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Master of Science Thesis

Ultrasound Image Processing and Analysis Framework

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Extended Abstract

In the field of analysis and processing of medical images a variety of technologies have been introduced enabling improved quality and sensitivity for the representation of human organs and tissues. A variety of methods are available for the representation of inner structures of human body including Ultrasonography, Nuclear Medicine, ElectroCardiographic Imaging, Tomography, Magnetic Resonance Imaging, Positron Emission Tomography. In recent years Ultrasonography evolved to a quite valuable imaging modality, combining virtues such as ease of use, low cost, safe, non invasive and fast examination. Ultrasonography has been proved effective for the examination of various tissues of human body including thyroid, breast and prostate.

Since the early 80s' a variety of image analysis methods for texture characterization of tissue on ultrasound images have been introduced. Initially attempts towards less subjective techniques for the evaluation of ultrasound images were based on first-order statistical texture features. Local grey level histograms [1] have been utilized in some of the first studies to measure local textural information in ultrasound images. Latter studies on ultrasound images suggested spatial features based on the original pixel greylevels and on transformations of them such as gradient magnitude, vertical curvature and horizontal curvature [2]. More recent studies proposed statistical features extracted from the co-occurrence matrix [3] for the texture characterization of US images. Also other approaches suggested features extracted by a modern kind of transform, the wavelet transform [4], which has been shown to be as powerful and versatile as the Fourier transform, yet without some of its limitations. Textural information encoded by means of Local Binary Patterns (LBP) [5], has also been applied to detect uniform texture patterns on ultrasound images. However, their

performance has been seriously affected by uncertainty and noise appearing in ultrasound images. On those grounds different approaches for the fuzzification of the LBP approach have been explored in this thesis, resulting in the proposition of fuzzy LBP features.

An integrated framework, named "*Experimental Image Processing & Analysis Framework*" (EIPAF), has been developed for the exploration of modern image analysis methodologies and their experimental application on real ultrasound images. Such experimental evaluation includes discreet phases such as image preprocessing, feature extraction, selection and classification. A set of different parameters play important role in each phase, majorly affecting the final result. EIPAF framework incorporates in six discreet and independent phases the necessary functionalities for an image analysis study. These six phases are namely: color space transformation, image normalization, feature extraction, feature selection, feature classification, results processing and representation. A variety of different methods have been incorporated in each phase. Extra effort has been dedicated in order to build this framework based on properties such as functionality, usability, expendability, and the ability to be efficiently used for exhaustive experiments.

For the diagnosis and follow up of the thyroid cancer the most common imaging modality is the B-mode ultrasound. Due to the surface position of the thyroid gland high quality ultrasound grey scale images can depict its physiology, anatomy and a variety of pathological conditions with remarkable clarity and accuracy. For the experimental evaluation of different approaches in this thesis, a set of 145 thyroid ultrasound images (256x256 pixels) have been digitized from analog examination videos. Each image presents a longitudinal view of a thyroid lobe with none, one or more thyroid nodules. Images have been evaluated and thyroid nodules have been delineated by expert radiologists, for the discrimination between nodular and normal tissue.

Different approaches have been tested for feature extraction and the classification phases, in order to investigate performance of different methods combined for each experimental phase. For feature extraction phase seven approaches have been experimentally evaluated: Pixel Values of the image, Local Binary Patterns, Fuzzy Local Binary Pattern, Histogram Features, Wavelet Transform Features, Krishnan Features, and Concurrence Matrix Features. For the classification phase two classification approaches have been tested, Support Vector Machine [6] with linear and polynomial kernel functions and k-Nearest Neighbors classifier [1] with Euclidian and Histogram Intersection distances.

Extensive experiments showed that the best overall classification accuracy of 86.9% has been obtained with the fuzzy Local Binary Patterns features classified by the histogram intersection k-Nearest Neighbors classifier. For the case of the Support Vector Machine classifier the best classification accuracy of 80.1% has been acquired by the Wavelet Transform features. These results proved the effectiveness of the fuzzy Local Binary Patterns features for texture representation of inherently noisy US images. Additionally it has been observed that feature extraction approaches that form vectors of statistical distributions resulted in higher classification accuracies when combined with histogram intersection k-Nearest Neighbors classifier, while for the rest feature extraction approaches best results obtained with SVM classifier.

Future work based on this thesis could include the incorporation of more methodologies suitable for image processing and analysis of ultrasound images in each one of the six phases of the EIPAF. Additionally the fuzzy approach of the Local Binary Patterns could be further investigated and tested through the framework on natural texture images where noise can severally affect performance of common texture representation approaches.

References

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