Tumour Detection By Volumetric Image Analysis

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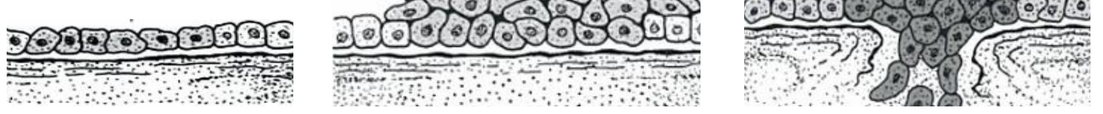
OBJECTIVE:

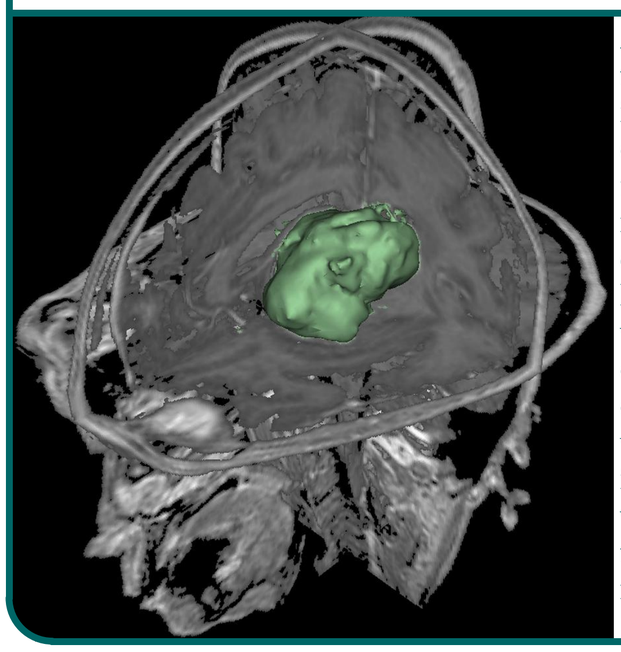
This research review covers techniques available for detecting tumours in the human body with respect to practical implications in image processing and machine learning. An architecture is proposed in order to give direction to research and to allow consideration of stage interaction. Normal conventions are followed but as targeted towards medical review a sub-module is included that provides confidence information for a domain expert. Volumetric image analysis techniques for pre-processing and feature extraction are reviewed followed by methods for feature selection and classification.

Tumour Features

All types of tumours are areas for concern. Fig. 4 shows an initial accelerated growth rate producing a benign tumour which eventually becomes malignant as it spreads to nearby tissue. Benign tumours and carcinomas in situ can be easily removed by surgery.



Pre-Processing



Anisotropic diffusion is a powerful technique used to enhance images where it is possible to remove noise yet retain clear edges. The technique has been expanded from common 2D applications to 3D medical usage on MRI data [19]. The diffusion effect has the same outcome as a low pass filter with reasonably adjusted values for resolution, □t, and the decay constant, k. The spatial scaler decay constant is a function of the image and time which must preserve edges by setting iterative approach is provided in Eq. (6) where the original image is the value of I at time zero. Iteration monitoring and reasonable scalar values in the

Feature Extraction

The active contour model is a method for flexible shape extraction and has been thoroughly trialled in 2D [18]. Volumetric implementations are state of the art and have been successfully applied to prostate, nerve fibre and artery segmentation [22]–[24]. These are not pure active contours and emulate behave by segmenting 2D regions then using volumetric growth algorithms to actively converge upon a 3D shape. This works for certain parts of human anatomy but typically known geometry is required to influence the growing algorithm. Pure active contours could improve performance and using current research it is possible to expand dimensionality. The surface is defined as v(r; s) = [x(r; s); y(r; s); z(r; s)] where r; s 2 [0; 1]. Surface energy is defined as Eq. (8) where the objective is minimisation of internal, external and constraint functions with respect to the entire surface [18], [22]. The internal energy is measured using the first and second order differentials of the surface contour. Eq. (9) describes internal energy with two parametric functions chosen prior to fitting. These control elasticity, , and stiffness, , of the contour.

Feature Selection

Commonly large datasets contain some features in the input space will be have no effect upon or even reduce the performance of a classifier. It is naive to use just the raw image data. Tumour features for extraction have been considered in section III which already removes some redundant information. Mapping input data into a lower dimensional space is possible and can improve performance but if ill-applied can remove key features. A brute-force approach would find the optimal combination of features but the input space is expected to be too large, 2n is a challenge even moderate value of n, to be completely shattered within reasonable execution time. A. Sequential Floating Search (SFS) This heuristic algorithm uses feature subsets and has been applied to tumour classification [3]. It is possible to start from either the full or empty set of features then iteratively add and remove features to improve the performance of the classifier. A performance function is required for feature set comparison. Listing 1 contains the algorithm starting from an initial subset of no features and repeated until convergence.

Classification

Classification must differentiate between extracted geometric shapes that are expected and those which may potentially be tumours. Tumours will also be attached to normal internal body parts so the classifier must be able to handle any abnormalities in organs. Supervised techniques for classification are considered even though datasets have not yet been sourced. A. Artificial Neutral Networks (ANNs) ANNs contain summation nodes where data is propagated through weighted connections towards an output. As a supervised technique weights are trained by propagating the error backwards through the network. Multilayer nets can provided non-linear separation functions and increasing the number of layers only increases possible function complexity. Neural networks have been applied successfully to classification of brain tumours [27]. Eq. (12) is an example of a two layer network with an n dimensional input space and m hidden nodes. A tanh activation function is used on the output of the hidden nodes but only the sign is used for the binary classification task. There is also a scalar offset, b, on the output and an offset vector, c, on the hidden layer.

CONCLUSIONS:

The confidence analysis unit will take noise information from the initial image by differencing the input and output of the pre-processing stage. In feature extraction it can report on the quantity of shape extraction from an image. Dimensionality reduction will have no output as the reduction value is tuned prior to deployment. The binary classifier also has a non-discrete output before hard thresholding which can used be used as a measure of confidence. This can also be used to adaptively control the number of boosting rounds.

This research review has provided a recommendation for population of a convectional image processing architecture ending with standard a machine learning approach. Volumetric techniques for pre-processing and feature extraction have been reviewed extensively. Cutting edge implementations have been considered for anisotropic diffusion along with active surface contours which have

Confidence Analysis

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References

[1] G. Lohmann, *Volumetric Image Analysis*, 1st Edition, Wiley, 1998.

[2] Eggar et al., *GBM Volumetry using the 3D Slicer Medical Image Computing Platform, CoRR,* 2013.

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