

Brain Tumor Growth and Volume Detection by Ellipsoid-Diameter Technique Using MRI Data

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Abstract

Magnetic resonance (MR) images are a very useful tool to detect the tumor growth in brain but precise brain image segmentation is a difficult and time consuming process. Manual segmentation of brain tumors from MR images is a challenging and time consuming task. In this paper our approach has been discussed to detect the volume of brain tumor cells using ellipsoid-Diameter and graph based method [1] to find the volume. Here MRI data set from 100 patients were collected. The graph based on pixel value is drawn taking the various points from the tumor cells lies in the original position from the affected region. Here the affected region is considered as ellipsoid shape and the volumes have been calculated from it. In this system the mean has been found from the volumes grown in the affected region (tumor area). The experimental results show that 97% brain tumor growth and volume can be measured by this Ellipsoid diameter Technique

Key Words: MRI, Imaging, Segmentation, Advanced graph based technique, Ellipsoid Diameter method.

1. Introduction

Medical image analysis typically involves heterogeneous data that has been sampled from different underlying anatomic and pathologic physical processes. In the case of glioblasto mamultiforme brain tumor (GBM), for example, the heterogeneous processes in study are the tumor itself, comprising a necrotic (dead) part and an active part, the edema or swelling in the nearby brain, and the brain tissue itself. To complicate matters, not all GBM tumors have a clear boundary between necrotic and active parts, and some may not have any necrotic parts. In Fig. 1, we show a 2-D slice of a magnetic resonance (MR) image in the T1 weighted and T2 weighted channels presenting an enhancing GBM brain tumor. Its resolution is approximately 100 microns [9-10]. MR imaging is currently the method of choice for early detection of brain tumor in human brain. However, the interpretation of MRI is largely based on radiologist's opinion. Generalization of brain screening programs requires efficient. Double reading of MR image, which allows reduction of false negative interpretations, but it may be difficult to achieve. Computer aided detection systems are dramatically improving and can now assist in the detection of suspicious brain lesions, suspicious masses. The task of

Manually segmenting brain tumors from MR imaging is generally time consuming and difficult. An automated segmentation method is desirable because it reduces the load on the operator and generates satisfactory results [11]. The region growing segmentation is used to segment the brain tumors due to its wide range of applications and automatic features. After taking the image of the tumorous brain there is a need to process it. The image clearly shows the place of the tumorous portion of the brain. The image does not give the information about the numerical parameters such as area and volume of the tumorous portion of the brain. After segmentation the desired tumor area is selected from the segmented image. This selected region is used to calculate the area and volume of the tumor present in the MR image.

2. MRI analysis

Given a brain MRI image, the first step enhances the image, the second step segments the brain tumor image and in the third step post processing using morphological operations and windowing technique takes place. As a result of these steps, we get a final brain tumor detected image. The diagnosis was confirmed pathologically in each patient. All participants in this study remained Blinded as to the arms to which any patients had been assigned. Each MRI study was performed according to a standardized protocol that included pre- and post contrast T1-weighted imaging in multiple planes, as well as a high-resolution (3- or 1.5-mm slice thickness) gradient echo acquisition. Clinical data, such as Patient survivals, treatment parameters, and so on, are not described in this report because they are not relevant to the main focus of this work, the reproducibility of the measurement techniques. The following fig1 shows the MRI images.

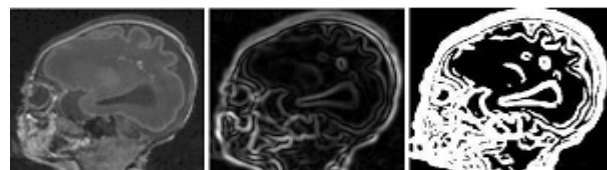


Fig.1: Head MRI Image

3. Proposed Methodology

Implementation of this novel approach contains various processing steps, like raw image collection, image preprocessing, thresholding image segmentation and volume calculation. The sequences of the processing steps are arranged in a meaningful manner as shown in Fig.2

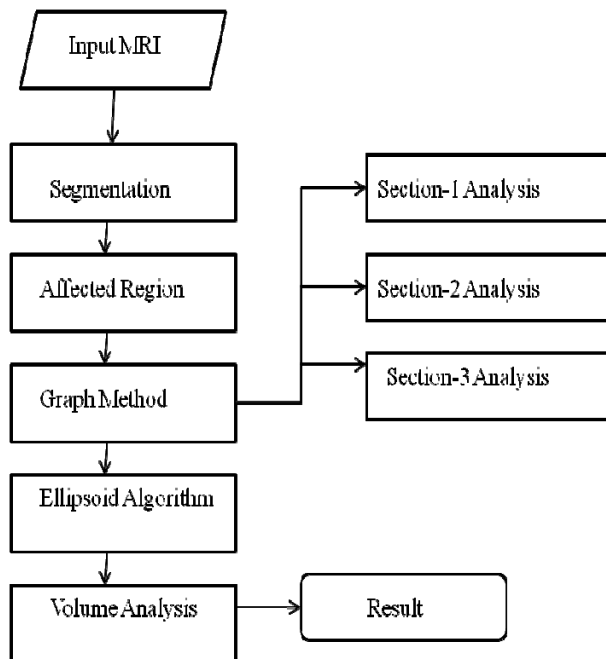


Fig.2: The Proposed methodology

3.1 Input Data

The MR images are acquired on a 1.5T using T2-weighted axial contrast images.

3.2 Approach of Preprocessing

Image preprocessing is the very first step in the image processing. In this process the image is converted into the Accessible form. Also image intensity adjustment and noise reduction processes are carried out. After this the Gaussian image filtering is performed. Filtering is necessary because it reduces the noise present in the image

3.3 Affected area from Normal Cells

This method, the point is to group pixels of the same or

similar brightness or color into region according to the given membership criteria. The membership criteria are based on some threshold value. The membership in a region can be based on multiple criteria. The confidence connected region-growing algorithm based on extraction of connected set of pixels whose pixel intensities are consistent with the pixel of a seed point. First, the mean and variance across an 8-connected neighborhood are calculated for a seed point. The pixels connected to this seed point whose values are within the confidence interval for the seed point are grouped. The width of this confidence interval is controlled by the user Defined factor f according to equation, the following equation

$$I(x) \in [m-f \sigma, m+f \sigma]$$

Where m and σ are z the mean and standard deviation of the region intensities, f is a factor defined by the user. Small values of the factor f will restrict the inclusion of pixels to those having very similar intensities to those in the current region. Larger values of this multiplier factor will relax the accepting condition and will result in more generous growth of the region - I is the image and x is the position of the particular neighbor pixel being considered for inclusion in the region.

4. System Overview

In this study the tumor growth has been measured by graph based technique. Here input is the MRI image which is divided into four sections by one horizontal and vertical line shown in fig .3

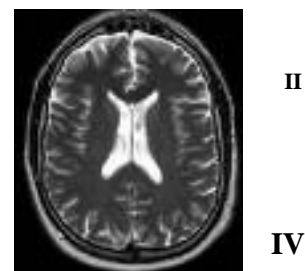


Fig.3: MRI Sections-I affected area

Region growing group's pixels or sub regions into larger regions based on predefined criteria. The basic idea is to start with a pixel or a group of pixels and examine the neighboring pixels. If a neighboring pixel meets a certain criteria, it is added to the group and if it does not meet the criteria, it is not added. This process is continued until no more neighboring pixels can be added to the group. Thus, a region is defined. In The divided four sections of the MRI have been denoted as I, II, III and IV The MRI image divided into 4 sections that is I, II, III, and IV. If the affected region lies in section the graph has been drawn from it. This type of approach is better than other approaches because this system has been taken by only the affected region. The graph has been drawn based on the daily report from the MRI dataset as shown in fig 4(b). The graph has been drawn based on pixel values from

the tumor cells that lie in the affected region from day by day report from MRI data. Here the Experimental result (graph) shows the growth of brain tumor cells.

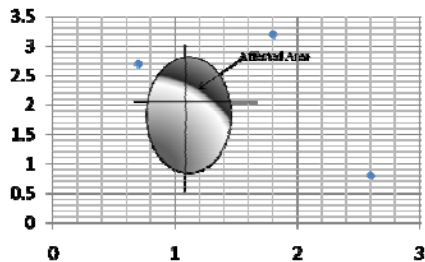


Fig.4 (a): MRI Sections-I affected area

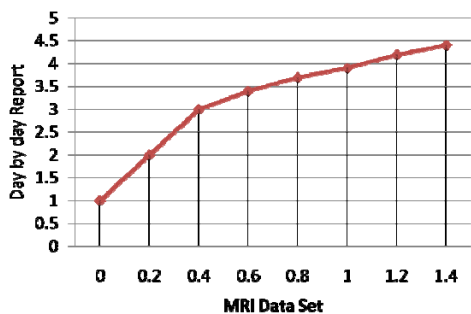


Fig.4 (b) MRI Section-I Glioma Growth

Here the First step is to mark the affected region in section-I (fig 4.) Now take the affected region from the MRI data and match it with the graph as shown in fig(5).After matching them ,from the affected regions the points have been selected and using them the graph has been drawn as shown in fig.5.

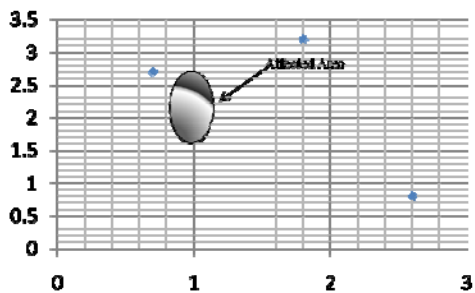


Fig.5: MRI Sections-I affected area lies in graph

Here 1 cm in x axis and 0.5 cm in y axis have been taken .So plot the graph based on the daily report. The graph has been drawn based on the daily report It given a detail picture of the growth rate of the brain cells. picture of the growth rate

of the brain cells. Fig 5(a) shows the original input of MRI of data set and Fig.5 Gaussian filtered image of dataset 1.In fig.6 (a)

graph has shown the glioma growth in section –I from select the appropriate points from the affected regions by day by day report of patients MRI data and in fig.6 (b) has been shown the glioma growth in section –II from the affected MRI data set-2. Likewise, in section III and section IV the graphs have been drawn in the same method. II



Fig. 6 (a): Original input MR image of dataset - 1.

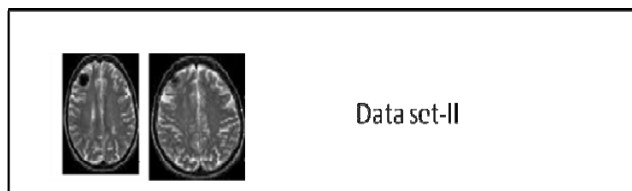


Fig.6 (b): Gaussian filtered image of dataset - 1.

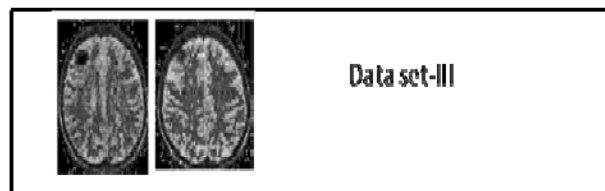


Fig.6(c): Intensity adjusted image of dataset 1.

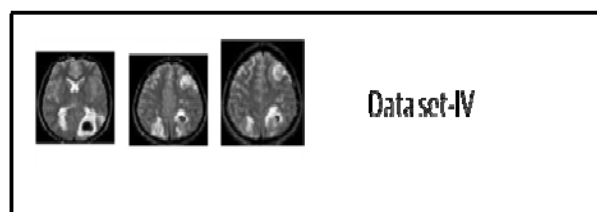


Fig. 6(d): The results after segmentation for data set 1.

5. Brain Tumor Growth Graph

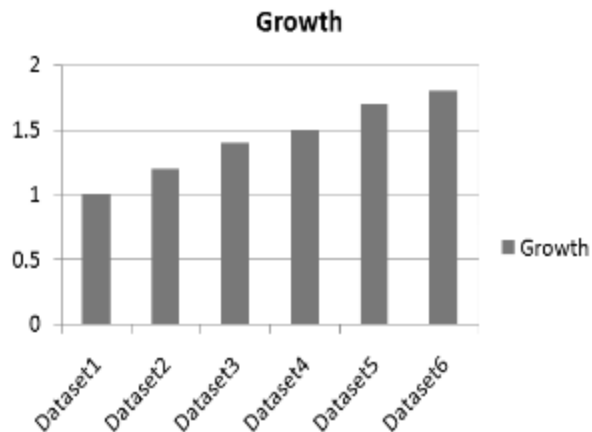


Fig.7(a): Graph result for section-I affected region

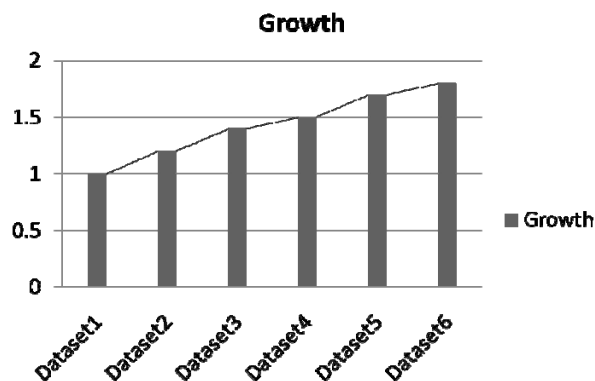


Fig.7(b): Graph result for section-II affected region

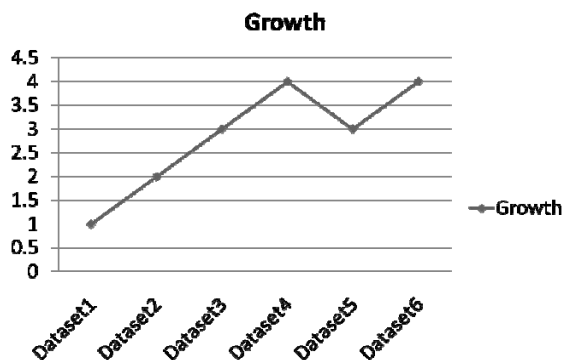


Fig.7(c): Graph result for section-III affected region

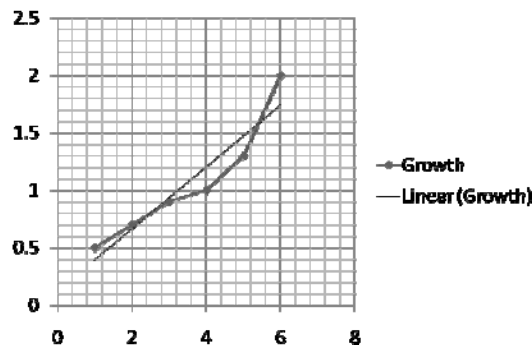


Fig.7(d): Graph result for section-IV affected region

6. Ellipsoid-Diameter Algorithm

Readers were instructed to identify the three largest orthogonal diameters of the lesion. Diameters were manually measured on MRI films with calipers (dividers) (Fig 8). In each case where a second lesion was present, or the shape of the lesion was best characterized by two ellipsoids, a second set of three diameters was also recorded, and the volumes were summed. If one or more necrotic or cystic areas were thought to be present, additional diameters for the cystic component were recorded, and the computed cystic volume was Subtracted from the overall volume Readers were not aware that an end point of this study was the determination of how many sets of diameters (one v two v three diameter measurements) were thought to be required to accurately characterize the lesion volume. The formula used to compute volumes was the standard volume of an ellipsoid, as follows:

$$V = 4/3 \pi (a * b * c^*)$$

An ellipsoid is a closed type of quadric surface

If all three radii are equal, the solid body is a sphere;
 if two radii are equal, the ellipsoid is a spheroid:

if $a=b=c$ then shape sphere
 volume= $4/3 \pi abc$

if $a=b>c$ then shape Oblate spheroid (disk-shaped)
 volume = $(axbxc) x 8/3 \sqrt{3}$

if $a=b<c$ then shape Prolate spheroid (like a rugby ball)
 volume = $(axbxc) x 8/3 \sqrt{3}$

if $a>b>c$ then Scalene ellipsoid ("three unequal sides")
 volume= $8xaxbxc$
 Mean $V_1+V_2...+V_n$
 Mean: Result(volume)

Where a , b , and c are the three radii (half the diameters). In addition to the total volume, the individual diameters were also recorded to allow analysis on a single- or dual-diameter basis, ie, diameter or area rather than a volume estimate.

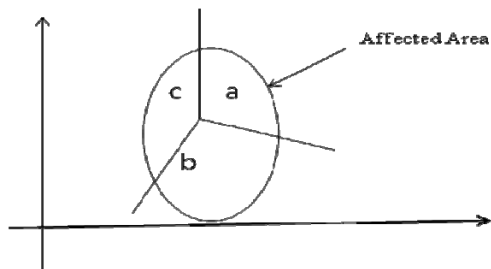


Fig.8: Ellipsoid method

In this diameter method the volume has been calculated using formula-2. Table-I shows the volumes it has been calculated from dataset-1 and dataset-2.

Table.1 graph result for section-I affected region

MRI Data	a(cm)	b(cm)	C(cm)	Vol(cm ³)
Dataset-1	0.27	0.31	0.13	0.03416634
Dataset-2	0.33	0.41	0.37	0.15719154

Process from our input MRI image; the affected region has been changed as ellipse or circle shape. In formula -2 the volume has been found from MRI data set using different parameters (a , b , c). to find out the volume from MRI data set-1. This result will produce out the volume of brain tumor. Again this same diameter method has been used and has found out the volume -2 upto N times. N is a number of steps to determine the volume by different parameters as shown in fig. 8 (a), 8(b), 8(c). The mean has been measured from these volumes using formula-3 which is equal to average of volumes calculated using different parameters. From this mean the volume of glioma has been determined from day by day MRI report. The graph shows the brain tumor growth affected in brain cells.

$$\text{Mean} = V_1 + V_2 \dots + V_n \quad (3)$$

Where v_1, v_2 are the volumes it has been calculated from dataset-1 and dataset-2.

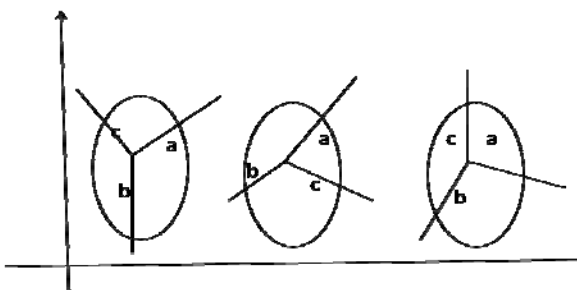


Fig.9: Volume measurements

7. Conclusions

Imaging plays a central role in the diagnosis and treatment planning of brain tumor. Tumor volume is an important diagnostic indicator in treatment planning and results assessment for brain tumor. The measurement of brain tumor volume can assist tumor staging for brain tumor volume measurements is developed which overcome the problem of inter-operator variance, besides partial volume effects and shows satisfactory performance for segmentation. This method is applied to 8-tumor contained MRI slices from 2 brain tumor patients data sets of different tumor type and shape, and better segmentation results are achieved In this study a new approach has been discussed to detect the volume of brain tumor using diameter and graph based method to find the volume. Here MRI data set from 200 patients were collected. The graph based on pixel value is drawn taking the various points from the tumor cells lies in the original position from the affected region. Here the affected region is considered as ellipse shape and the volumes have been calculated from it. In this system the mean has been found from the volumes grown in the affected region. The experimental results show that 96% brain tumor growth and volume can be measured by graph and diameter method

8. References

- [1] S.Karapagam and S.Gowri, "Detection of Glioma(Tumor) Growth by Advanced Diameter Technique using MRI data," Medical Proceedings of the World congress on Engineering 2011 Vol I WCE 2011, July 6 - 8, 2011, London, U.K.
- [2] K. M. Iftekaruddin, "On techniques in fractal analysis and their applications in brain," Medical imaging systems: technology and applications, Analysis and Computational Methods, vol. 1, World Scientific Publications, ISBN 981- 256-993-6, 2005.
- [3] L. P. Clarke, R. P. Velthuizen, M. A. Camacho, J. J. Heine, M. Vaidyanathan, L. O. Hall, R. W. Thatcher and M. L.

- Silbiger, "MRI segmentation: methods and applications", Magn. Reson. Imaging, vol. 13, Issue 3, pp. 343–368, 1995.
- [4] H. S. Zadech and J.P. Windham, "A comparative analysis of several transformations for enhancement and segmentation of magnetic resonance image scene sequences," IEEE Trans. Med. Imaging, vol. 11, no. 3, pp. 302–318, 1992.
- [5] D. Wang and D. M. Doddrell, "A segmentation-based partial-volume compensated method for an accurate measurement of lateral ventricular volumes on T1-weighted magnetic resonance images," Magn. Reson. Imaging, vol. 19, pp. 267–272, 2001.
- [6] M. Just and M. Thelen, "Tissue characterization with T1, T2 and proton density values: results in 160 patients with brain tumors," Radiology, vol. 169, pp. 779–785, 1988.
- [7] K. M. Iftekhharuddin, J. Zheng, M. A. Islam and R. J. Ogg "Fractal based brain tumor detection in multimodal MRI," Journal of Applied Mathematics and Computation, pp. 1-19, 2008
- [8] S. M. Haney, P. M. Thompson, T. F. Cloughesy, J. R. Alger and A. W. Toga, "Tracking Tumor Growth Rates in Patients with Malignant Gliomas: A Test of Two Algorithms," AJNR American Journal of Neuroradiology, vol. 22, pp. 73-82, January 2001.
- [9] R. S. Khanpur, "Handbook of Bio-Medical Instrumentation", 2nd edition 1999.
- [10] K. Xie, J. Yang, Z. G. Zau and Y. M. Zhu, "Semiautomatic Brain Tumor and edema segmentation using MRI", European Journal of Radiology, vol. 56 Issue 1, pp. 12-19, 2005.
- [11] D. L. Pham, C. Xu and J. L. Prince, "Current Methods in Medical Image Segmentation", Annual Review of Biomedical Engineering, volume 2, pp 315-337, 2000.
- [12] R. Damadian, K. Zaner, D. Hor, T. DiMaio, L. Minkoff and M. Goldsmith, "Nuclear magnetic resonance as a new tool in cancer research: human tumors" by NMR, Ann N Y Acad Sci, vol. 222, pp. 1048-76, 1973.
- [13] M. Edman, "Segmentation Using a Region Growing Algorithm", Rensselaer Polytechnic Institute, 2007
- [14] Clarke LP, Velthuisen RP, Clark M, et al: MRI measurement of brain tumor response: Comparison of visual metric and automatic Segmentation. Magn Reson Imaging 16:271-279, 1998
- [15] J. Hwang, Y. Han and H. W. Park, "Segmentation of Brain Parenchyma using Bilateral Filtering and Region Growing", International Conference of IEEE EMBS, pp. 6263-6266, 2007.
- [16] P. Gibbs, DL. Buckley, SJ. Black band, et al., "Tumor volume determination from MR images by morphological segmentation," Phys Med Biol, vol. 41, Issue 11, pp. 2437-46, 1996.
- [17] DN. Kennedy, PA. Filipek and V. Caviness, "Anatomic Segmentation and volumetric calculations in nuclear magnetic resonance image," IEEE Trans Med Imag, vol. 8, pp. 1-7, 1989.
- [18] MMJ. Letteboer, OF. Olsen, EB. Dam, et al., "Segmentation of tumors in magnetic resonance brain images using an interactive multiscale watershed algorithm," Acad Radiol, vol. 11, pp. 1125- 1138, 2004.
- [19] M. Droske, B. Meyer, M. Rumpf, et al., "An adaptive level set method for interactive segmentation of intracranial tumors", Neuro Res, vol. 27, no. 4, pp. 363-70, 2005.
- [20] Y. Boykov and V. Kolmogorov. An experimental comparison of mincut/max-flow algorithms for energy minimization in vision. *submitted IEEE Trans. Pattern Anal. and Machine Intell.*, 2004.
- [21] C. Carson, S. Belongie, H. Greenspan, and J. Malik. Blobworld: Image segmentation using expectation-maximization and its application to image querying. *IEEE Trans. Pattern Anal. And Machine Intell.*, 24(8):1026–1038, 2002.
- [22] C. M. Christoudias, B. Georgescu, and P. Meer. Synergism in low level vision. In *16th International Conference on Pattern Recognition., Quebec City, Canada*, volume IV, pages 150–155, 2002.
- [23] D. Comaniciu and P. Meer. Mean shift: A robust approach toward feature space analysis. *IEEE Trans. Pattern Anal. and Machine Intell.*, 24:603–619, 2002.
- [24] T. Cour, S. Yu, and J. Shi. Normalized cuts matlab code. Computer and Information Science, Penn State University. Code available at <http://www.cis.upenn.edu/~jshi/software/>.
- [25] F.J. Estrada, A.D. Jepson, and C. Chennubhotla. Spectral embedding and min-cut for image segmentation. In *British Machine Vision Conference*, 2004.