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Towards low cost automated smartphone- and cloud-based otitis media diagnosis

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ABSTRACT

Otitis media is one of the most common childhood illnesses. Access to ear specialists and specialist equipment is rudimentary in many third world countries, and general practitioners do not always have enough experience in diagnosing the different otitis medias. In this paper a system recently proposed by three of the authors for automated diagnosis of middle ear pathology, or otitis media, is extended to enable the use of the system on a smartphone with an Internet connection. In addition, a neural network is also proposed in the current system as a classifier, and compared to a decision tree similar to what was proposed before. The system is able to diagnose with high accuracy (1) a normal tympanic membrane, (2) obstructing wax or foreign bodies in the external ear canal (W/O), (3) acute otitis media (AOM), (4) otitis media with effusion (OME) and (5) chronic suppurative otitis media (CSOM). The average classification accuracy of the proposed system is 81.58% (decision tree) and 86.84% (neural network) for images captured with commercial video-otoscopes, using 80% of the 389 images for training, and 20% for testing and validation.

1. Introduction

One of the most common childhood illnesses is otitis media, also known as middle-ear infection. Acute otitis media (AOM) is associated with inflammation of the middle-ear and the tympanic membrane [1]. The two other forms of otitis media are otitis media with effusion (OME) and chronic suppurative otitis media (CSOM) [2]. Acquired hearing impairment in children is usually caused by CSOM, which is usually formed after recurrent AOM [3], but can also follow after a single episode. In most developing countries limited access to medical care increases the prevalence of otitis media [4], which could in some cases lead to permanent hearing loss. The most common method to diagnose otitis media is by an otologist or trained medical professional using an otoscope to examine the tympanic membrane [3]. Because of the potential high cost involved as well as the lack of access to these services, there exists a need for an automated otitis media diagnosis system mainly for use in developing countries. In these countries the children versus the adult population is much higher [5], and this raises the expected benefit of such a system to children.

An automated otitis media classification or diagnosis algorithm for two different forms of otitis media, namely AOM and OME, was proposed by Kuruvilla et al. in [6]. This algorithm was validated by three general pediatricians as well as eight classifiers. Using this method otitis media diagnosis is only possible after the removal of obstructing wax or masses in the ear canal, in order to have a clear view of the tympanic membrane [3]. The drawback of this algorithm is that it does not detect wax or foreign body obstructions in order to diagnose the possibility of AOM and OME, and it does not diagnose CSOM.

In a recent paper we have demonstrated that otitis media can be automatically diagnosed using image processing and decision tree classification [7]. This system was able to diagnose AOM, OME, CSOM, wax or foreign body obstruction and a normal tympanic membrane. The image analysis classification system could load tympanic membrane images from a personal computer, running the custom developed Matlab software. The system extracted the visual features using tailor-made feature extraction algorithms, which were then classified using a decision tree. The system also made provision for the use of a low cost custom-made otoscope, also developed by the authors, to be used to take pictures of the tympanic membrane. Such a low cost custom-made otoscope could be provided to underserved communities in to dramatically reduce

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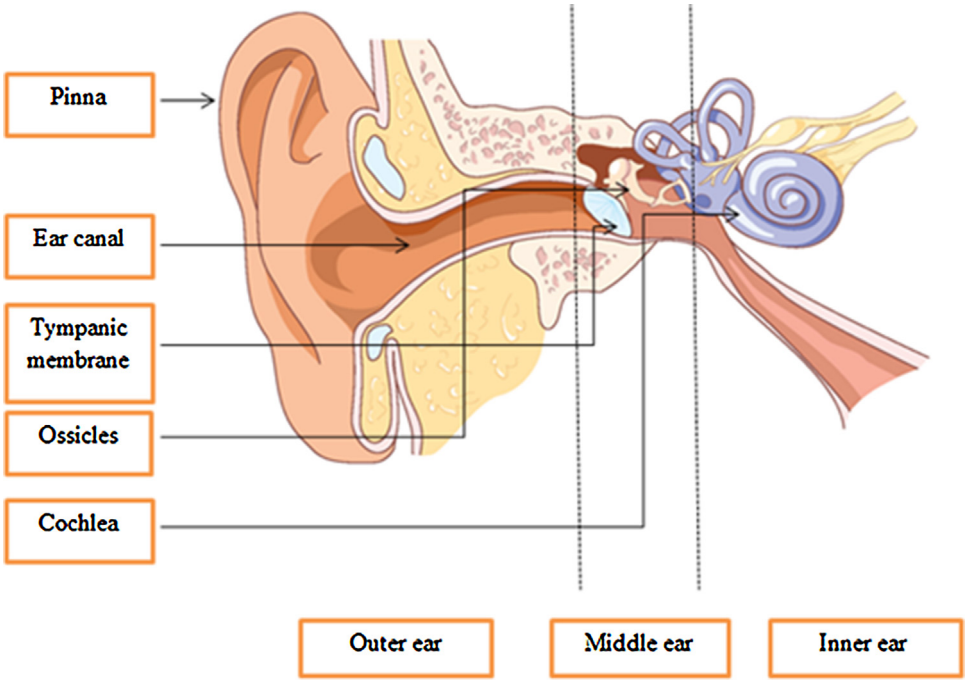

Fig. 1. Basic anatomy of the ear. Modified from [14].

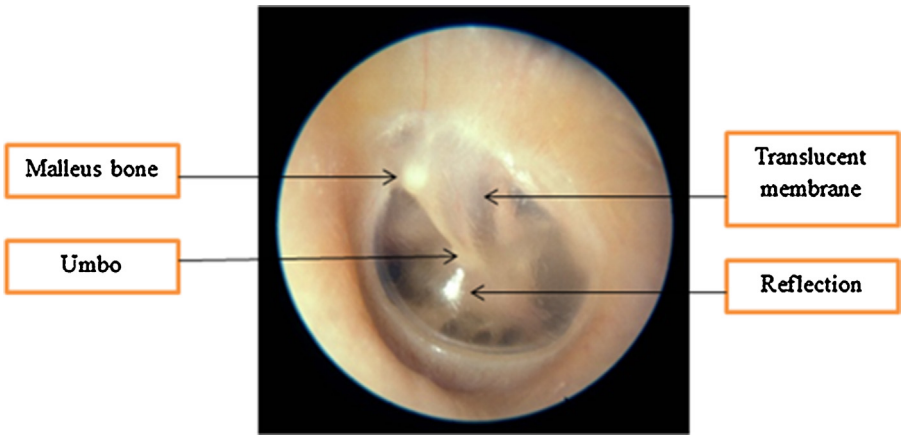

Fig. 2. Normal tympanic membrane [16].

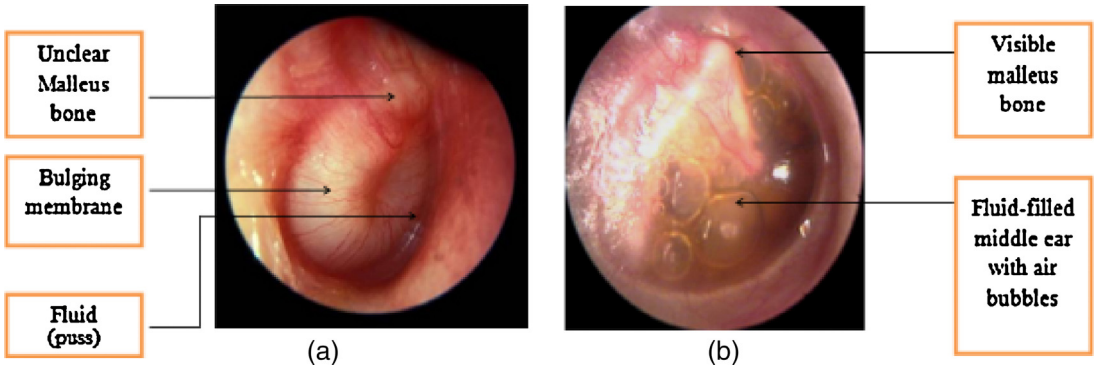

Fig. 3. Tympanic membrane with AOM (a) and OME (b) [18].

cost. Reported performance was 81.6% for video-otoscope captured tympanic membrane images, and 78.7% for custom-made video-otoscope images captured in an emergency room.

The smartphone revolution has resulted in unprecedented access to smartphones and smart mobile devices globally. Today one in five people owns a smartphone [8], and it is estimated that in the year 2020, 6.1 billion smartphones with internet access will