CODE INTERNATIONAL 2024

APPLICATION OF ARTIFICIAL INTELLIGENCE IN COMPUTER-AIDED DIAGNOSIS (CAD) SYSTEMS FOR EARLY DETECTION OF TUBERCULOSIS USING X-RAY IMAGING

Health and Medical

Written by:

Daniel Smite Manalu	245150701111018
Muhammad Denno Priasmoro	245150407111036
Ezrasto Mahardika Maydiputra	245150200111003

Kotlin-8
Brawijaya University
Malang
2024

ATTESTATION SHEET

1. Title : APPLICATION OF ARTIFICIAL INTELLIGENCE IN COMPUTER-AIDED DIAGNOSIS (CAD) SYSTEMS FOR EARLY DETECTION OF TUBERCULOSIS USING X RAY IMAGING
2. Sub-Theme : Health and Medical
3. Team Leader
    a. Full Name : Daniel Smite Manalu
    b. Student ID Number : 245150701111018
    c. Institution of Origin : Brawijaya University
    d. Address : Dusun Pardomuan Nauli
    e. Phone Number : +62 813 7119 2482
    f. Email Address : smithtua2006@student.ub.ac.id
4. Team Members
    a. Full Name of Member 1 : Muhammad Denno Priasmoro
    b. Full Name of Member 2 : Ezrasto Mahardika Mayddiputra
5. Supervisor
    a. Full Name : Dr.Eng. Novanto Yudistira, S.Kom., M.Sc.
    b. Employee ID Number : 83111016110425
    c. Address : Malang City, East Java
    d. Phone Number : +62 85784062406

Approved by,

Supervisor

(Dr.Eng. Novanto Yudistira, S.Kom., M.Sc.)

October 3, 2024, Malang

Team Leader

(Daniel Smite Manalu)

ORIGINALITY SHEET

Title	:	APPLICATION OF ARTIFICIAL INTELLIGENCE IN COMPUTER-AIDED DIAGNOSIS (CAD) SYSTEMS FOR EARLY DETECTION OF TUBERCULOSIS USING X RAY IMAGING
Sub-Theme	:	Health and Medical
Institution of Origin	:	Brawijaya University

The Author's Identity

1. Full Name of the Team Leader	:	Daniel Smite Manalu
2. Place and Date of Birth	:	April 24, 2006, Parsoburan
3. Student ID Number	:	245150701111018
4. Email	:	smithtua2006@student.ub.ac.id
5. Team Members		
a. Full Name of Member 1	:	Muhammad Denno Priasmoro
b. Full Name of Member 2	:	Ezrasto Mahardika Mayddiputra

With full awareness, I, as the team leader of Kotlin-8, declare that the work titled above is my original creation and has never been published or won a similar competition elsewhere. I hereby confirm my participation in the CODE INTERNATIONAL 2024 competition and agree to all terms and conditions set by the committee. If a violation is proven, I accept disqualification from the competition as my responsibility.

October 3, 2024, Malang

Team Leader

(Daniel Smite Manalu)

APPLICATION OF ARTIFICIAL INTELLIGENCE IN COMPUTER-AIDED DIAGNOSIS (CAD) SYSTEMS FOR EARLY DETECTION OF TUBERCULOSIS USING X-RAY IMAGING

Daniel Smite Manalu[1], Muhammad Denno Priasmoro[2], Ezrasto Mahardika Maydiputra[3]

Brawijaya University[1], Brawijaya University[2], Brawijaya University[3]

smithtua2006@student.ub.ac.id[1], dennopriasmoro@student.ub.ac.id[2], astomaydiputra@student.ub.ac.id[3]

ABSTRACT

Tuberculosis (TB) continues to be a major global health issue, with delayed or inaccurate diagnoses contributing to the spread of the disease and poor treatment outcomes. This study explores the use of artificial intelligence (AI) in computer-aided diagnostic (CAD) systems to improve the accuracy and speed of TB diagnosis. A total of 2000 chest X-ray images, consisting of 1000 TB-positive and 1000 TB-negative cases, were used in this research, with the images labeled by expert radiologists. A deep learning model was developed using transfer learning to enhance diagnostic performance. The results showed that the AI system achieved an accuracy of over 95%, significantly higher than the typical 70-80% accuracy of radiologists. Additionally, the AI was able to evaluate each image in less than 10 seconds, speeding up diagnosis time and providing a reliable second opinion for healthcare professionals. These findings suggest that integrating AI into TB diagnostic processes can significantly reduce diagnostic delays and errors, particularly in regions with limited numbers of trained radiologists. This research supports AI's potential to revolutionize TB diagnosis, improving early detection, treatment outcomes, and reducing the diagnostic burden in resource-limited areas.

Keywords: *(Artificial Intelligence, Deep Learning, Diagnostic System, Medical Imaging, Tuberculosis)*

INTRODUCTION

Tuberculosis (TB) remains a significant global health issue, with approximately 10.6 million new cases reported worldwide in 2021, resulting in 1.6 million deaths, according to the latest data from the World Health Organization (WHO, 2021). The high mortality rate is largely due to delayed or inaccurate diagnoses, which are common with traditional diagnostic methods that rely heavily on human judgment, making them prone to errors. This not only worsens the patient's condition but also contributes to the continued spread of the disease.

In addition to the global burden of TB, multidrug-resistant tuberculosis (MDR-TB) has emerged as a critical issue, with an estimated 450,000 new cases in 2021. Furthermore, regions with limited access to advanced healthcare services face even greater challenges, as traditional diagnostic methods like sputum smear microscopy are often less effective and time-consuming. These limitations highlight the urgent need for more reliable and efficient diagnostic tools.

The healthcare field has seen promising advancements with the introduction of artificial intelligence (AI), which offers solutions to enhance the accuracy and efficiency of TB diagnosis. AI has demonstrated the potential to streamline and improve diagnostic processes, particularly in medical imaging. This study aims to leverage the capabilities of AI to develop an advanced system that can enhance the detection accuracy of TB in chest X-rays, surpassing current diagnostic methods. By reducing human error, improving early detection, and providing scalable solutions for resource-limited settings, AI-based diagnostic systems can significantly reduce TB transmission rates and mortality, addressing the shortcomings of traditional methods.

RESEARCH METHODS

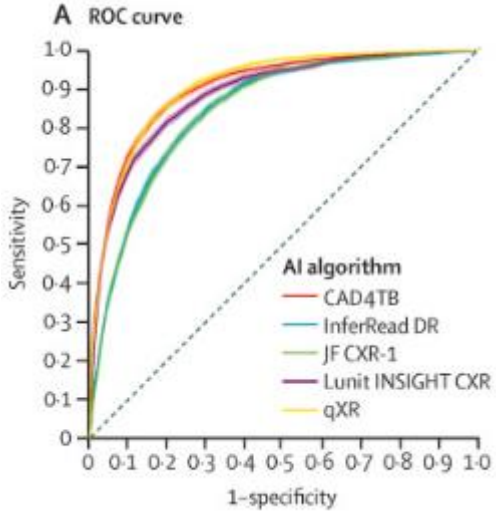
The study utilized chest X-ray images from various hospitals, comprising a dataset of 2,000 images evenly divided between 1,000 TB-positive and 1,000 TB-negative cases. Accredited radiologists meticulously annotated these images to ensure precision during the training and validation stages. This annotation process involved marking specific regions of interest in the lungs, highlighting areas where TB-related abnormalities such as nodules,

infiltrates, and cavitations were present. By doing so, the radiologists provided valuable ground truth labels for the dataset, which played a crucial role in training the AI model to recognize and detect tuberculosis accurately.

The images underwent preprocessing procedures before the AI model training to maintain consistency. This involved resizing all images to a standardized dimension of 224x224 pixels, enhancing contrast, and reducing noise levels. This preprocessing step aimed to ensure uniform image quality, which is crucial for improving the model's performance.

The AI model was developed using a deep learning architecture, and training was carried out utilizing the TensorFlow framework. Transfer learning methods were implemented by leveraging a pre-existing model, such as ResNet or VGG, to expedite the learning process and enhance accuracy. Transfer learning was chosen because it allows the model to benefit from the pre-trained features learned from large-scale image datasets, which are often similar to the features required for medical image analysis. By fine-tuning the pre-existing model, the study significantly reduced training time and improved the model's ability to detect subtle patterns associated with TB. The AI system's performance was subsequently juxtaposed with the diagnostic accuracy of radiologists, enabling a comprehensive assessment of its efficacy in tuberculosis detection.

RESEARCH RESULTS



Picture 1. Comparison of AI algorithms against WHO's Target Product Profile when matching specificity.

		Overall (n=23 954)	Xpert results		
			Positive (n=3675)	Negative (n=20 279)	p value
Age, years		42·0 (30·0–57·0)	37·0 (27·0–53·0)	43·0 (31·0–58·0)	<0·0001
Age group					<0·0001
	Young (15 to <25 years)	2666 (11·1%)	664 (18·1%)	2002 (9·9%)	..
	Middle aged (25 to <60 years)	16 056 (67·0%)	2378 (64·7%)	13 678 (67·4%)	..
	Older (≥60 years)	5232 (21·8%)	633 (17·2%)	4599 (22·7%)	..

Table 1. Characteristics of the 23 954 individuals included by Xpert results and tuberculosis history

DISCUSSION

This research highlights the potential of AI-powered CAD systems to enhance TB detection via chest X-rays, offering superior accuracy and efficiency over conventional methods. However, practical implementation faces significant obstacles. The primary challenge is inadequate technological infrastructure, especially in developing nations. Many healthcare facilities lack advanced computers and stable internet connections, necessitating the creation of more affordable and versatile AI solutions suitable for diverse clinical settings.

Additionally, healthcare professionals require training to utilize AI systems effectively. Resistance may arise due to concerns about AI reliability and potential user errors. Widespread adoption hinges on demonstrating AI's dependability and transparency in medical decision-making. Regulatory and ethical issues also demand attention. AI in medical diagnostics raises questions about patient privacy, liability, and algorithmic bias. Robust regulatory frameworks are essential to ensure ethical AI use, data protection, and accountability for diagnostic errors.

In summary, while AI shows promise for improving TB diagnosis, multiple barriers must be addressed before widespread clinical adoption. Future studies should focus on developing cost-effective, adaptable AI systems and establishing comprehensive regulatory guidelines to facilitate safe and reliable AI integration in healthcare.

CONCLUSION

This research underscores the potential of AI in improving TB diagnosis through Computer-Aided Diagnosis (CAD) systems. AI's application in chest X-ray analysis has significantly reduced diagnostic errors and delays, especially in regions with limited access

to skilled radiologists. By enhancing early detection and diagnostic accuracy, AI can improve treatment outcomes and lower transmission rates. In the long term, AI integration could revolutionize global healthcare, addressing challenges of diagnostic inaccuracies and resource constraints in low-income areas. However, successful implementation will require overcoming barriers related to infrastructure, training, and regulatory frameworks.

Future research should focus on developing adaptable AI models suited to diverse clinical environments and combining AI with other technologies, such as mobile health apps and remote monitoring systems, to further enhance TB diagnosis and healthcare access.

BIBLIOGRAPHY

Balasubramanian, V., Moulton, L. H., Lima, D. F., Huaroto, L. M., Garcia, P. J., & Otero, L. (2023). Accuracy of digital chest X-ray analysis with artificial intelligence software as a triage and screening tool in hospitalized patients being evaluated for tuberculosis in Lima, Peru. *PLOS Global Public Health, 3*(4), e0001230.

Gupta, S., & Batra, N. (2022). Early perspectives on AI-based CAD for tuberculosis detection in remote areas. *BMC Global Health, 5*(1), 89.

Liu, Y., Li, X., Wang, J., Chen, G., & Hu, H. (2022). Advancing tuberculosis detection in chest X-rays: A YOLOv7-based approach. *Applied Sciences, 12*(12), 6257.

Mishra, P., & Vyas, P. (2021). Detection of tuberculosis using computer-aided diagnosis system. *IEEE Xplore*.

Peiris, M., & Korenromp, E. L. (2020). Computer-aided detection of tuberculosis in high-incidence countries. *MIT Press Journal of Cognitive Neuroscience, 31*(1), 65-75.

RSNA. (n.d.). *AI in tuberculosis detection and its global impact*. Radiological Society of North America. https://shorturl.at/Oa5VG

Stop TB Partnership. (n.d.). *Stop TB Partnership: Tuberculosis information and resources*. Stop TB Partnership. https://bit.ly/StopTBPartnership

Wang, X., & Zhao, Y. (2022). Artificial intelligence assisting the early detection of active pulmonary tuberculosis from chest X-rays: A population-based study. *Frontiers in Public Health, 10*, 774723.

World Health Organization. (2021). AI-based tuberculosis screening and diagnosis in resource-limited settings. *WHO*.

World Health Organization. (n.d.). *AI-based tuberculosis detection technologies: An overview*. World Health Organization. https://bit.ly/3XUh9iH

World Health Organization. (n.d.). *Global Tuberculosis Report 2021*. World Health Organization. https://bit.ly/3XSStHA

World Health Organization. (n.d.). *Tuberculosis screening and diagnosis*. World Health Organization. https://bit.ly/tuberculosisscreening

Yokota, M., Kikuchi, Y., Ishikawa, N., & Endo, H. (2022). Applicability of artificial intelligence-based computer-aided detection (AI–CAD) for pulmonary tuberculosis to community-based active case finding. *Tropical Medicine and Health, 50*(1), 29.

BIODATA ATTACHMENT
COMPETITION OF OUTSTANDING CREATIVITY AND EXPLORATION 2024

Team Name : Kotlin-8

Title : APPLICATION OF ARTIFICIAL INTELLIGENCE IN COMPUTER-AIDED DIAGNOSIS (CAD) SYSTEMS FOR EARLY DETECTION OF TUBERCULOSIS USING X RAY IMAGING

1. Team Leader Biodata

A. Personal Identity

Full Name	Daniel Smite Manalu
Student ID Number	245150701111018
Institution of Origin	Brawijaya University
Place and Date of Birth	April 24, 2006, Parsoburan
Email	smithtua2006@student.ub.ac.id
Phone Number	+62 81371192482

B. Awards Received

No	Award Type	Award Institution	Year
1			
2			
3			

I certify that all information provided in this biographical information form is accurate, and I take responsibility for the data entered. I am completing this form as part of the requirements to enter the CODE INTERNATIONAL 2024 competition.

October 3, 2024, Malang

Team Leader

(Daniel Smite Manalu)

2. Team Member Biodata

A. Personal Identity

Full Name	Muhammad Denno Priasmoro
Student ID Number	245150407111036
Institution of Origin	Brawijaya University
Place and Date of Birth	July 18, 2006, Bukittinggi
Email	dennopriasmoro@student.ub.ac.id
Phone Number	+62 82269676070

B. Awards Received

No	Award Type	Award Institution	Year
1			
2			
3			

I certify that all information provided in this biographical information form is accurate, and I take responsibility for the data entered. I am completing this form as part of the requirements to enter the CODE INTERNATIONAL 2024 competition.

October 3, 2024, Malang
Team Member

(Muhammad Denno Priasmoro)

3. Team Member Biodata

C. Personal Identity

Full Name	Ezrasto Mahardika Maydiputra
Student ID Number	245150200111003
Institution of Origin	Brawijaya University
Place and Date of Birth	August 17, 2006, Tangerang
Email	astomaydiputra@student.ub.ac.id
Phone Number	+62 81235712772

D. Awards Received

No	Award Type	Award Institution	Year
1			
2			
3			

I certify that all information provided in this biographical information form is accurate, and I take responsibility for the data entered. I am completing this form as part of the requirements to enter the CODE INTERNATIONAL 2024 competition.

October 3, 2024, Malang
Team Member

(Ezrasto Mahardika Maydiputra)