Problem Statement for CS16 Reducing Patient Dose from Diagnostic Imaging Using Machine Learning

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Abstract

Diagnostic imaging techniques such as X-rays and mammograms require a dose of radiation in order to create an image. This image is intended to reveal objects of interest. Current methods for choosing the dosage amount simply pick a pre-determined value that is likely to be sufficient. The goal of this project is to improve upon this method by optimizing for the minimum required dosage of radiation while maintaining image quality.

Rather than using a fixed value for dosage, the imaging process could be stopped once it is determined that an optimal value has been reached. At this point, the process can terminate. A machine learning algorithm will be used to approximate when this optimal dosage has been reached.

I. Definition and Description of Problem

Radiation is required in diagnostic imaging techniques in order to create an image with high enough saturation that any objects of interest are clearly visible by humans. If the dosage is not enough, these objects won't be visible due to low saturation. Further, radiation exposure must be minimized as prolonged amounts can cause a host of issues for patients. Because of this, each patient has a finite amount of radiation that they can be safely exposed to over the course of their lifetime.

Since the process happens so quickly, it wouldn't be feasible for a person to manually monitor the image quality and stop the process once it has reached a certain point. Instead, the process ends after a predetermined burst of time has passed. This has worked traditionally, but with the advent of advanced methods of computation, there is no doubt room for improvement.

II. Proposed Solution

The project proposes a machine learning approach to this issue. The reasons for this choice are as follows:

- The problem is complex enough that classical programming techniques may likely not perform well.
- Large quantities of related data exist which could aid in the development and training of a machine learning algorithm.
- This approach has not been significantly attempted for this issue in the past.

Detecting when an X-ray or mammogram image has reached a point of high saturation and quality is a difficult task for a computer. Patterns in these images no doubt arise and attempts could be made to write a program that looks for these patterns and attempts to distinguish a "good" image from a "bad" image based on nothing more than the image itself. However, this type of problem is a prime example of when a machine learning approach would perform at much higher capacities. This is due to the fact that the algorithm must change as it becomes aware of more data.

A program might work well in some restricted data sets, but this may not be the general case. Instead of trying to develop a traditional program to solve this problem, the program can instead be created from the establishment of relationships found after training on large datasets. Fortunately, large quantities of this data exist. For this project, we will leverage the data collected by an analogous detector at the Oregon State University TRIGA (Training, Research, Isotopes, General Atomics) reactor.

III. Performance Metrics

The success of the project will be measured by the ability of the algorithm to reliably stop radiation emissions once an optimal dosage has been reached without reducing image quality. This will most likely be verified by means of simulation using existing data. The algorithm will also need to display a high degree of reliability due to the sensitive nature of its applications. This means that simulated and/or physical tests must be extremely comprehensive and numerous. These stages will most likely not be reached during the duration of my team's work, however.

The first main task for this project will be to manipulate existing data into a certain format for use by the WEKA (Waikato Environment for Knowledge Analysis) software. Finishing this conversion according to our client's specifications will be our first major milestone. We will also be assigned regular reading assignments to bring my team up to speed with terminology and high-level understandings of diagnostic imaging techniques. Future tasks will be assigned as needed.