

Letter of Transmittal

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March 8, 2020

Dear Mr. Harris,

I submit herewith the report titled *Computer Vision and Image Analysis to address maternal, newborn and child health issues* as per the date of agreement, March 9 2020.

This report discusses computer vision technology, the problem of maternal and infant mortality and all their significant aspects. The purpose of the report is to convey the potential of this technology by discussing the field, current advances in its applications and research.

Questions relating to any aspect of the report should be directed to me at *sidharth@govlassonde.ca*. Your consideration of my proposal is appreciated. I look forward to hearing your feedback.

Sincerely,

A handwritten signature in black ink, appearing to read 'Sidharth', with a stylized flourish at the end.

Sidharth Sudarsan
Software Engineering Student

Enclosed: Technical Report

ENG 2003
Effective Engineering Communication
Winter 2020
Instructor: Jeffrey Harris

Assignment 4

Technical Report

Computer Vision and Image Analysis to address
maternal, newborn and child health issues

by

SIDHARTH SUDARSAN
216697120

Date: February 24, 2020

Following professional engineering practice, I bear the burden of proof for original work. I have read the York University's Senate policy on Academic Honesty (<http://secretariat-policies.info.yorku.ca/policies/academic-honesty-senate-policy-on/>) and confirm that this work is in accordance with the policy.

Executive Summary

The mortality rates associated with maternal, newborn and child health problems is at an alarming state. The perpetuating exchange of vulnerabilities between the mother and the child makes the situation worse and causes negative social impact. To tackle this problem from its depth, we need to focus on prevention by early diagnosis and appropriate treatments. A major portion of pregnancy related complications can be spotted during its onset by effective monitoring and diagnosis prior to pregnancy. Computer vision technology aims to replicate human vision and use that level of complexity on top of the enormous amount of data that it can analyze from. This makes it the best piece of technology to combat this problem. We continue to accumulate a huge amount of data in hospitals everyday for different cases and patients. This data can help in refining these systems and enhancing efficiency consistently. The foundation for this use of computer vision has been laid by a few startups in medicine through working prototypes of image analysis and monitoring tools. The importance of solving this problem and the efficiency of this technology is further elaborated on this technical report.

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Introduction

This report provides an overview of the use of Computer Vision and Image Analysis to address maternal, newborn and child health issues. This issue has been an area of focus as a global health priority by Bill and Melinda Gates Foundation with their goal being "Ensure that women and newborns survive and remain healthy before, during, and after childbirth by identifying and addressing underlying biological vulnerabilities."

Improvements in maternal, newborn, and child survival are among the most significant achievements in global health during the 21st century. However, we need to move beyond developing tools for single diseases and focus on growth and resilience. The highest risk periods occur during pregnancy, the perinatal period; the period immediately before and after birth, and the first few months of life. This means that the traditional "big killers," for which we have treatments and vaccines, are less likely to be causing deaths for newborns. The underlying risks such as intrauterine growth restriction, prematurity and stunting must be addressed. These biological vulnerabilities often begin with the mother and are tragically transferred to her newborn, perpetuating a cycle of vulnerability. [1]

Background

Approximately 800 women die from pregnancy or childbirth complications every day and 7.6 million children die before they reach the age of five.[2] There are concerted efforts being made by different organizations against this issue since it aligns with one of the UN Sustainable Development Goals. Emerging technologies have massive potential to contribute to their success by focusing on one crucial need; timely and precise medical diagnosis. These underlying risks mentioned need to be diagnosed and managed in their early stages to reduce complications during childbirth. Prevention, early diagnosis and appropriate treatment can drastically reduce these mortality rates.

Applications Of Computer Vision

Computer vision is a field that aims to replicate the human vision system in computers. It involves extracting data from images and videos to process and make sense of it. On a smaller scale, Computer vision is all about pattern recognition. You feed millions of labelled images and subject it to some algorithm which analyzes the visual data and figures out patterns that relate to the labelled data.

Thanks to advances in artificial intelligence, the field has been able to grow tremendously and has been able to surpass humans in some tasks involving detecting and labeling objects. One of the major factors behind this growth is the amount of data we gather today that is then used to train and make these systems better.

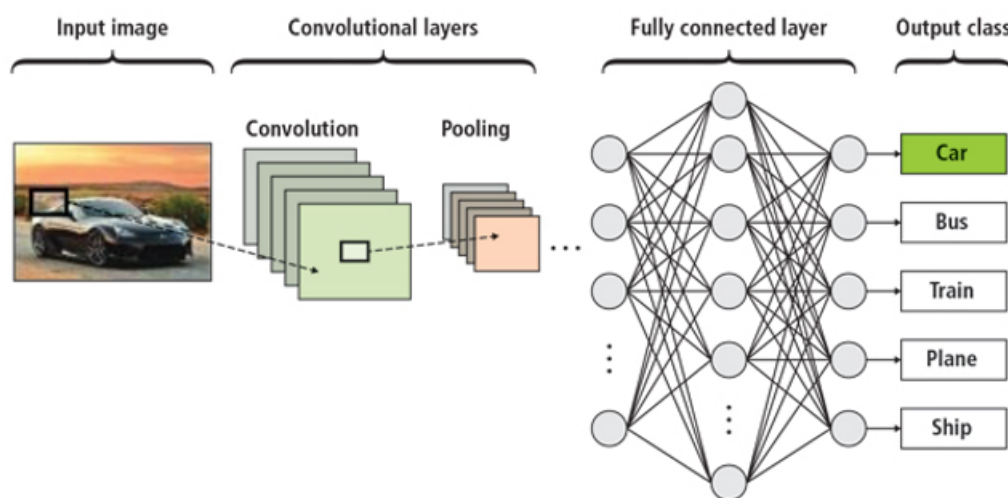


Figure 4.1: *Convolutional Neural Networks (CNNs)*

Artificial Intelligence identifies patterns, makes predictions, and analyses complex situations. Healthcare is the ultimate combination of the above three. The current promising healthcare applications of computer vision are in the fields of radiology, cancer screening, surgery and medical research. It has shown major

promise in identifying cancerous and tumours from biopsy results. These algorithms have produced breakthroughs in dermatology and have proven themselves to be better than doctors. Using deep convolutional neural networks (CNNs), scientists at the Stanford University Artificial Intelligence Lab created a model that analyzes skin images against a dataset of more than 120,000 skin cancer images. The results showed that this CNN model detects and classifies skin cancer as efficiently as certified dermatologists. [3] At the intersection of computer vision and augmented reality is surgical simulation and surgical assistance technology. Microsoft's InnerEye project aims to identify tumors using 3D imaging. The deep learning algorithm can identify the difference between dangerous tumors and benign ones. As computer vision improves in its recognition capacity, surgeons might be able to use augmented reality in real-life surgeries. They could receive guidance, warnings, and updates in real time based on what the computer vision algorithm sees in the operating room. [4] In medical research, computer vision promises to accelerate the identification of trends in patient images, making connections that would be time-consuming, if not impossible, for human researchers to discover on their own. An Indian startup called Wadhvani AI is taking the first steps to combat neonatal mortality using computer vision by creating smartphone based solutions to screen for low birth weight babies in rural homes. By now, it is evident that computer vision has a wide variety of applications in healthcare and medical diagnosis is one of the most important among them.

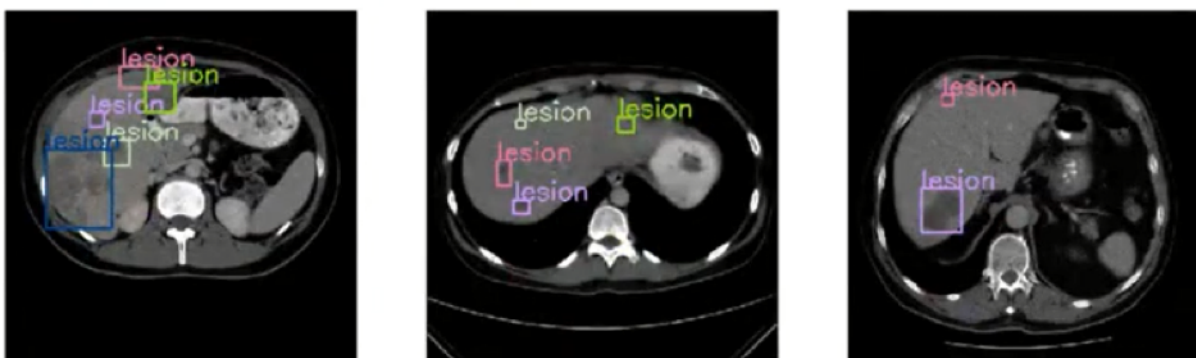


Figure 4.2: *Bounding boxes around lesions placed by an object detection model*

Discussion

The mother's diet and lifestyle during pregnancy can affect fertility and the baby's chances of developing a chronic condition. For stable maternal and newborn health, pregnant women should be screened for any problems and need to be diagnosed early. Statistically, the risk of death is highest for infants in the first week of life. Timely detection and treatment of symptoms has also indicated a decline in mortality and birth complications. Maternal mortality is a leading cause of death and disability for adult women worldwide, responsible for an estimated 289,000 deaths in 2013. [5] A comprehensive study on maternal mortality conducted in Ethiopia concluded, "When a woman in our study population experienced a maternal death, her infant was much more likely to die than to survive—and the survival trajectory of these children is far worse than those of mothers who do not die postpartum." [6]

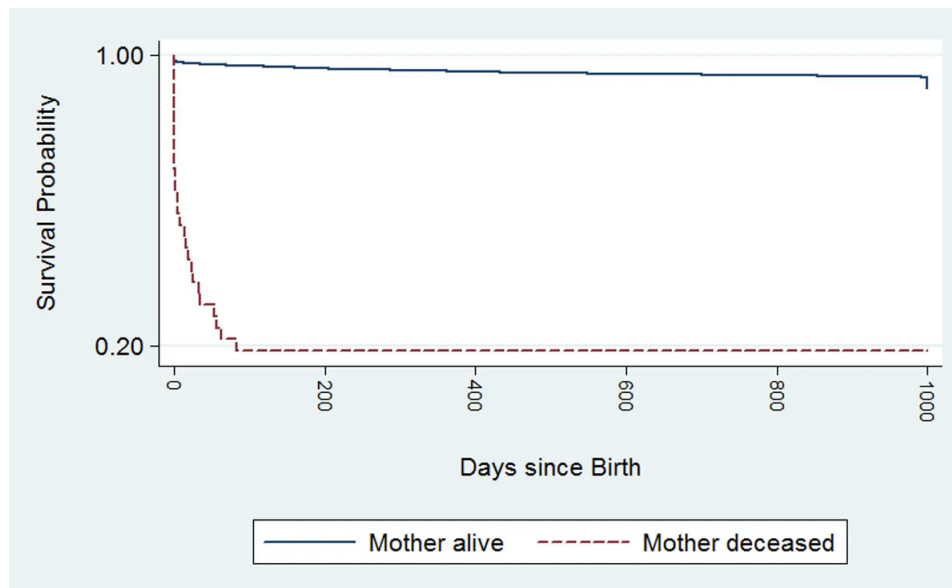


Figure 5.1: *Kaplan-Meier Survival Probability Curve by maternal mortality status in Butajira, Ethiopia, 1987-2011*

The third UN Sustainable Development Goal is associated with health. The Sustainable Development Goals (SDGs) were declared in 2015 with the objective of a sustainable future. One of the targets of this goal is to decrease the global maternal mortality rate by 6 to 9 percent annually by 2030. To achieve this we need to keep pushing and solve more problems.

Having mentioned all the great applications computer vision is capable of, a discussion of its strengths and weaknesses is necessary. These systems can carry out monotonous, repetitive tasks at a faster rate, making any process simpler. The accuracy of these systems are also not a surprise. The same algorithms can be reused for other patients and data from other medical centres can be easily transferred to the system for further algorithm training, thus enhancing the accuracy rates consistently. Human error can be completely ruled out for the tasks the algorithms perform. Consequently, they leave no room for error in these processes thereby saving time and money of the stakeholders that would be otherwise spent on fixing these flaws. A limitation of computer vision systems is their need for regular monitoring. To ensure any breakdowns or glitches don't happen, companies have to get a dedicated team onboard for regular monitoring and evaluation of their performance. Another obstacle to their growth is the lack of specialists required to train the computer vision systems powered by AI and ML. The real challenge of training such a system is in finding the right sets of relevant images for training, including of rare cases. To get an excellent accuracy, such training sets should have proper tagging and enough variations to avoid over-training on simple cases. Concerns about data privacy and personal security are also on the priority list, but with proper data anonymisation techniques, one patient's data can save the lives of many others. [5]

This technology has all the power and potential to address the need mentioned in the introduction; timely and precise medical diagnosis. Computers are excellent assistants when it comes to performing high-volume, structured tasks. Newer techniques like segmentation that improve the ability of this technology to better identify and distinguish objects also help improve the accuracy of these systems. Relying on extensive data sets that combine years of medical knowledge, computer vision-equipped ultrasound systems can show more experience than a single physician would. [6] The benefit of these systems is that they can be trained to spot even the slightest abnormalities. Therefore, prediction accuracy can be significantly enhanced and potential problems identified before they get out of hand.

Conclusion

The objective of this report is to provide an insight into how computer vision has the potential to address health problems among mothers and newborns while reducing maternal and infant mortality rates. The traditional killer diseases for which we have vaccines are less likely to be causing deaths for newborns since the risks associated with pregnancy are much more dangerous if not diagnosed and treated on time. There is also a risk of this being transferred from the mother to her newborn. The death numbers on childbirth related statistics are shocking and has a perpetual negative impact on the society in multiple aspects. Some studies have even linked maternal mortality rates to economic impact in developing countries. The severity of this global health priority is evident from one of the UN SDG targets which aims at reducing global maternal mortality rate by 2030. The field of computer vision has proven to have great potential in bringing these numbers down through research and its current applications.

Computer vision is a subset of artificial intelligence that aims to reproduce the power of human vision in computers. By training and "teaching" machines how to analyze, extract and interpret visual data, we can create complex systems that can process huge amount of data and use that to do tasks efficiently and accurately while saving on man-power. The above mentioned training is done with the help of labeled data from which these machines can figure out patterns. Naturally, it has shown promise through applications in cancer screening, surgery and research. Medical diagnosis is one of the most powerful applications of computer vision that can help a lot of areas under medicine. In this case, the system would need lots of labeled data concerning patients, their diseases and diagnosis scans along with scans of patients that have been diagnosed with such complications during pregnancy. The accuracy of these systems also rule out errors to a huge extent saving the time and money all the stakeholders involved. The major drawbacks are the requirement of highly skilled specialists and privacy concerns among users. However, we can adopt measures to counter these problems to save millions of lives by timely diagnosis and treatments.

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