Chapter 43
CytoNet, a Versatile Web-Based System for Accessing Advisory Cytology Services: Application of Artificial Intelligence

Rallou Perroti
National Technical University of Athens, Greece

Abraham Pouliakis
National and Kapodistrian University of Athens, Greece

Niki Margari
National and Kapodistrian University of Athens, Greece

Eleni Panopoulou
National and Kapodistrian University of Athens, Greece

Efrossyni Karakitsou
University of Barcelona, Spain

Dimitra Iliopoulou
National Technical University of Athens, Greece

Ioannis Panayiotides
National and Kapodistrian University of Athens, Greece

Dimitrios Dionysios Koutsouris
National Technical University of Athens, Greece

ABSTRACT

This article describes how the use of artificial intelligence applications as a consultation tool on a cytological laboratory's daily routine has been suggested for several decades. In addition to the use of high-resolution thyroid ultrasonography and fine-needle aspiration cytology, a further reduction of the number of unnecessary thyroidectomies can be achieved through the access to such techniques. Despite the evident advantages, artificial intelligence applications hardly ever find their way to end-users due to the specialized knowledge necessary for designing and using them, as well as the users' unfamiliarity with the required technology. The authors aimed to design an easy-to-use online platform (CytoNet) that gives access to a learning vector quantizer neural network (LVQ NN) that discriminates benign from malignant thyroid lesions to users (medical doctors) with no specialized technical background on artificial intelligence.

DOI: 10.4018/978-1-5225-8903-7.ch043

INTRODUCTION

Thyroid lesions appear in a high population frequency, with a prevalence of 2-6% in palpation, 19-35% in ultrasound and 8-65% in autopsy data. Nevertheless, the risk of malignancy only concerns 5 to 10% of the nodular disorders (Dean & Gharib, 2008, 2015). The introduction of fine-needle aspiration (FNA) biopsy has reduced the number of additional diagnostic explorations by 25-50% and increased the percentage of malignant results in the number of patients who ultimately underwent surgical treatment. Despite the benefits of fine needle aspiration (FNA), most patients who are referred for surgery because of abnormal cytology still have the benign disease (Yassa et al., 2007).

Numerous technological tools aim to alleviate this shortcoming. These are grouped into two broad categories: a) statistical methods and artificial intelligence (AI) methods. Statistical methods have been suggested for over twenty-five years in the evaluation of thyroid lesion. Logistic regression analysis of FNA cytological features have been many times presented as a tool to predict malignancy (Basu & Jayaram, 1992; Miller, Bottles, Holly, Friend, & Abele, 1986; Rout & Shariff, 1999), as well as logistic regression analysis of thyroid ultrasound (TUS) findings (Park et al., 2009). Receiver-operating Characteristic (ROC) plots have also significantly been used to enhance classification, as they provide additional diagnostic accuracy by demonstrating the limits of a test's ability to discriminate between alternate states of health, introducing the concepts of sensitivity and specificity (Metz, 1978; Zweig & Campbell, 1993). As a result, ROC curves can be used to define the accuracy of thyroid FNA. The method demonstrates significantly increased accuracy with the repeated aspiration of nondiagnosed cases and demonstrates that sub-categorization does not improve the overall accuracy of the test.

The second group of techniques, AI -based, are more sophisticated and have already been proposed in the field of cytopathology (Pouliakis et al., 2016) and thyroid cytopathology. Support Vector Machines (SVMs), have been used to predict thyroid diagnosis by classifying different features in one or multiple stages over FNA or ultrasound (Chen HL, 2011; Gopinath & Shanthi, 2013; Seryasat & O, 2013; Tsantis et al., 2005). Fuzzy Logic Systems (FLS) can handle incomplete or ambiguous data. Textural feature extraction methods based on fuzzy logic, have been used for thyroid disease (Azar, El-Said, & Hassanien, 2013; Keramidas, Iakovidis, Maroulis, & Dimitropoulos, 2008; Liu et al., 2012; Pavlopoulos et al., 2000). Artificial neural networks (ANNs), can facilitate the diagnosis of nodular thyroid lesions and have been a study subject. From a more general approach of the use of ANNs in diagnosis (Guoqiang Zhang, 2015; Ippolito et al., 2004; Naum Shapiro, 2005; Salamalekis et al., 2002; Sharpe, Solberg, Rootwelt, & Yearworth, 1993; Sordo, 2002; Vasios et al., 2001; Zhu L-C, 2013) to much more targeted applications such as ANNs for follicular lesions, (John A. Ozolek, 2014; Tatiana L. Poloz, 2006), suggestions of different ANNs (Rızvan Erol, 2008) or even specific condition combinations (Lahner et al., 2008). Clearlly, research shows that ANNs can be considered as a potential clinical decision support tool. (Cochand-Priollet et al., 2006; Guoqiang Zhang, 2015; Ippolito et al., 2004; Karakitsos, Cochand-Priollet, Guillausseau, & Pouliakis, 1996; Karakitsos, Cochand-Priollet, Pouliakis, Guillausseau, & Ioakim-Liossi, 1999; Lahner et al., 2008; Pouliakis et al., 2016; Sharpe et al., 1993; Siristatidis, Chrelias, Pouliakis, Katsimanis, & Kassanos, 2010; Siristatidis, Pouliakis, Chrelias, & Kassanos, 2011; Vilhena et al., 2017; Wolk & Marasek, 2016).

However, and despite most of the studies show that implemented applications could offer an effective advisory service in thyroid cytopathology and medicine in general, fail to become popular and practical. Cumbersome applications and the specialized technical knowledge they require are not appealing to health professionals, resulting in less than prevalent high technology services. In this paper, we present