Automated Leukemia Detection: A Low-Cost, All-In-One Method to Detect Leukemia from Blood Smear Images Using Convolutional Neural Networks

EWH Design Proposal

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I. Problem Definition

Every year, 65% of all deaths associated with leukemia occur in developing countries (Singh, 2015). Many of these deaths are preventable with early detection, proper treatment, and accurate diagnoses, yet there is little infrastructure in place to accurately detect leukemia in developing nations. Currently, more than 85% of pediatric cancer cases, leukemia being the most common type, are from developing countries (White, et al 2013). The survival rates shed light on the global disparities of how leukemia is detected. According to a recent study comparing childhood survival rates of leukemia, some countries have five-year survival rates as high as 90% and others have rates well below 60% (PDQ Pediatric Treatment Editorial Board 2021). The areas with the lowest five-year survival rates included regions in Africa, Southeast Asia, and Latin America, where access to adequate medical technology is scarce.

The process for diagnosing leukemia can be performed through various tests. Manual diagnoses are done by experienced medical professionals/trained operators for physical examinations, blood tests, blood counts, bone marrow and cerebrospinal fluid biopsies. However, there are many problems with current diagnosing procedures and processes. Manual diagnosing is time-consuming, tedious, and prone to errors or missed observations as they are usually performed by individuals. A 2006 review found that the diagnostic error rate in surgical pathology ranged from 4% to 8% (Frable 2006). Additionally, individuals must be trained in the techniques and skills to interpret these exams which may be costly and time-consuming for clinics, especially in developing nations. Furthermore, exams such as blood work exams are often not affordable to cancer patients who live in impoverished communities. Recently, the idea of using machine learning to aid in the cancer diagnostic process has become increasingly prevalent, with widespread use cases in breast cancer and myeloma detection. According to a study published in Nature, AI-based cancer detection has been shown to reduce false positive rates by 11% and false negative rates by 5% (Savage 2020). Data-driven techniques, however, suffer from a lack of high quality pathology slides for training. To combat these issues and address the need for improved leukemia diagnostic techniques in developing countries, we sought to create a machine learning-based (ML) solution targeted at detecting leukemia from blood smear images taken by our low-cost phone-based microscope.

Currently, cancer-related healthcare accessibility in developing countries significantly trails behind the care available in developed countries. The gap between healthcare in developed countries and developing countries can be analyzed in a variety of ways: lack of capacity for prevention, public education, screening and early detection, and diagnosis and treatment. A high proportion of patients reject treatment primarily due to high financial costs. To further complicate this scenario, diagnostic procedures such as standard cytogenetic and molecular analyses are still not routinely performed in most institutions that specialize in hematological malignancies treatment. This severely limits the number of options for patients who wish to seek treatment. One of the main issues in developing countries regarding cancer detection is simply that patients with cancer are not being diagnosed at all. Cancer is often detected only when the patient has already reached a late stage. On average, 70% of cancer patients in developing countries are diagnosed at a very late stage of illness (World Health Organization 2010). In the event that a patient requests treatment, doctors in developing countries lack the resources and time needed to accurately diagnose and receive results. The lack of resources for healthcare professionals fails to provide much incentive for cancer patients to pursue treatment. Through our low-cost ML and imaging based leukemia solution, we hope to eliminate some of the cost and knowledge barriers associated with detecting leukemia in developing countries and improve the lives of thousands of people worldwide.

II. Impact on the Developing World

In general, developing countries suffer from a lack of access to both hardware and software technologies. However, mobile technologies are more widely available in such countries; studies have shown that more people in developing countries have access to phones than water or electricity. With 53% of people in developing countries having access to phones with internet and app capabilities, we believe that developing a mobile solution will be one of the simplest ways to ensure that both healthcare professionals and consumers alike are able to utilize our solution (Silver 2020)

Additionally, imaging technologies, such as staining dyes and microscope slides, are not widely available to the public, and they often require hazardous materials, such as bromothymol blue. Since our phone-based microscope eliminates the need for a microscope, imaging slides, and dye by creating an all-in-one device, we make blood smear-based diagnostics much more accessible and easy to use than traditional techniques. Our device utilizes SMS messaging, a widely accessible mode of communication, to transfer blood smear images to our server, which runs an ML-based algorithm to accurately determine malignancy.

With machine learning techniques already implemented to diagnose chronic kidney disease in Brazil having a high success rate of 93.3%, we believe that leukemia can be diagnosed in a similar fashion in developing countries, greatly increasing the possibility of early diagnosis in developing countries (Sobrinho, 2020). Our algorithm operates at 92% currently and with further adjustments we expect it to be well up in the high 90's. This ensures that our software and hardware will play a monumental role in increasing the efficiency of leukemia detection in developing countries.

Essentially, taking advantage of mobile phone cameras will provide an easy, portable, and cost-effective method to capture images needed for analysis. Moreover, deploying our machine learning algorithm on a central SMS server will provide leukemia diagnosis with a high success rate aimed at assisting healthcare professionals that do not have access to intensive processing capabilities. Finally, with a consumer focused healthcare-facing app that provides medical recommendations after a positive leukemia diagnosis, our solution will contribute to the overall awareness around leukemia and ensure that patients are fully cognizant of their options when seeking out future treatment. By making leukemia detection more accessible and efficient, this all-in-one solution will have a long lasting impact on the developing world.