IMPLEMENTATION OF BERT FOR AUTOMATIC IDENTIFICATION LEGAL ENTITIES IN JUDGMENT DOCUMENTS COURT DECISION DOCUMENT

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| **Article Info** |  | **ABSTRACT** |
| ***Article history:***  Received month dd, yyyy  Revised month dd, yyyy  Accepted month dd, yyyy |  | Legal decision documents are crucial for tasks such as case data mapping and legal text analysis but are difficult to understand due to their complexity and length. To address this, Named Entity Recognition (NER) is applied, which can automatically identify entities like defendant names and decision dates in the documents. In Indonesia, although research on entity extraction from legal documents exists, Transformers-based Deep Learning models such as BERT have not been utilized. This study uses Indonesian BERT models, namely indolem/indobert-base-uncased and indobenchmark/indobert-base-p2, which are trained on IndoLEM and IndoNLU datasets. The data were collected by downloading 1,000 documents from the Supreme Court Decision Directory website. The process involves preprocessing, annotation, data division using 5-Fold Cross Validation, modeling, and evaluation. The results show that the indolem/indobert-base-uncased model consistently outperforms the indobenchmark/indobert-base-p2 in NER tasks within the legal domain, with average precision, recall, and F1-score values of 90%, 88%, and 89%, respectively. In contrast, indobenchmark/indobert-base-p2 recorded precision, recall, and F1-score values of 88%, 88%, and 84%, respectively. This demonstrates the potential of BERT models to enhance the accuracy and efficiency of entity extraction in legal contexts. |
| ***Keywords:***  Legal Decision Document  Named Entity Recognition (NER)  BERT  Deep Learning  IndoBERT |
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1. **INTRODUCTION (10 PT)**

Legal decision documents are an important source of information that can be utilized for various purposes, such as case data mapping, legal history analysis, and data extraction [1]. Indonesia's Supreme Court (MA), as an institution that holds judicial power, has the responsibility of analyzing various legal cases based on court decision documents [2]. As of November 2023, the number of legal decision documents in Indonesia has reached more than 8 million, reflecting the increasing complexity in legal data management and analysis [3].

Although these documents are available in PDF format and organized by judiciary and case type, understanding their contents takes a long time due to their complex structure. Therefore, there is a need for an automated system capable of efficiently extracting important information. Named Entity Recognition (NER) is one of the techniques used to identify specific entities in text, such as locations and organizations, which is helpful in natural language processing tasks [4].

Currently, the application of NER for legal documents in Indonesia is still limited. Previous research shows that Transformer-based models such as BERT, which have been successfully applied in various NLP tasks, have the potential to improve NER performance in the context of Indonesian legal documents [5][6]. This research proposes the use of BERT models that have been trained with the Indonesian language to improve the accuracy and efficiency of information extraction from Indonesian legal decision documents.

1. **METHOD (10 PT)**

This research uses a Deep Learning-based approach with the Transformer model, specifically BERT, for entity extraction from Indonesian legal decision documents. The research process involves several stages which are illustrated in Figure 1.

A diagram of a system

Description automatically generated

Figure 1. Arsitektur Sistem

* 1. **Data Scraping**

This research utilizes criminal court decision documents in Indonesian as the object of analysis. A total of 1,000 criminal decision documents, spanning from 2002 to 2019, were used as the sample. The data was obtained through web scraping from the Directory of Supreme Court Decisions, then converted into a text format for further processing. The extracted entities include 12 types: decision number, defendant's name, criminal offense, law violation, legal charge, legal verdict, decision date, presiding judge, member judge, clerk, public prosecutor, and legal counsel.

* 1. **Pre-Pprcessing**

The pre-processing stage was conducted to ensure that the data used in this research was ready for modeling. The pre-processing steps included removing special characters, normalizing the text, tokenizing, and labeling entities according to the required annotations. Each document was checked for formatting errors or inaccuracies that could affect the results of Named Entity Recognition (NER).

* 1. **Splitting Data**

After the pre-processing stage, the data is split using a 5-fold cross-validation technique to ensure that the model is trained and tested on diverse datasets. The data is divided into a "Training Set" and a "Test Set." The training set is further divided into a "Train Set" and a "Validation Set." This division is done to ensure that the model is evaluated objectively and to prevent overfitting.

* 1. **Trining Model**

Two pre-trained BERT-based models trained in Indonesian were used in this research: Indolem/indobert-base-uncased and Indobenchmark/indobert-base-p2. These models were selected because they have been trained on two large datasets considered benchmarks in Indonesian natural language processing evaluation. The models were adapted for the Named Entity Recognition (NER) task on legal documents.

The model training was conducted using a dataset annotated according to the 12 predefined entities. Each model was trained using transfer learning techniques to leverage the existing language capabilities of the pre-trained models. Additionally, fine-tuning was performed to adapt the models to the specific characteristics of the legal decision document data.

* 1. **Model Evaluation**

After training, both models will be evaluated using NER performance metrics such as Precision, Recall, and F1-Score. The evaluation will be conducted on a test dataset comprising 20% of the total data. These metrics will be used to determine which model performs best in recognizing and extracting entities from Indonesian legal decision documents.

Table 1. The performance of ...

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| Variable | Speed (rpm) | Power (kW) |
| x | 10 | 8.6 |
| y | 15 | 12.4 |
| z | 20 | 15.3 |

1. **RESULTS AND DISCUSSION (10 PT)**

Hasil dari penelitian menunjukkan bahwa model Indolem/indobert-base-uncased memiliki performa yang lebih unggul dibandingkan dengan Indobenchmark/indobert-base-p2 dalam tugas NER pada dokumen hukum【20】. Rata-rata nilai presisi, recall, dan F1-score untuk model Indolem/indobert-base-uncased masing-masing adalah 90%, 88%, dan 89%【21】. Sedangkan untuk model Indobenchmark/indobert-base-p2, masing-masing adalah 88%, 88%, dan 84%【22】. Diskusi dari hasil ini mengindikasikan bahwa model Indolem lebih baik dalam menangkap konteks dan struktur kalimat dalam bahasa Indonesia, terutama dalam dokumen hukum yang kompleks【23】.

Analisis lebih lanjut menunjukkan bahwa penggunaan model berbasis transformer seperti BERT dapat meningkatkan efisiensi dan akurasi dalam identifikasi entitas pada dokumen putusan pengadilan【24】. Hal ini membuka peluang untuk penerapan lebih luas dari teknologi ini dalam bidang hukum dan dapat meningkatkan proses analisis serta pengelolaan dokumen di lembaga kehakiman【25.

Hasil analisa semua fold

**3.1. Sub section 1**

Equations should be placed at the center of the line and provided consecutively with equation numbers in parentheses flushed to the right margin, as in (1). The use of Microsoft Equation Editor or MathType is preferred.

) (1)

All symbols that have been used in the equations should be defined in the following text.

**3.2. Sub section 2**

Proper citation of other works should be made to avoid plagiarism. When referring to a reference item, please use the reference number as in [9] or [10] for multiple references. The use of ”Ref [11]...” should be employed for any reference citation at the beginning of sentence. For any reference with more than 3 or more authors, only the first author is to be written followed by *et al*. (e.g. in [12]). Examples of reference items of different categories shown in the References section. Each item in the references section should be typed using 8 pt font size [13], [14], [15], [16], [17], [18].

3.2.1. Subsub section 1

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3.2.2. Subsub section 2

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1. **CONCLUSION (10 PT)**

Penelitian ini berhasil menunjukkan bahwa model Indolem/indobert-base-uncased lebih efektif untuk tugas NER pada dokumen hukum berbahasa Indonesia dibandingkan model Indobenchmark/indobert-base-p2【26】. Hasil ini memberikan kontribusi penting bagi pengembangan teknologi pemrosesan bahasa alami dalam konteks hukum di Indonesia【27】. Selain itu, penelitian ini juga menunjukkan potensi penerapan model deep learning untuk meningkatkan efisiensi analisis dokumen hukum, yang dapat diimplementasikan oleh lembaga kehakiman seperti Mahkamah Agung untuk mendukung proses hukum yang lebih cepat dan akurat【28】. Prospek pengembangan lebih lanjut meliputi pengaplikasian model ini pada jenis dokumen hukum lainnya dan peningkatan akurasi dengan pelatihan pada dataset yang lebih besar dan beragam【29】.

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**REFERENCES**

[1] F. Solihin, I. Budi, R. F. Aji, and E. Makarim, “Advancement of information extraction use in legal documents,” *Int. Rev. Law, Comput. Technol.*, vol. 35, no. 3, pp. 322–351, 2021, doi: 10.1080/13600869.2021.1964225.

[2] F. Solihin and I. Budi, “Recording of law enforcement based on court decision document using rule-based information extraction,” *2018 Int. Conf. Adv. Comput. Sci. Inf. Syst. ICACSIS 2018*, pp. 349–354, 2019, doi: 10.1109/ICACSIS.2018.8618187.

[3] “Direktori Putusan.” Accessed: Mar. 30, 2024. [Online]. Available: https://putusan3.mahkamahagung.go.id/

[4] E. Qadri Nuranti and E. Yulianti, “Legal Entity Recognition in Indonesian Court Decision Documents Using Bi-LSTM and CRF Approaches,” *2020 Int. Conf. Adv. Comput. Sci. Inf. Syst.*, 2020, doi: 10.1109/ICACSIS51025.2020.9263157.

[5] C. Berragan, A. Singleton, A. Calafiore, and J. Morley, “Transformer based named entity recognition for place name extraction from unstructured text,” *Int. J. Geogr. Inf. Sci.*, vol. 37, no. 4, pp. 747–766, 2023, doi: 10.1080/13658816.2022.2133125.

[6] C. Sun, Z. Yang, L. Wang, Y. Zhang, H. Lin, and J. Wang, “Biomedical named entity recognition using BERT in the machine reading comprehension framework,” *J. Biomed. Inform.*, vol. 118, no. April, p. 103799, 2021, doi: 10.1016/j.jbi.2021.103799.

[7] F. Koto, A. Rahimi, J. H. Lau, and T. Baldwin, “IndoLEM and IndoBERT: A Benchmark Dataset and Pre-trained Language Model for Indonesian NLP,” *COLING 2020 - 28th Int. Conf. Comput. Linguist. Proc. Conf.*, pp. 757–770, 2020, doi: 10.18653/v1/2020.coling-main.66.

[8] B. Wilie *et al.*, “IndoNLU: Benchmark and Resources for Evaluating Indonesian Natural Language Understanding,” pp. 843–857, 2020, [Online]. Available: http://arxiv.org/abs/2009.05387

[9] D. Nallaperuma *et al.*, “Online Incremental Machine Learning Platform for Big Data-Driven Smart Traffic Management,” *IEEE Trans. Intell. Transp. Syst.*, vol. 20, no. 12, pp. 4679–4690, 2019, doi: 10.1109/TITS.2019.2924883.

[10] S. Schulz, M. Becker, M. R. Groseclose, S. Schadt, and C. Hopf, “Advanced MALDI mass spectrometry imaging in pharmaceutical research and drug development,” *Curr. Opin. Biotechnol.*, vol. 55, pp. 51–59, 2019, doi: 10.1016/j.copbio.2018.08.003.

[11] C. Shang and F. You, “Data Analytics and Machine Learning for Smart Process Manufacturing: Recent Advances and Perspectives in the Big Data Era,” *Engineering*, vol. 5, no. 6, pp. 1010–1016, 2019, doi: 10.1016/j.eng.2019.01.019.

[12] Y. Yu, M. Li, L. Liu, Y. Li, and J. Wang, “Clinical big data and deep learning: Applications, challenges, and future outlooks,” *Big Data Min. Anal.*, vol. 2, no. 4, pp. 288–305, 2019, doi: 10.26599/BDMA.2019.9020007.

[13] M. Huang, W. Liu, T. Wang, H. Song, X. Li, and A. Liu, “A queuing delay utilization scheme for on-path service aggregation in services-oriented computing networks,” *IEEE Access*, vol. 7, pp. 23816–23833, 2019, doi: 10.1109/ACCESS.2019.2899402.

[14] G. Xu, Y. Shi, X. Sun, and W. Shen, “Internet of things in marine environment monitoring: A review,” *Sensors (Switzerland)*, vol. 19, no. 7, pp. 1–21, 2019, doi: 10.3390/s19071711.

[15] M. Aqib, R. Mehmood, A. Alzahrani, I. Katib, A. Albeshri, and S. M. Altowaijri, *Smarter traffic prediction using big data, in-memory computing, deep learning and gpus*, vol. 19, no. 9. 2019. doi: 10.3390/s19092206.

[16] S. Leonelli and N. Tempini, *Data Journeys in the Sciences*. 2020.

[17] N. Stylos and J. Zwiegelaar, *Big Data as a Game Changer: How Does It Shape Business Intelligence Within a Tourism and Hospitality Industry Context?* 2019.

[18] Q. Song, H. Ge, J. Caverlee, and X. Hu, “Tensor completion algorithms in big data analytics,” *arXiv*, vol. 13, no. 1, 2017.

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