generates a medial representation and the latter is used for elongated objects generating a centreline representation which is combination of many curves[35].

3-D edge detection is the area of where the researches are concentrating in the recent past . 3-D edge is similar to 2-D in spite of its computational complexity making the system slow, having higher geometric accuracy it is already discussed in canny that edge can be detected from local maxima of gradient magnitude along the gradient direction . This ides is expoited and 3-d edges are detected by the recursive filters. The edge points are edge gels which are nothing but as analogy pixels in an image relevant to edge elements. At 2-d edge separates two regions where 3-d edge separates the surface hence 3-d edge points are called surfels. Christian, Bahnish et.al proposed a 3-d edge detection algorithm where the 3-d image is first modelled and then voxel based edge detection is performed for that sub pixels are refined and edges are identified[36]. Khromov D et. al proposed a novel approach for skeletonization in 1D that is applied over 3D objects. This process has reduced in such a way that it has become a numerical optimization problem. As we have already discussed that skeleton is nothing but 1D thinning which gives the original shape of the object. In the case of the 2d the skeleton is usually the medial axis of the shape, which is the set of all points that are close to the boundary of the shape. So a 1D set is the medial axis of a 2D shape and in the case of a 3D the medial axis is the 2D sheet[37]. However, 3D edge detectors lack accuracy and speed. Christian et. al proposed a sub voxel edge detector which detects an edge in a faster way and showed that the proposed technique works well with 3D planar, spherical and cylindircal surfaces[38].

For comparison of images using edges in particular 3-d images having 2-d distance function are appropriate . Roben strange et al proposed distance function on 3-d grids this distance

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functions are delineated on cubic, fcc, bcc, honey com and diamond grids. The proposed techniques should be in such a way that they have the lowest rotational dependency. It is observed that fcc has lowest rotational dependency forward by cubic grid [33]

Based on the above discussion it is clearly understood that there is a need for development of 3D image processing techniques. It is quite necessary in applications like free viewpoint television (FTV)[21] where the user can interactively select the scene and further he can change the angle that is viewed. Such a protability is provided by the use of depth maps which allows the user to use the system interactively. This technique adopts geometry information for view synthesis. In the recent past different multimedia services are available and there is a huge demand for the 3D TV which is rapidly evolving. As this is said to be the next generation broadcasting service which deliver real experience to the user that is accomplished interactively. A tutorial is provided for acquisition, representation of 3D images[22].

The 3D processing technique is further can be used in medicaly image representation and analysis. CT scan is one such example which is based on reconstruction using 2D cross sections obtained from a scanner. Another model was developed by Mehta et al. which reconstructs a 3D image using Microscribe 3D digitizing unit. Further these models are stressed using FEM techniuqe and are compared for the better representation[23]. Such 3D processing techniques are also used in the analysis of inter coronary diseases[24]. In the case of endoscopic bimage which are of two dimensional in nature, cover limited area of the bladder. 3D endoscopes which output stereoscopic vision principles are validated based on the 2D texture image and few 3D points over the internal wall surfaces provided by endoscopes[25].

Agarwal et al. proposed 2d to 3d transformation using wavelets. This technique was compared to other existing techniques like stereo photogrammetry and edge information technique. It is observed that wavelet analysis is simplest method to obtain 2D to 3D and to process for further analysis[26].

Another application of 3D image processing technique is its use in SONAR. The signal received is taken as an input to the 3D image formation and an approach is developed by exploiting the maximum of the obtained signal, which is then compared to to the existing 3D interpolation and voxel based techniques[27].

Cracks will be developed on roads upon aging and due to other environmental effects. 3D profiles are collected from the road inspection system which uses an external scan camera that scans the area. The technique proposed by Medina et al.[28] uses adaboost algorithm for analysis of the image results to identify the cracks. 3D image models can also be formed from 2D images[29]. A generalised technique for estimation of surfaces from stereo pairs is presented by Ramey et al.[30]. This technique is an iterative process and updates the surface representations directly from the image fromation[30]. Acka D proposed proposed least square matching algorithm to 3D surfaces. This is based on the least squares matching concept used in 2D image matching that offers higher flexibility to any kind of 3D surface based problems. It is observed that this technique can handle multi-resolution, temporal, scale and sensor data[xnew5].

IV. Conclusions

Image enhancement is the prime step in image processing where in the original image will be enhanced in various directions like that of improvement in contrast, increase in brightness etc. so that the user can identify the required portions of the image and can classify based on the features extracted from the enhanced version of the image either automatically or manually. So in the juncture this paper surveys various features that can be extracted from 2d images. Different techniques were surveyed which extracts the skeleton, edge of the 2d image. But the features that can be extracted from such techniques are limited. The main aim of such detection is the visualization that can aid the user in the classification process. Hence it is further surveyed for an extension of 2d which is 2.5d. Various surface and edge detection algorithms

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exists in 2.5d which are shown as 3d. This can be assessed based on the grid structure that the user uses to process the image. Real 3D visualization algorithms work on processing the images using 3D rectangular arrays which results in better visualization ultimately leading to the classification of the image. Here in this case classification is nothing but, considering an example of brain tumor person. When a 3D image is constructed based on the existing visualization algorithms and 3D processing techniques the result must lead to the quantification of the tumor in terms of area, benign or malignant, depth etc. Such features help the doctor in detecting the stage of the tumor, so that medication can be easily provided. Till now this visualization is lacking in medical image analysis. As a future scope we try to extend the existing visualization techniques that are using rectangular grid array for processing by taking hexagonal grids so that the visualization improvement may be possible.

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