Light Field Otoscope 3D Imaging of Diseased Ears in an Alaska Native Population

Manuel Martinello[1], Harshavardhan Binnamangalam[1], Philip Hofstetter[2], John Kokesh[3], Samantha Kleindienst[2], Tiffany Romain[1], Noah Bedard[1], Ivana Tosi[1]

[1]Ricoh Innovations Corp. [2]Norton Sound Health Corp. [3]Alaska Native Medical Center

Ear infection affects 93% of people by the age of 7. One of the most frequent conditions is acute otitis media, which is also the most common reason for antibiotic prescriptions to children in United States. Nevertheless, otitis media and tympanic membrane retractions are often misdiagnosed: leading to increased morbidity and over-prescription of antimicrobial agents, and contributing to the worsening problem of antimicrobial resistance. Previous attempts to increase the diagnostic accuracy of clinicians using simple learning-based approaches work for a very narrow range of conditions.

In our opinion, the problem is that two-dimensional (2D) images limit the ability to extract more shape-related features that characterize each disease. In this work, we investigate how data collected by a Light-Field Otoscope (LFO), such as the one recently developed by Ricoh, can be used to create a tool that makes objective assessment of ear infection based on both color and shape, that is applicable to a wider range of conditions.

To collect the widest range of data, we worked with the Alaska native population, where the prevalence of a myriad of ear diseases (including otitis media and retraction) is very high. In Alaska, the use of telemedicine is required to assess many of these conditions due to the majority of the population living in remote villages, off the road system. This creates more reliance on static images of the tympanic membrane, and diagnosis and management can be challenging even for the most experienced clinicians.

Data was collected during an otolaryngology field clinic at Norton Sound Health Corporation in Nome, Alaska. A senior otolaryngologist examined all enrolled patients referred into the clinic for management of ear disease using a standard binocular microscope. His clinical impressions were recorded. Patients were then imaged by trained audiologists with a standard 2D video otoscope and with the proposed LFO, which generates both 2D and three-dimensional (3D) image of the eardrum from a single snapshot. Two focus groups were held with the participating otolaryngologist, audiologists, and Ricoh research team to visually compare LFO 2D+3D images to standard 2D digital otoscope images, and discuss the relation of these to the binocular microscope findings. Insights from those discussions suggest that the 3D reconstruction rendered from the LFO image data provided important information, especially in cases of bulging and retracted tympanic membranes.

Once we collected and analyzed the data, we extracted 3D features to build a learning- based algorithm capable of distinguishing different types of ear infection with higher degree of accuracy. Preliminary results with our machine learning algorithm show marked improvement over traditional clinician accuracy level.