

## CHAPTER V

### CONCLUSION AND RECOMMENDATION

#### 5.1. Conclusion

This research has successfully demonstrated that the integration of single architecture models, ResNet-50 and EfficientNet-B2, through the Soft Voting Ensemble Learning paradigm is capable of mitigating the challenges of visual diagnosis in Tinea Capitis skin disease by significantly improving classification accuracy compared to single architecture models, particularly in distinguishing ambiguous inflammatory and non-inflammatory subtypes. Through dataset splitting experiments, scenario 1 with a medical visual image dataset proportion of 70:20:10 was confirmed as the most superior dataset configuration, yielding the best generalization capability with a testing accuracy that reaching 89.47%, which effectively and efficiently reduces the potential for local overfitting phenomena. Furthermore, the comparative analysis of weight optimization strategies confirms the superiority of deterministic Grid Search method over the stochastic Random Search approach, where the Grid Search method consistently finds the optimal convergence point for the ensemble contribution weights (0.45 for ResNet-50 and 0.55 for EfficientNet-B2), thereby ensuring stability in system performance.

In terms of implementation, this research also successfully transformed the developed artificial intelligence into a website-based Clinical Decision Support System that is ready to be utilized by medical professionals. The utilization of the Laravel 12 framework for business logic and the backend system, Tailwind CSS for the user interface design, and MySQL as the Relational Database Management System has resulted in a secure and user-friendly platform to bridging the gap between advanced technology and the practical needs of medical personnel in the field. The integration of this system enables a efficient, effective, fast, precise, and accurate classification process, and holds great potential in reducing the error rates that frequently occur in manual diagnosis processes due to visual subjectivity among medical personnel in the field and the high cost of modern dermoscopic equipment, which results in the limited capabilities of advanced and modern classification processes at various primary healthcare facilities.

## 5.2. Recommendation

Based on the research experience regarding the application of Soft Voting Ensemble Learning Paradigm for the Classification of Tinea Capitis Skin Disease using the ResNet-50 and EfficientNet-B2 architectural models, the following are several recommendations that can be considered and applied to enrich and expand future research:

1. Future research experiment can utilize and integrating more advanced individual artificial intelligence architectural models, particularly the latest generation models associated with more fast, precise, and accurate visual processing capabilities (such as Vision Transformers or hybrid models), which are designed to enhance the stability of feature representation and robustness against variations in dermatological images. This approach has the potential to expand the system's capability in recognizing complex fungal infection patterns with a higher degree of precision.
2. The use of generative modeling techniques is expected to be the next research direction to enrich the diversity of the available Tinea Capitis dataset, especially to balance the minority classification classes, both the minority in the original data and the classification classes with the lowest accuracy in this study. The application of modern generative technology can produce realistic and safe synthetic medical image variations, thereby strengthening the training of individual and ensemble architectural models without a high dependence on the expansion of actual clinical data.
3. Further research is recommended to profoundly explore various highly adaptive hyperparameter and weight optimization methods and techniques, such as the Bayesian Optimization or the Genetic Algorithms. This aims to complement and perfect the comparative analysis approach between the deterministic Grid Search method and also the stochastic Random Search method conducted in this study, in order to achieve optimal convergence of the contribution weight combinations from each single architectural models (ResNet-50 and EfficientNet-B2) to the ensemble architectural (Soft Voting Ensemble Learning) model with a more efficient and effective computational time compared to exhaustive search methods.

4. The integration of a more comprehensive model interpretability approach (Explainable AI and Heatmap methods and techniques) becomes crucial for further research and experiment as an effort to improve transparency and accountability in medical image-based classification systems. The use of advanced interpretation methods will enable all medical personnel to understand the reasoning behind the predictions more deeply, ensuring that the developed classification system can be used more broadly in clinical contexts rather than merely remaining a black-box.
5. The development of a more integrated clinical implementation that is ready for use within primary-class healthcare facility environments is the best strategic development direction. The automated Tinea Capitis skin disease classification systems to be developed in the future can be further adapted into mobile apps, clinical dashboards, or digital dermatological examination devices to support fast and accurate diagnostic processes.
6. Regarding the website-based interface system that has been designed and built using the Laravel 12 framework and Tailwind CSS, future backend development can focus on implementing microservices architecture or integration with the cloud computing. This infrastructure enhancement is necessary to maintain the scalability and responsiveness of the website system when handling high access loads and the storage of large amounts of medical record data in real-time.
7. Future research is recommended to develop multimodal architectural models by integrating the dermoscopic medical image inputs with patient clinical data record (age, gender, residence, history of animal contact, history of human contact, history of soil contact, symptom duration, or inflammation level) or visually imperceptible symptom data (such as itching). The fusion between visual features and this medical history and symptom data is believed to be the key solution to resolving the ambiguity of Tinea Capitis skin disease subtypes that possess high morphological similarities, where visual image features alone have proven insufficient to differentiate them precisely without additional clinical context.