Optimizing Cardiovascular Disease Diagnosis for Mobile Deployment Using Advanced Machine Learning

Principal Investigator: ARNAOUT, RIMA
Institution Receiving Award: CALIFORNIA, UNIVERSITY OF, SAN FRANCISCO
Program: PRMRP
Proposal Number: PR181763
Award Number: W81XWH-19-1-0294
Funding Mechanism: Technology/Therapeutic Development Award
Partnering Awards:
Award Amount: $4,751,570.00

PUBLIC ABSTRACT

Background: Our proposal aims to improve prenatal diagnosis for heart birth defects, known as congenital heart disease (CHD). CHD is the most common type of birth defect and while it may not cause problems for the unborn baby (fetus), it can cause significant health problems once the baby is born, requiring heart surgery that is hard for the baby and very costly for the healthcare system. The earlier heart defects are diagnosed, the better the options for repair (including some repairs before birth), the better the outcomes, and the lower the costs. Because of these benefits, every woman is supposed to get a prenatal ultrasound to look for heart defects, and doctors are supposed to be able to detect over 90% of serious heart defects before birth. However, in practice, doctors are only finding 30%-50% of defects.

Rationale: There are two practical reasons so many heart defects are being missed by ultrasound when it works so well in an ideal world. First, it is hard to acquire good images of the fetus's heart because the heart is small and the fetus moves around. An ultrasound technician needs to be an expert in moving the probe around to acquire the right images, and that expertise is not available everywhere. Second, the doctors viewing the images have to be experts at interpreting the images and knowing what they are looking at. Because CHD is relatively rare, and spread out throughout the world, it's common that the doctor nearby is not expert enough to read the images well. Improving CHD diagnosis therefore requires solutions to delivering expertise in image acquisition and image interpretation no matter where the patient is in the world. Importantly, these solutions are just as applicable to the unborn baby with CHD as they are to the Warfighter who needs an ultrasound in the field.

Goals: How do we deliver the expertise of a specialty ultrasound technician (image acquisition) and a specialty doctor (image interpretation) to any place in the world? We will use deep learning (DL), which is a cutting-edge type of computer program that is really good at analyzing images. Our goal is therefore to build a portable ultrasound machine that has the advanced DL computer programs in it that will help a non-expert sonographer acquire good images of the fetal

heart and give a first-pass decision on the spot, about whether or not the heart is normal or whether the mom/baby need to see a specialist or get more testing.

Aims: We have already written some preliminary computer programs that are doing a good job on fetal hearts. However, to achieve our goal, we need to (1) do more research into making our computer programs as close to perfect as possible and (2) build a prototype machine and put our computer programs into it and test it out.

Study Design: We will do our research using ultrasound images that have already been collected from standard testing.

Impact: Medical imaging (and ultrasound in particular) is critical to almost every type of diagnostic and management decision. In the short term, the work proposed will provide valuable tools and insight into how to write the computer programs and how to build the computer-enhanced portable ultrasound. This will be valuable to the entire field of medical image analysis and will lay the groundwork for testing the system in real patients. In the longer term, the work will (i) improve CHD diagnosis for all patients, (ii) lower costs of care and repeat testing and improve outcomes for CHD, and (iii) provide a comprehensive long-distance solution for ultrasound diagnostics in both civilian and active military settings.

Relevance: This proposal uses DL to develop ultrasound diagnostics that can be deployed where expert sonographers and reading physicians may not be present. The use case emphasized here is for CHD, while the tools from this proposal can serve telemedicine needs for the Warfighter and Americans more broadly (including for cardiomyopathy and women's heart disease). Within the CHD Topic Area, numerous studies have shown that CHD diagnosis before birth (compared to after birth) is directly relevant to planning better surgeries and treatments for CHD and improving the health and brain function of CHD patients throughout their lives. Notably, improved fetal diagnosis will allow researchers to continue developing treatments for CHD before birth, giving the still-developing heart to form more normally and avoid more serious surgeries after birth. Improved CHD diagnosis can also help researchers find cases of CHD so that they can look at the genes, proteins, and other factors that cause it.