Dynamic Contrast Enhanced (DCE) MRI : Hierarchical Clustering-based Segmentation (HCS) as an aid to diagnosis

SELVAN, Arul <http://orcid.org/0000-0001-9222-5538> and WRIGHT, Chris

DCE MRI : Hierarchical Clustering-based Segmentation as an aid to diagnosis

Dr. Arul N. Selvan[1] and Dr. Chris Wright[2]

[1]Materials and Engineering Research Institute, Sheffield Hallam University, UK (a.n.selvan@shu.ac.uk)
[2]Health and Well-Being, Sheffield Hallam University, UK (chris.wright@shu.ac.uk)

BACKGROUND

Dynamic Contrast Enhanced Magnetic Resonance Imaging (DCE-MRI) has become an important component in the diagnostic imaging pathway and is emerging as a useful clinical technique for evaluating the severity, location, and extent of primary and recurrent cancer.

DCE-MRI typically generates around 30 images per section and image interpretation requires substantial experience to detect and categorize lesions.

Tissue abnormality is usually related to a dissimilar part of an otherwise homogeneous image. Choosing the optimal post processing threshold value can be difficult because the image composition may vary depending on the acquisition parameters and the type of tissue.

Hierarchical Clustering-based Segmentation (HCS) is an approach to Computer Aided Monitoring (CAM) that enables a user to define a region of interest and the process generates a hierarchy of segmentation results to highlight the varied dissimilarities that might be present.

This new HCS process based CAM system offers a versatile and flexible environment by allowing the user to derive the maximum benefit from the computational capability (perception) of the machine. At the same time, the user is able to incorporate their own interpretation in the appropriate place and thus limit the machine's interpretive function to achieve a complementary synthesis of both computer and human strengths [1].

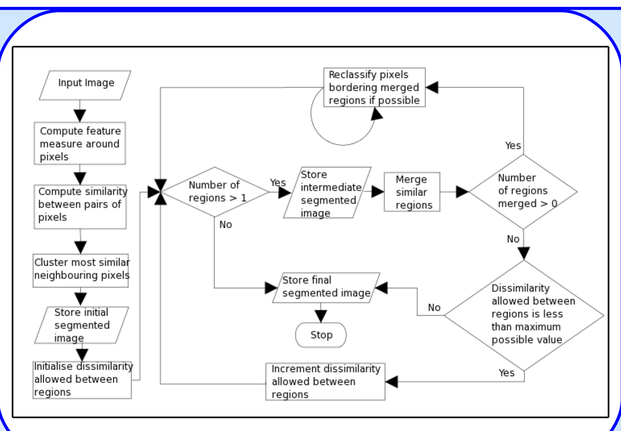
Hierarchical Clustering-based Segmentation (HCS)

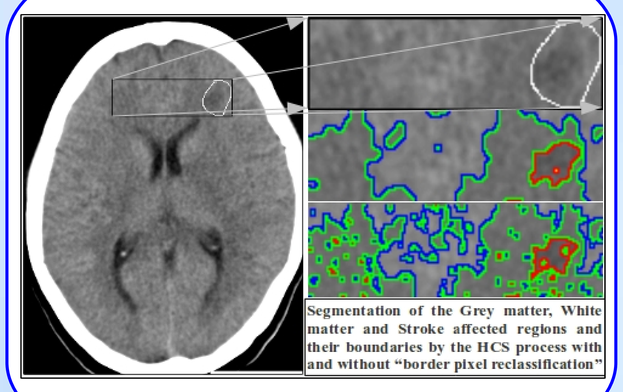
Hierarchical Clustering-based Segmentation (HCS) implements the traditional bottom-up approach of agglomerative clustering, where the regions of an initial partition are iteratively merged. HCS automatically generates a hierarchy of segmented images.

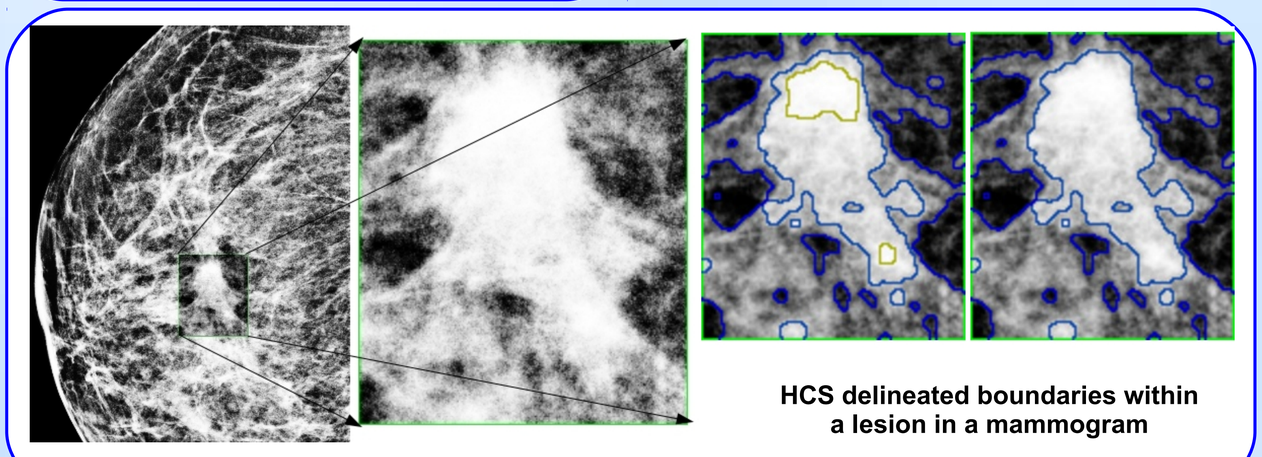
The hierarchy of segmented images is generated by partitioning an image into its constituent regions at hierarchical levels of allowable dissimilarity between its different regions. At any particular level in the hierarchy, the segmentation process will cluster together all the pixels and/or regions which have dissimilarity among them less than or equal to the dissimilarity allowed for that level.

A unique operation of the HCS process is the border pixel reclassification. Border pixel reclassification aides in overriding local inhomogeneity while clustering similar regions.

The algorithmic diagram, on the right, illustrates the overall operation of the HCS process [2].




Segmentation of the Grey matter, White matter and Stroke affected regions and their boundaries by the HCS process with and without "border pixel reclassification"

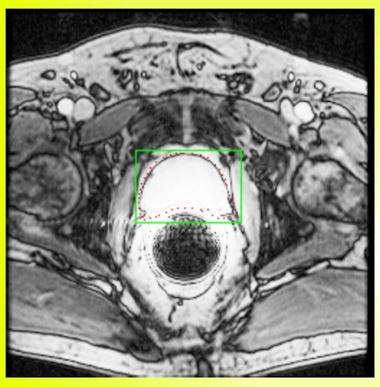

HCS delineated boundaries within a lesion in a mammogram

REFERENCES

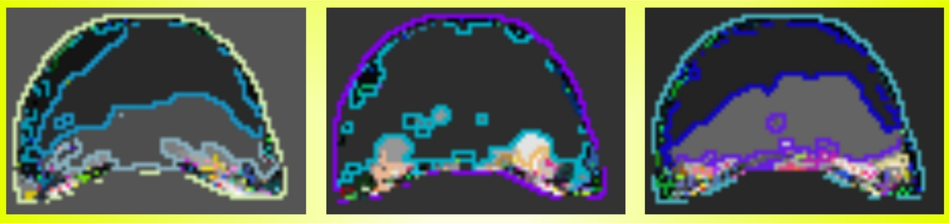
1. A. N. Selvan, "Hierarchical Clustering-based Segmentation (HCS) Aided Diagnostic Image Interpretation and Monitoring" Doctoral dissertation, Faculty of Arts Computing Engineering and Sciences Sheffield Hallam University, Sheffield, UK, 2012
2. A. N. Selvan, "Highlighting Dissimilarity in Medical Images Using Hierarchical Clustering-based Segmentation (HCS)" M. Phil. dissertation, Faculty of Arts Computing Engineering and Sciences Sheffield Hallam University, Sheffield, UK, 2007

HCS PROCESS BASED COMPUTER AIDED MONITORING

As a diagnostic aid for the analysis of DCE-MRI image data, the process starts with the user defining a rough region of interest (ROI) on a section/slice of choice. Within the user defined ROI, the HCS process is applied to all the DCE-MRI temporal frames of the slice. HCS process output provides heat map images based on the normalised average pixel value of the various dissimilar regions within the ROI. Time intensity curves of the contrast wash-in, wash-out process are then plotted for suspicious regions confirmed by the user.

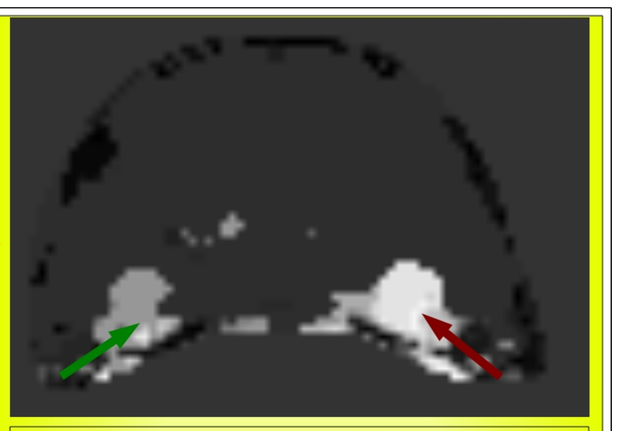


Using user given approximate locations the ROI is identified

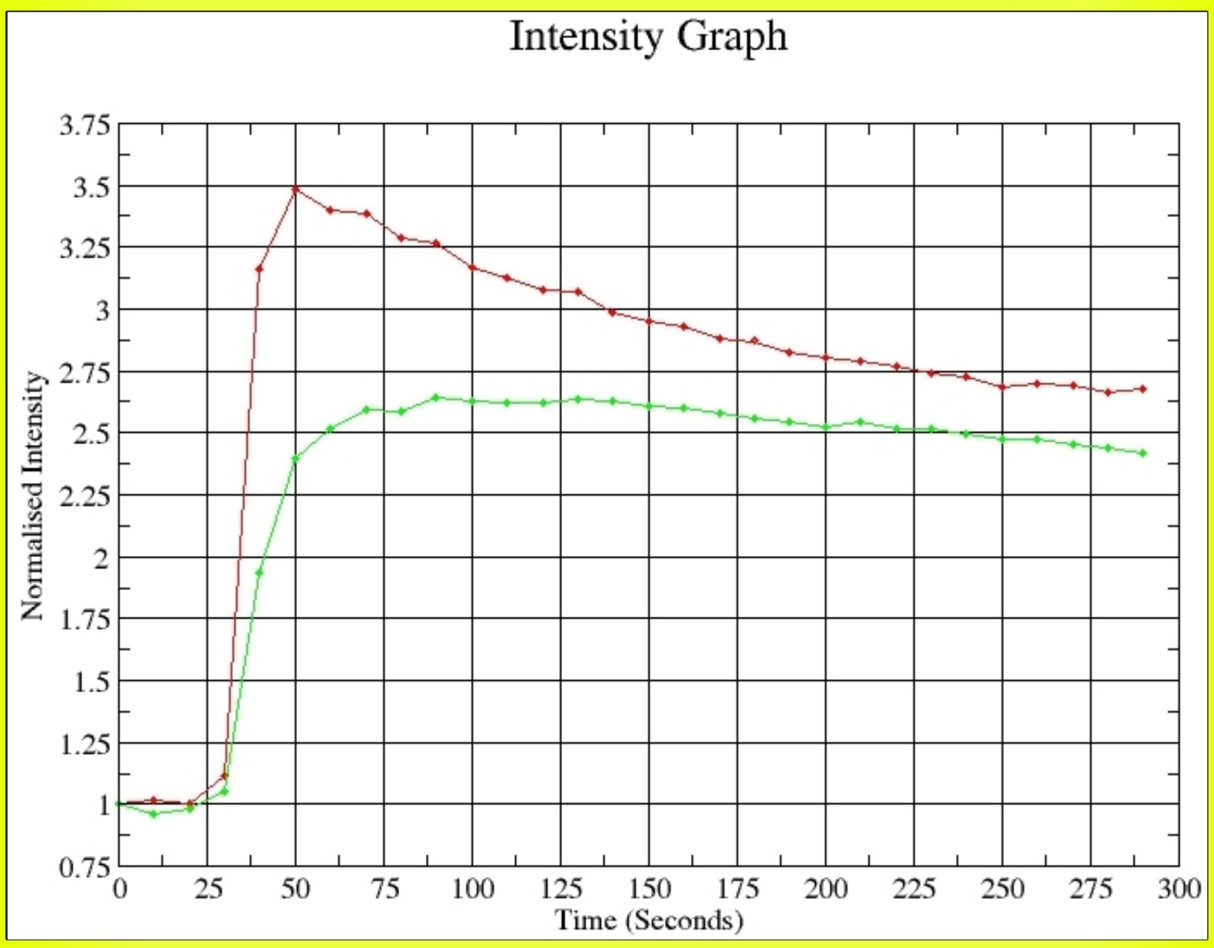


Within the ROI the HCS process is applied to all the temporal frames of the section.

A hierarchy of segmented images are generated by partitioning each of the temporal frame into its constituent regions at hierarchical levels of allowable dissimilarity between the regions.



Using the HCS process output user identifies dissimilar areas of interest in a temporal frame (arrow heads)

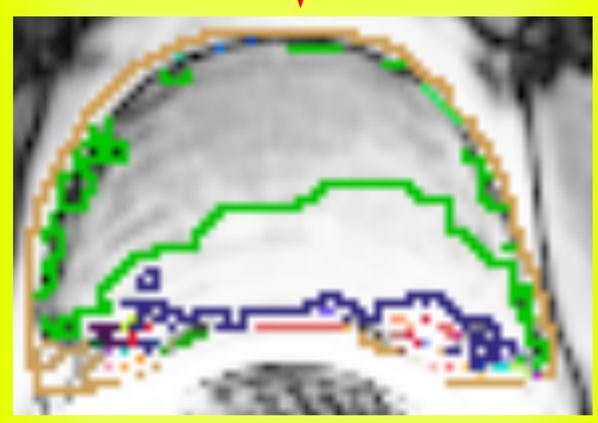


As a quantitative diagnostic aid : To objectively visualise the effect of the contrast agent the normalised average pixel value of the pixels, within the user identified areas, are estimated across the temporal frames and shown as a graph.

As a qualitative diagnostic aid : Helps the user to visualise the varied dissimilar regions

Plots show the contrast wash-in and wash-out for user identified areas of interest.

For probable tumour region, plot (red) shows earlier onset, shorter time to peak, high peak, and faster washout.



CONCLUSION

Early results suggest that the HCS process based Computer Aided Monitoring (CAM) system offers increased capability to differentiate suspicious areas by combining users' expertise and computer system's processing capability. The application, using border pixel reclassification to highlight key areas, is particularly useful at the point of first diagnosis because lesions are commonly not solitary in nature, which can result in an incomplete treatment regime and affect prognosis; and also in monitoring the effects of drugs or radiotherapy. New clinical partners are sought in order to develop larger scale trials.

A.N.Selvan@shu.ac.uk