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Literature Review Study on the Implementation of Convolutional Neural Network for Lung Medical Images Segmentation and Classification

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Abstract – Medical image processing has become an essential aspect of healthcare, enabling accurate disease diagnosis and monitoring through advanced technologies. One of the most widely used methods in this domain is the Convolutional Neural Network (CNN), which has demonstrated high effectiveness in segmentation and classification tasks, particularly for chest X-ray images used in diagnosing lung-related diseases. This study aims to evaluate and analyze various CNN architectures implemented in lung X-ray imaging through a Systematic Literature Review (SLR) approach. The research explores the application, accuracy, challenges, and future opportunities of CNN-based models such as VGG, ResNet, AlexNet, and GoogLeNet. A total of 15 relevant studies published between 2019 and 2023 were selected after applying rigorous inclusion and exclusion criteria. The findings indicate that CNN architectures significantly enhance the accuracy of lung disease detection and support both segmentation and classification tasks. However, challenges such as dataset variability, model generalization, and ethical implications remain. This review provides comprehensive insights into CNN applications in medical imaging, emphasizing their potential and highlighting areas for further research.

Keywords *– CNN architecture, CNN, medical imaging, lung*

I. INTRODUCTION

Imagery is a visual representation of objects in the real world in the form of two dimensions. Mathematically, the image or *Image.* It can be described as a two-dimensional function (x,y), where x and y represent the coordinates in dimensional space, and the amplitude (f) on each coordinate pair (x,y) depicts the intensity in the image. In a digital image, a number of elements are composed of what are known as pixels or grayness values. Each pixel has a different position (coordinates) as a representation of the brightness or color level at that location. Pixel intensity can be expressed in the form of discrete values that typically range from 0 to 255. This value represents different levels of brightness or color in the image, where 0 represents black and 255 represents white. These pixel intensities are stored in digital images and processed in various image processing processes, such as contrast enhancement, quality improvement, object segmentation, and image analysis.

Digital image processing is concerned with converting images into digital formats and processing them using digital computers. Digital image analysis is related to the description and introduction of the content of the digital image. The input of an image analysis process is the digital image and as an output, the digital image produces a description of the image in symbolic form. Image processing is of course carried out for various purposes such as increasing contrast, increasing brightness, image rotation, image fading, and removal [1]. *Noise*, segmentation or separation of objects from their background, extraction of features for the sake of analysis, and artistic effects such as giving the effect as if an image was drawn with a pencil.

Image processing has been applied in various studies which identified rice diseases with one of the methods in digital image processing, namely CNN-BiGRU. Another study was also conducted for the detection of fire smoke in wild forests from synthetic smoke imagery using the Faster R-CNN method [2][3],[4].

Image processing can be used in various fields such as research on fire smoke, license plate detection, plant disease detection, and others. Image processing is also of course possible to be applied in the medical world because image in the medical world itself is a fundamental need used in monitoring and determining disease diagnosis. As in lung disease, which generally has similar symptoms, a supporting procedure is usually needed in determining the diagnosis which is usually done through a chest X-ray examination procedure.

Segmentation and Classification in digital image processing are two different things. Segmentation is a process in image processing to separate objects in an image into several regions based on the difference in the grayness value of an image without labeling a specific category. Meanwhile, image classification is the process of giving certain labels or categories to all images. Both play an equal role in image analysis to achieve certain goals such as object recognition.

One of the methods in digital image processing that can be used in segmentation and classification is *Convolutional Neural Network (CNN). Convolutional Neural Network (CNN)* has evolved in the analysis of medical images performed and provides greater opportunities for radiologists to perform detection and

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diagnosis with a high degree of accuracy by adopting topological mapping that has been optimized within its convolutional layer to extract important features from medical images at each stage, ultimately improving the model's suitability with the expected results. With this concept, CNN has significantly improved the diagnostic and analytical capabilities of medical images [5].

Convolutional neural networks (CNNs) are a type of classification algorithm in the deep learning domain that is capable of receiving images as input [6]. CNN is a good method to identify elements or objects in an image so that computers can learn and distinguish the images from each other. The structure of CNN consists of several main architectures, namely *Input*, *feature learning* and *classification* [7]. *Convolutional Neural Network (CNN)* has different types of architectures such as VGG-16 CNN, Res-Net CNN, Alex-Net CNN, Google-Net, COVID-Nets, and others [8].

The implementation of the CNN architecture has been tested in several studies related to the medical world, especially the implementation of lung medical imaging. An example of a study that has been conducted by for the detection of Covid-19 from an X-ray image using nine CNN architectures namely AlexNet, GoogleNet, ResNet-50, Se-ResNet-50, DenseNet121, Inception V4, Inception ResNetV2, ResNeXt-50, and Se-ResNeXt-50 and results in a level of accuracy achieved on the model [9].*pre-trained* Se-ResNeXt-50 with the highest classification accuracy of 99.32% for binary class and 97.55% for *multi-class* among all models *pre-trained.* Another study was conducted to classify skin cancer with the VGG-16 architecture and produced an accuracy of 99.70%, [10]. *Loss* 0,0055, *precision* 0,9975, *Recall* 0,9975.

Since the accuracy and performance vary across different CNN architectures, this study employs a Systematic Literature Review (SLR) to examine and evaluate the implementation of various CNN architectures in processing lung X-ray images. The research aims to identify the role of CNN in segmentation and classification tasks related to lung diseases based on imaging data, as well as to analyze the challenges encountered in applying these CNN architectures.

II. RESEARCH METHODOLOGY

To conduct a literature review regarding the implementation of various Convolutional Neural Network (CNN) architectures for lung X-ray imaging, this study adopts a Systematic Literature Review (SLR) method. A good literature review requires a well-defined search strategy and selection criteria to ensure that the collected studies are relevant and of high quality. In this case, the SLR was carried out through several stages in the search strategy and selection criteria, as follows:

1. Determine keywords appropriate to the topic, such as "CNN," "Convolutional Neural Network," "X-ray," "medical imaging," "radiology," "chest radiograph," "lung disease," and specific CNN architecture names such as "VGG," "ResNet," "AlexNet," and "GoogLeNet."
2. Selecting a research-appropriate database from relevant sources can include Science Direct, IEEE Xplore, Google Scholar, Scopus, and Springer.
3. Create a Search Query that includes the keywords that have been identified. For example, "(CNN OR Convolutional Neural Network) AND (X-ray OR medical imaging) AND (VGG OR ResNet OR AlexNet OR GoogLeNet) AND (lung disease OR pneumonia)."
4. Using search filters to narrow down search results based on research publications in the range of 2019 - 2023 with the type of journal and conference documents in Indonesian and English.
5. Use a search query on a predefined database and log the search results.

After following this search strategy and selection criteria, relevant literature was obtained regarding the implementation of various CNN architectures in chest X-ray images. From the entire search process, a total of 21 relevant articles were initially identified. This helps in evaluating the various approaches that have been used in previous research and compiling an informative literature review.

In this digital era, medical image processing has become one of the most important aspects in the field of medical science. Medical image processing technology allows healthcare professionals to diagnose diseases, monitor patient progress, and make informed medical decisions. In this context, the use of Convolutional Neural Network (CNN) architecture has become a growing focus of research. Relevant research questions in this area are of essence in an effort to understand and maximize the potential of CNN architecture in medical image processing.

RQ1 : Can the application of the CNN architecture be used in segmentation as well as classification of medical images?

RQ2 : What is the level of accuracy that can be achieved by using the CNN architecture in the segmentation and/or classification tasks of a lung image?

RQ3 : What are the obstacles and future research opportunities in the implementation of various CNN architectures in lung medical imaging research?

The RQ1 statement is important to uncover CNN's architectural capabilities in supporting two important tasks in medical image processing. RQ2 question highlights effectiveness of CNN in producing accurate results in recognizing or grouping various features in lung images. The RQ3 question aims to evaluate barriers that may arise, such as access to data and hardware complexity, as well as identify opportunities, such as the use of more advanced technologies and cooperation between researchers and medical practitioners, that could advance research in this area.

After applying inclusion and exclusion criteria such as relevance to the research questions, availability of full text, and avoidance of duplicate studies, a final set of 15 articles was selected for in-depth review. In order to answer these questions, this study will conduct a comprehensive literature review of recent works in the domain of medical image processing using the CNN architecture.

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III. Finding Analysis and Discussion

In this literature analysis, a number of studies that have been conducted in the field of implementation of various types of architecture on CNN in lung imaging will be investigated to understand and answer the research questions that have been determined. This study aims to identify the use of architecture in segmentation and classification and evaluate the implementation of various CNN architectures in lung imagery. Understanding the existing literature is an important step in guiding our research and making a valuable contribution to scientific understanding. Table 1 contains Research Data found through search strategies and target criteria. The introduction of the entire article is summarized in a table with columns of Authors, Datasets Size, Year, CNN Architecture, and Application Deployments.

Table 1. Relevant Research Data

Author	Dataset Size	Year	CNN Architecture	Application
(Arvind et al., 2023) [11]	944	2023	U-Net	Segmentation
(Aslan, 2022) [12]	2905	2022	Alex-Net	Segmentation
(Ilhan et al., 2023)	100	2023	U-Net	Segmentation
(Chen et al., 2021) [13]	240	2021	Seg-Net	Segmentation
(Xu et al., 2019)	201	2019	CNN	Segmentation
(Salama & Aly, 2022) [14]	746	2022	AlexNet, GoogLeNet, ResNet, VGG16, VGG19, and U-Net	Segmentation and Classification
(Hastomo et al., 2021) [15]	10300	2021	Res-Net 152	Segmentation and Classification
(Hira et al., 2021)	8830	2021	AlexNet, GoogleNet, ResNet-50, Se-ResNet-50, DenseNet121, Inception V4, Inception ResNetV2, ResNeXt-50, and Se-ResNeXt-50)	Segmentation and Classification
(Hastomo et al., 2021)	4000	2021	ResNet-152, InceptionResNet-V2, MobileNet-V2 CNN	Segmentation and Classification
(Mohd Ashhar et al., 2021) [16]	1646	2021	GoogleNet, SqueezeNet, DenseNet, ShuffleNet and MobileNetV2 CNN	Segmentation and Classification
(Alshazly et al., 2021) [17]	4173	2021	CovidResNet dan CovidDenseNet	Segmentation and Classification
(Kusmareni et al., 2022) [18]	566	2022	U-Net	Segmentation
(Astuti, 2021) [19]	135	2021	Mask R-CNN	Segmentation
(Khultsum et al., 2022) [20]	720	2022	Mobile-Net	Klasifikasi
(Yopento et al., 2022) [21]	2217	2022	CNN	Klasifikasi

Identified 15 articles related to the implementation of the CNN architecture for lung imaging. Please note, segmentation and classification are two different things and have been explained in the Introduction Section. In this case, the research data will be broken down into 3 tables, namely for the application of segmentation, classification, and segmentation as well as classification.

Table 2. Implementation of CNN Architecture for Image Segmentation

Writer	Dataset Size	Year	CNN Architecture	Application
(Arvind et al., 2023)	944	2023	U-Net	Segmentation
(Aslan, 2022)	2905	2022	Alex-Net	Segmentation
(Ilhan et al., 2023)	100	2023	U-Net	Segmentation
(Chen et al., 2021)	240	2021	Seg-Net	Segmentation
(Xu et al., 2019)	201	2019	CNN	Segmentation
(Kusmareni et al., 2022)	566	2022	U-Net	Segmentation
(Astuti, 2021)	135	2021	Mask R-CNN	Segmentation

Table 3. Implementing the CNN Architecture for Classification

Writer	Dataset Size	Year	CNN Architecture	Application
(Khultsum et al., 2022)	720	2022	Mobile-Net	Klasifikasi
(Yopento et al., 2022)	2217	2022	CNN	Klasifikasi

Table 4. Implementation of CNN Architecture for Segmentation and Classification

Writer	Dataset Size	Year	CNN Architecture	Application
(Salama & Aly, 2022)	746	2022	AlexNet, GoogLeNet, ResNet, VGG16, VGG19, and U-Net	Segmentation and Classification
(Hastomo et al., 2021)	10300	2021	Res-Net 152	Segmentation and Classification
(Hira et al., 2021)	8830	2020	AlexNet, GoogleNet, ResNet-50, Se-ResNet-50, DenseNet121, Inception V4, Inception ResNetV2, ResNeXt-50, and Se-ResNeXt-50)	Segmentation and Classification
(Agustina et al., 2022)	4000	2022	VGG-16	Segmentation and Classification
(Hastomo et al., 2021)	4000	2021	ResNet-152, InceptionResNet-V2, MobileNet-V2 CNN	Segmentation and Classification
(Mohd Ashhar et al., 2021)	1646	2021	GoogleNet, SqueezeNet, DenseNet, ShuffleNet and	Segmentation and Classification

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			MobileNetV2 CNN	
(Alshazly et al., 2021)	4173	2021	CovidResNet dan CovidDenseNet	Segmentation and Classification

The literature analysis was followed by exploring additional components, namely the function and accuracy of the implementation of the CNN architecture on lung imagery. Previous research has provided insights into how Convolutional Neural Network (CNN) architecture has been applied to the task of segmentation or classification of lung images. At this stage, it will be further explored by exploring how CNN specifically contributes to the segmentation or classification function, as well as the extent of the accuracy of its implementation. Understanding how CNNs perform in the context of lung imagery is essential for evaluating its potential and limitations in broader medical applications, as well as providing a foundation for research in developing more sophisticated methods.

Table 5. Application and Accuracy of CNN Architecture for Image Segmentation

Writer	**Dataset Size**	**CNN Architecture**	**Application**	**Accuracy**
(Arvind et al., 2023)	944	U-Net	Separating the lungs from the heart, ribs, diaphragm, sternum, and collarbone	The training accuracy is 92.71% and the generalization accuracy is outstanding at 93.87% Adam optimizer and underlying loss function is Dice coefficient.
(Aslan, 2022)	2905	Alex-Net	Diagnostic COVID-19	As a result, 3 class data consisting of the Normal, Viral Pneumonia, and COVID-19 classes were classified with 99.8% success
(Ilhan et al., 2023)	100	U-Net	Diagnostic COVID-19	The proposed system achieves an accuracy of 97.75%, 0.85, and 0.74, dice scores, and a Jaccard index
(Chen et al., 2021)	240	Seg-Net	Lung Cancer Diagnosis	The SegNet model has a sensitivity of 98.33%, specificity of 86.67%, accuracy of 92.50%, and a total segmentation time of 30.42 seconds
(Xu et al., 2019)	201	CNN	Segmentasi parenkim paru	The CNN model obtained an average F-score of 0.9917
(Kusmareni et al., 2022)	566	U-Net	Abnormalities of lung size	the average accuracy value is 0.9632, the sensitivity is 0.9586, and the specificity is 0.9675, the F1-Score is 0.9920, and the Jaccard coefficient is 0.9842
(Astuti, 2)	135	Mask R-CNN	Lung Cancer Malignancy	Rerata precision 0.852, sensitivity 0.958, specificity 0.82, dan Dice Similarity 0.894

Table 6. Application and Accuracy of CNN Architecture for Classification

Writer	**Dataset Size**	**CNN Architecture**	**Application**	**Accuracy**
(Khultsum et al., 2022)	720	Mobile-Net	Lung Cancer	Accuracy of 96.70% and Validation accuracy of 90.45%
(Yopento et al., 2022)	2217	CNN	Pneumonia	Precision is 91%, Recall is 92.8% and Accurasy is 91.54%. The accuracy level obtained based on the Epoch value is 50, the learning rate is 0.0001 and the batch value is 20.

Table 7. Implementation and Accuracy of CNN Architecture for Segmentation and Classification

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Writer	Dataset Size	CNN Architecture	Application	Accuracy
(Salama & Aly, 2022)	746	AlexNet, GoogLeNet, ResNet, VGG16, VGG19, and U-Net	Covid-19	The classification results showed that the use of pre-processed lung CT images as inputs for the U-Net hybrid with ResNet50 achieved the best performance. The proposed classification model achieved an accuracy (ACC) of 98.98%, area under the ROC curve (AUC) of 98.89%, sensitivity (Se) of 98.89%, precision (Pr) of 97.99%, F1 score of 97.88%, and a computational time of 1.8974 seconds.
(Hastomo et al., 2021)	10300	Res-Net 152	Covid-19, Lung Opacity, Pneumonia	The results of the study with 50 epoch trainings obtained excellent scores for training and validation accuracy of 95.5% and 91.8%. The test test with a total of 19,300 test data images obtained 99% testing accuracy, with the precision of each class being Covid (99%), Lung Opacity (99%), Normal (98%) and Viral Pneumonia (98%)
(Hira et al., 2021)	8830	AlexNet, GoogleNet, ResNet-50, Se-ResNet-50, DenseNet121, Inception V4, Inception ResNetV2, ResNeXt-50, and Se-ResNeXt-50)	Covid-19	The experimental results showed that the Se-ResNeXt-50 pre-training model achieved the highest classification accuracy of 99.32% for the binary class and 97.55% for the plural class among all pre-training models.
(Hastomo et al., 2021)	4000	ResNet-152, InceptionResNet-V2, MobileNet-V2 CNN	Covid-19, Lung Opacity, Pneumonia	The test accuracy of ResNet-152 is 99%, higher than InceptionResNet-V2 with a 98% result, and MobileNet-V2 with a 93% result. with the precision of each class isCovid (99%), Lung_Opacity (97%), Normal (99%), Viral_Pneumonia (99%)
(Mohd Ashhar et al., 2021)	1646	GoogleNet, SqueezeNet, DenseNet, ShuffleNet and MobileNetV2 CNN	Tumor Paro-Paro	Accuracy 94.53%, specificity 99.06%, sensitivity 65.67% and AUC 86.84%.
(Alshazly et al., 2021)	4173	CovidResNet dan CovidDenseNet	Covid-19	The CovidDenseNet model obtained the best performance with an accuracy of 81.77%, precision of 79.05%, sensitivity of 84.69%, specificity of 79.05%, F1 score of 81.77%, and an AUC score of 87.50%.

In conducting research, researchers often face various obstacles that can affect the smooth running of research. On the other hand, research also has the potential to present many opportunities in the future. Table 8 contains an explanation related to the barriers and future research opportunities of the researcher.

Table 8. Future Research Barriers and Opportunities

Research	Obstacles	Chance
(Arvind et al., 2023)	Difficulties in obtaining consent in data collection in the field of medical imaging	Optimization and equalization of the range of boundary boxes or organ edges
(Aslan, 2022)	Citra does not have real clinical data so it casts doubt on the results	Implementation of different hyper-parameter optimization techniques to give more optimal results

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(Ilhan et al., 2023)	-	A more comprehensive system by considering pneumonia data in addition to the COVID-19 dataset.
(Chen et al., 2021)	-	-
(Xu et al., 2019)	The results of filling *holes* did not include the area of pleural effusion of the right lung and the pulmonary bular near the pulmonary field boundary	Propose a machine learning-based framework for finding and analyzing lung lesions
(Salama & Aly, 2022)	Data loses spatial information and is not reversible so that the fully connected layer is only implemented at the end of *the network.*	Future research can be carried out the process of classifying abnormalities in the lungs.
(Hastomo et al., 2021)	The system has not been able to detect and segment the area of malignant type cancer nodules .	Development of detection and segmentation techniques for areas with very low contrast
(Hira et al., 2021b)	-	-
(Hastomo et al., 2021)	The computational process takes up a lot of space so that the number of datasets used in the training process is affected	-
(Mohd Ashhar et al., 2021)	After the augmentation process, some important information in the CT image is lost	-
(Alshazly et al., 2021)	-	-
(Kusmareni et al., 2022)	-	Research with a larger dataset approach for medical problems of cancer, tumors, etc and other fields with the exploration of image data augmentation techniques to further improve accuracy while avoiding overfitting
(Astuti, 2021)	The accuracy of the train and the valid loss are still quite large (>40%) and need to be improved again so that the value becomes smaller	-
(Khultsum et al., 2022)	MobileNetV2 *misclassified* data into benign cancer type	Further studies on the GoogleNet network are needed to improve the accuracy of the classification of lung lesions in CT images.
(Yopento et al., 2022)	-	Collection of datasets from *larger* CT Scans

In the discussion stage, the findings from the literature analysis will be evaluated that discuss the function and accuracy of the implementation of Convolutional Neural Network (CNN) architecture on lung imagery. The results of the literature analysis show that the use of CNN architecture in lung image processing has resulted in significant advances in this field. The main function of CNNs in the task of segmentation or classification of lung images is its ability to automatically extract important features from the image, which in turn allows the identification and separation of relevant structures in the image. This is important in the diagnosis and monitoring of lung diseases such as pneumonia, COVID-19, and lung cancer.

In addition, most of the studies evaluated showed that the implementation of CNN architecture on lung imagery achieved a satisfactory level of accuracy. This high accuracy gives confidence that this technique can be used as an aid in medical diagnosis. However, some studies also underscore the challenges of dealing with variations in human lung imagery and uncertainty in the datasets used.

Furthermore, our discussion also discusses potential future developments in applying CNN architecture to lung imagery. This includes improvements in more sophisticated methods, the use of larger and more representative datasets, and ethical considerations in the implementation of these technologies in medical decision-making. Additionally, it is important to continuously improve the accuracy and generalization of CNN models to improve their role in the medical world.

IV. CONCLUSION

This literature review study examines the application of Convolutional Neural Network (CNN) architecture in segmentation and classification of pulmonary medical images. The results of the literature analysis show that the use of CNN in lung imaging is a positive step in the advancement of medical technology. CNN's ability to segment and classify, as well as varying degrees of accuracy, has strengthened its role in supporting the diagnosis of lung disease. Nonetheless, it is worth noting the challenges faced, and more research should be conducted to maximize the benefits of this technology in health monitoring and patient diagnosis.

1. Answer to Question RQ1: This study confirms that the CNN architecture can be effectively used in segmentation as well as classification of lung medical images.
2. Answer to Question RQ2: The results of the literature study show that the implementation of the CNN architecture on lung medical images for segmentation and classification generally achieves an adequate and satisfactory level of accuracy.
3. Answer to Question RQ3: The majority of studies face certain barriers and challenges in the implementation of CNN architecture on pulmonary medical imaging. However, future research opportunities are directed at the development of more appropriate methods and datasets to optimize research results in this field.

should only answer the objectives of the research. Tells how your work advances the field from the present state of knowledge. Without clear Conclusions, reviewers and

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readers will find it difficult to judge the work, and whether or not it merits publication in the journal. Do not repeat the Abstract, or just list experimental results. Provide a clear scientific justification for your work, and indicate possible applications and extensions. This conclusion should be provided as a paragraph. You should also suggest future experiments and/or point out those that are underway.

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