OPEN ACCESS

International
Journal
Of Modern Engineering Research (IJMER)

Cuckoo Search Optimization of Blebs in Human Embryonic Stem Cells

Lakshmi Thara.R[1],S.P.Sivagnana Subramanian[2]
**(Electronic AndCommunication Department,SriVenkateswaraCollege Of Engineering/ Anna University, India)*
*** (Electronic AndCommunication Department,SriVenkateswaraCollege Of Engineering/ Anna University, India)*

ABSTRACT: *The main aim of this project is to segment the bleb from human embryonic stem cells (hESC). The behavior of bleb can be used to distinguish apoptotic bleb from the healthy bleb. The health of the human embryonic stem cells can be determined using the portion of bleb formed on the surface of the stem cells. The complete bleb formation contains bleb extraction and retraction. This paper uses the active contour algorithm for the segmentation of bleb from human embryonic stem cells. The output of the segmentation, input video and area of bleb can be used as an input to the optimization process. The cuckoo search algorithm is utilized for optimization, which inspired from the brooding parasitism will enhance the segmentation result. The proposed method attains the quick and accurate analysis in the bleb extraction process.*

Keywords:*Apoptotic bleb, Bleb Extraction, Dynamic bleb, Human Embryonic Stem Cell (hESC),Stem Cells.*

I. INTRODUCTION

Embryonic Stem Cells (ESC) deduced from the inner cell mass (ICMs) of blastocyst, the sperm in the oocyte can be divided into number of totipotent cells which cannot be differentiated. These cells when enter into the blastocyst it can be differentiated into number of specialized cells. Embryonic stem cells are the pluripotent cells that can be derived from the inner cell of mammalian blastocyst. The specialized cells can be further differentiated to produce more number of stem cells. The word "ES cells" was used to differentiate these embryo-derived pluripotent cells from teratocarcinoma-derived pluripotent embryonal carcinoma (EC) cells.

Embryonic stem (ES) cells have been recognized from several mammalian species, including mouse, monkey, and human. It is well established that various signaling pathways, including phosphoinositide 3-kinase (PI3K)/Akt and Wnt/β-catenin signaling in the maintenance of ES cell pluripotency, and is known about the signaling pathways, involved in the derivation ES cells from ICMs.Embryonic stem (ES) cells go through protracted proliferation while remaining composed for multilineage differentiation. A sole network of transcription factors may illustrate self-renewal and simultaneously suppress differentiation. First, the generation of mature lineage from ES cells in culture delivers access to populations of initial precursors that are difficult, if not impossible, to access in vivo. Evaluates of these mutations in vivo are habitually tricky by the early death of the embryo in utero. Second, the developmental potential of ES cells carrying targeted mutations of genes vital for embryonic development can be formed in culture.Moreover, under well-defined conditions, embryonic stem cells are adept of propagating themselves indefinitely. This permits embryonic stem cells to be hired as beneficial tools for both research and regenerative medicine, as they can yield vast numbers of themselves for continual research or clinical use.For the reason, of their manipulability and hypothetically boundless capacity for self-renewal, ES cell therapies have been suggested for regenerative medicine and tissue replacement after injury or disease.

Our impact of my works are précised as follows: (i) 3x3 median filter is applied to remove noises in the time lapse videos; (ii) after pre-processing active contour segmentation algorithm is applied for extraction of blebs from human embryonic stem cells; (iii) to enhance the segmentation result optimization is done using cuckoo search algorithm.

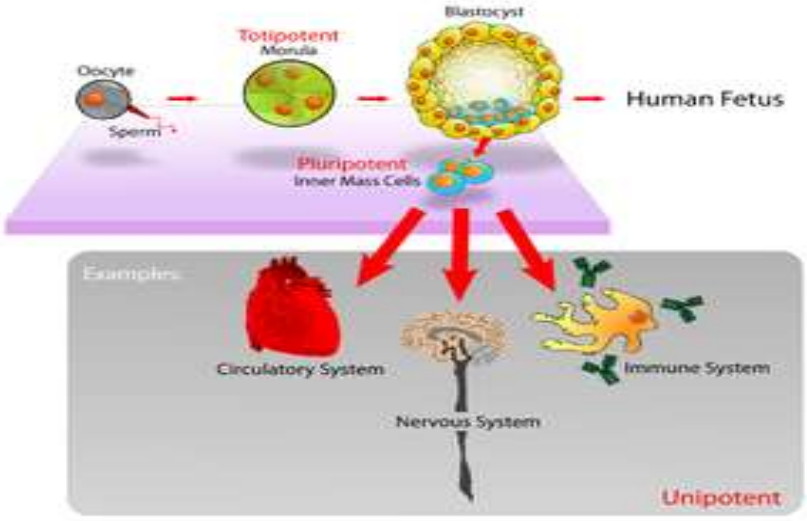

Figure 1. Embryonic Stem cells

II. HUMAN EMBRYONIC STEM CELLS

Human blastocyst-derived, pluripotent cell lines are defined that have common karyotypes, express extraordinary stages of telomerase movement, and express cell surface indicators that illustrate primate embryonic stem cells but do not describe other initial lineages. Later identical production in vitro for 4 to 5 months, these cells quiet preserved the growing potential to form trophoblast and derivatives of all three embryonic germ layers, including gut epithelium (endoderm); cartilage, bone, smooth muscle, and striated muscle (mesoderm); and neural epithelium, embryonic ganglia, and stratified squamous epithelium (ectoderm). These cell lines ought to be beneficial in human developmental biology, drug discovery, and transplantation therapies for diseases ranging from heart disease to Parkinson's disease to leukemia.

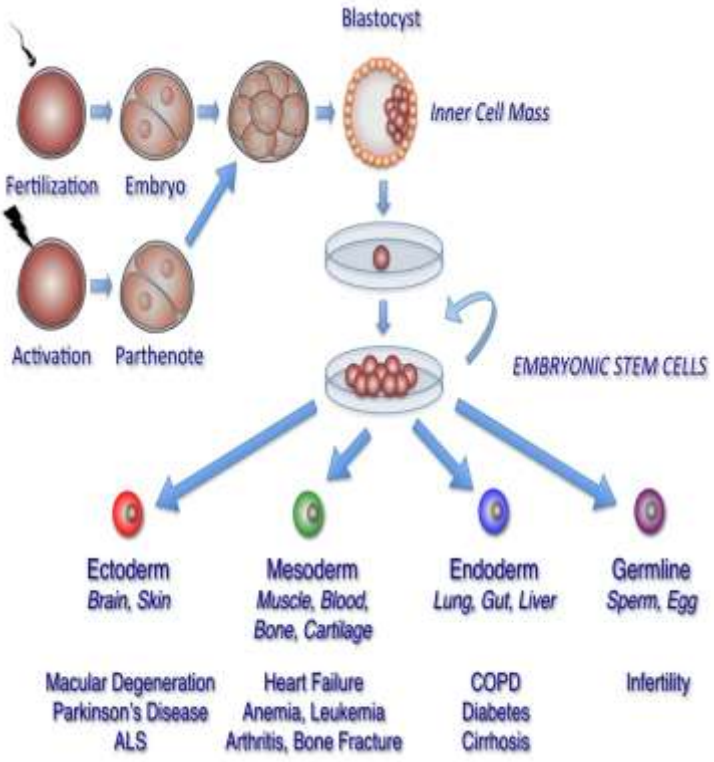

Figure 2. Generation of pluripotent human embryonic stem cell line

Generation of human embryonic stem cell (hESC) lines involves several steps. Donor embryos are first acquired subsequently in vitro fertilization or by egg activation (parthenogenetic embryos) and permitted to progress in vitro. Pluripotent cells are then isolated either from the inner cell mass of pre-implantation blastocysts or from 4, 8, or 16 – cell stage morulae. Finally, isolated cells are plated in distinct hESC medium with or without feeder cell layers to propagate and choose for pluripotent cell populations. These procedures have given rise in hESC lines able to produce tissues from all three embryonic germ layers and the germ line.

III. BLEBBING OF HUMAN EMBRYONIC STEM CELLS

Blebs are bulges that seem and vanish from the surface of cells. The mining of blebs and their altering area over time in live videos is vital for understanding the mechanisms and purpose of human embryonic stem cell (hESC) blebbingbehavior. The behaviour of blebbing can be used to weigh, cell health dynamic blebs specify healthy cells and apoptotic blebs show dying cells. The capability to examine rates of bleb expansion and retraction are significant in the field of toxicology and might form the base of an assay that hinge on a functional cytoskeleton.

The biologists effort to elucidate the dissimilarity between healthy and dying cell blebbings in hESC by equating the time of their occurrences. Blebbing is considered to be associated to signalling pathways. It is noteworthy for biologists to have adequate indication to govern whether Calcium, P2_ 7 and ATP inhibitors can converse the behaviour of blebbing through the Rho-Rock Pathway or not. Inhibitors can adjust blebbingbehavior by either hindering the pathway leading to myosin activation or constrain myosin directly.

The bleb enlarges due to cytoplasmic pressure until polymerization of actin underneath the sheath reduces bleb development and can ultimately cause bleb retraction. Hence blebs are diverse from other cellular protrusions, such as lamellipodia or filopodia where the membrane is pushed onward by actin filament polymerization. Bleb formation is well-known to happen during apoptosis, but is experiential in dynamic cells during cytokinesis, migration and spreading. Even though non-apoptotic blebbing has been informed in stem cells, no preceding studies have inspected the biomechanics of bleb formation in stem cells.

Factors

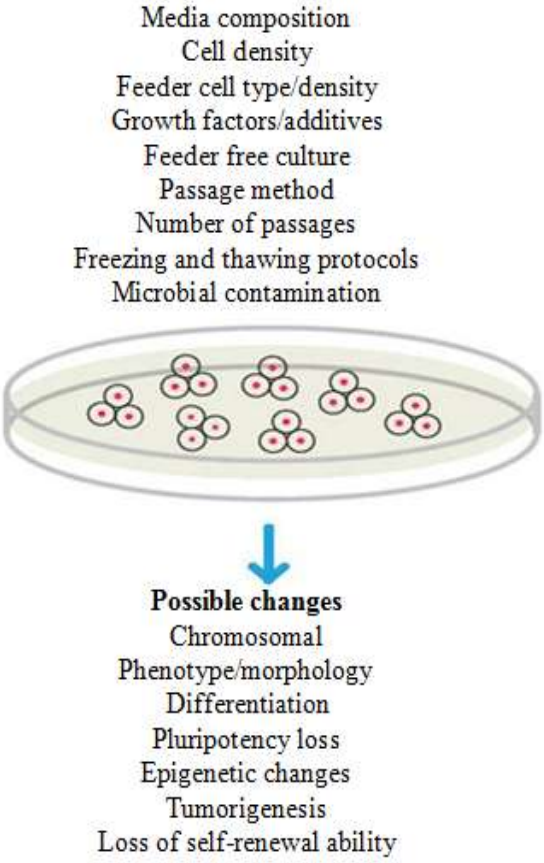

Figure 3 shows the sequences of both bleb expansion and retraction. Two separate phases make up the lifespan of a bleb, each of which has their own biology and physics. During expansion, bleb size rises, while cell

physique size reduces which lasts;30s. In contrast, during bleb retraction, bleb size reduces while cell body size grows, which lasts;2 min. The intermediate bleb specifies that switches from expansion to retraction are occurring. The intermediate bleb has the full bleb size in complete bleb formation procedures.

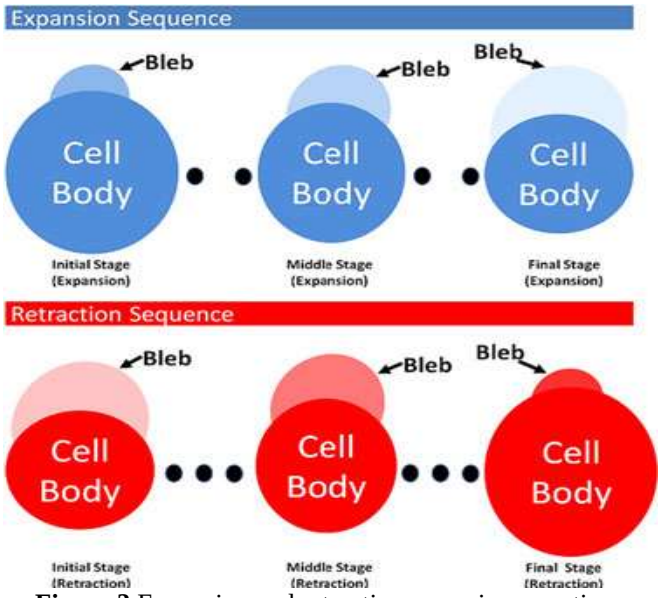

Figure 3. Expansion and retraction occurring over time

IV. ACTIVE CONTOUR

Active contours or snakes are used broadly for image processing and segmentation applications, mainly to trace object boundaries.It can attain the segmentation results near to the object contours, which can be appropriately used for analysis and recognition of the object shape. The active contours exploit numerous types of previous knowledge, such as intensity distribution information of the image, information about the boundary shape, and texture information, to attain accurate results for object boundaries in image analysis.

It can be characterized as region-based models or edge-based models. Edge-based segmentation seems for breaks in the image intensity. Region-based segmentation seems for homogeneity within a sub-region; under desired property, e.g. intensity, color, and texture. Instinctive interpretation of images is a very tough problem in computer vision. Numerous ways are developed in past decade to enhance the segmentation performance in computer vision. Our approach is based in the active contour algorithm with the region based segmentation.

The following energy functional for calculating the snake energy:

$$E_{snake} = E_{intern\ al} + E_{external} + E_{constraint} \quad (1)$$

Snake energy ($\mathbf{E_{snake}}$) contains of three terms. Eint denotes the internal energy of the snake while Eimg represents the image forces, Econ represents external constraint forces.

Internal Energy (Eint) hinges on the inherent properties of the curve and is the addition of elastic energy and bending energy, which is given in equation

$$E_{int} = E_{elastic} + E_{bending} \quad (2)$$

$$E_{int} = \int \frac{1}{2}(\alpha|v_s|^2 + \beta|v_{ss}|^2)ds \quad (3)$$

Where α(s) and β(s) are user defined weights.

External energy (Eext) of the contour is derived from the image.

$$E_{ext} = \int E_{image}\,(v(s))ds(4)$$

Image energy (Eimage) is function of the features of the image.

$$E_{image} = w_{line}\,E_{line} + w_{edge}\,E_{edge} + w_{term}\,E_{term}\ (5)$$

w_{line} , w_{edge} , w_{term} are the weight of salient features.

V. CUCKOO SEARCH ALGORITHM

Cuckoo search is an optimization algorithm, which is inspired from brooding parasitism of cuckoo species in nature with of Lévy flight behaviour. It is used to resolve structural optimization problem. Two

important features as follows: 1) Intensification, 2) Diversification. Intensification expects to examine about current best solution and choose the best applicants or results. Diversification makes define that the algorithm can discover the search space more effectively, by randomization.Cuckoo Search is a metaheuristic algorithm developed by Yang and Deb. Heuristic is an optimization technique intended for resolving a problem hurriedly when conventional approaches are too slow, or when it cannot find the exact solution. Metaheuristic optimization is a genetic algorithm and heuristic is the application.

Cuckoo search algorithm is better than other algorithm such as PSO and GA by solving the problem in a quick manner, resolving larger problem, attaining robust algorithm and a small number of parameters are required for fine tuning. The female cuckoo relies on the other host birds to raise their young. If the eggs of the cuckoo in the host bird nest are revealed, the host bird may throw away or her nest will be abended and raise her own brood somewhere else. In the CS algorithm, each egg in the host bird nest characterizes a solution, and a cuckoo egg signifies a new solution. If a new solution is better than nest available, it will replace the worst one. If there is a large search space, Levy flight are typically supplementary efficient. It is a distance approach could optimize efficient search under definite condition and the undertaking parameter are firmed by the power law. Law of Lévy flight revealed that random-walk style search is better implemented rather than simple random walk.

Three rules of the CS algorithm are defined as follows:
1) One egg is laid by each cuckoo at one time and randomly the nest has been chosen to dump their egg.
2) High quality of egg can be moved on to the further generation with the better nest.
3) The integer of existing host nests is stationed, and the cuckoo eggs are learned with a probability $pa \in (0, 1)$ of the host bird.

VI. IMPLEMENTATION RESULT

The video frames are phase contrast images. Each video was captured using 2 x objectives with 512x512 resolutions. Each video frame is acquired at 0.1 seconds time interval. The input video is shown in figure.

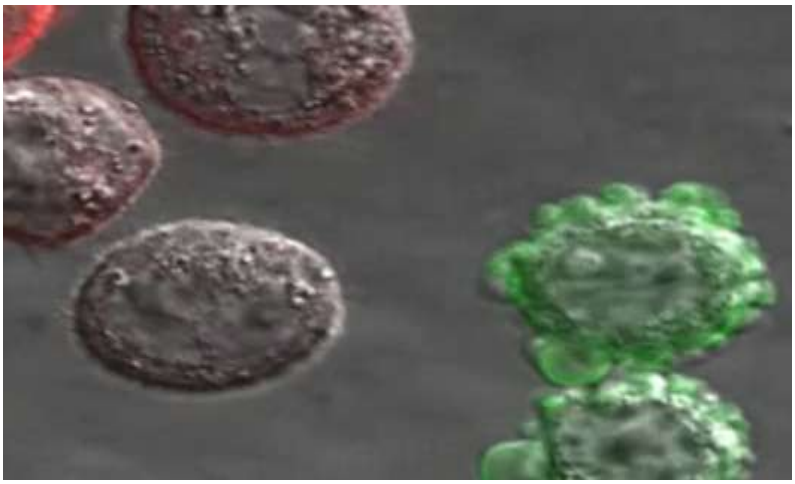

Figure 4. Input stem cells

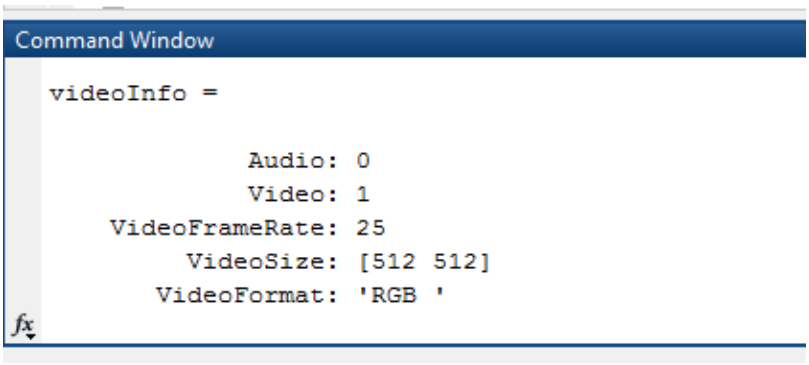

Figure 5. Video information in command window

The command window gives information about the video format; here 25 frames were obtained per interval. The video is acquired in color format which is not effective for image processing. HSV is very useful in image processing applications. The color information is typically noisy than the HSV information. Henceforth RGB can be altered into HSV.
Median filter is applied to clean the image from acquisition noise.
$v(m,n) = \text{median}\{y(m-k,n-l),(k,l) \in W\}$

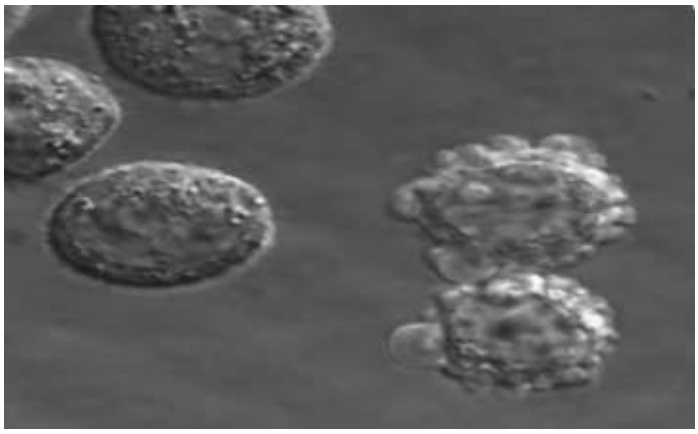

Figure 6. Preprocessed output

Region based active contour is used for extraction of blebs from human embryonic stem cells. The automatic changes in the topology of the image during the progression of the curve can be efficiently deal by this method. The image displays the thin white line which indicates the area of bleb region.

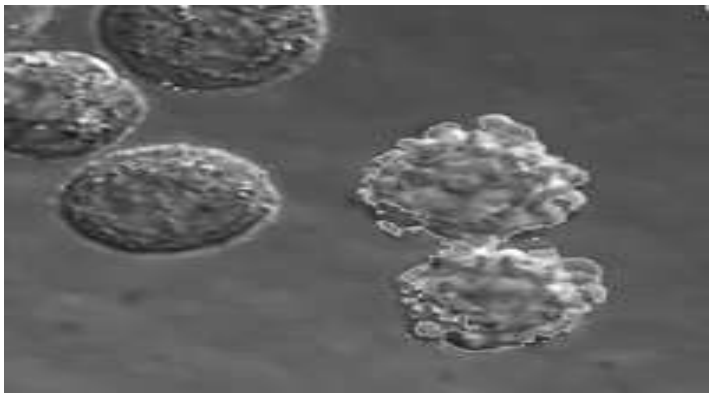

Figure 7. Segmented output

The optimization is a technique which enhances the quality of segmentation result. Cuckoo Search algorithm is applied on the segmentation result to find out the area of bleb region exactly.

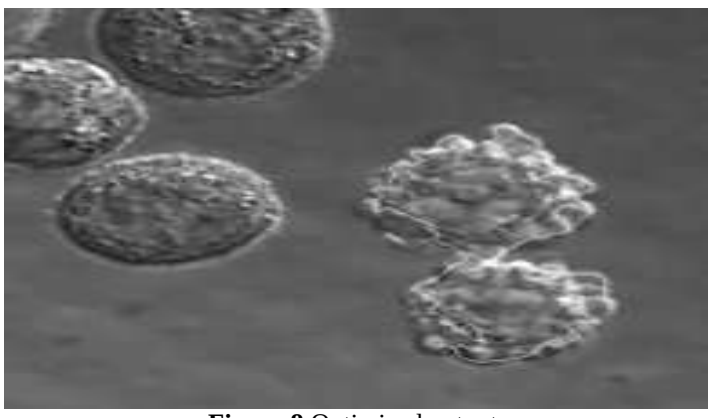

Figure 8. Optimized output

VI. CONCLUSION

The bio-optimized segmentation methods have better performances than their conventional counterparts. With the bio-inspired optimization metric, low performance due to over-segmentation is reduced. A new concept that the bleb formation/retraction process can be used as a biological indicator of cell health. Healthy cells retract their blebs back to the cell body, while non-healthy cells do not retract them or retract them slowly. Bleb area detection by active contour segmentation followed by cuckoo search optimization is implemented. The method yields high true positive rate white it gives low false positive rate. The method also matches the trend of the ground truth experiment closely. To improve the accuracy further, it is necessary to investigate into getting more frames per second to establish inter frame relationship for detecting small tiny bleb regions.

REFERENCES

[1]. H. J. RIPPON AND A. E. BISHOP, "EMBRYONIC STEM CELLS", CELL PROLIF., 37, 23–34, 2004.
[2]. Anne E. Bishop, Lee D. K. Buttery and Julia M. Polak , "Embryonic stem cells", J Pathol ; 197: 424–429, 30 May 2002 in Wiley InterScience (www.interscience.wiley.com).
[3]. Okabe M, Ikawa M, Kominami K, Nakanishi T, Nishimune Y. 'Green mice' as a source of ubiquitous green cells. FEBS Lett, ; 407: 313–319, 1997.
[4]. AtindriyaBiswas and Robert Hutchins, "Embryonic Stem Cells", Stem Cells and Development 16:213–221, 2007.
[5]. Pera MF and AO Trounson, "Human embryonic stem cells: prospects for development", Development 131: 5515–5525, 2004.
[6]. Martin F. Pera, Benjamin Reubinoff and Alan Trounson, "Human embryonic stem cells", Journal of Cell Science 113, 5-10, 2000.
[7]. Benjamin X. Guan, BirBhanu, Prue Talbot, and Nikki Jo-HaoWeng, "Extraction of blebs in human embryonic stem cells"IEEE transaction on biomedical and health informatics, vol. 13, no. 4, August 2016 .
[8]. G. T. Charras, et al.,"Life and times of a cellular bleb", Biophysical J., vol. 94, pp. 1836–1853, Mar. 2008.
[9]. J. Tinevez, U. Schulze, G. Salbreux, J. Roensch, J. Joanny, and E. Paluch, "Role of cortical tension in bleb growth," Proc. Nat. Acad. Sci. USA, vol. 106, no. 44, pp.18581–18586, Nov. 2009.
[10]. David A. Claassen, Michelle M. Desler, & Angie Rizzino, "ROCK inhibition enhances the recovery and growth of cryopreserved human embryonic stem cells and human induced pluripotent stem cells", Molecular Reproduction & Development 76:722–732, 2009.
[11]. WATANABE K, UENO M, KAMIYA D, NISHIYAMA A, MATSUMURA M, WATAYA T, TAKAHASHI JB, NISHIKAWA S, NISHIKAWA S, MUGURUMAK, SASAI Y., "A ROCK INHIBITOR PERMITS SURVIVAL OF DISSOCIATED HUMAN EMBRYONIC STEM CELLS", NAT BIOTECHNOL 25: 681–686, 2007.
[12]. ODESSA YABUT AND HAROLD S. BERNSTEIN, "THE PROMISE OF HUMAN EMBRYONIC STEM CELLS IN AGING- ASSOCIATED DISEASES", AGING, VOL 3, NO 5, MAY 2011.
[13]. CLARK AT, BODNAR MS, FOX M, ET AL. HUM MOL GENET; 13:727–739, 2004.
[14]. Wobus, A. M., and Boheler, K. R., "Embryonic stem cells: Prospects for development biology and cell therapy", Physiol. Rev. 85, 635–678, 2005.
[15]. Lisa M Hoffman & Melissa K Carpenter, "Characterization and culture of human embryonic stem cells", Nature Biotechnology, Vol. 23, No.6, June 2005.
[16]. Gavin L. Bates &SaeidNooshabadi, "FPGA Implementation of a Median Filter", IEEE TENCON - Speech and Image Technologies for Computing and Telecommunications, 1997.
[17]. T. S. Huang, G. J. Yang and C. Y. Tang, "A fasttwo-dimensional median filtering algorithm", IEEETrans.Acoustic Speech and Signal Processing, ASSP-28, pp. 415-421, Aug. 1980.
[18]. M 0. Ahmed and D. Sundararajan, "A fast algorithm for two-dimensional median filtering", IEEE Trans.On Circuits and Systems, CAS-34, pp. 1364-1375, NOV. 1987.
[19]. J. T. Astolla and G. Campbell, "On computing of running median", IEEE Trans. Acoustic Speech and Signal Processing, ASSP-37, pp.572-574, Apr. 1989.
[20]. L. A Christopher, W. T. Mayweather and S. S. Perlman, "VLSI median filter for impulse noise elimination in composite or component TV signals", IEEE Trans. on Consumer Electronics, vol34, no. 1, pp. 263-267, 1988.
[21]. Patrenahalli M. Narendra, Member, IEEE, "A Separable Median Filter for Image Noise", IEEE Transactions On Pattern Analysis And Machine Intelligence, Vol. Pami-3, No. 1, January 1981.
[22]. M. Kass, A. Witkin, and D. Terzopoulos, "Snakes: active contour models", Int. J. Comput. Vis., Vol.1, No.4, pp.321–331, Apr. 1987.
[23]. A. Gooya, H. Liao, K. Matsumiya et al., "A variational method for geometric regularization of vascular segmentation in medical images", IEEE Trans. Image Process., Vol.17, No.8, pp.1295-1311, Aug. 2008.
[24]. V. Caselles, R. Kimmel, and G. Sapiro, "Geodesic active contours", International Journal of Computer Vision, Vol.22, No.1, pp.61–79, Feb. 1997.
[25]. T. Chan and L. Vese, "Active contours without edges", IEEE Trans. Image Process., Vol.10, No.2, pp.266–277, Feb. 2001.
[26]. C. Li, C. Kao, J. Gore et al., "Minimization of region-scalable fitting energy for image segmentation", IEEE Trans. Image Process., Vol.17, No.10, pp. 1940-1949, Oct. 2008.
[27]. Y. Zheng, G. Li, X. Sun et al., "Geometric active contours without reinitialization for image segmentation",

Pattern Recognition, Vol.42, No.9, pp.1970-1976, Sep. 2009.
[28]. R. Malladi, J. A. Sethian and B. C.Vemuri, "Shape modeling with front propagation: a level set approach," IEEE Trans. Pattern Anal. Mach. Intell., Vol.17, No.2, pp.158–175, Feb. 1995.
[29]. C. Li, C. Xu, C. Gui et al., "Level set evolution without reinitialization: A new variational formulation," in Proc. IEEE Conf. Computer Vision and Pattern Recognition, 2005, Vol. 1, pp.430–436.
[30]. O. Michailovich, Y. Rathi, and A. Tannenbaum, "Image segmentation using active contours driven by the bhattacharyya gradient flow," IEEE Trans. Image Process., Vol.16, No.11, pp.2787–2801, Nov. 2007.
[31]. Y. Xiang, A. Chung and J. Ye, "An active contour model for image segmentation based on elastic interaction", J. Compt. Phys., Vol.219, No.1, pp.455-476, Nov. 2006.
[32]. C. Li, C. Kao, J. Gore et al., "Implicit active contours driven by local binary fitting energy," in Proc. IEEE Conf. Computer Vision and Pattern Recognition, 2007, Vol.1, pp.1–7.
[33]. Abhinav Chopra and Bharat RajuDandu, "A Comprehensive Active Contour Model", International Journal of Computer Applications (0975 – 8887), Volume 49– No.13, July 2012.
[34]. Soppannappa and Virupakshappa, "A Novel Geometric Snake Model for Medical Image Segmentation", IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 6, June 2015.
[35]. Tian Yun, Zhou Ming-quan, Wu Zhong-ke, Wang Xing-ce, "A Region-based Active Contour Modelfor Image Segmentation", International Conference on Computational Intelligence and Security, 2009.Amit, M., Carpenter, M.K., Inokuma, M.S., Chiu, C.P., Harris, C.P., Waknitz, M.A. Itskovitz-Eldor, J., and Thomson, J.A. (2000). Clonally derived human embryonic stem cell lines maintain pluripotency and proliferative potential for prolonged periods of culture. Dev. Biol. 227,271-278.
[36]. Benjamin X. Guan, BirBhanu, Prue Talbot, and Nikki Jo-HaoWeng, "Extraction of blebs in human embryonic stem cells"IEEE transaction on biomedical and health informatics, vol. 13, no. 4, August 2016 .
[37]. Yuncheng Du, Hector M. Budman, Thomas A. Duever, "Segmentation and Quantitative Analysis of Normal and Apoptotic Cells from Fluorescence Microscopy Images" Elsevier international federation of automatic control, vol. 49, June 2016.
[38]. Ngaam J. Cheung, Xue-Ming Ding, and Hong-Bin Shen, "A Nonhomogeneous Cuckoo Search Algorithm Based on Quantum Mechanism for Real Parameter Optimization" IEEE transaction on cybernetics, Jan 2016.
[39]. Benjamin X. Guan, BirBhanu, Prue Talbot, and Sabrina Lin, "Bio-Driven Cell Region Detection in Human Embryonic Stem Cell Assay" IEEE transactions on computational biology and bioinformatics vol. 11, no. 3, June 2014.
[40]. B.X. Guan, B. Bhanu, P. Talbot, and S. Lin, "Automated Human Embryonic Stem Cell Detection," Proc. IEEE Second Int'l Conf. Healthcare Informatics, Imaging and Systems Biology, pp. 75-82, Sept. 2012.
[41]. E.Meijering, "Cell segmentation: 50 years down the road [life sciences],"IEEE Signal Process.Mag., vol. 29, no. 5, pp. 140–145, Sep. 2012.
[42]. B. X. Guan, B. Bhanu, P. Talbot, and S. Lin, "Detection of nondynamicblebbing single unattached human embryonic stem cells," in Proc. IEEE Int. Conf. Image Process., Sep. 2012, pp. 2293–2296.
[43]. B. X. Guan, B. Bhanu, P. Talbot, and S. Lin, "Automated human embryonic stem cell detection," in Proc. 2nd IEEE Int. Conf. Health Informat., Imag. Syst. Biol., Sep. 2012, pp. 75–82.
[44]. Getreuer, P., 2012. Chan-Vesesegmentation.Image processing online, Volume 2, pp. 214-224.
[45]. Z. Yin, R. Bise, T. Kanade, and M. Chen, "Cell segmentation in microscopy imagery symposium on biomedical imaging," in Proc. Int. Symp.Biomed.Imag., 2010, pp. 125–128.
[46]. G. T. Charras, et al., "Life and times of a cellular bleb," Biophysical J., vol. 94, pp. 1836–1853, Mar. 2008.
[47]. Chan, T. F. &Vese, L. A., 2001. Active contours without edges. IEEE Transactions on Image Proceessing, 10(2), pp. 266-277.