**Software Engineering**

**Graduation Project-I Report**



Covid-19 Detection Using Chest X-ray

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**I Project Description**

**1 Project Overview**

A brief description of the product to be produced, before getting into details. The COVID-19 pandemic, also known as the coronavirus pandemic, is an ongoing pandemic that is fatal. As of 9 November 2020, more than 50.4 million cases have been confirmed with more than 1.25 million deaths attributed to COVID-19, and more than 32.8 million recovered. As it is known, early diagnosis is vital in any of the diseases. In such cases as COVID-19, early diagnosis can save millions of lives. If a patient is diagnosed, then he can be quarantined and prevented from spreading by the authority. This is the place where our project steps in. The project can diagnose COVID-19 by only using x-ray images of a potential patient which helps to protect millions.

**RELATED WORK WILL BE HERE!**

1. **The Purpose of the Project**

**2a The User Business or Background of the Project Effort**

The project has been planned over 3 (three) months and contributed by professionals in this area (i.e., doctors and professors). Subsequently, it was decided on the neural network architecture — which was the best among various of them. In those days, there were some nonsensical apps, that want you to blow through your microphone to detect whether you are infected or not, on the market. People who have created those apps were mocking with users and it was obvious that something must be done to prevent people from believing that absurdity. There was a clear need for a system that gives a genuine result whether you are infected or not. In the beginning, users will be able to upload X-ray images of their chests and get the results as soon as possible. There is going to be a variety of improvements in the oncoming versions not only about speed but also on the accuracy and images part.

**2b Goals of the Project**

The goal of this project is to use Artificial Intelligence, especially a deep learning-based approach, to detect COVID-19 infection from chest X-ray images. In addition, it is to verify and test the convolutional neural network for classification. The diagnosis of COVID-19 is typically associated with both symptoms of pneumonia (Pneumonia is an infection that inflames the air sacs in one or both lungs) and Chest X-ray tests. Chest X-ray is the first imaging technique that plays an important role in the diagnosis of COVID-19 disease. Another goal is to accurately identify at least 93% of COVID-19.

**2c Measurement**

To test the goal of the project, we need to calculate the accuracy of COVID-19 test. So, what is accuracy? The accuracy of a machine learning classification algorithm is one way to measure how often the algorithm classifies a data point correctly. Accuracy is the number of correctly predicted data points out of all the data points. How we calculate accuracy is:

![Text

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Figure 2.1: Accuracy Calculation Method

The accuracy can be defined as the percentage of correctly classified instances Where TP, FN, FP and TN represent the number of true positives, false negatives, false positives and true negatives, respectively. For good classifiers, TPR and TNR both should be nearer to 100%.

![Text

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Figure 2.2: Accuracy Calculation by Confusion Matrix

In accuracy, the actual value is the value that is obtained by observation or by measuring the available data. It is also called the observed value. The predicted value is the value of the variable predicted based on the regression analysis.

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Figure 2.3: Confusion Matrix

Now, we know the accuracy. In our project we are going to identify at least %93 of the COVID-19 correctly. In there, we calculate at least %93 using the accuracy of the dataset.

There are some other metrics to evaluate measurement. Such as, we already learn what true positive, true negative, false negative, false positive is. Let’s learn what recall and precision is. Precision measures the number of positive class predictions that belong to the positive class. Recall measures positive class predictions created by all positive samples in the dataset.

Text, letter

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Figure 2.4: Recall and Precision Calculation by Confusion Matrix

Accuracy interested in classified observations both positive and negative sides. What if we only check the positive side. For that, we may want to use F1-score. F1-score is a measure of a test’s accuracy. Unlike accuracy, F1-score only measures precision and recall on the positive class.

A picture containing text

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Figure 2.5: F1-Score Calculation Method

There are some metrics generally used for medical areas. These are sensitivity and specificity, and they are quite popular metrics. Sensitivity is the ability of a test to accurately identify patients with a disease. The ability of a test to accurately identify people who do not have the disease.

Graphical user interface, application

Description automatically generated with medium confidence

Figure 2.6: Sensitivity and Specificity Calculation by Confusion Matrix

If we want to know the relationship between sensitivity and specificity what will we use? For this, we can use the ROC curve. Then, what is the ROC curve? ROC curve is a graph that shows performance of a classification.

Diagram

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Figure 2.7: Sensitivity Over Specificity Plot

In a ROC curve the true positive rate which is sensitivity is plotted in function of the false positive rate which is specificity for different cut-off points of a parameter. Each point on the ROC curve represents a sensitivity and specificity pair corresponding to a particular decision threshold.

We also may want a quick summary of the ROC curve. Let’s use AUC for that. AUC means Area Under the Curve which measures the two-dimensional area under the ROC curve.

Chart

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Figure 2.8: ROC and AOC Curves

**3 The Scope of the Work**

Scope of Work is the field in a contract where the work to be done is explained. The Scope of Work should include all milestones, reports, deliverables and final products expected to be achieved by the performing party. The Scope of Work should also include a timetable for all deliverables. The Scope of Business also defines the business environment in which the product will be used.

**3a The Current Situation**

The current situation of COVID-19 is affecting almost all countries around the world.

New cases and deaths of people due to COVID-19 are increasing. Some countries and territories deal with the second wave of COVID-19. Even some of them are dealing with the third wave. Many countries try to find the vaccine and some of them succeed.

The current situation is dealing requirements before the implementation part. We have been dealing with the planning, analyzing, and designing parts of the project very carefully and successfully.

**3b The Context of the Work**

Work context refers to concepts that can be used to describe the specific context of different works in the same profession. The working context can describe, for example, a workplace, types of companies, environmental conditions, products, technologies or business activities.

This product will be used by doctors, nurses and health care workers. So, this product will be used in hospitals. Hospital is an institution that is equipped for diagnosing and curing the disease both medical and surgical. Hospitals are the main place for detection and cure of COVID-19. Types of hospitals are an important part of health care. Some of the hospitals don’t even have X-ray devices for detection of disease. For those hospital’s options of detection of COVID-19 are PCR and rapid diagnostic tests. But if hospitals have x-ray devices, we recommend them to use it for diagnosing of COVID-19 because it is fast and effective.

Our product is highly recommended for detection of the disease. It is so simple to understand the system for use. Any person who has the X-ray film upload the film, wait for the process and the result will be printed on the screen. This workplace that runs the film is a computer or an android device. The requirement of the devices is internet connection.

**3c Work Partitioning**

The event list includes the following elements:

●      Uploading chest x-ray as an image

●      Probability of having the disease

●      Users (doctor, nurse or health worker) upload a chest x-ray as an image and wait for the process. After that, the program will print the result.

Using our program is very effective. You can see the result very fast. It is faster than other diagnosing ways like PCR and rapid diagnostic tests. People who take PCR or other tests will get a result in 48 hours. Imagine how much the disease will change if we take the results in one hour. People who take other tests will be still working or interacting with other people so it will increase the disease transmission. If they could get chest X-ray results, they could go directly in quarantine and that would decrease so much the number of cases and deaths.

**3d Competing Products**

To compare the product with other alternatives that already exist, it must be understood well. First, it needs to be comprehended that what do the other products on the market do exactly. Secondly, what can be added extra to the other products to create a brand-new one. However, it was discussed with all the developers that the product must be faster and better. On the other hand, if the product cannot be used by anyone on the face of the planet, then it is nothing but a waste. A light bulb went on in every individual's head in the team simultaneously. These bulbs led the project to a broader area.

The product has now two different kinds of areas to serve. Anyone, who is mature enough to know how to use a smartphone, can use the product both by installing its mobile application and uploading her/his chest x-ray image easily or by clicking its website and again following the same uploading procedure. Either way is elementary level and sufficient for a complex project like this. Any other project, which has the same goal with this project, does not have any place to serve neither their technology nor results, yet this project has bested all over its opponents based on accuracy.

**4 Product Scenarios**

Scenarios are somewhat informal stories describing how the end users would use the product once it is completed. They take the form of narratives and may involve specific individuals and examples.

**4a Product Scenario List**

The product scenario list is quite simply a list of the product scenarios that will appear in the next section. It is a good idea to either number or name each scenario for later reference, and it can also be a good idea to organize the list so that related scenarios appear together. (Depending on the naming / numbering scheme, they can be grouped into sections and subsections, etc. )

**4b Individual Product Scenarios**

Product scenarios are written in a natural narrative fashion, easily understood by clients and other non-technical stakeholders. Each one tells a story of how the end users are expected to eventually use the finished product. For example:

In both cases image(s) should not be any blurred or glared or as little as possible to prevent to detect wrongly.

**Upload Images:** As soon as Mary got her chest’s X-ray image(s), she now can either take a photo of the image(s) by her phone or scan them with help of a scanner. Thereafter, she uploads the image(s) into our system to make it predict through the product’s android app or website. As she sees the uploading process completed successfully, then she needs to wait 2 hours to get the results. Even if there is a slight evidence of Covid-19, then the product notifies the patient, who is Mary in this case, as she is infected, and she needs to see a doctor or call the hospital to have them checked on her. On the other hand, if the product says that she is not infected, she will be seeing another notification that says she is healthy but still she needs to protect herself.

1. **Stakeholders**

**5a The Client**

Clients will be private hospitals or clinics, mostly. According to the accuracy rate we offered, some of the head doctors of the relevant hospitals were thrilled. We are not looking for many clients thanks to the alpha version of the product which will be released by us, anytime soon. Even though clients provide money and space to build a product, we want to release it for benefit of humanity. Also, Clients, who supported us in the first place, will have some special access through the product, undoubtedly.

**5b The Customer**

The customers are anyone who has internet access. They will open either the internet page of the product or the android app and upload their chest x-ray image (s). If uploading would be finished successfully, the system will show a result to the customer in 2 hours.

In spite of the product will be released as free, a system that involves anything we need working properly will also have some particular needs and to meet them, we need to earn as much as money the product needs. We will not show ads to prevent irritating the customers, but we determined to ask for money, which is an insignificant amount, to show results as soon as possible.

**5c Priorities Assigned to Users**

* Key users: They are critical to the continued success of the product. Give greater importance to requirements generated by this category of user. In this case the key users will be the doctors who can help to continue the success of the product by interpreting the results, suggesting new techniques on improving the speed of detection or at least leaving a comment about UI/UX designs in both app and website.
* Secondary users: They will use the product, but their opinion of it has no effect on its long-term success. Where there is a conflict between secondary users’ requirements and those of key users, the key users take precedence. Secondary users would be any adult who could use the product appropriately. They may not add things to the product, but the developers can deduce things by interpreting the behaviors of the secondary users.
* Unimportant users: This category of user is given the lowest priority. It includes infrequent, unauthorized, and unskilled users, as well as people who misuse the product. If the subject is medical, then no user is unimportant but, in this case, there is an exception. The exception is children. They might not know how to use the product and upload some irrelevant images. Which makes children have the lowest priority.

**5d User Participation**

The most critical part of the product’s improvement is user participation. Once the alpha version of the product is released, so many people will be willing to use the product, but it will need some improvements, eventually. Even though ordinary users would not be able to contribute, their logs are going to be inspected and there will be enhancements on the product if needed.

Furthermore, the clients’ participation means a lot more than regular users. Firstly, they will have the products way before the regular user has it. Secondly, they will provide some high-quality feedback due to avoid spending money for nothing. Last but not least, they have a medical background, and this is such a marvelous thing to build a medical product because the clients can be the director for the functionality of the product.

**5e Maintenance Users and Service Technicians**

Maintenance users are a special type of hands-on users who have requirements that are specific to maintaining and changing the product. In the project, maintenance users will be the clients who are doctors, especially, and employees in the hospital. They have every right to criticize and maintain the product.

**6 Mandated Constraints**

This section describes constraints on the eventual design of the product. They are the same as other requirements except that constraints are mandated, usually at the beginning of the project. Constraints have a description, rationale, and fit criterion, and generally are written in the same format as functional and nonfunctional requirements.

**6a Solution Constraints**

This specifies constraints on the way that the problem must be solved. Describe the mandated technology or solution.

Description:

In this paper, a convolutional neural network (CNN) is used to classify the COVID-19-infected patients as infected (+ve) or not (−ve).

Rationale:

COVID-19 patients must be detected as soon as possible. A model which is created by plain CNN is not satisfying. Accuracy must be higher whilst prediction does not take too much time.

Fit criterion:

The initial parameters of CNN are tuned using multi-objective differential evolution (MODE). Extensive experiments are performed by considering the proposed and the competitive machine learning techniques on the chest CT images. Extensive analysis shows that the proposed model can classify the chest CT images at a good accuracy rate.

Description:

The product shall accept X-ray chest images.

Rationale:

Users want to upload input images easily

Fit criterion:

Both the mobile app and websites should be understood by users at first sight. Apart from the sophisticated artificial intelligence model, that is used to predict, UI/IX design will be minimal and even a 7-year-old would use it although the audience is not her/him.

**6b Implementation Environment of the Current System**

This describes the technological and physical environment in which the product is to be installed

By the time it was decided to build the product, all the technological and physical environments, which the product is to be installed, were determined. For building the product, all the newest and the stabilized of the state-of-art technologies are used. Thanks to the best tools in the market, developing the product, running it on the server and the other users to use it were eased.

To begin with, the deep learning model was created and trained on TensorFlow’s Keras API by using public datasets, and thanks to features of the API, it was feasible to both saving and loading the model that was trained. Moreover, training was half of the project because if you cannot serve what you have done, then it can be said that you have done nothing, basically. Thanks to TensorFlow Lite, the model’s size decreased but the accuracy of the model was not affected. Then, the lite model was transferred to the Android project to use it on the Android app. Whilst the Android app’s outputs have been working quite well and sufficient, then the idea of using the Lite model on the website is become sensible due to the normal model’s heaviness. Finally, the TensorFlow model has been switched to the Lite model in order to reduce heaviness and increase the prediction time in the backend of the website. In the backend, Python programming language was used due to working with TensorFlow would be easier with the native language the model has been trained and as Python’s Django Rest API framework was used as a backend framework because of it is easy to read, write and relatively fast.

**6c Partner or Collaborative Applications**

AFAIK WE DO NOT USE ANY 3RD PARTY APPLICATION, YET.

Content

This describes applications that are not part of the product but with which the product will collaborate. They can be external applications, commercial packages, or preexisting in-house applications.

Motivation

To provide information about design constraints caused by using partner applications. By describing or modeling these partner applications, you discover and highlight potential problems of integration.

Examples

This section can be completed by including written descriptions, models, or references to other specifications. The descriptions must include a full specification of all interfaces that have an effect on the product.

Considerations

Examine the work context model to determine whether any of the adjacent systems should be treated as partner applications. It might also be necessary to examine some of the details of the work to discover relevant partner applications.

**6d Off­the­Shelf Software**

Initially, it needs to be clarified that what is “off-the-shelf” software. If the software needs to be specially configured to match the customer’s needs, then the software is not “off-the-shelf”.

The product, which has been describing in the report, is off-the-shelf because a client won’t have to add any configuration to it. The client or the customer is going to upload her/his chest X-ray image, then the product will assign a number to it to avoid confusion. This is all the user will do.

The product does not get any off-the-shelf application to run, although it is off-the-shelf. The product was created by configuring all the hyperparameters and adding more to the trained models. Needless to say, the website and the app created from scratch.

**6e Anticipated Workplace Environment**

There is not anticipated workplace environment for using the product, but a proper chest x-ray image must be uploaded into the system not to obtain an error or, worse, a misleading result, such as false negative. In that case, the result could be catastrophic. There will be precaution appeared on the screen once the user open product’s user interface.

The chest x-ray is one of the foremost common imaging tests performed in clinical practice, generally for cough, shortness of breath, chest pain, chest wall trauma, and assessment for the occult disease. normal x-rays are performed with the patient standing facing an X-ray film or digital cassette, 6 feet far from an x-ray tube. The tube fires x-rays thru the patient from the lower back to front, i.e., posterior to anterior (PA). This reduces the magnification of the center and different anterior mediastinal structures that are placed near to the film within the PA position. different factors to contemplate for a decent quality chest x-ray are centering (the trachea ought to be equal between the clavicular heads), penetration (the spine should be simply clear through the internal organ density), and breath effort (at the full inspiratory effort, the anterior finish of the correct sixth rib should purpose mid-way on the right hemidiaphragm).

**6f Schedule Constraints**

Schedule constraints are any known deadlines or windows of opportunity. It is crucial to identify critical times and dates that have an effect on product requirements.

The vast majority of the medical sector has been looking for a product like this for over 12 months. The product’s marketing opportunity is enormous, and investors will trust the project blindfolded. Not to exaggerate, the project gives power to its developers to select the investors, but the product must be ready —or at least an alpha version is released— for letting developers have this kind of authority.

The schedule has been varied several times due to technology and procedure issues. Nonetheless, the final schedule was decided eventually. The project must be ready at the end of January, uttermost. The beginning of February is not even a matter of discussion. Besides the client and the many customers are waiting for the product and the financial impact will be huge if the product is late even a day, the whole human race needs a product like this. That is why the product will be ready on the 15th of January and even if the project has been developing by testing, it will take another 15 days to make sure that the product is almost perfect to serve the human race.

**6g Budget Constraints**

The financial budget for the project is so low that a student can create this project in her/his room, but the real budget for the project is time. Every part of the project wants more time than any others in the market.

The time budget is very narrow, and this steers the planners to either hire more developers/mentors or buy/rent much more powerful servers to train models by using brute force instead of training wisely. These days, servers are server rents are lower than mentors', then the team has decided to rent a powerful server to train the model by using the cross-validation method which was surprisingly satisfactory.

To answer the following question “Is it realistic to build a product within this budget?”, it totally is. In the first place, the project was handled by two students who have an average budget. Later on, a few hospitals wanted to invest in the product after the alpha version has been released. If the investments come true, then the product will rival the companies, globally.

1. **Proposed Method**

This section will indicate the proposed multi-objective differential evolution (MODE)—based on convolutional neural networks (CNN) for classification of COVID-19 infected patients from chest X-ray images. In this project, Classification of COVID-19 patients from chest CT images using multi-objective differential evolution–based convolutional neural networks [1] paper will be implemented. Required parts will be developed around the essential idea of the paper.

**7a Convolutional Neural Networks**

Convolutional neural network (CNN)[2], a class of artificial neural networks that have emerged as dominant in various computer vision tasks, is attracting interest throughout a lot of domains, such as radiology. CNN is designed to automatically and adaptively study spatial hierarchies of features via backpropagation through the use of a couple of constructing blocks, which include convolution layers, pooling layers, and fully connected layers. This part of the report of the project gives an angle on the fundamental principles of CNN and its application to diverse tasks and discusses its challenges and future guidelines withinside the subject. Two challenges in making use of CNN to the medical duties, small dataset and overfitting, may also be included in this part of the report, in addition to strategies to reduce them. Being acquainted with the principles and advantages, in addition to limitations, of CNN is vital to leverage its potential in diagnosing diseases, with the purpose of augmenting the overall performance of medical personnel and enhancing affected person care.

1. Feature Extraction

Feature extraction is a significant approach to decreasing the size of high-dimensional data is the choice of features. It begins from an initial collection of measured data and generates derived values called features, intended to be descriptive and non-redundant, to promote the subsequent steps of learning and generalization and, in certain instances, to contribute to better human interpretations.

Convolutional Neural Network Feature Maps Figure Will be here.

1. Classification

With the idea of deep learning, the models are trained better and are able to identify different levels of image representation. The convolutional neural networks revolutionized this field by learning the basic shapes in the first layers and evolving to learn features of the image in the deeper layers, resulting in more accurate image classification. Fully connected layers serve as a classifier. It uses derived features and evaluates the likelihood of an item in the picture. In order to create non-linearity and mitigate overfitting, the activation function and dropout layer are typically used.

1. **Naming Conventions and Definitions**

**8a Definitions of Key Terms**

All Terms, including acronyms and abbreviations, used in the project is defined at some point. The most important ones are listed here.

Names are very important. They invoke meanings that, if carefully defined, can save hours of explanations. Attention to names at this stage of the project helps to highlight misunderstandings. The glossary produced during requirements is used and extended throughout the project.

SARS: Severe acute respiratory syndrome is a viral respiratory disease caused by a SARS-associated coronavirus.

ROC: Receiver operating characteristic curve is a graph showing the performance of a classification model at all classification thresholds.

AUC: Area under the ROC curve measures the entire two-dimensional area underneath the entire ROC curve form (0, 0) to (1, 1).

API: An application programming interface is a computing interface that defines interactions between multiple software intermediaries.

LOC: Source lines of code (SLOC), also known as lines of code (LOC), is a software metric used to measure the size of a computer program by counting the number of lines in the text of the program's source code.

**8b UML and Other Notation Used in This Document**

This document generally follows the Version 2.0 OMG UML standard, as described by Fowler in [4]. Any exceptions are noted where used.

1. **Relevant Facts and Assumptions**

**9a Facts**

* Implementation will be written on platforms such as PyCharm for neural network and modelling, VSCode for web development, android studio for android development.
* Implementation will be written in several programming languages such as Python, Java, JavaScript.
* When a user clicks the upload button, she/he can choose x-ray as an image and that image must be successfully uploaded to the system.
* When a user clicks the application. The application must open without any error.
* The system must print whether the person has the virus or not.
* The existing application is 2000 LOC.

**9b Assumptions**

* Identify at least %95 of the covid-19 correctly
* This project will help the situation of pandemic.
* The application will get around five hundred requests a day

References:

[1] Classification of COVID-19 patients from chest CT images using multi-objective differential evolution–based convolutional neural networks

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7183816/>

[2] Convolutional Networks for Images, Speech, and Time-Series

<https://www.researchgate.net/publication/2453996_Convolutional_Networks_for_Images_Speech_and_Time-Series>