A Low-Cost Pneumonia Pre-Diagnostic Tool

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MOTIVATION

Among all infectious diseases, pneumonia is the single largest source of mortality in children under the age of five. Pneumonia is particularly fatal for infants; 80% of these deaths come from children under the age of two. According to a recent UNICEF report, 100 children die every hour from the disease [1]. Pneumonia disproportionately affects developing countries; the pneumonia death rate, among children under the age of five, is up to 30 times greater in Sub-Sharan African countries compared to the US [2]. This is due in part to the difficulties associated with diagnosis in under-resourced countries. Current clinical diagnostic techniques often misdiagnose pneumonia as malaria [3]. Thus, we seek a cost-effective method for pneumonia detection with the goal of improving the accuracy of diagnosis, and reducing mortality rates associated with the disease.

STATE OF THE ART

Current US practices for diagnosing and treating pneumonia are more advanced than those established in developing countries. Accuracy of diagnosis is highly subjective—physicians listen to patient breathing, and recommend further testing if they hear abnormal sounds. As a result, in ambiguous cases, physicians order X-Rays to ensure the safety of the patient.

Chest X-Rays (CXR) are the most commonly used technology for pneumonia diagnosis. They have a sensitivity of 43.5% and a specificity 93.0%. The low sensitivity is countered by a high negative predictive value of 96.5%. This allows physicians to accurately rule out pneumonia with a negative result, and to order further testing in the case of a positive result. These follow up tests can include gram stain smearing (sens. = 84%, spec. = 98%) [13], urinary antigen testing (sens. = 60%, spec. = 99%) [14] and ultrasounds (sens. = 97%; spec.= 94%) [12].

While treatment for pneumonia in developing countries is equivalent to that in the US, barriers to entry exist in terms of diagnostic techniques. The primary issue is not the act of treating pneumonia, but identifying the presence of pneumonia. The CXR, CT-scan and other follow-up tests are not commonly implemented in low-resource regions because of their high costs and the necessity for trained medical professionals to interpret results. This results in pneumonia to be misdiagnosed as malaria, or simply not diagnosed at all. A low-cost solution that can accurately diagnose children with pneumonia could scale better than current diagnostic techniques and allow treatment of those who would not have otherwise received care [4].

Developing countries are lacking innovative solutions that exclusively address the process of pneumonia diagnosis. In 2015, UNICEF published a guideline for an "Acute Respiratory Infection Diagnostic Aid" that details the target specifications of a pneumonia diagnostic device that would meet their standards [4]. Currently, UNICEF uses a simple breathing rate timer to fill this role, however they have stated that there is nothing commercially available that meets their needs [10]. UNICEF has published the *Integrated Management of Childhood Illness* (IMCI) guidebook for care providers to diagnose and treat patients using the supplied timer [6]. Unfortunately, the IMCI faces criticism for broad categorizations of conditions with symptoms that often overlap with other diseases, frequently leading to the misdiagnosis of children [7]. This was recently confirmed by Kenyan researchers modeling the misdiagnosis rate of malaria, who have found that "more lives continue to be lost particularly due to [pneumonia] being misdiagnosed as malaria [11]."

PROPOSAL

The goal of this project is to develop a clinical pre-diagnostic device to accurately detect pneumonia in low-resource regions. Our device will be portable, easy to use, and inexpensive when compared to modern pneumonia diagnostic tools. The device will utilize machine-learning based classification models of waveform data (e.g., respiratory sounds, thoracic vibrations, sound permeation, etc.) in order to distinguish between patients with and without pneumonia. As a pre-diagnostic tool, the device will be used by physicians in conjunction with current standing diagnostic practices of pneumonia. Many researchers have been taking steps towards developing methods of computationally detecting pneumonia. They have explored machine learning, signal processing and statistical methods as diagnostic tools. Our team plans on building off of their previous work in order to create an accurate and robust device [8][15].

CHALLENGES & NEXT STEPS

1) Data collection of pneumonia coughing sounds is necessary to strengthen the machine-learning classifier. This data should include patients with pneumonia, healthy individuals, and people ill with other diseases affecting breathing and coughing sounds to account for confounding variables. Obtaining this data has been difficult, but we have been actively searching for a cough sound database. Alternatively, we can develop our own database by collecting sounds from patients at hospitals.
2) The current design will collect and store consistent sound signals from the patient to be classified by the analysis algorithm. The physical device will be wearable and adjustable to various body types, while adhering to numerous quality and safety standards.

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