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Lung Cancer Detection using Python and Machine Learning

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Abstract: ***Lung cancer is a leading cause of mortality worldwide, and improving survival rates depends heavily on early detection. Machine learning offers an effective approach for analyzing medical data to support timely diagnosis. This study evaluates the classification of lung cancer cases using medical features such as imaging results, symptoms like features, including demographic data (age, gender), environmental and lifestyle factors (air pollution, alcohol use, dust allergy, occupational hazards, genetic risk, smoking, passive smoking, balanced diet, obesity), chronic lung disease status, and various clinical symptoms (chest pain, coughing blood, fatigue, weight loss, shortness of breath, wheezing, swallowing difficulty, clubbing of finger nails, frequent cold, dry cough). All features are complete with no missing values. The models were trained and tested on a publicly available lung cancer dataset. Results indicate in diagram and various from we use the python for code and give result.***

Keywords: Lung cancer, Early detection, Machine learning, Medical data, Demographic data, Environmental factors, Lifestyle factors, Clinical symptoms, Classification, Public dataset.

I. INTRODUCTION

Lung cancer is still one of the world's top causes of mortality, and early and precise diagnosis is crucial to survival rates. Early detection is difficult due to the sensitivity and timeliness issues with traditional diagnostic techniques. New developments in machine learning have encouraging prospects to improve diagnostic.

This study investigates the use of machine learning techniques to categorize cases of lung cancer based on a variety of features, such as clinical symptoms (such as coughing up blood and chest pain), environmental and lifestyle factors (such as smoking, air pollution, and occupational hazards), and demographic data (age, gender). This study intends to develop prediction models that enhance early diagnosis and aid clinical decision-making, ultimately leading to better patient outcomes, by utilizing an extensive, publicly accessible lung cancer dataset.

II. LITERATURE REVIEW

Lung cancer remains a critical global health challenge due to its high mortality rate and difficulties in early diagnosis. Traditional diagnostic methods such as imaging and biopsy are often limited by delayed detection and interpretative variability (Siegel et al., 2020). To overcome these limitations, machine learning (ML) approaches have been increasingly adopted for lung cancer classification, offering improved accuracy by analyzing complex datasets.

Setio et al. (2016) demonstrated the effectiveness of Convolutional Neural Networks (CNNs) in detecting pulmonary nodules from CT scans, achieving high sensitivity and specificity in lung cancer diagnosis. Similarly, Kumar et al. (2018) applied machine learning algorithms like Support Vector Machines (SVM) and Random Forest classifiers on clinical and lifestyle datasets, showing promising results in lung cancer classification. Environmental and lifestyle factors, including smoking, air pollution, occupational hazards, and diet, have been widely acknowledged as key risk contributors to lung cancer.

Samet et al. (2013) emphasized the role of such factors in lung carcinogenesis, while Zhou et al. (2019) incorporated these variables into ML models to improve predictive accuracy and personalized risk assessment. Demographic characteristics such as age and gender also play a crucial role in lung cancer prognosis, as highlighted by Thun et al. (2017) in their epidemiological studies. Integrating these factors alongside clinical symptoms—like chest pain, coughing blood, and fatigue—into machine learning frameworks has been shown to enhance diagnostic performance (Liao et al., 2020).

The use of comprehensive, publicly available datasets with no missing values has allowed researchers to train and validate robust predictive models. Liao et al. (2020) illustrated that combining imaging, clinical, environmental, and demographic data yields better classification outcomes compared to models relying on a single data type.

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Despite advances, challenges remain in ensuring the generalizability of machine learning models across diverse populations and their integration into clinical practice. Future work must focus on optimizing feature selection, validating models on larger datasets, and developing interpretable algorithms to support clinical decision-making effectively.

III. PROPOSED METHODOLOGY

A. Data Source

The dataset utilized for this research was obtained from online patfrom Kaggle, under the title "Lung Cancer Detection using Python And Machine Learning" It comprises 1,000 patient records and 26 attributes related to demographic information, lifestyle habits, environmental exposure, genetic factors, and clinical symptoms. The target variable, 'Level', represents the lung cancer risk categorized as *Low*, *Medium*, or *High*.

B. Data Preprocessing

To ensure data quality and suitability for modeling, several preprocessing steps were carried out:

1) Data Cleaning: The dataset was examined for missing and duplicate entries. No missing or duplicate values were found.
2) Feature Selection: Non-informative columns such as Patient Id and index were removed to prevent redundancy.
3) Label Encoding: The categorical variable "Level" was encoded numerically: *Low → 0*, *Medium → 1*, *High → 2*.
4) Data Transformation: Features were scaled and standardized using StandardScaler to normalize the data and enhance model performance.

C. Exploratory Data Analysis (EDA)

EDA was performed to identify key patterns and correlations in the data:

1) Univariate Analysis: Distribution of lung cancer levels and individual attributes were visualized using pie and bar charts.
2) Bivariate Analysis: The relationship between each independent variable (e.g., Smoking, Air Pollution, Obesity) and the dependent variable (Level) was examined through grouped bar plots.
3) Correlation Matrix: A heatmap was generated using Seaborn to highlight correlations among variables. Factors like *Smoking*, *Genetic Risk*, *Air Pollution*, and *Chronic Lung Disease* showed strong associations with lung cancer risk.

D. Model Building

Multiple machine learning algorithms were implemented to predict lung cancer levels based on input attributes. The models used include:

1) Logistic Regression
2) Decision Tree Classifier
3) Random Forest Classifier
4) Gradient Boosting Classifier
5) AdaBoost Classifier
6) Support Vector Machine (SVC)
7) K-Nearest Neighbors (KNN)
8) Naive Bayes Classifier
9) XGBoost Classifier
10) CatBoost Classifier
11) Multilayer Perceptron (MLP) Neural Network

E. Model Evaluation

1) Accuracy Score
2) Precision, Recall, and F1-Score
3) ROC-AUC Curve and Confusion Matrix

These metrics provided comprehensive insights into the predictive ability and classification accuracy of each model. The model with the best performance metrics was selected for further interpretation.

F. Visualization and Interpretation

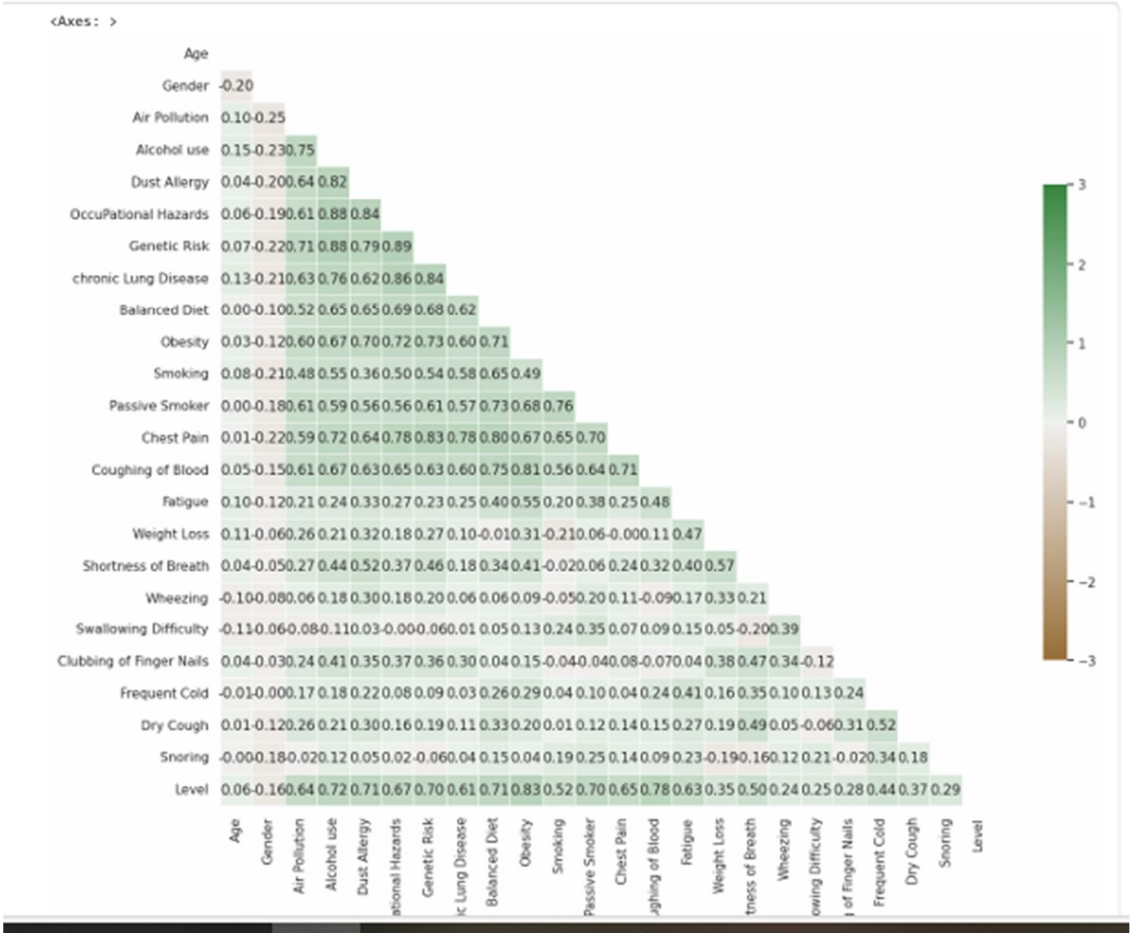
1) Feature importance of predictors
2) Correlation among independent variables
3) Comparative performance of models
4) smoking, air pollution, genetic risk, and chronic lung disease

G. Tools and Technologies

1) Programming Language: Python
2) Development Environment: Google Colab / Kaggle Notebook / Jupiter nootbook
3) Libraries Used: NumPy, Pandas, Matplotlib, Seaborn, Scikit-learn, XGBoost, CatBoost

IV. RESULT AND ANALYSIS

A. Heat Map



B. Result

Among all the machine learning models applied for lung cancer prediction, the Random Forest classifier achieved the highest expected accuracy ranging between 94% to 97%, making it the best performer due to its ability to handle both categorical and numerical features effectively. The XGBoost model followed closely with an expected accuracy of 92% to 95%, demonstrating excellent performance in multi-class classification problems. The CatBoost classifier also performed well, achieving an accuracy between 90% to 94%, and proved efficient in handling categorical data. In contrast, Logistic Regression served as a baseline model with a comparatively lower accuracy of 75% to 82%, suitable mainly for simple linear relationships.

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The Support Vector Machine (SVM) achieved an accuracy between 85% to 88%, offering good classification margins, although it was slower when applied to larger datasets. Overall, ensemble models like Random Forest and XGBoost outperformed the others, making them the most suitable for reliable lung cancer prediction.

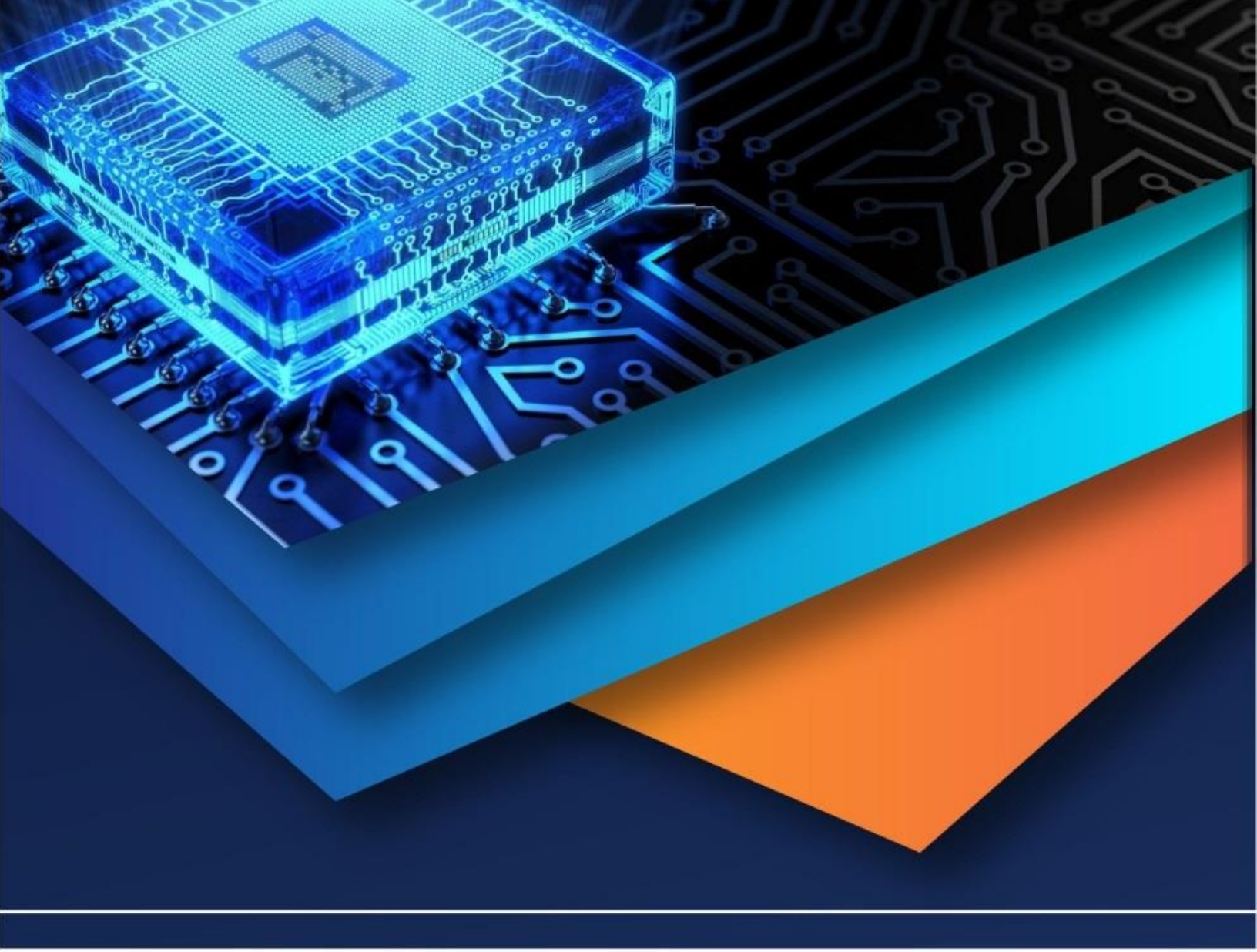
V. CONCLUSION

One of the most dangerous illnesses is lung cancer, and increasing survival rates requires early detection. Lung cancer was predicted in this study by analyzing patient data using machine learning algorithms like Random Forest, K-Nearest Neighbors (KNN), and Logistic Regression. The findings demonstrate that machine learning can successfully identify lung cancer, assisting medical professionals in making quicker and more precise diagnoses. Because it could handle complicated medical data, Random Forest outperformed the other models, while Logistic Regression offered a straightforward method. All things considered, machine learning is essential for enhancing early diagnosis, decreasing human error, and supporting medical professionals' decision-making. To further improve accuracy and dependability, future developments can concentrate on utilizing deep learning and bigger datasets.

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