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| C:\Documents and Settings\Mohammad Alzubaidi\My Documents\YU\logo2.jpg  **Yarmouk University**  **Hijjawi Faculty for Engineering Technology**  **Department of Computer Engineering**  **Graduation Project Report**  **Lung Cancer Detection Using Deep learning**  **Heba Abu Shareefeh 2019980186**  **Rudaina Alyaseen 2019980261**  **Mohammad Mrayyan 2019980212**  **Dr. Mahmoud Masadeh**  **Semester: First 2023/2024**  **Date: 10th January 2024** |

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# Abstract

As advancements in technology continue in healthcare, detecting cancer, especially lung cancer, presents high challenges because it's complex and there's a huge amount of data from medical images and patient records to manage, making detection both challenging and time-consuming. Moreover, Sharing of medical data among healthcare professionals can greatly enhance diagnostic accuracy and treatment outcomes However, existing methods of data sharing often lack efficiency and security. Therefore, our project aims to build a model using AI algorithms to provide an effective solution for enhancing diagnostic accuracy, enabling early detection of lung cancer, and use web techniques that make our model easier to use.

**Keywords**— Lung cancer, Deep Learning, convolutional neural networks (CNN) ,---------------------------------------------------------------------------------------

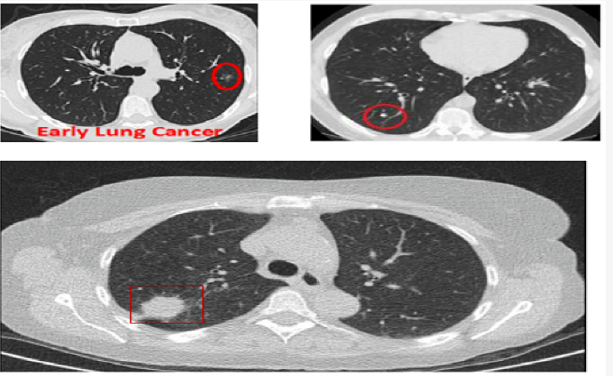
# Chapter 1: Introduction

* 1. **problem statement**:

Globally, lung cancer is the most commonly diagnosed cancer over the past few decades [1]. Initially, cancer cells are tiny and hard to spot, but after a while, they enlarge and become more severe. For this reason, a key factor in enhancing patient outcomes is early detection.

To detect cancer, a radiologist must perform a large number of CT scans. However, because lung nodules resemble surrounding structures, such as blood vessels, it can be challenging to distinguish between blood vessels and cancer nodules in the early stages of the disease so this can be time-consuming and prone to human error. In Figure 1, three CT images are shown: The top two show lungs containing early-stage cancer; the first being malignant and the second being benign. It is difficult to differentiate between vessel and cancer nodules during this stage. The last image is of cancer in its late stage, with a large nodule size making it easier to detect, but survival rates are low [2].

Therefore, our project focuses on developing a model to early detecting lung cancer from CT images.

  
Figure 1. CT scan based on intensity projection. [3]

* 1. **Background.**

Doctors face difficulty in detecting lung cancer in its early stages due to its complexities and the large amount of data it requires. This can lead to the disease progressing to advanced stages.

To address these challenges, this project aims to train a model using DL algorithms on a dataset. The model will be able to predict the probability of having the disease in its early stages, enabling early treatment.

The table below show some of the datasets that can be used to train model.

Table 1. datasets used for lung cancer.

|  |  |
| --- | --- |
| Datasets | **About data set** |
| Chest CT-Scan images Dataset [5] | **Data** folder consists of train , test and valid folders each folder contain 3 folders of different chest cancer types(adenocarcinoma,large cell carcinoma,squamous cell carcinoma) and 1 folder of normal CT-Scan images (normal) **train** folder contain the training images (adenocarcinoma 195 files, large cell carcinoma 115 files, normal 148 files, squamous cell carcinoma 155 files) **test** folder contain the testing images (adenocarcinoma 120 files, large cell carcinoma 51 files, normal 54 files, squamous cell carcinoma 90 files)  **valid** folder contain the validating images(adenocarcinoma 23 files, large cell carcinoma 21 files, normal 13 files, squamous cell carcinoma 15 files) |
| CT-Scan images [6] | Images were collected from the hospital situated in Iran. Part of this CT-scan images of lungs were belonged to lung cancer patients and classified as cancerous images, and the rest of them were belong to other lung diseases, for instance patients who caught COVID-19, and classified as non-cancerous images. The total number of CT-scan images, which were used in this paper is equal to 364 that 238 of them belong to cancerous images and 126 of the rest belong to non-cancerous images. All of each these images were collected with the help of a pulmonologist in order to skip any probable error in classifying these images. |
| The IQ-OTH/NCCD lung cancer dataset [7] | The IQ-OTH/NCCD lung cancer dataset  Lung Cancer CT Scans from Iraqi hospitals: (Normal 416 files , Benign120 files , and Malignant Cases 561 files) |
| CheXpert: Chest X-rays [8] | CheXpert is a dataset consisting of 224,316 chest radiographs of 65,240 patients who underwent a radiographic examination from Stanford University Medical Center between October 2002 and July 2017, in both inpatient and outpatient centers. The CheXpert dataset includes train, validation, and test sets. The validation and test sets include labels obtained by board-certified radiologists. The train set includes three sets of labels automatically extracted from associated radiology reports using various automated labelers (CheXpert, CheXbert, and VisualCheXbert). |

* 1. **Aims and objectives:**

The project aims to develop an accurate disease prediction system for lung cancer using convolutional neural networks (CNNs) objectives of the project are:

* analyze medical CT scan images with high accuracy, enabling the early detection of lung cancer and quickly treatment early for patients.
* creating a centralized platform for healthcare professionals to upload images.
  1. **Evaluation of solution**

For the evaluation phase, we will use confusion matrix and compute the accuracy, precision, recall, and specificity. Then we’ll compare our results with related paper.

For the performance Confusion Matrix was used. **Figure 2** and **Table 2** describe them.

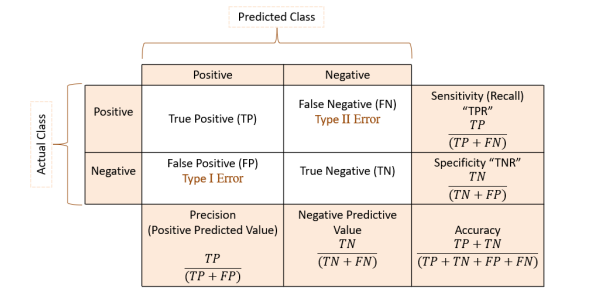


Figure 2. Confusion Matrix [9]

Table 2. Performance Metrics Description.

|  |  |
| --- | --- |
| **Performance Measure** | **Description** |
| Sensitivity(recall) | actual positive cases that the model correctly identifies |
| Specificity | specificity quantifies the model's ability to correctly identify negative cases |
| Precision | reflects the accuracy of the model's positive predictions |

* 1. **List of contributions:**

A list of contributions with short descriptions

The contributions of the project include:

• User-friendly front-end interface: the system features easy to use user interface, designed with modern web technologies.

• improving the accuracy of lung cancer prediction: by using efficient algorithms and calculate the accuracy.

* 1. **High Level Figure of Our workflow:**

Figure 3. Schematic diagram for lung cancer detection.

Figure 3 describes the steps that we’ll follow to build the model.

* 1. **Summary of report structure.**

The report structure provides a brief description of the lung cancer diagnosis challenge, and how our model will address this challenge.

# Chapter 2: Background

* 1. **Background of the problem:**

Lung cancer is a major cause of death worldwide and a major public health problem. Lung cancer continues to be the most common cause of cancer-related death, accounting for 1.8 million deaths (18%) in 2020, according to the International Agency for Research on Cancer's (IARC) GLOBOCAN 2020 estimates of cancer incidence and mortality.

The type of lung cancer, the extent of its dissemination, and the patient's medical history all influence the treatment options. Improved outcomes and therapies for lung cancer may result from early identification.

Early detection of lung cancer is a difficult task. Treatment becomes more challenging since by the time symptoms show up, the cancer has frequently progressed to a later stage. This emphasizes how crucial it is to create precise and effective early detection techniques. Errors can occur while analyzing CT scans of the lungs for lung cancer using traditional procedures. Besides, conventional techniques might not be able to manage the massive volumes of intricate data needed for precise prediction. By automatically identifying patterns and generating predictions from the data, machine learning algorithms can assist in overcoming these constraints.

Give some background information regarding the issue, its importance, its uses, etc.   
Conventional techniques for identifying lung cancer frequently depend on radiologists visually analyzing CT scan and other imaging data. However, because it mostly depends on the radiologist's knowledge and experience, this procedure can take a while. Furthermore, it may be difficult to recognize faint or weak symptoms, which could result in an incorrect diagnosis or a delayed discovery of lung cancer. In our study, machine learning will be used to identify lung cancer. This will help us improve patient outcomes by increasing the efficiency and accuracy of lung cancer detection and by providing more objective and consistent analysis, which will produce more dependable results. When medical imaging data is available, it is utilized in diagnostic centers, hospitals, and medical research facilities. Through the use of AI algorithms in CT scan processing, physicians can have access to more precise and effective lung cancer detection.

* 1. **Target the market and their needs.**

Radiologists, healthcare providers, and other medical professionals involved in lung cancer diagnostics comprise the core target market. Their main requirement is for a more accurate and efficient diagnostic tool that can operate smoothly with current workflows to identify lung cancer from CT scans in a timely and trustworthy manner.

* 1. **Potential ethical and/or environmental issues.**

Data privacy is one of the potential ethical concerns in a project like employing machine learning to detect lung cancer. Patient data must be handled with the highest care and must be secured, anonymized, and secure. Preventing biases in the dataset is also essential, as they may result in discriminatory or unfair predictions. The prediction model's transparency is another ethical factor to take into account. It is critical to comprehend how the model generates its predictions and to have accurate documentation. This promotes accountability and results-based trust.

**2.4 Summarize the different approaches currently/previously used to solve the problem.**

1. Conventional Manual Analysis: Historically, scientists have forecasted lung cancer by manually analyzing data. In order to determine the possibility of lung cancer, this method involves professionals looking at a variety of characteristics and trends in the data, such as tumor size, shape, and location. The specialists' expertise and knowledge served as the foundation for their interpretation of these features. This method was constrained by subjectivity and the possibility of human mistake, even if it yielded insightful results.

2. Machine Learning Algorithms Machine :learning algorithms have become highly effective instruments for the prediction of lung cancer, as opposed to manual analysis that follows convention. Large datasets can be automatically processed by these algorithms to identify patterns and links, leading to more precise predictions. Support vector machines (SVM), decision trees, and logistic regression are a few machine learning methods that are frequently employed in the prediction of lung cancer. In order to generate prediction models, these algorithms examine different characteristics and trends in the data.

# Chapter 3: Design

* 1. **Design Overview:**
     1. **Design Description**

The project's goal is to construct a predictive model for estimating the probability of lung cancer. To enhance accessibility, we implement a user-friendly web platform. So the project comprises two primary components: the web interface and the predictive model. In the predictive model, we employ a deep learning algorithm known as Convolutional Neural Networks (CNNs).

The web interface serves is the gateway for users to interact with the predictive model. where users can input relevant data and receive predictions regarding lung cancer probability.

* + 1. **plan to address the problem statement**

1. identify an appropriate dataset containing samples of both cancerous and noncancerous cases

Example on data set :



Figure 4. cancerous image.

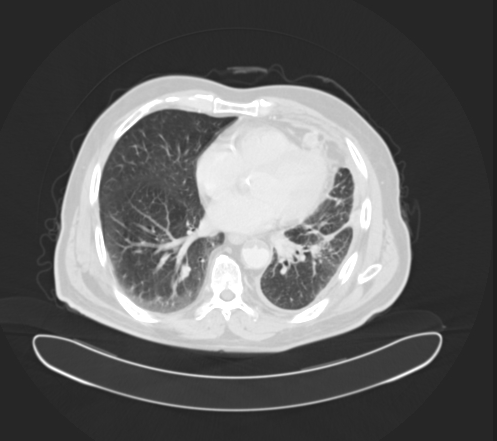


Figure 5. non-cancerous image.

1. Next, we'll preprocess the dataset, which involves tasks such as resizing images, handling imbalanced data, and partitioning the dataset into training and testing sets.
2. Constructing the model with CNNs
3. Training the model on the training set.
4. predicting the testing set and evaluating the train and test models using performance metrics such as accuracy, precision, recall, or area under the curve (AUC). This assessment aids in gauging the model's effectiveness in predicting lung cancer.
5. Develop the App Interface: designed in a way that makes it easy for users to input data, receive results
6. Integrate AI Model into the App : Integrate the trained AI model into our app’s backend infrastructure. This involves implementing the necessary APIs to facilitate communication between the app’s front end and the AI model.
   * 1. **Detailed Figure.**

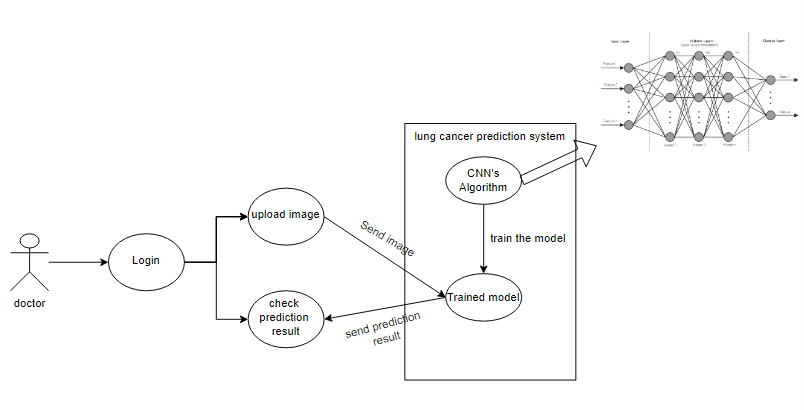


Figure 6. use case diagram.

Figure 6 shows the use-case diagram of the system. It illustrates the interactions and processes within the system

**Scenarios where the end user can use the system**:

* the doctor submits a CT scan image for assessment. Behind the scenes, the system's backend employs advanced machine learning algorithms to meticulously analyze the uploaded image. Once the analysis is complete, the system promptly delivers an accurate diagnosis to the doctor, empowering them with timely insights for effective patient care
  1. **Design Details**:
     1. **Design Specifications**
* Design Dimensions:

The IQ-OTHNCCD lung cancer dataset was obtained from Kaggle [here] (<https://www.kaggle.com/datasets/hamdallak/the-iqothnccd-lung-cancer-dataset>) , It consists of 1097 samples of lung cancer patients, covering cases categorized as Normal, Benign, and Malignant

* Quality:

In the preprocessing stage, our objective is to implement strategies that help us avoid overfitting the data. For example, we aim to standardize image sizes across datasets and balance distributions to prevent any single class from dominating excessively.

* Safety:

Given the objective of identifying patients with cancer, mitigating False Negative (FN) errors is paramount. False Negative errors occur when the model incorrectly predicts that a patient does not have cancer when they actually do. So in our project, our primary focus is on minimizing False Negative (FN) errors.

* Environmental Factors:

We aim to create a project that is compatible across multiple devices, and thus, we incorporate web technology into our project.

* + 1. **Design Process**

In this section, we focus on the method that we have utilized, as they represent the main concept of our work. Additionally, we compared between our method and those outlined in related papers to assess the efficacy of our prediction model.

The methods that we used is Convolutional Neural Networks:

* **Why CNNs**?

If we have 64\*64 image, When using another method like ANN, each pixel is considered a separate feature, leading to a large number of features (4096 pixels in this case), which can make the system fail as the image size increases. On the other hand, CNN's Convolutional Layer performs feature selection, identifying important pixels to train the model effectively, helping in extracting distinctive patterns from the image. This makes CNN a better choice.

The images below show the significance of the convolutional layer:

|  |  |
| --- | --- |
| Figure 7 ANN visualization | Figure 8 CNN visualization |

The image 10 show the visualization of a simple image when using an Artificial Neural Network (ANN). It shows that the ANN consists of fully connected layers, where the number of connections between the input layer and each neuron is significant (In the image, the number of connections shown is only for a single neuron in the first layer and there are same connection for each neuron in same layer and additional connections in the second layer). Therefore, if the image size is large, the ANN might fail due to the extensive number of connections, impacting its performance.

This is where the convolutional layer in CNN comes into play, as its role is to retain only the important pixels through feature selection, as show in figure 11

* What CNN?

Convolutional Neural Network (CNN) is a type of neural network Architecture that is widely used for performing deep learning on image data.

CNN consists of an input layer, a hidden layer(s), and an output layer. differentiates CNNs from ordinary ANNs is that the hidden layers of a CNN consist of a special series of layers called the convolutional and pooling layers.

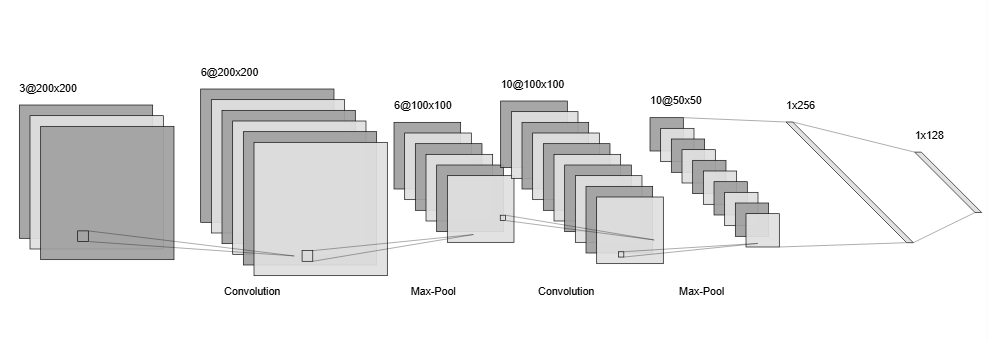


Figure 9: CNN architecture

* **Input layer:**

The input layer represents the initial stage which accepts input data in the form of multi-dimensional arrays (tensors).For example, if you have grayscale images of size 200x200 pixels, the input tensor would be of shape (200, 200, 1) because it has one channel. If you have RGB images of the same size, the input tensor would be of shape (200, 200, 3) because it has three channels

.

* **hidden layer:**

In a Convolutional Neural Network (CNN), the hidden layers consist of convolutional layers, pooling layers, and fully connected layers.

* **convolutional layers:** these layers apply convolution operations to the input data. Each convolutional layer consists of multiple filters extracting features**.**

The number of filters in a convolutional layer determines the depth of the output feature maps. In figure 9, with an input layer of dimensions 200×200×3 and a convolutional layer consist 6 filters, the output feature's shape would be 200×200×6.

* **Pooling layer or Downsampling layer:** reduce the dimensionality of feature maps generated by convolutional layers This downsampling process retains essential information while reducing the spatial dimensions**.** In Figure 9, applying max pooling with a filter size of 2×2 will halve the dimensionality of the feature maps. So the shape become 100×100×6

Note the shape after applying 2 Convolutional layers and 2 Pooling layers 50×50×10 about 25000 pixels and the shape of input images 200×200×3about 120000 pixels

* **Fully connected layer(Dense layer):**
  + - **Flatten layer:** After the convolutional and pooling layers, the feature maps are flattened into a one-dimensional vector

For example, if the shape of the feature maps 50×50×10 it maps to 25000×1

* + - **Fully connected**: process this flattened data by connecting every neuron in one layer to every neuron in the next layer
* **Activation Functions in Hidden and Output Layers:**
* **ReLU**utilized between layers when we aim for the model to only predict positive values. It retains positive values as they are and converts negative values to zero.

In our project we handle with image and the pixel must be positive so we will use it in hidden layer

* **Softmax**commonly used in the output layer of neural networks for multiclass classification and the output values represent the probability of each class
* **Sigmoid**Used in hidden layer as scaller and in output layer in binary classification as probability Our project binary classification so we will use sigmoid in output layer
* **Image below shows the visualization of CNN:**

Top of Form

Bottom of Form

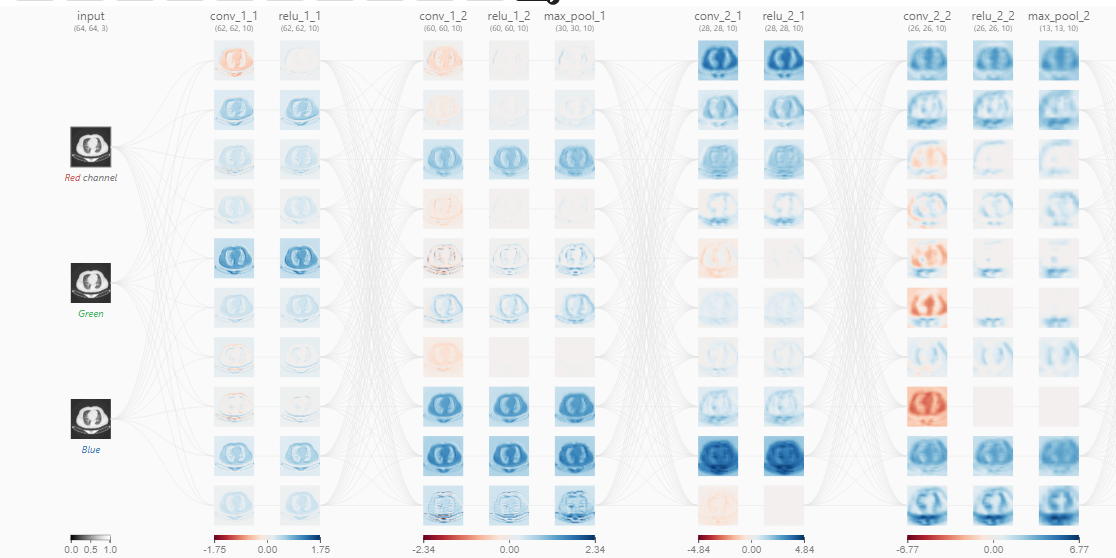


Figure 10: CNN visualization

* + 1. **Legal Aspects**

Ensure that the system maintains the patient’s privacy and maintains the patient’s medical history and private data. The intellectual property rights of the original owner of the idea and his research must be preserved.

* + 1. **Design Constraints**

Use Python as programming languages and MYSQL for database.

The system available every time

* + 1. **Design Standards**

Designing an easy-to-use user interface, verifying the validity of the system and that it works correctly and efficiently, ensuring that this system protects patient privacy.

* + 1. **Design Alternatives**

The design can be modified to allow users to use it from the phone with ease.

* + 1. **Safety Consideration**
* such as data backup and recovery, periodic test, secure design, and regular update.
  + 1. **Design considerations table.**

Table 3. Design considerations.

|  |  |  |
| --- | --- | --- |
| Design consideration | Project application | Relevant location in report |
| Performance | ML algorithms for accurate lung cancer detection | Section 3.2.1 Design Specification |
| Serviceability | Web application interface | Section 3.1.3  Section 3.2.2 |
| Economic | Cost-effective development and maintenance | Section 3.2.1 Design Specification |
| Environmental | The system compatible with the specific platform it will be running on | Section 3.2.1 Design Specification |
| Environmental Sustainability | Using efficient algorithms and data structures can help reduce the computational resources required by the application | Section 3.2.1 Design Specification |
| Manufacturability | N/A | N/A |
| Ethical | System provides data protection protocols | Section 3.2.4 |
| Health and safety | Ensuring that sensitive user data is protected from unauthorized access | Section 3.2.7 Safety Consideration |
| Social | User-friendly interface for users | Section 3.2.1 Design Specifications |
| Political | Compliance with healthcare data protection laws | Section 3.2.3 Legal Aspects |

# Chapter 4: Implementation

* 1. **Implementation Details of Our Solution: Methods and Tools**:

For trained model We used various tools to implement our solution of predicting lung cancer. We used Python programming language and dealt with multiple libraries, such as Scikit-Learn, Tensorflow, OpenCV ,Numpy, and Matplotlib.

Scikit-learn was used for data preprocessing, model evaluation, and performance metrics calculation. The `train\_test\_split` function from `sklearn.model\_selection` was employed to split datasets for training and testing, Categorical target label was encoded using the `LabelEncoder` from `sklearn.preprocessing` and performance evaluation metrics such as confusion matrices and precision\_score, recall, and F1 were calculated from `sklearn.metrics`.

OpenCV was used to handle with images .Numpy was used to help us to work with the numbers and arrays.TensorFlow and Keras were utilized to construct and train the model. Additionally, we utilized visualization library Matplotlib for data visualization.



Figure 11: Libraries used

VS code and jupyter notebook were used to write all codes as it provide excellent code completion, which is particularly useful when dealing with large and complex AI projects. It also has a powerful debugging tool allowing us to quickly review our code and find errors.



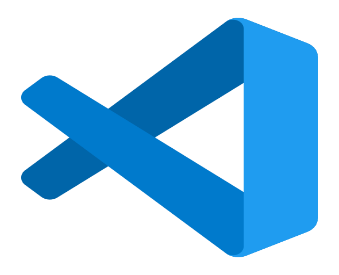


Figure 12 Jupyter Icon

Figure 13 VS Code Icon

For web

* 1. **Solution Infrastructure**

The data set was downloaded from kaggle , It consists of 1097 samples of lung cancer patients, covering cases categorized as Normal, Benign, and Malignant but when we examined the class distribution, we observed imbalance. To address this, we used several method like One Class Classification, Undersamlpling , Data augmentation.

* **Over-sampling:**

duplicate random records from the minority class.

* **Under-sampling:**

the simplest technique involves removing random records from the majority class

* **One-Class Classification:**One-class classification involves training a model on only one class and then using it to identify data points that do not belong to that class
* **Data augmentation:**Using transformation techniques like rotation, reflection and flipping to generate new images.

|  |  |
| --- | --- |
| Figure 14 Before One-Class Classification | Figure 15 After One-Class Classification |

The figure 14 show that the malignant cases significantly outnumber the others, which can lead to biased models favoring malignant cases and reduced overall performance.and figure 15 shows the distribution after using one class-classification .The training data consist of 70% of the total data, with the remaining 30% being used as test sets.

Now if we looked at the shape of the images, we noticed that there are some images with different shapes, so we need to resize all images to the same shape.

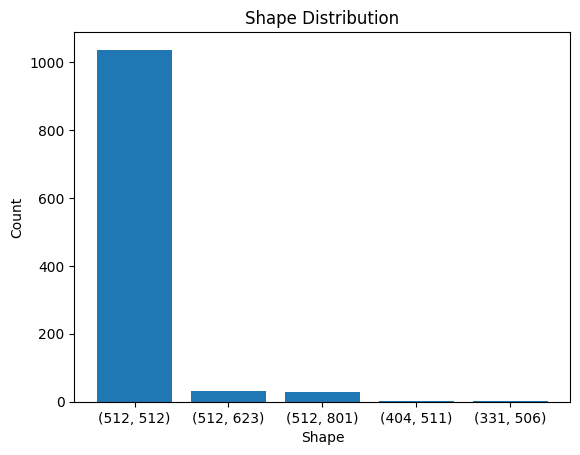


Figure 16 Shape Distribution Before Resizing

**Hyper-parameter Tuning:** We used grid search technique to find the optimal parameters for the model using GridSearchCV from scikit-learn library. CV stands for K-fold Cross Validation which split the training sets to k folds randomly and each time use one from these folds as testing set and the rest of them as training to find the best accuracy.

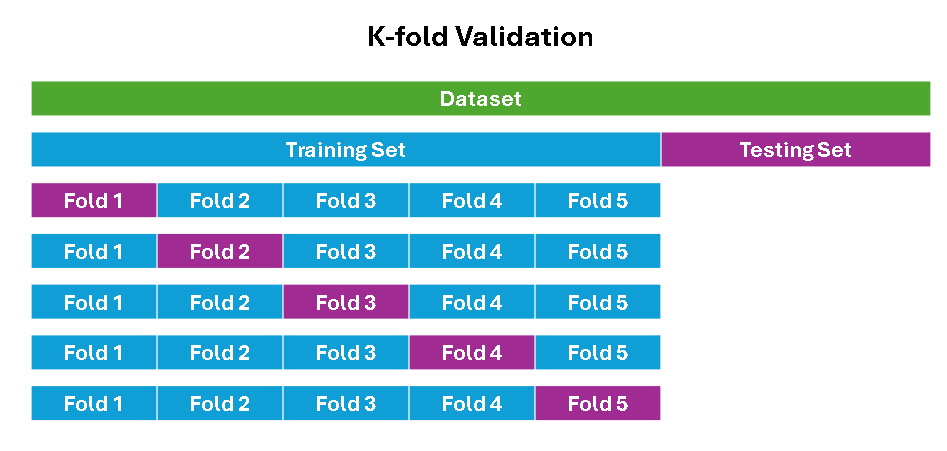


Figure 17 K-Fold Validation

For model creating we used CNN because we’re working with images and the figure below shows the details of our model.

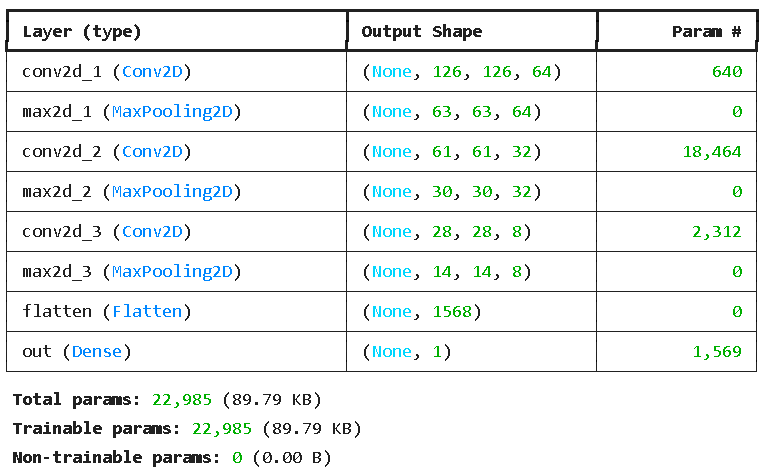


Figure 18 Model Structure

Finaly, we compared our result with related paper [9]

|  |  |
| --- | --- |
| Figure 19 Our CM Result | Figure 20 Related Paper Result [9] |

Our model has accuracy about 99% and they have 93.548%

And these some reasons that may affect the results:

* They used AlexNet Architecture whish is may not be the best choice for this problem.
* They used some filters that may not be the best choice for this problem. (e.g. the filters may be good for some images and not good for the rest of them) and In our work we don't use any filters because we used CNN which is need lower pre-processing (CNN works to find the best filters).
* May they used less data for training than we used.
  1. **The trade-offs**

Designing deep learning model involves balancing between accuracy and complexity, complex model may have high accuracy but require more computational time but in medical model we need high accuracy, and balancing between specificity and sensitivity, in our model we focused on the sensitivity because we need to reduce the risk of missing Malignant cases (reduce FN/ increase TP)

* 1. **Assumptions of our implementation.**

Our solution assumes that the prediction model can generalize well to unseen data, i.e., it can predict lung cancer for new CT scan image that does not present in the training data. The quality of the input data is crucial for the accuracy of our prediction mode

# Chapter 5: Results and Discussion

* 1. Present the results of your work and discuss them in detail and how they are linked to what has been discussed in the design chapter.
  2. Discuss the strengths and weaknesses of your solution/system.

# Chapter 6: Economical, Ethic, and Contemporary Issues

* 1. **Preliminary Cost Estimation and Justification**

The development of the project is undertaken with no financial costs as it uses open-source technologies and free development tools. The main tools to use in the development process include VS Code with the Jupyter extension to trained and built a model and --------------------

* 1. **Relevant Codes of Ethics and Moral Frameworks**

We have adhered to the guidelines set forth by the IEEE Global Initiative for Ethical Considerations in AI and Autonomous Systems in our research project. Launched by the Institute of Electrical and Electronics Engineers (IEEE) in 2016, this initiative aims to develop comprehensive guidelines and recommendations for the ethical design and deployment of AI and autonomous systems. By following these guidelines, we strive to ensure that our research contributes to responsible and ethical practices in AI, aligns with human values, and promotes the public good

* 1. **Ethical Dilemmas and Justification of Proposed Solution**
* Dependency on technology can lead to doctors relying too heavily on the CNN-based system, potentially neglecting their own expertise and observations. Emphasizing the role of the CNN as a tool to support decision-making rather than replace human expertise helps mitigate this risk. It's important to maintain a balance where technology aids medical professionals rather than supplants their judgment entirely.
* The use of patient data raises concerns about data privacy and consent. Without proper safeguards, there's a risk of unauthorized access or misuse of sensitive medical information. to address this dilemma, access to the data is to authorized personnel only
  1. **Relevance to Jordan and Region (Social, Cultural, and Political)**

Healthcare holds significant importance in addressing the challenges of lung cancer detection and treatment. By developing a centralized platform for medical data training , we aim to address the unique needs and obstacles encountered by healthcare professionals in Jordan to detect lung cancer in the early stage. This project aligns with the government's vision of advancing healthcare technology and supports the nation's goals of improving healthcare services and outcomes for patients affected by lung cancer.

# Chapter 7: Project Management

* 1. **Timeline of Project Schedule**

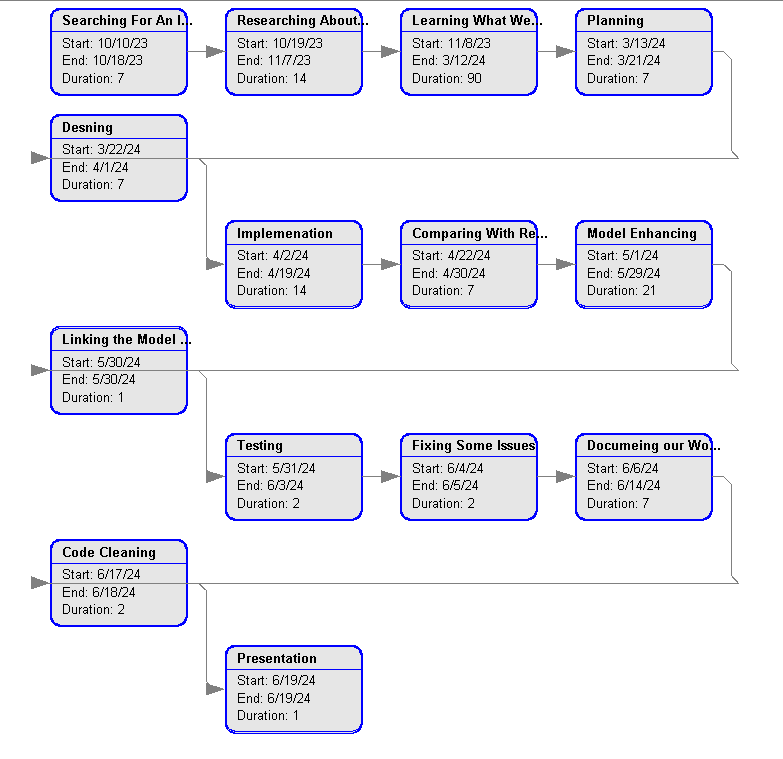
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Figure 21 PERT Chart

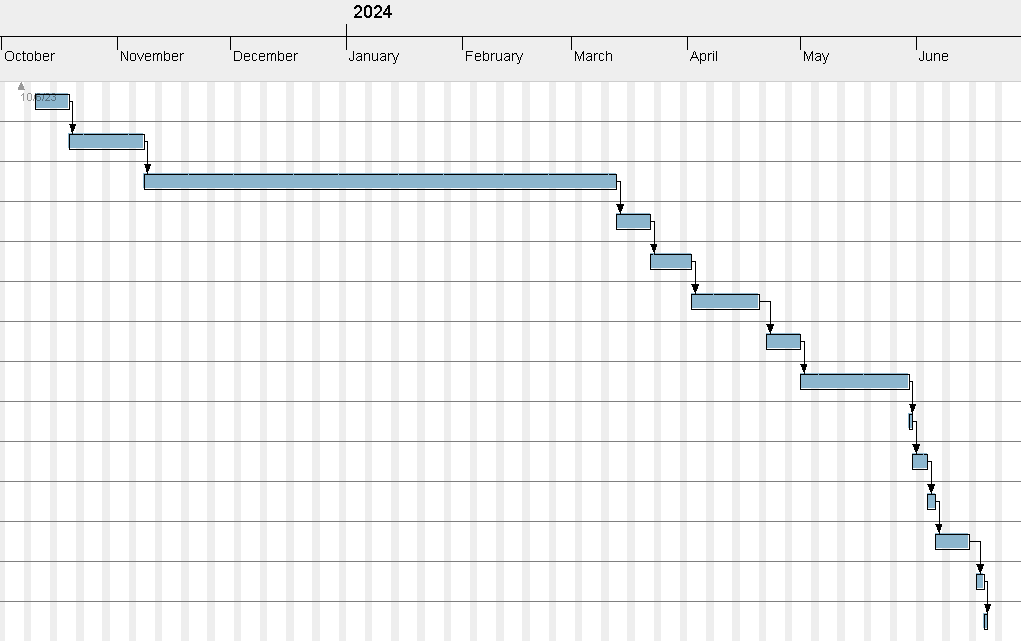
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Figure 22 Gantt Chart

* 1. **Resource and Cost Management**

Using existing resources, such as open-source software, developing the project did not cost money. The project costs time and effort

* 1. **Quality Management**

To ensure quality management throughout the project, we implemented the following measures:

* We made sure everyone on the team knows the requirements and understand their role in meeting them.
* Implement automated testing and validation processes to ensure the project meets quality standards.
* Define and track key performance metrics for the project, such as AUC, Precision, and Recall
  1. **Risk Management**

Plans development and compliance will mitigate any risk of delivery delay. The biggest risk that might be faced is the lack of time

# Chapter 8: Conclusion and Future Work

* 1. **Main contributions of the work.**

This project has successfully developed a lung cancer prediction System marking a significant advancement in healthcare resource management. The main contributions of this work are as follows:

* **Centralized Platform Creation:** We achieved the objective of simplifying the organization of medical data by creating a centralized platform for healthcare professionals to upload images and obtain probabilities of lung cancer.
* **Early Detection:** analyze medical CT scan images with high accuracy, enabling the early detection of lung cancer and increases treatment options for patients.
* **Reduced Workload for Healthcare Professionals:** This frees up time for clinicians to focus on patient care
  1. **Further future** **work**

We could add a database that records patient histories, test results, types of treatment received by patients, and any changes in their health status over time can help improve models and provide accurate and useful information to enhance lung cancer detection

# References

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# APPENDIX A: User Manual

Provide a detailed user manual to explain how to use your solutions with the help of figures, screenshots, or detailed diagrams.

**A.1 Guidance on the use of the design consideration table\***

Performance – How is the design to function? What need is it filling? What does it have to do? Is it reliable?

Serviceability – Is maintenance or repair a concern? If so, can it be easily performed?

Economic – Is the production and/or use costs considered?

Environmental – Does this have positive or negative impact to the environment? Are there any environmental effects due to the production, use or end-of-use of the design? Are appropriate materials selected?

Environmental Sustainability – *(Sustainability refers to the practice of having minimal impact on the environment. Completely sustainable practices do not deplete or degrade the environment.)* Does the design consider recycling, and using sustainable materials and manufacturing methods? Are renewable energy sources used (such as solar)? Does the product promote sustainable practices?

Manufacturability – Can the design be economically produced? Can critical elements be inspected?

Ethical – Has the student followed the code of ethics established by professional organizations such as ASME? Does the design benefit humanity? Have appropriate standards been applied? Are the design documents accurate with claims not overstated?

Health and safety – Have appropriate codes and standards been applied to prevent harm? Does the design mitigate harmful effects of failure to prevent injury? Does the design directly improve the health and safety of users?

Social – Does it benefit society? Are there societal implications of the product?

Political – Are there political implications of the project? What materials or parts would need to be imported? Would this be exported or imported?

\*Information reference: <http://faculty.up.edu/lulay/ME481-482/Example-DesignConsiderationTable-13x.pdf>.

**A.2 Incorporating Standards in a design project.**

Some of the Resources for faculty and students researching standards include but are not limited to:

1. The National Standards Network (NSSN) that can be accessed at http://www.nssn.org/ .
2. International Organization for Standardization (ISO)
3. International Electrotechnical Commission (IEC) standards
4. The National Institute of Standards and Technology (NIST): guides for medical devices, the low voltage directive, and other sector specific issues as well as more general guides dealing with issues such as product liability and product safety
5. The IEEE -Standards Association (IEEE-SA): the leading developer of global industry standards in a broad-range of industries, including Power and Energy, Biomedical and Healthcare, Information Technology, Telecommunications, Transportation, Nanotechnology, and Information Assurance
6. The American Society of Civil Engineers (ASCE)
7. The American Society of Mechanical Engineers (ASME)
8. The American Society for Testing and Materials (ASTM)
9. Occupational health and safety organization (OSHA)
10. Ministry of labor (Jordan) standards for safety and occupational health.
11. Jordan standards and metrology organization (JSMO)
12. The International Committee for Information Technology Standards (INCITS)
13. Standards Engineering Society (SES)
14. Alliance for Telecommunications Industry Solutions (ATIS)
15. The International Telecommunication Union (ITU)
16. National Electrical Manufacturers Association (NEMA)
17. Website Standards Association (WSA)
18. The Joint Electron Device Engineering Council (JEDEC)
19. The American National Standards Institute (ANSI)
20. The Association for Computing Machinery (ACM)
21. European Computer Manufacturers Association (ECMA)
22. CENELEC is the European Committee for Electrotechnical Standardization
23. Electronic Industries Association of Japan (EIAJ) and the Japan Electronic Industries Development Association (JEIDA)

\*Please note that this is a list to provide some guidance, standards organizations might change based on your discipline.