
ABSTRACT

Ultrasound scan is one of the most reliable imaging for detecting/diagnosing of gynaecological abnormalities. Ultrasound imaging is widely used during pregnancy and has become central in the management of the problems of early pregnancy, particularly in miscarriage diagnosis. Also, ultrasound is considered as the most important imaging modality in the evaluation of different types of ovarian tumours.

The early detection of ovarian carcinoma and miscarriage continues to be a challenging task. It mostly relies on manual examination, interpretation by gynaecologists, of the ultrasound scan images that may use morphology features extracted from the region of interest. Diagnosis depends on using certain scoring systems that have been devised over a long time. The manual diagnostic process involves multiple subjective decisions, with increased inter- and intra-observer variations which may lead to serious errors and health implications.

This thesis is devoted to developing computer-based tools that use ultrasound scan images for automatic classification of Ovarian Tumours (Benign or Malignant) and automatic detection of Miscarriage cases at early stages of pregnancy. Our intended computational tools are meant to help gynaecologists to improve the accuracy of their diagnostic decisions, while serving as a tool for training radiology students/trainees on diagnosing gynaecological abnormalities. Ultimately, it is hoped that the developed techniques can be integrated into a specialised gynaecology Decision Support System.

Our approach is to deal with this problem by adopting a standard image-based pattern recognition research framework that involves the extraction of appropriate feature vector modelling of the investigated tumours, select appropriate classifiers, and test the performance of such schemes using sufficiently large and relevant datasets of ultrasound scan images. This thesis is aim to complement the automation of certain parameters that gynaecologist experts and radiologists determine manually, by image-content information attributes that may not be directly accessible without advanced image transformations. This is motivated by, and benefit from, advances in computer vision that led the emergence of a variety of image processing/analysis techniques together with recent advances in data mining and machine learning technologies.

An expert observer makes a diagnostic decision with a level of certainty, and if not entirely certain about their diagnostic decisions then often other experts' opinions are

sought and may be essential for diagnosing difficult “Inconclusive cases”. Here I defined a quantitative measure of confidence in decisions made by automatic diagnostic schemes, independent of the accuracy of a decision.

In the rest of the thesis it is reported the development of a variety of innovative diagnostic schemes and demonstrate their performances using extensive experimental work. The following is a summary of the main contributions in this thesis.

1. Developed enhancement methods for ultrasound images, using a combination of spatial domain filters and operations as pre-processing procedures to enhance ultrasound images for both applications, namely miscarriage identification and ovarian tumour diagnosis. The results show that the Non-local means filter is effective in reducing speckle noise from ultrasound images, and together with other filters. This method succeeds in enhancing the inner border of malignant tumours and reliably segmenting the gestational sac.
2. Developed reliable automated procedures to extract several types of features to model gestational sac dimensional measurements, few of which are manually determined by radiologist and used by the gynaecologists to identify miscarriage cases. I demonstrate that the corresponding automatic diagnostic schemes yield excellent accuracy when classified by the k-Nearest Neighbours.
3. Developed several local as well as global image-texture based features in the spatial as well as the frequency domains. The spatial domain features include the local versions of image histograms, first order statistical features and versions of local binary patterns. From the frequency domain, I propose a novel set of Fast Fourier Geometrical Features that encapsulates the image texture information that depends on all image pixel values. I demonstrate that each of these features define Ovarian Tumour diagnostic scheme that have relatively high power of discriminating Benign from Malignant tumours when classified by Support Vector Machine. The result show that the Fast Fourier Geometrical Features are the best performing scheme achieving more than 85% accuracy.
4. Introduced a simple measure of confidence to quantify the goodness of the automatic diagnostic decision, regardless of decision accuracy, to emulate real life medical diagnostics. Experimental work in this thesis demonstrates a strong link between this measure and accuracy rate, so that low level of confidence could raise an alarm.

5. Conducted intensive investigations of fusion models of multi-feature schemes at the different level. I show that feature level fusion yields degraded performance compared to all its single components, while score level fusion results in improved results and decision level fusion of three sets of features using majority rule is slightly less successful. Using the measure of confidence is useful in resolving conflicts when two sets of features are fused at the decision level. This leads to the emergence of a *Not Sure* decision which is common in medical practice. Considering the Not Sure label is a good practice and an incentive to conduct more tests, rather than misclassification, which leads to significantly improved accuracy.

The thesis concludes with an intensive discussion on future work that would go beyond improving performance of the developed scheme to deal with the corresponding multi-class diagnostics essential for a comprehensive gynaecology Decision Support System tool as the ultimate goal.