Training a Machine Learned Algorithm to Diagnose Pneumothorax on Lung Ultrasound

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Introduction

The objective of this project was to create a graduated machine learned algorithm (MLA) that could detect pneumothorax (PTX) on ultrasound videos, with the ultimate aim of incorporating this artificial intelligence (AI) into an Automated Needle Decompression Device (ANEED) to assist clinicians in the evaluation and needle decompression of trauma patients. Our project was formulated in response to DOD solicitation for improved PTX treatment in a battlefield setting[1]. This DHMC IRB approved study is part of a phase II DOD SBIR collaboration with Creare LLC, an engineering firm in Hanover, NH.

PTX has several observable characteristics on ultrasound (Figure 1) with combined 88% sensitivity and 99% specificity in acutely and critically ill patients[2,3], much improved over Chest X-Ray[4]. The presence of these easily identifiable signs has led to previous success creating AI that can detect pneumothorax. In human clinical settings, these algorithms can perform as well as physicians[5], while in controlled porcine studies they perform with near perfect accuracy, sensitivity, and specificity[6]. Though highly accurate, these algorithms are computationally inefficient and time consuming limiting their use in real time. This study seeks to improve on past algorithms by creating a more efficient MLA to diagnose PTX in real time allowing a novice operator to use the ANEED device to deploy needle decompression.

Figures

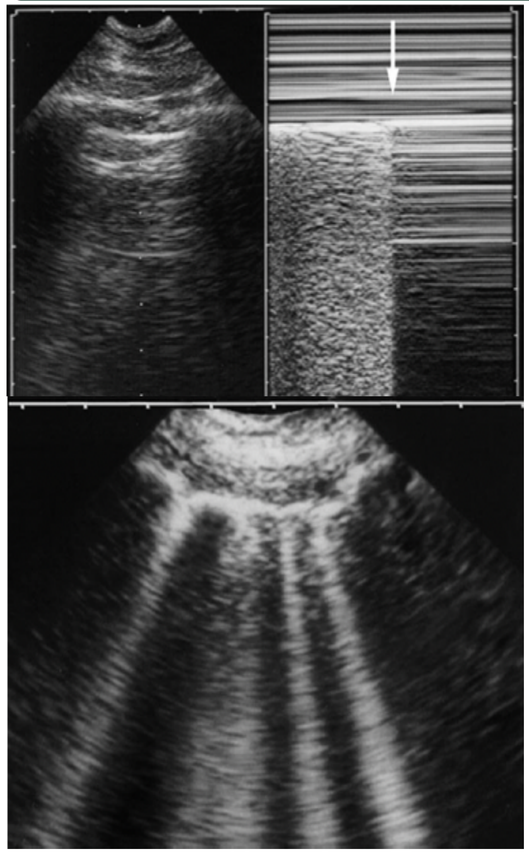

Figure 1: *Top:* B-mode and M-mode ultrasound images of a ”lung point,” indicating the transition between an area with normal lung sliding and absence of lung sliding, indicative of PTX[7]. *Bottom*: B-mode ultrasound image of “B-lines,” from areas containing large changes in echogenicity within them ruling out PTX[8]. ***Images sourced from Lichtenstein (2005)[9]***

Figure 2: ANEED deployment on cadaveric swine specimen (left) with successful catheter placement (right).

Preliminary Results

Machine Learned Algorithm:

A preliminary algorithm has been trained and tested on two human videos to successfully identify pleura, ribs, and lung sliding (no PTX) and no lung sliding (+PTX).

ANEED Electromechanical Device

A preliminary ANEED Device (pictured) effortlessly deployed three catheters in deceased pig with functional operation of all basic commands.

***Due to setbacks from Covid 19 and a Synchronicity database corruption progress has been slowed and work is ongoing.

Methods

Through the DH Data Analytics Institute all patients with diagnosis of PTX in the ED were identified. Patients were assigned a random study number. Resulting data sets were cross referenced with the ED thoracic ultrasound database. Using the ED US viewer, Synchronicity, videos were screen recorded using “SnagIt” and sorted into positive and negative folders labelled A and B, with the positive folder being randomly assigned one of those two labels. These positive and negative images will be independently evaluated by two experts to validate results prior to transfer and use by computer scientists at Creare to create the MLA.

Future Directions

The ANEED device is in early development with phase II grant support from the United States Department of Defense. The ultimate goal is marriage of an accurate, computationally quick and efficient ultrasound algorithm with an easy to use electromechanical device to provide sufficient guidance for a paramedic to decompress a pneumothorax in the field. Algorithm training and device operation began winter 2022 with planned live swine studies late spring 2022 to determine accuracy. After determining safety and efficacy in animal trials human trials will be pursued.

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