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Morphometric information to reduce the semantic gap in the characterization of microscopic images of thyroid nodules

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ABSTRACT

Background: The analyses of several systems for medical-imaging processing typically support the extraction of image attributes, but do not comprise some information that characterizes images. For example, morphometry can be applied to find new information about the visual content of an image. The extension of information may result in knowledge. Subsequently, results of mappings can be applied to recognize exam patterns, thus improving the accuracy of image retrieval and allowing a better interpretation of exam results. Although successfully applied in breast lesion images, the morphometric approach is still poorly explored in thyroid lesions due to the high subjectivity thyroid examinations.

Objective: This paper presents a theoretical–practical study, considering Computer Aided Diagnosis (CAD) and Morphometry, to reduce the semantic discontinuity between medical image features and human interpretation of image content.

Method: The proposed method aggregates the content of microscopic images characterized by morphometric information and other image attributes extracted by traditional object extraction algorithms. This method carries out segmentation, feature extraction, image labeling and classification. Morphometric analysis was included as an object extraction method in order to verify the improvement of its accuracy for automatic classification of microscopic images.

Results: To validate this proposal and verify the utility of morphometric information to characterize thyroid images, a CAD system was created to classify real thyroid image-exams into Papillary Cancer, Goiter and Non-Cancer. Results showed that morphometric information can improve the accuracy and precision of image retrieval and the interpretation of results

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in computer-aided diagnosis. For example, in the scenario where all the extractors are combined with the morphometric information, the CAD system had its best performance (70% of precision in Papillary cases).

Conclusion: Results signalized a positive use of morphometric information from images to reduce semantic discontinuity between human interpretation and image characterization.

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1. Introduction

The thyroid gland is a two-lobed endocrine gland located in the lower front of the neck that regulates the function (metabolism, growth, and development) of many of the body's important organs [14,23,1]. The most common thyroid diseases are characterized by thyroid nodules which refer to the abnormal growth of thyroid cells, forming a lump within the thyroid gland [26,29,41]. The vast majority of thyroid nodules are noncancerous – only five percent of the nodules are malignant. Such nodules are categorized in four main varieties: Papillary, Follicular, Medullary and Anaplastic [7]. Palpable nodules are found in 4–7% of the adult population (with higher incidence among women and the elderly). That percentage increases to 19–67% in ultrasound examinations due to their higher accuracy [28]. These statistics justify the need for an accurate diagnosis before initiating the appropriate treatment of the patients.

Fine Needle Aspiration Biopsy (FNAB) is a biopsy exam used to evaluate thyroid nodules. A very thin needle is inserted into the thyroid nodule to aspirate the parenchymal cells into the needle. The collected sample is then spread onto the glass slide and stained for the microscopic examination of the cells [29,40]. This examination, called thyroid cytology, is typically complemented by a screening strategy for detecting or ruling out the presence of cancer. This kind of screening is based on the identification of cytological features of cancer affected cells, a strategy that may depend on the pathologist's experience and that may lead to an earlier diagnosis, over-diagnosis or misdiagnosis [16]. Therefore, the classification of cytological features by a clinician may vary from professional to professional. Recent efforts indicate the use of imaging-cytology to improve the precision of the diagnosis. For instance, imaging-cytology has been helping to reduce the number of false negative results of FNAB in thyroid nodules [39]. The complexity of analysis of cyto and histopathological images is due to many factors that hinder the diagnosis: (i) ROI selection cannot be well carried out, (ii) images cannot be well acquired, (iii) cell boundaries cannot be well-defined and (iv) tissues cannot be well prepared. Therefore the automatic analysis of this kind of image is desirable. A Computer-Aided Diagnosis (CAD) system can be used to automatically extract cytological features and distinguish the different types of nodules. Traditionally, these systems in medical imaging are developed using Image Processing and Content-Based Image Retrieval (CBIR) techniques and focus on the attributes of the images [13]. CAD systems can speed up the diagnostic process and allow for large-scale screening.

Some research groups advocate that the use of morphometric information can improve the accuracy of image retrieval and the interpretation of its result [16,17,34]. Morphometric information can be obtained using morphometric data analysis extracted from the cell nuclei in microscopic images. CAD systems can automatically carry out this task and help pathologists by providing useful information. Using this information, pathologists can detect a cancer or eliminate the suspicion of cancer, thus avoiding unnecessary procedures in benign tumors or increasing the accuracy of cancer diagnosis. Moreover, CAD systems can be used by pathologists as a second opinion system. In situations of early diagnosis, the 10-year survival rate of Papillary Thyroid Cancer happens in 95% of the cases and in 75% of the cases for people with Follicular Cancer. However, one of the largest challenges in the automatic analysis of cytological images is the segmentation of nuclei [25].

In an attempt to reduce the discontinuity between computerized retrieval of medical images and the human interpretation of its content, this paper presents a theoretical study (a method) and a practical study (a CAD system) of a hypothesis: the aggregation of morphometric information to other extractors aiming to improve the performance of classification by a CAD system. The method relates the content of nuclei in microscopic images and morphometric data. To validate this method, a CAD system was created to segment nuclei in microscopic images, extract features, label the nuclei and classify them. Morphometric attributes was exploited by the CAD system aiming to describe cellular components as pathologists do. The idea is the use of morphometric features together with other features (textural and spectral) to characterize nuclei in thyroid images. In a near future work, textual information from medical records to create semantic relationships between images will be exploited, and image processing techniques will be applied to improve the quality of images, redrawing cell boundaries that are not well-defined.

This paper is organized as follows. Section 2 depicts related works. Section 3 presents our approach to reduce semantic discontinuity in medical images considering a traditional image processing pipeline augmented by morphometric manipulation. Section 4 shows some experiments. Last, Section 5 presents the final remarks and future work.

2. Related work

Kothari et al. reviewed the main computer methods used on the process of pathology imaging analysis, assessments of semantics level and prediction model for diagnosis/prognosis by image exam [24]. They believe that cancer and other histopathological disorders could be detected through image features. Kothari et al. highlighted the complexity of analysis of a histopathological image, because there are many factors

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