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# A Study of Improving Lung Cancer Detection Using IoT Technology: A Review

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***Abstract*— Cancer is becoming an alarming threat for the whole world, all types of cancers are dangerous, but lung cancer is reaching its peak position because of having a low survival rate as compared to its death ratio. The main aim of this review is to identify various IOT technologies for the proper diagnosis of lung cancer along with which technology is performing better for lungs cancer identification nodules. Luckily, with advancement in healthcare industry there are various procedures, strategies, tools that are becoming very beneficial for reversing the survival and death proportions of lung cancer. In this review, a study is conducted for improving the diagnosis of the lung cancer by using IOT technology, death and survival rate of the patients from the lung cancer is included statistically, review paper comprised of previous studies for understanding numerous technologies, systems, limitations and future works deeply for the diagnosis of the lung cancer properly. A comprehension about MRI, CT scan, x-ray is also performed with the analysis of which technology is better for the lung cancer detection.**

***Index Terms*—IoT technology, CT scan, MRI, X-Ray, Internet of Things, Lung Cancer and Detection of Lung Cancer**

## I. INTRODUCTION

THE Internet of Things (IoT) is a new gauge that has clinched more interest in modern technology of the medical field, and it is considered as the most innovative concept for smart life [3]. The IoT can be elucidated as an infrastructure of global information society that sanction knowledgeable services by connecting things, though IoT contributed to the technological advances of the contemporary interval [4]. Latterly, the contribution of the Internet of Things (IoT) in healthcare assistance and in sensing technology led towards more broad and better significant research areas. High-cost healthcare services and the existence of countless diseases, it is entailed to shift the hospital-centric system into a person-centric environment instantly [5].

The medical sector is contemplated as one of the domains that has felt the pressure due to increased insistence of services of the medical, so the IOT bestowed a lot in the medical domain [6]. According to statistics 40% IoT-related technology played a significant role in the health domain, as compared to any other category, a $117 billion market has been produced [7]. IoT can effectively meet its condition to process gigantic amounts of data for the sake of accurate decision making because IOT related devices can play a significant role in Remote patient monitoring (RPM), Connected inhalers, Glucose monitoring, Hand hygiene monitoring [8] to obtain advantage for the processing for the big data [9].

Currently, numerous techniques relating to the IOT technology such as MRI (Magnetic Resonance Imaging) scan, x-ray (chest radiograph) and CT (Computed Tomography) scan are used for diagnosing lung cancer, especially detection of mimi lumps [10]. These advances create on-screen images of the human body and require gigantic amount of data of patients [1] along with this the evolution in the Medical Internet of Things (MIoT) technologies has empowered the outlying monitoring of patients so the MIoTs refer to wearable healthcare devices [2].

Techniques of Image processing can also play a pivotal role to predict and identify the symptoms of lung cancer and it can be diagnosed through imaging technologies such as X-ray, Magnetic Resonance Imaging (MRI), Computerized Tomography (CT) scan [13] and symptoms can be diagnosed by these technologies. The key approach of MRI for detecting lung cancer is dependent on the high-frequency signals which are based on the resonance of protons in tissues and liquids which is so far called proton MRI [11].

With the further advancement in medical imaging technology, CT imaging has become the most popular imaging methods for identifying diseases, submillimeter resolution has been achieved by CT imaging and provided high accuracy in finding small and concealed nodules [12]. The images of Conventional chest X-ray are used for the screening of lung tumors and the shadows of cancerous tumors on X-ray images are usually indeterminate and it is not an easy task to detect them [14].

Lung Cancer can be defined as expeditious growth of cancerous cells in the human body due to the spread of a minority number of cells from the lungs [15], statistics proclaim that the World Health Organization (WHO) reported 1.8 million new cases and around 1.6 million lung cancer-related deaths were found in previous years [16]. In the United States, lung cancer is observed as the second most common diagnosed cancer which is causing cancer-related death. It is inspected as one of the most aggressive cancer types, diagnosis of this

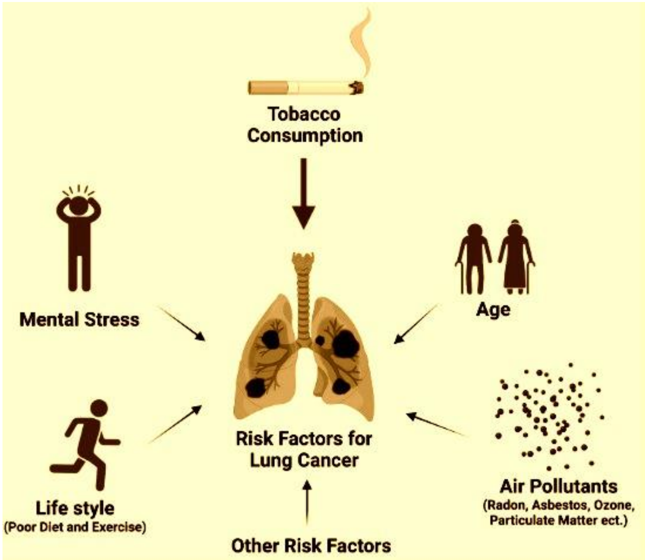


Fig. 1. Risk Factors for Lung Cancer

disease at an early stage is difficult rather than its symptoms getting revealed at the final stage [17] its survival rate in patients increases to 60-70% if this disease is identified at its early stage as compared to the final stage [18]. Its survival rate in both men and women is low, which is 7.8% and 9.3% respectively because of diagnosis of this disease at the final stage [19]. Having a low survival rate this is considered as one of the most dangerous cancer types globally due to carelessness shown by patients [20].

More than 38,000 people in the UK and approximately 170,000 people in the US faced problems from this disease. Earlier diagnosis allows the patients to choose the path of curative surgery and get rid from this disease [21]. When emotional issues are evaluated concurrently with a lung cancer diagnosis, it creates a window of opportunity for early intervention to lessen the long-term effects of emotional issues [22].

New cough and chronic cough present the most distressing symptom in people with lung cancer, Long-term smoking is considered as another factor, shortness of breath, evict of blood from the lungs and chest discomfort and tightness in breast are strongly connected with a preliminary lung tumor, before diagnosis hemoptysis and dyspnea can longer remain for 180 days and these symptoms contribute to earlier diagnosis of lung cancer [23]. There are also other symptoms that cause lung cancer in people such as clusters of fatigue, sickness, reduction in weight, reduced appetite, vomiting, and tasteless buds [24]. Mostly the patients go to death because of low availability of consultations when their comparison is making with those patients having breast cancer [25].

Cancer patients also face mental depression when compared with other illnesses, symptoms of depression are highly found in the patients of lung cancer, and this causes an early death of them [26]. In addition, early diagnosis is most important for the proper treatment of sufferers of lung cancer [27], Although lung cancer treatment as increased in past years but the issue which faced by patients is that proper medication is not more effective in the final stage and mostly sufferers having cancerous cells in early stage [28]. Surgery is also the treatment for lung cancer; but surgical results do not have a suitable influence on the whole survival statistics [29], Lung cancer treatment and management are related to several problems.

For example, individuals with this illness frequently receive false diagnoses for varying lengths of time, misidentifying them as having pulmonary tuberculosis. This misdiagnosis not only postpones the initiation of an accurate medical diagnosis but also exposes the patient to harmful, unnecessary, and inappropriate medication, which worsens the patient's condition [30]. It is imperative to investigate novel approaches for the timely identification of lung cancer [31], which means that improving patient survival rates following these investigations will be important.

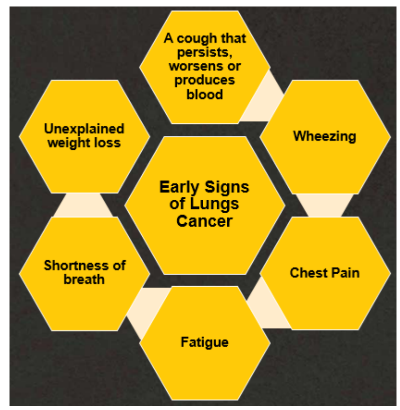


Fig. 2. Early Signs of Lungs Cancer

Improving the chances of survival for people with lung cancer mainly relies on spotting the disease early, Using advanced technology like special computer programs can help doctors find signs of cancer faster. Also, it is important to make sure people know about the symptoms, especially if they have been heavy smokers [32]. Regular check-ups can catch any problems early and watching out for symptoms like coughing a lot, trouble breathing, coughing up blood, or chest pain is crucial. New tools that use smart technology can also help doctors find cancer sooner by looking at different clues in a person's health records. Besides, checking out the feelings of the person alongside medical tests can help catch any emotional struggles early on and get support [33]. By bringing together new tech, regular check-ups, and caring for the emotional health of person, we can boost the chances of beating lung cancer.

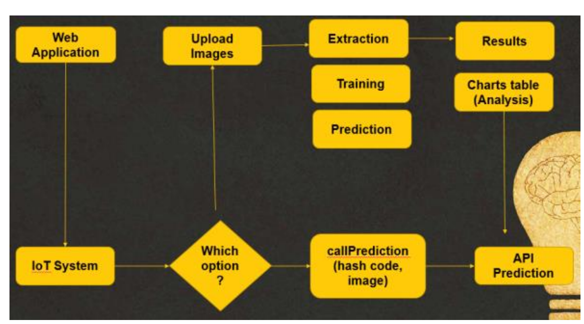


Fig. 3. Web Interface complete overflow

## II. LITERATURE SURVEY

In the smart IoT environment P. D. M. Paul [34] delineated a network for upgrading the solubility of anti-corona virus-Henry gas for lung cancer diagnosis and dataset consisted of 1000 rows and 25 columns. Algorithm anti-corona virus-Henry gas solubility optimization (ACV-HGSO) and bee colony-based algorithm was utilized to designate the right approach for transmitting the medical information of patients. On training data these outcomes have been generated 0.910, 0.914, and 0.912 for the accuracy testing, sensitivity, and the specificity and hereafter, for enhancing the performance, method of selection of feature can be solicited on the input data to improve more accuracy.

M.A.Yousuf [35] introduced a neural network-based deep-convolutional model instructed on CT scan and medical IoT (MIoT) sensor based data. The main emphasis of the research was to shift the conventional method into the MIoT based system for healthcare. 525,000 images were classified into five classes using hybrid classifiers using CNN algorithm providing (96.81%) high accuracy and the stages of lung cancers were classified into 1A, 1B, 2A and 2B correspondingly with the 91.6% accuracy. Although there are several limitations of this research such as not having a mechanism for MIoT fault detection, require image processing feature enhancement, no strive to find the augmented images based on optimization, absence of appropriate Graphical User Interface (GUI).

C. Usharani et al. [36] investigated techniques based on image processing by utilizing algorithms of Convolutional Neural Network (CNN) along with Residual Network ResNet), Visual Geometry Group (VGG), U-Net, Semantic Segmentation Network (SegNeT), ButterflyNet models. Performance evaluation metrics engaged for the examination of CT imaging and Semantic Segmentation Network (SegNeT) model furnished 99% accuracy amongst all. Accessibility of large dataset, regularity of protocols based on imaging and the occurrence of the false-negative or false-positive scrutinize are the hindrances and these can be resolved in the future after exploiting mechanisms of Artificial Intelligence for diagnosing lung cancer based on CT imaging detection for the investigators and chiropractors.

N.Faruqui et al. [37] presented Health As A Service (HAAS) model who used the Convolutional Neural Network (CNN) algorithm for detecting lung cancer at earlier stage to reduce the mortality rate of lung cancer and outcomes produced on the 1108 CT images having average precision, recall, and F1-scores of 96.47%, 95.39%, and 94.81%, respectively. There are some constraints of this article including deficiency of performance investigation, the statistics regarding geographical locations are vague, and structure is adaptable for up till eight concurrent identification requests, server undergo performance issuing having more than eight requests, sensors are not obtainable commercially, the model is still undergoing study and development, accessible only on web. The future path is to produce a better prototype of HAAS by introducing a compact devices model, magnifying the expandability, and conducting exploratory research based on its geographical locations.

A.I.Chowdhury et al. [38] presented a relative analysis of preceding literature in order to deal with various approaches for deeper understanding of lung cancer detection procedure. Algorithms like Deep Neural Network (DNN), Recurrent Deep Neural Network (RNN), Convolutional Neural Network (CNN) and Artificial Neural Network (ANN) are engaged in 58 CT scan images of the participants to diagnose procedure. Different methods such as Support Vector Machine (SVM), Back Propagation Network, Bayesian classification, Genetic Algorithm used for the diagnosis and Back Propagation Network achieved 99.28% accuracy amongst all.

A. Masleka et al. [40] utilized Deep Convolutional Neural Networks (DCNN) for the detection of lung cancer on the CT images which aimed to detect cancer and non-cancer lung nodes and experimented on 100 CT scan images. The Preprocessing was done prior to applying input CT images to the network model for the purpose of equal sized images. Dataset used in investigation work is the property of lung cancer image dataset institute (LIDC); moreover, 97% accuracy was achieved which was better than the former papers.

### *A) Limitations and Future Work*

The literature review section covers some limitations and future work of the review papers that are as follows:

*Limitations:* Accessibility of large dataset, regularity of protocols based on imaging and the occurrence of the false-negative or false-positive scrutinize [36].

Deficiency of performance investigation, the statistics regarding geographical locations are vague, and structure is adaptable for up till eight concurrent identification requests, server undergo performance issuing having more than eight requests, sensors are not obtainable commercially, model is under ongoing research and development period, accessible only on web [37].

Not having a mechanism for MIoT fault detection, requiring image processing feature enhancement, no striving to find the augmented images based on optimization, absence of appropriate Graphical User Interface (GUI) [35].

*Future Directions:* Exploiting mechanisms of Artificial Intelligence [36].

To improve the HAAS prototype by adding a small device model, enlarging its expandability, and carrying out exploratory studies based on its geographic locations [37].

Method of feature selection can be solicited on the input data to improve more accuracy [34].

### *B) Challenges in Lungs Cancer Detection*

Detecting lung cancer presents significant hurdles despite the strides made in medical technology, often resulting in delayed diagnoses and compromised treatment outcomes. A major challenge lies in the subtle progression of lung cancer during its early stages, frequently devoid of noticeable symptoms until the disease has significantly advanced. This delay in detection limits treatment options and diminishes overall survival rates [42]. Furthermore, lung cancer symptoms often overlap with those of other respiratory ailments, making accurate diagnosis intricate. Symptoms like persistent cough, chest pain, and shortness of breath can lead to misdiagnosis or delayed diagnosis, permitting the disease to advance unchecked. Additionally, the interpretation of imaging methods like chest X-rays and computed tomography (CT) scans can vary among radiologists, introducing inconsistencies in nodule detection and

Table I: Illustrates different paper and work on improving lungs cancer detection

| Index | Title | Author | Year | Algorithm | Data | Purpose | Accuracy |
|---|---|---|---|---|---|---|---|
| 1. | View of lung cancer detection in CT images using deep learning techniques: A survey review | C. Usharani et al. [36] | 2024 | Convolutional Neural Network (CNN) | 177 CT scan-based images | Providing better path for diagnosis of lung cancer based on CT images for the investigators and chiropractors | Semantic Segmentation Network (SegNeT) model furnished 99% accuracy |
| 2. | Healthcare As a Service (HAAS): CNN-based cloud computing model for ubiquitous access to lung cancer diagnosis | N.Faruqui et al. [37] | 2023 | Convolutional Neural Network (CNN) | 1018 CT scan based images | Reducing the lung cancer mortality rate by providing the opportunity of early detection of lung cancer | Average precision, recall, and F1-scores of 96.47%, 95.39%, and 94.81%, respectively |
| 3. | A Framework for Lung Cancer Detection at Early Stages with IoT and Decision Support System | A.I.Chowdhury et al. [39] | 2023 | Deep Neural Network (DNN), Recurrent Deep Neural Network (RNN), Convolutional Neural Network (CNN) and Artificial Neural Network (ANN) | 58 CT scan-based images | To deal with various approaches for deeper understanding of lung cancer detection procedure | Back Propagation Network achieved 99.28% accuracy |
| 4. | Review on Computer Aided Diagnostic System for Detection of Lung Cancer by using Image Processing | A. Masleka et al. [40] | 2023 | Deep Convolutional Neural Networks (DCNN) | 100 CT Scan images | Diagnosis of cancer and noncancer nodes of lungs | 97% accuracy |
| 5. | Deep maxout network for lung cancer detection using optimization algorithm in smart Internet of Things | P.D.M.Paul [34] | 2022 | Anti-corona virus-Henry gas solubility optimization (ACV-HGSO) | 1000 rows, and 25 columns | Upgrading the solubility of anti-corona virus-Henry gas for lung cancer diagnosis | 0.910, 0.914, and 0.912 for the testing accuracy, sensitivity, and specificity |
| 6. | LungNet: A hybrid deep-CNN model for lung cancer diagnosis using CT and wearable sensor-based medical IoT data | M.A.Yousuf [35] | 2021 | Convolutional Neural Network (CNN) | 525,000 images | Shift the conventional method into the MIoT based system for healthcare | 96.81% accuracy on the classified images |

potentially yielding false-positive or false-negative results.

The detection of small lung nodules, particularly those under 5 millimeters, poses another substantial challenge. These nodules may indicate early-stage lung cancer and require sensitive detection methods for accurate diagnosis. Moreover, establishing the optimal criteria for lung cancer screening, encompassing factors like age, smoking history, and additional risk elements, remains intricate, hampering effective targeting of at-risk populations for screening programs [41].

Despite the acknowledged benefits of lung cancer screening initiatives, limited accessibility remains a barrier, particularly in underserved regions and rural areas. This lack of access contributes to disparities in early detection and treatment outcomes among various demographic groups. Furthermore, implementing advanced screening and diagnostic technologies, such as low-dose CT scans and molecular testing, faces obstacles related to cost and resource constraints.

Encouraging high-risk individuals, they should undergo screening of lung cancer and follow-up diagnostic procedures faces challenges regarding patient compliance and awareness. Addressing misconceptions about screening risks, benefits, and the criticality of early detection is imperative for enhancing screening participation and improving patient outcomes. Overcoming these multifaceted challenges demands comprehensive strategies integrating advancements in medical imaging technology, refining risk stratification approaches, and establishing robust patient education initiatives. Such endeavors aim to bolster early detection efforts and ultimately mitigate the burden of lung cancer mortality.

*C) Our Contribution*

Our contribution to this review paper encompasses several key aspects aimed to provide a thorough understanding of the lung cancer detection landscape, particularly concerning the integration of IoT (Internet of Things) technology. Through an extensive review of existing literature, we have synthesized and analyzed a diverse array of studies, research papers, and reports to offer a comprehensive overview of the current state of the field. Central to our contribution is the identification and examination of critical challenges and opportunities within lung cancer detection. Our analysis delves into the nuanced complexities of detecting lung cancer, highlighting how IoT technology can be strategically employed to address these challenges. By meticulously scrutinizing existing literature, we illuminate areas where innovative IoT solutions hold promise in enhancing early detection rates and ultimately improving patient outcomes.

Moreover, our contribution involves a thorough evaluation of various IoT-based approaches proposed or implemented for lung cancer detection. We critically assess the strengths, limitations, and efficacy of these approaches, providing valuable insights into their practical applications within clinical settings. Through this evaluation, we aim to facilitate informed decision-making regarding the adoption and implementation of IoT technologies in the realm of lung cancer detection. In addition to summarizing existing research, we offer forward-thinking insights into future directions for research and development in this domain. By exploring emerging trends, technological advancements, and avenues for further investigation, we endeavor to guide future research endeavors and inspire innovation in lung cancer detection leveraging IoT technology.

Our contribution culminates in a robust conclusion and a set of actionable recommendations tailored for researchers, healthcare practitioners, and policymakers alike. Grounded in our comprehensive analysis, these recommendations are designed to catalyze progress in the field of lung cancer detection and drive tangible improvements in patient outcomes through the strategic integration of IoT technology. In essence, our contribution to this review paper serves as a catalyst for advancing the understanding and application of IoT technology in lung cancer detection. Through our comprehensive analysis and forward-thinking insights, we strive to empower stakeholders with the knowledge and guidance needed to navigate the evolving landscape of lung cancer detection and ultimately enhance patient care.

## III. DETECTING LUNG CANCER THROUGH CT SCAN, X-RAY AND MAGNETIC RESONANCE IMAGING (MRI)

*A) CT scan*

Lung CT screening helps in analysis of information in more comprehensive form rather than ordinary X-rays because it makes it possible for detecting and diagnosing lung cancer earlier and more appropriately. CT is known as Computed Tomography, because CT uses a specific form of X-ray, integrated with computer technology, in order to build a cross-sectional portrait of the soft tissues, organs, bones and blood vessels in any part of the body. It revolutionized medical imaging by CT lung cancer screening which revolutionized medical imaging by equipping more comprehensive information instead of conventional X-rays and providing improved care of patients [43].

For screening of the cancer low-radiation-dose CT is satisfactory this is because it has been illustrated as more delicate than X-ray in diagnosis of the cancer, having not so much exposure to the radiation than quality chest CT. For early manifestations of lung cancer, CT technology is used to identify pulmonary nodules, grouping of abnormal tissue in the lungs so these nodules are rarely diagnosed besides CT before physical indication of lung cancer grows [50].

Most of the individuals may have pulmonary nodules, but these are all not cancerous. In reality, mostly nodules are brought about by marked tissues from a previous lung infection and these are not cancerous. Screening based on Computed Tomography (CT) diagnoses small nodules that are behind set on as non-cancerous. If there are benign nodules, you will be promoted to go back for CT screening annually for one to two years to identify properly that they do not enlarge. If a nodule is considerate of cancer, then more and more diagnostic assessment will be proposed.

A CT scan is just like a screening test that utilizes both computer and technology of X-ray. These non-surgical tests can grab a 360-degree visualization of any area of the body and build numerous images for radiologists to identify in more detail. After that scan makes portions or cross-sectional images that display the domain of part of the body and tumors inside the body. CT scan can diagnose compact abnormalities without struggling because of its high reactivity [44].

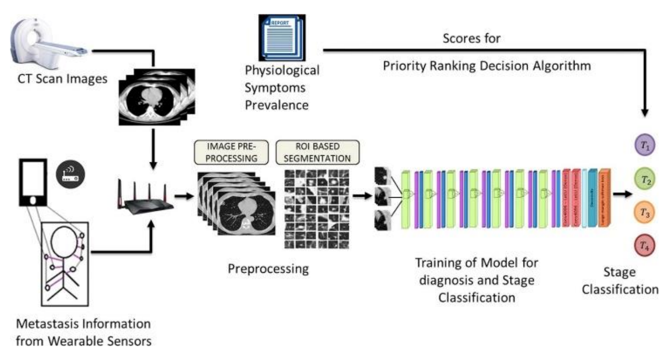


Fig. 4. How CT Scan work?

*B) X-ray*

Electromagnetic radiation with high-energy is being used for chest x-rays to examine the lungs and their adjacent tissues. The care team can observe the lungs, heart, bones, and other composition, but cellular abnormalities are not identified by the x-ray. X-ray of the chest helps in detecting abnormalities in any area of the lung, whether they are identified as lung lumps or cancerous growth [45].

An x-ray is frequently untimely on the detection of lung cancer and may guide towards other tests if beneficial. When anyone appears for x-ray, the radiographer may ask you to wear a hospital gown, a chest x-ray is normally grabbed against the x-ray apparatus, and the radiographer will not take many minutes to obtain the best position.

X-rays are pain-free and each one merely lay hold of scrap for a second. Your x-ray should be more than one x-ray which can be taken from various angles. Then you are asked to keep still and hold your breath for some time when x-ray is taken [46]. But it is considered the earliest test that is used to detect lung cancer or if a cancer has spread. Cancerous growth gravitates to appear on an x-ray in the form of white-grey mass, but there is no method to determine between cancer and other circumstances, such as a lung abscess, so for this purpose, an x-ray alone cannot give a conclusive detection. If the radiographer analyzes something relating to concern, they will send you further tests for further investigation.

Though the use of x-rays allows for the use of a smaller amount of radiation for taking a picture of the body internally. This procedure is a better way to observe small changes inside the body caused by lung cancer or other diseases. According to statistics, more than 96% of people with symptoms of lung cancer first prefer chest x-rays instead of going to a chest physician. But the normal x-ray of the chest does not include identification of lung cancer, if the people have high suspicion of lung cancer but their chest x-ray is normal, they should go to a respiratory physician for further examinations [47].

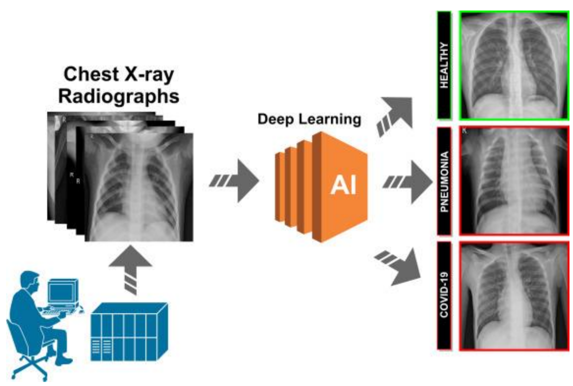


Fig. 5. Complete workflow of X-ray

*C) MRI*

Magnetic resonance imaging (MRI) is considered as one technique regarding medical imaging that utilize both magnetic fields along with radio waves generated from computers for the creation of the detailed visualization of organs along with tissues of the body. MRI is beneficial for evaluating the possibility of lung cancer for providing high quality visualization of the inside of the body; it includes both radio waves and magnetic field, so some people avoid having an MRI.

An MRI is beneficial for the physicians in such a way that it allows them to properly visualize the different locations of the lung cancer and also determine the size of the tumor accurately [49]. Magnetic fields are used by MRI instead of using x-ray for taking the clear picture using a medium which is considered as a specific dye. The dye is vaccinated into the vein of the patient, but the scanning of the MRI does not provide clear visualization of the parts of the body that are moving as like the lungs which moves with each breath.

For that reason, MRI is seldom used to visualize the lungs only, but it is helpful for detecting the lung tumor that has expanded towards the brain and bony framework. Like CT scan, MRI scanning provides the detailed visualization of the soft tissues that are present in the body and also utilizes radio waves and strong magnets rather than x-ray [48].

So, as a result both the CT scan and MRI are great, CT scans are preferable for spatial resolution on the other hand MRIs are beneficial for contrast resolution. It also depends on the condition of the patients from which stage they are suffering because each patient has a distinctive condition. If a patient is suffering from the pain and it is becoming hard for the patient to bear this pain, then CT scan is the preferable option to choose. If doctors are unsure from the visualization of the CT scan they may use an MRI for better visualization of the diagnosis whether the patient has lung cancer or not [38].

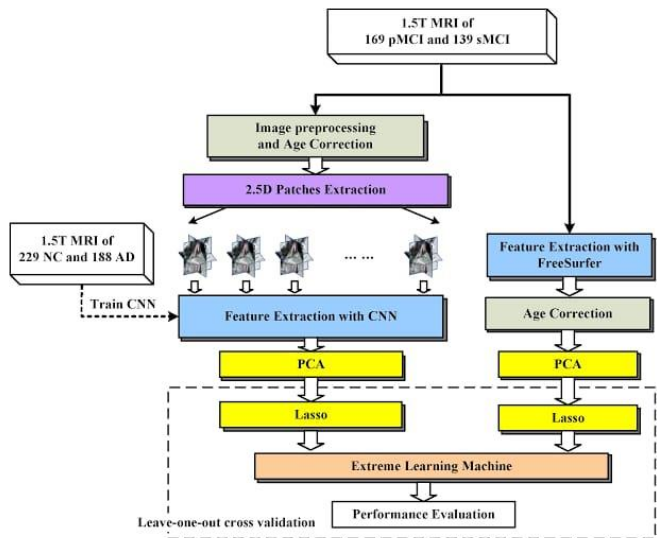


Fig. 6. MRI processing

## IV. RESULTS AND EVALUATION

The review paper explores the field of lung cancer detection in detail, with an emphasis on how Internet of Things (IoT) technology might be used to improve diagnostic precision. The study presents a comprehensive review of the literature to explain the effectiveness of different IoT-enabled strategies. Notable research using sophisticated machine learning algorithms, including CNN, is included. In terms of accuracy, sensitivity, and specificity in diagnosing lung cancer nodules, these investigations, carried out by researchers such as P. D. M. Paul, M.A. Yousuf, C. Usharani et al., N. Faruqui et al., A.I. Chowdhury et al., and A. Masleka et al., show encouraging results. Nevertheless, in spite of these developments, the study identifies important obstacles, such as restricted availability of extensive datasets and the lack of reliable failure detection systems in Internet of Things devices.

In addition, it clarifies important obstacles to lung cancer identification, including the disease's sneaky early development and symptoms that mimic those of other respiratory disorders.

In spite of these obstacles, the review paper makes progressive suggestions for further investigation, including the investigation of artificial intelligence techniques and the creation of more compact and geographically flexible Internet of Things devices. To sum up, the review paper offers a thorough road map for navigating the challenges of IoT-enabled lung cancer diagnosis, including insightful analysis and actionable suggestions to propel progress in this crucial field of medicine.

## V. CONCLUSION

There are several studies that provide various mechanisms regarding machine learning (ML), deep learning (DL) for the detection of lung cancer by using various advanced algorithms but very few studies focus on IoT for the diagnosis of lung cancer. Our proposed study includes death and survival rate of people from this disease, work of previous studies, puts a light on their limitations and recommends future direction for improving lung cancer detection by using IOT technology. Our study includes x-ray, MRI and CT scan for the better observation and examination of lung cancer which will be helpful and beneficial for the future research. We focused on various aspects of different technologies relating to IOT for determining a more improved method for lung cancer detection for fulfilling the aim of saving the lives of more and more people.

## REFERENCES


[1] Deepthi, S. A., Rao, E. S., & Giriprasad, M. N. (2022a). Secure MRI brain image transmission using IOT devices based on hybrid autoencoder and restricted Boltzmann approach. *arXiv (Cornell University), 2022*, 1–11. https://doi.org/10.1155/2022/5841630

[2] Faruqui, N., Yousuf, M. A., Whaiduzzaman, M., Azad, A. K. M., Barros, A., & Moni, M. A. (2021). LungNet: A hybrid deep-CNN model for lung cancer diagnosis using CT and wearable sensor-based medical IoT data. *Computers in Biology and Medicine*, *139*, 104961. https://doi.org/10.1016/j.compbiomed.2021.104961

[3] Ramkumar, M. P., Paul, P. D. M., Maram, B., & Ananth, J. P. (2022b). Deep maxout network for lung cancer detection using optimization algorithm in smart Internet of Things. *Concurrency and Computation: Practice and Experience*, *34*(25). https://doi.org/10.1002/cpe.7264

[4] Pradhan, K., & Chawla, P. (2020). Medical Internet of things using machine learning algorithms for lung cancer detection. *Journal of Management Analytics*, *7*(4), 591–623. https://doi.org/10.1080/23270012.2020.1811789

[5] Valluru, D., & Jeya, I. J. S. (2019). IoT with cloud based lung cancer diagnosis model using optimal support vector machine. *Health Care Management Science*, *23*(4), 670–679. https://doi.org/10.1007/s10729-019-09489-x

[6] Mouha, R. a. R. A. (2021). Internet of Things (IoT). Journal of Data Analysis and Information Processing, 09(02), 77–101. https://doi.org/10.4236/jdaip.2021.92006

[7] Garbeva, A. (2024, February 2). 10 Internet of Things (IoT) healthcare examples. BGO Software. https://www.bgosoftware.com/blog/10-internet-of-things-iot-healthcare-examples/

[8] Dimitrov, D. V. (2016, July). Medical internet of things and Big Data in Healthcare. Healthcare informatics research. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4981575/

[9] Mouha, R. A. (2021, March 18). Internet of things (IOT). SCIRP. https://www.scirp.org/journal/paperinformation?paperid=108574

[10] Venkatesh, C., & Bojja, P. (2022, April 6). A dynamic optimization and deep learning technique for detection of lung cancer in CT images and data access through internet of things - wireless personal communications. SpringerLink. https://link.springer.com/article/10.1007/s11277-022-09676-0

[11] Biederer, J., Beer, M., Hirsch, W., Wild, J., Fabel, M., Puderbach, M., & Beek, E. J. R. V. (2012, February 13). MRI of the lung (2/3). why ... when ... how? - insights into imaging. SpringerLink. https://link.springer.com/article/10.1007/s13244-011-0146-8

[12] Liang, F., Li, C., & Fu, X. (2021, August 17). [retracted] evaluation of the effectiveness of artificial intelligence chest CT lung nodule detection based on Deep Learning. Journal of Healthcare Engineering. https://www.hindawi.com/journals/jhe/2021/9971325/

[13] Detection of cancerous tumors on chest X-ray images - candidate detection filter and its evaluation. (1999). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&%20arnumber=817143

[14] Selvan, G. S. R. E., Jingle, I. D. J., Maram, B., & Ananth, J. P. (2022). IoT enabled lung cancer detection and routing algorithm using CBSOA-based ShCNN. International Journal of Adaptive Control and Signal Processing, 37(1), 224–243. https://doi.org/10.1002/acs.3518

[15] A Comparative Study of Lung Cancer Detection using Machine Learning Algorithms. (2019, February 1). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/8869001

[16] Sharma, Rajesh. "Mapping of Global, Regional and National Incidence, Mortality and Mortality-to-Incidence Ratio of Lung Cancer in 2020 and 2050 - International Journal of Clinical Oncology." SpringerLink, Springer Singapore, 12 Jan. 2022, link.springer.com/article/10.1007/s10147-021-02108-2.

[17] Schabath, Matthew B., and Michele L. Cote. "Cancer Progress and Priorities: Lung Cancer." Cancer Epidemiology and Prevention Biomarkers, vol. 28, no. 10, 1 Oct. 2019, pp. 1563–1579, https://doi.org/10.1158/1055-9965.EPI-19-0221.

[18] A Comparative study of Lung Cancer detection using supervised neural network. (2019, March 1). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/abstract/document/8862326

[19] Huang, S., Arpacı, İ., Al-Emran, M., Kılıçarslan, S., & Al-Sharafi, M. A. (2023). A comparative analysis of classical machine learning and deep learning techniques for predicting lung cancer survivability. Multimedia Tools and Applications, 82(22), 34183–34198. https://doi.org/10.1007/s11042-023-16349-y

[20] Responding to symptoms suggestive of lung cancer: a qualitative interview study. (n.d.). Responding to symptoms suggestive of lung cancer: a qualitative interview study. BMJ Open Respiratory Research. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4265089

[21] Saab, M. M., Noonan, B., Kilty, C., Fitzgerald, S., Collins, A., Lyng, Á., Kennedy, Ú., O'Brien, M., & Hegarty, J. (2021b). Awareness and help-seeking for early signs and symptoms of lung cancer: A qualitative study with high-risk individuals. European Journal of Oncology Nursing, 50, 101880. https://doi.org/10.1016/j.ejon.2020.101880

[22] Hospers-Brands, A., Ghorbani, R., Bremer, E., Bain, R. A., Litterick, A., Halder, F., Leifert, C., & Wilcockson, S. J. (2008). Effects of Presprouting, Planting Date, Plant Population and Configuration on Late Blight and Yield of Organic Potato Crops Grown with Different Cultivars. Potato Research, 51(2), 131–150. https://doi.org/10.1007/s11540-008-9095-0

[23] Morrison, E. J. P., Novotny, P. J., Sloan, J. A., Yang, P., Patten, C. A., Ruddy, K. J., & Clark, M. M. (2017). Emotional problems, quality of life, and symptom burden in patients with lung cancer. Clinical Lung Cancer, 18(5), 497–503. https://doi.org/10.1016/j.cllc.2017.02.008

[24] Crane, M., Scott, N., O'Hara, B., Aranda, S., Lafontaine, M., Stacey, I., Varlow, M., & Currow, D. C. (2016). Knowledge of the signs and symptoms and risk factors of lung cancer in Australia: mixed methods study. BMC Public Health, 16(1). https://doi.org/10.1186/s12889-016-3051-8

[25] Symptom management of lung cancer - ProQuest. (n.d.-b). https://www.proquest.com/openview/a2bb7b111f7efad6e1923f44314f8131/1?pq-origsite=gscholar&cbl=33118

[26] cluster of symptoms over time in patients with lung cancer : Nursing research. (n.d.-b). LWW. https://journals.lww.com/nursingresearchonline/abstract/2003/11000/a_cluster_of_symptoms_over_time_in_patients_with.7.aspx

[27] Walter, F. M., Rubin, G., Bankhead, C., Morris, H., Hall, N., Mills, K., Dobson, C., Rintoul, R. C., Hamilton, W., & Emery, J. (2015). Symptoms and other factors associated with time to diagnosis and stage of lung cancer: a prospective cohort study. British Journal of Cancer, 112(S1), S6–S13. https://doi.org/10.1038/bjc.2015.30

[28] Yount, S., Beaumont, J. L., Rosenbloom, S., Cella, D., Patel, J. D., Hensing, T. A., Jacobsen, P. B., Syrjala, K. L., & Abernethy, A. P. (2012). A brief symptom index for advanced lung cancer. Clinical Lung Cancer, 13(1), 14–23. https://doi.org/10.1016/j.cllc.2011.03.033

[29] Yount, S., Beaumont, J. L., Rosenbloom, S., Cella, D., Patel, J. D., Hensing, T. A., Jacobsen, P. B., Syrjala, K. L., & Abernethy, A. P. (2012b). A brief symptom index for advanced lung cancer. Clinical Lung Cancer, 13(1), 14–23. https://doi.org/10.1016/j.cllc.2011.03.033

[30] Altıntaş, Z., & Tothill, I. E. (2013). Biomarkers and biosensors for the early diagnosis of lung cancer. Sensors and Actuators B: Chemical, 188, 988–998. https://doi.org/10.1016/j.snb.2013.07.078

[31] Birring, S., & Peake, M. (2005). Symptoms and the early diagnosis of lung cancer. Thorax, 60(4), 268–269. https://doi.org/10.1136/thx.2004.032698

[32] Nooreldeen, R., & Bach, H. (2021). Current and future development in lung cancer diagnosis. International Journal of Molecular Sciences, 22(16), 8661. https://doi.org/10.3390/ijms22168661

[33] López-Sánchez, L. M., Jurado-Gámez, B., Feu-Collado, N., Valverde, A., Cañas, A., Fernández-Rueda, J. L., Aranda, E., & Rodríguez-Ariza, A. (2017). Exhaled breath condensate biomarkers for the early diagnosis of lung cancer using proteomics. American Journal of Physiology-lung Cellular and Molecular Physiology, 313(4), L664–L676. https://doi.org/10.1152/ajplung.00119.2017

[34] Ramkumar, M. P., Paul, P. D. M., Maram, B., & Ananth, J. P. (2022). Deep maxout network for lung cancer detection using optimization algorithm in smart Internet of Things. Concurrency and Computation: Practice and Experience, 34(25). https://doi.org/10.1002/cpe.7264

[35] Faruqui, N., Yousuf, M. A., Whaiduzzaman, M., Azad, A. K. M., Barros, A., & Moni, M. A. (2021b). LungNet: A hybrid deep-CNN model for lung cancer diagnosis using CT and wearable sensor-based medical IoT data. Computers in Biology and Medicine, 139, 104961. https://doi.org/10.1016/j.compbiomed.2021.104961

[36] View of lung cancer detection in CT images using deep learning techniques: A survey review. (n.d.). https://publications.eai.eu/index.php/phat/article/view/5265/2931

[37] https://www.cell.com/heliyon/pdf/S2405-8440(23)08728-5.pdf

[38] DeMarco, C. (2023, February 6). CT scan vs. MRI: What's the difference? MD Anderson CancerCenter. https://www.mdanderson.org/cancerwise/ct-scan-vs-mri--what-is-the-difference.h00-159616278.html#:~:text=CT%20scans%20are%20really%20good,for%20looking%20at%20brain%20tumors.

[39] LungNet: A hybrid deep-CNN model for lung cancer diagnosis using CT and wearable sensor-based medical IoT data. Computers in Biology and Medicine, 139, 104961. https://doi.org/10.1016/j.compbiomed.2021.104961_Decision_Support_System

[40] https://www.researchgate.net/profile/Reshma-Nitnaware/publication/368675981_Review_on_Computer_Aided_Diagonostic_System_for_Detection_of_Lung_Cancer_by_using_Image_Processing/links/63f4bd48b1704f343f6fc5f0/Review-on-Computer-Aided-Diagonostic-System-for-Detection-of-Lung-Cancer-by-using-Image-Processing.pdf?origin=journalDetail&_tp=eyJwYWdlIjoiam91cm5hbERldGFpbCJ9

[41] Boiselle, P. M., Ernst, A., & Karp, D. D. (2000). Lung cancer detection in the 21st century. American Journal of Roentgenology, 175(5), 1215–1221. https://doi.org/10.2214/ajr.175.5.1751215

[42] https://pubmed.ncbi.nlm.nih.gov/34331867/

[43] About us. (n.d.). https://www.emoryhealthcare.org/centers-programs/lung-ct-program/about

[44] https://www.pintas.com/practice-areas/lung-cancer/can-lung-cancer-be-seen-on-a-ct-scan/

[45] McNulty, M., Gersten, T., & MyLungCancerTeam. (2022, July 13). Lung cancer X-Ray photos — Examples of different types of results. MyLungCancerTeam. https://www.mylungcancerteam.com/resources/lung-cancer-x-ray-photos-examples-of-different-types-of-results

[46] Lung cancer diagnosis and how to test. (n.d.-b). City of Hope. https://www.cancercenter.com/cancer-types/lung-cancer/diagnosis-and-detection

[47] X-rays. (n.d.). Tests and Scans | Cancer Research UK. https://www.cancerresearchuk.org/about-cancer/tests-and-scans/x-rays

[48] Lung cancer - Non-Small cell - diagnosis. (2023, January 20). Cancer.Net. https://www.cancer.net/cancer-types/lung-cancer-non-small-cell/diagnosis

[49] MRI - Mayo Clinic. (2023, September 9). https://www.mayoclinic.org/tests-procedures/mri/about/pac-20384768

[50] How to detect lung cancer | Lung cancer tests. (n.d.). American Cancer Society. https://www.cancer.org/cancer/types/lung-cancer/detection-diagnosis-staging/how-diagnosed.html