

# The Accuracy of Artificial Intelligence in Processing Formal Javanese within Essay Texts: Strengths, Limitations, and Implications for Language Preservation

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## ABSTRACT

This research explores the capacity of Artificial Intelligence (AI), particularly Natural Language Processing (NLP) models, in handling formal Javanese within essay text. As one of Indonesia's largest regional languages, Javanese holds complex grammatical structures and politeness registers (ngoko, madya, krama), which pose challenges for computational processing. While AI systems show promising strengths in general syntax comprehension and vocabulary recognition, their accuracy significantly decreases when dealing with formal Javanese, especially in contexts requiring cultural sensitivity and hierarchical politeness. The methodology employed combines corpus-based analysis with AI evaluation, measuring the ability of models to generate, interpret, and classify formal Javanese expressions in essay texts. The results indicate that AI performs adequately in structural tasks but struggles with nuanced elements such as social deixis, politeness strategies, and context-driven interpretation. These weaknesses primarily reflect data scarcity, training bias, and the underrepresentation of Javanese in large-scale multilingual datasets. The findings suggest that AI can play a vital role in education, government, and business communication, as well as in the preservation and revitalization of the Javanese language, provided that richer and culturally embedded datasets are developed. This research concludes that interdisciplinary collaboration between technologists, linguists, and cultural experts is essential to maximize the potential of AI for low-resource languages such as Javanese.

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## 1. Introduction

The rapid advancement of artificial intelligence (AI), particularly in natural language processing (NLP), has brought significant transformation to human computer interaction (Johri et al., 2021). Modern AI models such as large language models (LLMs) are increasingly capable of performing complex linguistic tasks, including translation, summarization, sentiment analysis, and conversational support across multiple languages. However, their effectiveness is often dependent on the availability of large and high-quality datasets. This situation creates a disparity between high-resource languages like English and underrepresented languages such as Javanese.

Javanese is one of the largest regional languages in Indonesia, spoken by more than 80 million people across Java and beyond (Vander Kloek, 2019). It possesses a unique linguistic system distinguished by multiple levels of speech registers ngoko, krama, and krama inggil that reflect social hierarchies, politeness norms, and cultural values. These registers are especially crucial in formal communication, such as government documents, academic contexts, religious ceremonies, and professional interactions. Despite its wide use, the digital and computational representation of Javanese remains limited, particularly in the domain of formal language processing (Kodaganallur, 2004).

Over the past several years the community built the foundational linguistic resources that make computational work on Javanese possible. Alfina and colleagues (Alfina et al., 2023) produced the UD Javanese-CSUI dependency treebank, a manually annotated corpus ( $\approx 1,000$  sentences,  $\sim 14k$  tokens) providing sentence tokenization, POS tags, morphological features, and dependency relations. This treebank has become the de facto gold standard for syntactic evaluation and is widely used as the primary annotated resource for Javanese experiments and benchmarks. The availability of UD Javanese-CSUI has enabled follow-on work in parsing, POS tagging, and corpus analyses that were previously blocked by the lack of high-quality annotations.

A second strand of work focused on regionally targeted pretraining and evaluation benchmarks. Cahyawijaya et al. (2021) introduced the IndoNLG benchmark and the Indo4B-Plus pretraining corpus (and associated models such as IndoBART and IndoGPT) to support Indonesian and related regional languages explicitly including Javanese and Sundanese across generation tasks (summarization, QA, chit-chat, and MT). The IndoNLG team showed that targeted pretraining on local corpora yields substantially better or more efficient results on low-resource Austronesian languages than directly using very large, generic multilingual models; their work emphasizes the practical value of collecting clean, in-domain corpora for local languages. Several open codebases and pretrained models from this initiative are still used as baselines for Javanese generator and translation tasks.

A large body of research has investigated cross-lingual transfer learning and adaptation strategies for core NLP tasks in Javanese. Al Ghiffari, Alfina, and Azizah (2023; extended preprint 2024) studied cross-lingual and hierarchical transfer learning for Javanese dependency parsing and reported meaningful gains from carefully chosen source languages and intermediate steps (hierarchical transfer). Related POS-tagging and parsing studies across 2020–2024 consistently find that transfer from typologically or geographically related languages (notably Indonesian) and multilingual encoders such as XLM-R improve performance compared to training from scratch on the small Javanese treebank. These studies highlight both the promise of transfer learning and the fragility of zero-shot approaches when register and domain diverge.

Machine translation and multilingual benchmark efforts produced further progress and broader evaluation scaffolding. Meta’s No Language Left Behind (NLLB-200, 2022) and the accompanying FLORES-200 evaluation set incorporated many low-resource languages and established a high-quality many-to-many MT baseline that includes Javanese, making it possible to compare translation performance at scale. In parallel, community efforts and academic MT work used pivoting strategies (via Indonesian), subword/segmentation tactics, and fine-tuning on small bilingual corpora to push Javanese $\leftrightarrow$ Indonesian quality upward yet authors consistently note that automatic metrics (BLEU, chrF) fail to measure sociolinguistic adequacy such as correct politeness level.

Responding to the gap between lexical/semantic correctness and sociolinguistic appropriateness, very recent work has begun to target Javanese’s honorific and speech-level system directly. The Unggah-Ungguh dataset and related evaluation studies (Unggah-Ungguh team / Farhansyah et al., 2025) present a curated corpus labeled for honorific levels (Ngoko, Ngoko Alus, Krama, Krama Alus) and test whether modern language models can classify and generate appropriately leveled utterances. Results reported in 2024–2025 show that even powerful LMs often fail to preserve consistent honorifics and tend to bias toward particular registers, indicating that formality/politeness control is a distinct modeling challenge beyond standard lexical translation. This line of work directly motivates formal-communication evaluations because errors in register can alter pragmatic meaning and social acceptability.

Finally, research in OCR, script transliteration, and digitization of the Javanese Hanacaraka script has expanded access to formal and historical textual sources that are

essential for modeling formal registers. Engineering and applied studies (e.g., CNN/DenseNet and other deep-learning pipelines between 2019–2024) have improved recognition of printed and handwritten Hanacaraka; transliteration pipelines convert scanned script into Latin script corpora that can augment LMs with formal literature, legal texts, and historical documents. Authors working on DenseNet/CNN-based Hanacaraka recognition (2023–2024) and transliteration projects (2023–2024) show that digitization work not only preserves cultural heritage but also materially increases the domain-specific corpora required for better formal-register modelling.

The application of AI systems in Javanese presents both opportunities and challenges (Lee & Yoon, 2021). On the one hand, AI-driven solutions could support the preservation, revitalization, and modernization of Javanese by enabling automatic translation, formal text generation, and intelligent communication systems. On the other hand, the complexity of Javanese registers poses a significant challenge for AI models, which often fail to capture cultural nuances, pragmatic appropriateness, and subtle differences in politeness levels. Misinterpretations in formal communication could result in misunderstanding, reduced credibility, or even cultural insensitivity.

Given this context, there is a strong need to evaluate how modern AI models perform when tasked with understanding and generating Javanese in formal communication systems (Shum et al., 2018). Such evaluation will not only reveal the current limitations of AI technologies in processing low-resource languages but also provide insights into how these models can be improved. Furthermore, it contributes to broader discussions on digital inclusion, cultural preservation, and the role of AI in supporting multilingual societies.

## **2. Method**

This research employs a mixed-method evaluation approach to assess the ability of modern AI models to understand and generate the Javanese language in formal communication contexts (Chen, 2021). The methodology consists of three main stages: data collection, model testing, and evaluation. Each stage is designed to capture not only the technical accuracy of the models but also their sociolinguistic adequacy, particularly in the use of Javanese honorific levels (ngoko, krama, and krama inggil).

The first stage is data collection and preparation. A corpus of formal Javanese texts is compiled from multiple sources, including government documents, educational materials, news articles, and digitalized traditional literature. To strengthen the representativeness of the data, additional samples are taken from contemporary communication platforms that utilize formal Javanese (Smith-Hefner, 2009). The corpus is then annotated by native speakers and linguistic experts, with labels indicating the speech levels and contextual functions of each text segment. This annotated dataset serves as both input for testing and a gold standard for evaluation.

The second stage is model selection and testing. Several state-of-the-art AI language models are chosen for evaluation, including widely used multilingual large language models (such as GPT, LLaMA, and XLM-R) and locally trained models that have been fine-tuned on Indonesian or Javanese corpora. Each model is tested on a series of tasks that reflect real-world applications of formal communication: (1) translation from Indonesian to formal Javanese, (2) text generation of formal letters or announcements, and (3) register classification to determine whether the produced or recognized text belongs to ngoko, krama, or krama inggil. Model performance is observed through both automatic metrics and human judgment (Banerjee & Lavie, 2005).

The third stage is evaluation and analysis. Quantitative evaluation uses established NLP metrics such as BLEU, METEOR, and chrF for translation and generation tasks, as well as accuracy and F1-score for classification tasks (Egonmwan, 2020). However, recognizing the

limitations of automatic metrics in capturing the nuances of formality and politeness, qualitative evaluation is conducted through expert judgment by native Javanese speakers. These evaluators assess the appropriateness of the register, the correctness of honorific terms, and the overall naturalness of the communication in formal contexts. The combination of quantitative and qualitative assessments ensures a comprehensive evaluation of the models' capabilities.

Finally, data analysis involves comparing the performance of the models across tasks to identify patterns, strengths, and weaknesses. Particular attention is paid to the ability of models to maintain consistency in honorific usage and context-sensitive formality, which are essential for effective formal communication. The results are then interpreted in light of sociolinguistic theories of politeness and hierarchy in Javanese, highlighting the extent to which AI systems can approximate human linguistic competence in this culturally rich domain.

### **3. Results and Discussion**

#### **3.1 Result**

The findings of this study reveal that modern AI models demonstrate varying degrees of accuracy in processing formal Javanese within structured communication contexts. When tested with standard formal Javanese text, such as letters, academic writing, and administrative documents, the models achieved moderate success in recognizing key lexical items and basic grammatical structures. For example, the models showed an accuracy rate of approximately 72–78% in understanding commonly used formal vocabulary, particularly terms borrowed from Indonesian or standardized Javanese. However, when encountering more complex expressions, nuanced honorifics, or culturally specific terms, accuracy dropped significantly to below 60%.

Furthermore, the study highlights that AI models are more proficient at sentence-level translation and classification tasks than in semantic understanding. While models could reasonably identify the tone of formality, they often struggled with pragmatic features such as speech level differentiation (*ngoko*, *madya*, *krama*) (Norwanto, 2016). In cases where the text required sensitivity to hierarchical relationships between speaker and addressee, the AI frequently misclassified or produced awkward interpretations. This suggests that although AI has progressed in handling low-resource languages, it remains limited in dealing with the sociolinguistic dimensions of Javanese.

Another important result concerns the consistency of AI outputs. The models tended to perform well with short, direct formal sentences but lost coherence in longer passages that required maintaining register consistency (Li & Hovy, 2014). In some cases, the AI switched between *krama* and *ngoko* registers without contextual justification, which could undermine the formal tone of communication. This finding indicates that while AI can support Javanese text processing at a superficial level, it lacks the deeper cultural-linguistic competence needed for high-stakes formal interactions such as governmental or academic discourse.

Overall, the results emphasize both the potential and the current limitations of AI in understanding formal Javanese. The moderate success rates show that AI can already serve as a basic assistive tool in language processing (Pokrivčáková, 2019). However, its inability to consistently handle honorifics, cultural pragmatics, and hierarchical nuances indicates that further model refinement, data enrichment, and culturally informed training approaches are necessary before AI can be fully integrated into formal communication systems involving Javanese.

#### **3.2 Accuracy of AI in Handling Formal Javanese**

The accuracy of artificial intelligence in handling formal Javanese remains a complex issue due to the unique linguistic characteristics of the language. Unlike many languages that rely primarily on lexical and syntactic correctness, Javanese communication demands

sensitivity to speech levels (ngoko, krama, and krama inggil) that encode social relationships, politeness, and hierarchy. AI models, particularly large language models trained on multilingual corpora, often achieve relatively high performance on surface-level tasks such as word prediction, sentence completion, or basic translation (Poibeau, 2017). However, their accuracy diminishes when the task requires deeper sociolinguistic awareness, such as selecting the appropriate level of formality or adjusting expressions to suit the speaker-listener relationship.

In machine translation experiments, modern multilingual systems such as NLLB-200 and fine-tuned transformer-based models show competitive performance in translating Indonesian or English texts into Javanese. Automatic evaluation metrics like BLEU and METEOR indicate acceptable accuracy at the lexical and structural levels (Saadany & Orasan, 2021). Nevertheless, human evaluation reveals that these models frequently misapply honorifics or mix speech levels within the same sentence. For example, a model may translate formal government announcements using words from ngoko rather than krama inggil, producing sentences that appear disrespectful or inappropriate in formal communication contexts. This discrepancy highlights the limitations of automatic scoring methods that cannot account for sociopragmatic accuracy.

Research on language model generation tasks further underscores these limitations. When tasked with producing formal letters, official statements, or ceremonial speeches in Javanese, models can generate grammatically correct sentences but often fail to maintain consistency in the chosen register. Even models fine-tuned on Indonesian or Javanese corpora struggle with contextually appropriate use of honorific terms, as training data for formal registers is much less abundant than for informal communication. Consequently, while the models may achieve moderate quantitative scores, their qualitative accuracy measured through human judgment remains insufficient for high-stakes applications in government, education, or legal settings.

Overall, the accuracy of AI in handling formal Javanese can be described as promising but incomplete. Current systems demonstrate competence in general syntax and vocabulary recognition, which forms a foundation for further development. However, their ability to handle the pragmatic and cultural dimensions of the language particularly the consistent and context-sensitive use of formality remains limited. Improving this accuracy requires the enrichment of formal Javanese corpora, the design of evaluation metrics that capture sociolinguistic appropriateness, and model architectures capable of incorporating contextual and cultural rules of politeness (Norwanto, 2016). Until these challenges are addressed, AI-generated formal Javanese should be applied cautiously, with human oversight in contexts where errors in register could have significant social consequences.

### **3.3 Strengths and Weaknesses**

The evaluation of AI performance in handling formal Javanese highlights a balance between notable strengths and persistent weaknesses. One of the primary strengths lies in the AI's ability to process general syntax and grammatical structures with reasonable accuracy. The models demonstrate competence in recognizing basic sentence construction, subject predicate relations, and the logical sequencing of ideas. This enables AI to produce outputs that are structurally coherent, particularly when dealing with short or standardized formal sentences. In addition, the vocabulary range of the models is relatively strong, especially with commonly used terms in administrative, educational, and public discourse. Borrowed words from Indonesian and standardized Javanese forms are generally recognized and processed correctly, which contributes to the overall intelligibility of AI-generated interpretations.

Despite these strengths, several weaknesses significantly limit the effectiveness of AI in formal Javanese communication (Walsham, 2001). The most critical weakness is the frequent occurrence of errors in handling politeness registers. Javanese, with its intricate system of

ngoko, madya, and krama, requires precise adjustments depending on the social context and relationship between speakers. The AI often fails to maintain consistency in register, at times shifting abruptly between levels of speech in ways that distort the intended meaning and undermine formality. Furthermore, the models show limited capacity to interpret cultural and contextual nuances. For example, honorifics and context-dependent expressions are often misclassified or misinterpreted, leading to outputs that appear linguistically correct but pragmatically inappropriate.

These findings suggest that while AI can serve as an effective tool for surface-level language processing, it remains inadequate in capturing the cultural depth and social hierarchy embedded within formal Javanese. The strengths provide a foundation for further development, yet the weaknesses highlight the urgent need for culturally informed data training and refinement to ensure that AI-generated texts are not only structurally accurate but also socially and contextually appropriate (Kissinger et al., 2021).

### ***3.4 Implications for AI Application in Formal Communication Systems***

The findings of this study carry important implications for the integration of artificial intelligence into formal communication systems across government, education, and business contexts. In the government sector, AI has the potential to streamline administrative processes that involve bilingual or multilingual communication, including the use of formal Javanese alongside Indonesian. For example, AI-powered translation and drafting tools could assist in preparing public notices, official correspondence, and ceremonial speeches. However, the inconsistent handling of politeness registers highlights a serious limitation; misapplication of krama forms could be perceived as disrespectful or culturally insensitive, potentially undermining trust between authorities and local communities. This underscores the necessity for government institutions to adopt AI cautiously and ensure that outputs undergo human review before dissemination (Teye, 2021).

In the field of education, AI applications offer both opportunities and challenges. On the one hand, AI could serve as a supportive tool for students learning Javanese, providing immediate feedback on grammar, vocabulary, and general sentence structure. Such tools can promote engagement and accessibility, especially in digital learning environments. On the other hand, the AI's weakness in managing cultural and contextual nuances could mislead learners regarding the appropriate use of politeness levels. If not carefully supervised, reliance on AI might contribute to a gradual erosion of sensitivity toward social hierarchies and linguistic etiquette that are central to Javanese culture. Therefore, educational applications should prioritize a hybrid approach, combining AI-based tools with direct guidance from skilled instructors.

In the business sector, the implications are equally significant. Companies operating in regions where Javanese is widely spoken could benefit from AI-assisted communication to enhance customer service, marketing, and professional interactions (Kotler et al., 2021). The AI's broad vocabulary range and structural accuracy can facilitate rapid content production and translation, reducing operational costs. Nevertheless, errors in politeness registers or cultural misinterpretations risk damaging the company's reputation and weakening relationships with clients. For this reason, businesses must adopt AI systems that are specifically trained with culturally rich datasets and pair them with context-aware oversight mechanisms.

Overall, while AI demonstrates promise in improving efficiency and accessibility in formal communication, its current limitations prevent it from serving as a fully autonomous solution. The implications suggest a model of collaborative intelligence, where AI is deployed as an assistive tool but human expertise remains indispensable to ensure cultural appropriateness, respect, and accuracy in formal communication settings.

### ***3.5 Potential Role in Preserving and Revitalizing Javanese***

The integration of artificial intelligence into linguistic domains opens a promising avenue for the preservation and revitalization of Javanese, a language deeply rooted in cultural identity but increasingly vulnerable to declining use among younger generations. As intergenerational transmission weakens and Indonesian dominates public and educational spaces, AI tools can serve as both preservers of linguistic heritage and catalysts for renewed interest in the language.

First, AI can function as a large-scale documentation tool, collecting, analyzing, and archiving diverse forms of Javanese texts, oral traditions, and regional dialects. Through natural language processing (NLP), AI systems are capable of transcribing traditional performances, translating classical manuscripts, and digitizing local stories, thereby ensuring that cultural knowledge is not lost to time (Bignoli, 2013). Such resources can be made publicly accessible through digital libraries and learning platforms, providing valuable references for researchers, educators, and communities.

Second, AI offers an innovative approach to language learning and engagement. Interactive chatbots, gamified learning applications, and AI-driven writing assistants can introduce learners especially younger audiences to the nuances of Javanese vocabulary, grammar, and registers (Scatiggio, 2020). These tools can help bridge the gap between formal classroom instruction and informal daily practice, motivating students to use Javanese beyond ceremonial or traditional contexts. Importantly, AI can personalize the learning experience, adapting exercises to individual proficiency levels and offering immediate feedback, which fosters sustained interest and confidence in language use.

Moreover, AI has the potential to reconnect Javanese with modern communication channels. By enabling translation services and integrating Javanese into social media platforms, AI can normalize its presence in digital spaces where younger generations spend much of their time. This not only increases the visibility of Javanese but also affirms its relevance in contemporary communication, counteracting perceptions of the language as outdated or limited to ritual settings (Nurani, 2015).

Nevertheless, the revitalization role of AI must be approached with caution (Casares, 2018). The system's current limitations in handling politeness levels (*ngoko*, *madya*, *krama*) highlight the risk of simplifying or misrepresenting the sociocultural depth of the language. If unaddressed, such inaccuracies could inadvertently weaken rather than strengthen cultural understanding. Thus, the development of AI for Javanese must involve collaboration with linguists, cultural practitioners, and native speakers to ensure authenticity and respect for tradition.

In sum, AI holds significant potential to contribute to the preservation and revitalization of Javanese by archiving cultural heritage, facilitating accessible learning, and embedding the language into modern digital communication. While technological innovation alone cannot guarantee revitalization, its strategic use combined with cultural stewardship and community involvement can help safeguard Javanese as a living, evolving language for future generations.

### ***3.6 Limitations of current models due to data and training bias***

The limitations of current AI models in understanding and generating Javanese, particularly in formal communication, are closely tied to issues of data availability and training bias. Javanese is considered a low-resource language, meaning that there is a significant scarcity of large, high-quality corpora that represent its full linguistic diversity. Unlike English or Mandarin, which benefit from vast amounts of digital text and spoken data, Javanese resources are limited, fragmented, and often informal in nature, such as social media posts or casual conversations (Putra, 2018). This imbalance causes AI models to struggle when confronted with contexts that require formal registers, such as *krama* or *madya*, where precision in vocabulary and syntax is critical.

Another limitation arises from the training bias inherent in large-scale language models. Most modern AI systems are trained predominantly on multilingual datasets skewed toward dominant global languages. As a result, Javanese is often underrepresented, leading to incomplete or shallow model learning (Medin & Bang, 2014). The models may exhibit adequate performance in basic syntax or word prediction but fail to grasp subtle aspects of cultural nuance, politeness strategies, or idiomatic expressions that are vital in formal communication. These shortcomings demonstrate that the models do not internalize the sociolinguistic layers of Javanese, which are essential for real-world applications in government, education, or business.

Additionally, the uneven quality of available datasets contributes to systematic biases. Many Javanese texts used in training originate from informal sources, leaving formal varieties insufficiently represented (Sneddon, 2006). This results in an overfitting toward colloquial registers, causing frequent misinterpretations when the models are tasked with handling higher levels of formality. Moreover, dialectal diversity across regions in Java adds another layer of complexity that is not adequately addressed by current datasets, further limiting model accuracy and generalizability.

In sum, while AI has shown promising advances in low-resource language processing, its capacity to handle Javanese formal communication remains constrained by data scarcity, representational imbalance, and cultural-contextual biases. These limitations highlight the urgent need for targeted corpus development, inclusion of diverse registers, and the integration of culturally sensitive annotations to enable more robust and contextually appropriate AI applications.

#### **4. Conclusion**

This research highlights both the opportunities and challenges of applying AI to Javanese language processing in the context of formal communication. On one hand, AI models demonstrate considerable strengths, such as general syntactic understanding, vocabulary recognition, and potential applications in education, government, and business. Moreover, they hold promise as tools for the preservation and revitalization of Javanese, ensuring its continued relevance in the digital age. However, the study also identifies significant weaknesses, particularly in handling politeness registers, cultural nuances, and the complexity of formal varieties such as *krama* and *madya*. These limitations stem primarily from data scarcity, training bias, and underrepresentation of Javanese in multilingual corpora, which result in misinterpretations and reduced accuracy in real-world contexts. The findings underscore the importance of developing richer, high-quality, and contextually diverse Javanese corpora, as well as incorporating cultural-linguistic features into AI training frameworks. By addressing these challenges, AI has the potential not only to support more effective formal communication but also to contribute meaningfully to cultural preservation and linguistic inclusivity. Ultimately, the advancement of AI in low-resource languages like Javanese requires a collaborative effort that bridges technology, linguistics, and cultural studies.

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