

## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusions

Based on the entire research process, including the design, implementation, and analysis of test results on the Nglegena Javanese Script handwritten text recognition system, it can be concluded that the integration of the CNN, BiLSTM, and CTC architectures successfully addressed all research questions. The design process was carried out by combining the capabilities of CNN in extracting visual features, BiLSTM in modeling character sequence dependencies, and CTC as a loss function, enabling text recognition without the need for manual character alignment.

Exploration of various architecture variations showed that a combination of 5 CNN layers and 2 BiLSTM layers was the most optimal configuration for recognizing the morphology of the Nglegena Javanese Script. The use of 5 CNN layers proved to be a turning point in efficiency, resulting in fast and stable convergence. While shallower architectures (3-4 layers) tended to underfit, and deeper architectures (6-7 layers) actually triggered instability due to excessive sensitivity to data variations. A similar phenomenon was also found in the recurrence section, where the use of 2 BiLSTM layers enabled the construction of a hierarchical and stable feature representation, while adding and removing BiLSTM layers actually triggered optimization instability and extreme metric fluctuations during training. This emphasizes that architectural complexity must be proportionate to the characteristics of the dataset to ensure the model has high generalization capabilities without falling prey to gradient efficiency or overfitting.

The robustness of this model was also tested through test data evaluation, with a CER of 0.0682 and an EM of 0.7950 in its best configuration. This performance is reinforced by the distribution of error values, which shows a median of 0.0000, indicating that most samples were recognized with perfect accuracy. This confirms the model's high generalization capability in handling variations in authentic handwriting without losing precision in the character details of the Nglegena Javanese script.

As a final step, all of this development was successfully translated into a ready-to-use functional system in two forms: an API and a website. By building the API using the FastAPI framework, the model has the flexibility to integrate efficiently with

various other systems. Simultaneously, the model was also implemented into an interactive React.js-based website interface designed for general public use. The synergy between the API and the website allows the process of transcribing the Nglegena Javanese script text to be carried out automatically, interactively, and easily accessed, thus providing a practical solution for the wider community in recognizing and preserving traditional scripts in the digital era.

## **5.2 Recommendations**

Although this research has successfully achieved its expected performance targets, there are several potential strategic developments that can be undertaken in the future to improve the system. First, the dataset can be strengthened by expanding the data by adding variations in handwriting styles from more participants. Furthermore, the system's scope can be expanded beyond the Nglegena Javanese script by integrating other, more complex Javanese script components, such as Sandhangan and Pasangan, to create a more comprehensive and accurate transcription system.

In the next stage of development, the system's scope is also expected to be expanded to include row-level or full-document recognition directly, to support the digitization of ancient manuscripts with more complex layouts. From a technical architecture perspective, the implementation of mechanisms such as the Attention Mechanism, as well as adaptive optimization and dynamic regularization techniques, is crucial to ensure stable convergence as the model progresses further. Integrating these techniques is crucial for improving the model's accuracy and sharpness in predicting Javanese script characters.