Scoping natural language processing in Indonesian and Malay for education applications

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Abstract

Indonesian and Malay are underrepresented in the development of natural language processing (NLP) technologies and available resources are difficult to find. A clear picture of existing work can invigorate and inform how researchers conceptualise worthwhile projects. Using an education sector project to motivate the study, we conducted a wide-ranging overview of Indonesian and Malay human language technologies and corpus work. We charted 657 included studies according to Hirschberg and Manning's 2015 description of NLP, concluding that the field was dominated by exploratory corpus work, machine reading of text gathered from the Internet, and sentiment analysis. In this paper, we identify most published authors and research hubs, and make a number of recommendations to encourage future collaboration and efficiency within NLP in Indonesian and Malay.

1 Introduction

Limited natural language processing (NLP) resources currently available for Indonesian and Malay varieties do not reflect large speaker populations of these languages in Indonesia, Malaysia, and other South-East Asian nations[1]. Difficulties locating resources and existing work hinders progress in the field; it can result in duplicated or unnecessary work, clouding the ability of researchers to formulate useful research questions and study designs. Since Indonesian and Malay varieties are closely related (Sneddon, 2003; Basuki and Antaputra, 2020b), connecting research and

technologies developed for either language could provide useful insights and shortcuts for work in the other language.[2]

These challenges restrict the impact that advances in NLP might have in the education sector in Indonesia and Malaysia, and in the teaching of these languages. Ideally, teachers of Indonesian or Malay as a second or foreign language would draw on a wide range of human language technologies, machine learning methods, and corpus linguistics tools to enhance teaching and learning outcomes [3].

As part of a broader project investigating teacher-speech and materials for Indonesian language teaching (Maxwell-Smith et al., 2020; Maxwell-Smith, 2021), the aims of this study were to scope the state of play of existing work in Indonesian and Malay NLP to assist in the formulation of realistic research goals, and to identify useful networks and resources. As such, our study draws on the notion of scoping work as "reconnaisance" (Peters et al., 2015), where the goal is to first determine what range of quantitative and/or qualitative evidence is available on a topic and then to chart, map, or otherwise represent this located evidence visually.

Our research questions were as follows:

1. What language technologies and NLP resources exist for Indonesian/Malay (and therefore for education sector applications)?

2. How do they align with the trends seen more widely in NLP?

We begin by describing our search strategy and methods for charting 657 included studies by their

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[1]In 2011, the Indonesian Census recorded 197 million Indonesians as literate in Indonesian (Zein, 2020). In Malaysia, nearly the whole population speak Malay as a first or additional language (Coluzzi, 2017); in 2021, according to the Department of Statistics Malaysia, this was about 32 million people.

[2]As indicated in Lin et al. (2019c) and Nomoto et al. (2018a), some significant differences should caution NLP researchers from regarding the Indonesian and Malay languages as one.

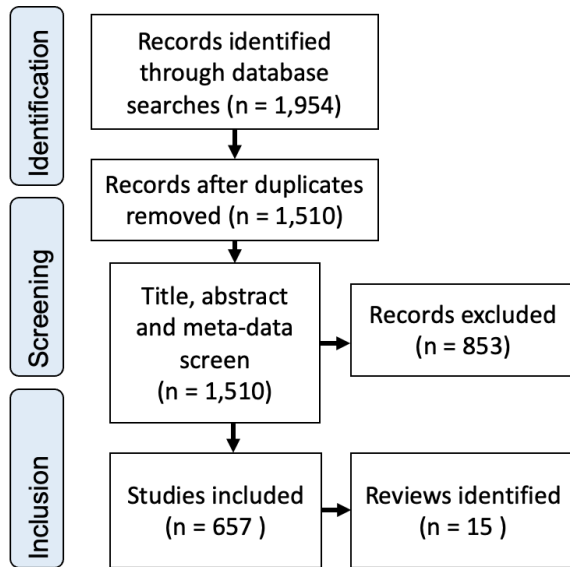[3]See for example Lee et al. (2020) in journals such as CALL and LLT.

Figure 1: Screening Process and Study Selection

topic and year of publication. We summarize existing literature reviews and notable work, graph most published authors and their affiliated research hubs, and describe recent educational applications of NLP. Finally, we make 7 recommendations to build collaboration and efficiency in Indonesian and Malay NLP, highlighting our contribution to these goals.

2 Methods

In order to capture a broad and rich picture of the recent literature, we applied a simplification of the Systematic Reviews and Meta-Analyses (PRISMA) for scoping reviews (Tricco et al., 2018; Page et al., 2021). Generally, we aimed to provide a descriptive overview and visualization of the reviewed material without detailed critical appraisal of individual studies or synthesis of evidence from different studies (Pham et al., 2014; Peters et al., 2015).

The review engaged with literature from many disciplines, including, but not limited to, Computational Linguistics, Computer Science, Indonesian Language Teaching, and NLP. Extensive consultations with research librarians resulted in a broad search strategy of the databases and terms (Figure 2). Both Indonesian/Malay and English search terms were used to maximize coverage. Additional search terms focused on our interest in Indonesian language teaching were used to mitigate the risk of missing relevant literature.

We experienced significant problems identifying studies with the Association for Computational Lin-

guistics (ACL) as their publisher. In searches via Google Scholar, Scopus, and Proquest; many ACL publications (e.g., Koto et al. (2020a) and Wilie et al. (2020)) were not returned[4]. We then added a direct ACL Anthology search to our database search list. Unexplained behaviour in the ACL Anthology sort by 'Year of Publication' functionality cut results by over 400%, missing, for example, the aforementioned two relevant papers. To identify a reasonable portion of the work presented at ACL events, we extended the set of identified records semi-automatically by manually opening and exporting studies from ACL Anthology searches.

Our inclusion criteria specified that studies be recent (published in 2016 or later), peer-reviewed, written in English, Indonesian or Malay, and relevant to our topic (work about other languages or unrelated to NLP was excluded). Topical relevance was determined by a single reviewer (the first author of this paper) screening the title, abstract, and metadata of each identified study ($n = 1,954$) that was unique ($n = 1,510$) (Figure 1).

Included studies were then classified according to Hirschberg and Manning's 2015 characterization of advances in NLP. We refer to these classifications in brief as: *Broad NLP*; *Machine Reading*; *Machine Translation*; *Spoken Dialogue Systems*; *Speaker State*; and *Social Media*. We added a class — *Statistical Work* — to group work which primarily contributes corpus data or statistical and pre-processing work which stands at the foundation of most NLP.

Two reviewers (the first and last author of this paper) worked as a classification team, thereby assuring the quality of this 'light-touch' manual content analysis (Saldaña, 2016). In total, 80 of the 657 included studies (12.2%) were classified independently by both reviewers, including studies whose classification was perceived as uncertain by the first reviewer, as well as a random selection of further studies to increase confidence in reviewer agreement. Reviewers' classification disagreements were resolved through reference to full-text articles and discussion reaching consensus[5].

While many studies were classified as belonging to more than one 'grouping', the primary class was

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[4]Not in the top 100 search results on Google Scholar.

[5]Both reviewers are academic researchers in NLP and teachers. Reviewer agreement of classification was very high. Most often the selection of a primary class was discussed and resolved by looking beyond brief, and at times misleading, information in article abstracts.

Database/Search Engine and search date/details	NLP and Indonesian/Malay keywords	Additional education keywords added to search string
Scopus **ProQuest** **EBSCO** **Limited to peer-review** **21 October 2021**	("natural language processing" OR nlp OR corpus OR corpora OR "computational linguistics" OR "pemrosesan bahasa alami" OR "pengolahan bahasa alami" OR korpus OR korpora OR "linguistik komputasional") AND ("indonesian language" OR "bahasa indonesia" OR malay)	AND ("language teaching" OR "language learning" OR "foreign language" OR bipa OR tifl OR tisol OR "belajar bahasa")
Google **Reduced length due to character limit** **8 July 2021**	("natural language processing" OR corpus OR corpora OR "computational linguistics" OR "pemrosesan bahasa alami" OR "pengolahan bahasa alami" OR korpus OR korpora OR "linguistik komputasional") AND ("indonesian language" OR "bahasa indonesia" OR malay)	("natural language processing" OR corpus OR "computational linguistics" OR "pemrosesan bahasa alami" OR korpus OR "linguistik komputasional") AND (indonesia OR malay) AND ("language teaching" OR "language learning" OR bipa OR "belajar bahasa")
ACL Anthology **25 October 2021**	(indonesian OR malay OR bahasa) AND ("language teaching" OR "language learning" OR "foreign language")	indonesian OR malay OR bahasa

Figure 2: Search Strategy

used in our analysis below. Appendix B is sorted by the second and third classification levels to improve search-ability and provide further information.

A search of titles and abstracts uncovered pre-existing reviews. These reviews were screened in full text and their findings are outlined in our results section to complement the scoping or quantitative map of the field. Literature outside our inclusion criteria which appeared highly relevant was retained separately for full-text review.

Unique names in the raw list of the top 50 most-published authors were manually normalized to prepare a publication-by-author count. Manual identification of name variants for authors with many publications were identified by matching author initials, affiliations, and profiles where possible to create Figure 5. Author affiliations for Figure 6 were taken from the most recent study of a given author included in this overview.

3 Results

A total of 657 from 1,954 studies met our inclusion criteria. Statistical and corpus work dominated throughout the last 5 years (from 2016 — Figure 3). Studies related to machine reading and sentiment analysis of online text such as news websites (included in 'Speaker States') and social media (sentiment analysis comprises much of our 'Social Media' classification) were popular and showed growth (Figure 4). The largest growth area was in

Figure 3: Indonesian and Malay NLP Research in 2016–2021

'Speaker Dialogue Systems' with a relative boom in publishing in 2019 (26 studies).

While our search terms were bilingual, the majority of studies that met our inclusion criteria were written in English or had an English title and abstract. The apparent stagnation of publications in 2020 (Figure 4) with a rebound in the first half of 2021 (which our search covered) could be related to the context of the COVID19 pandemic.
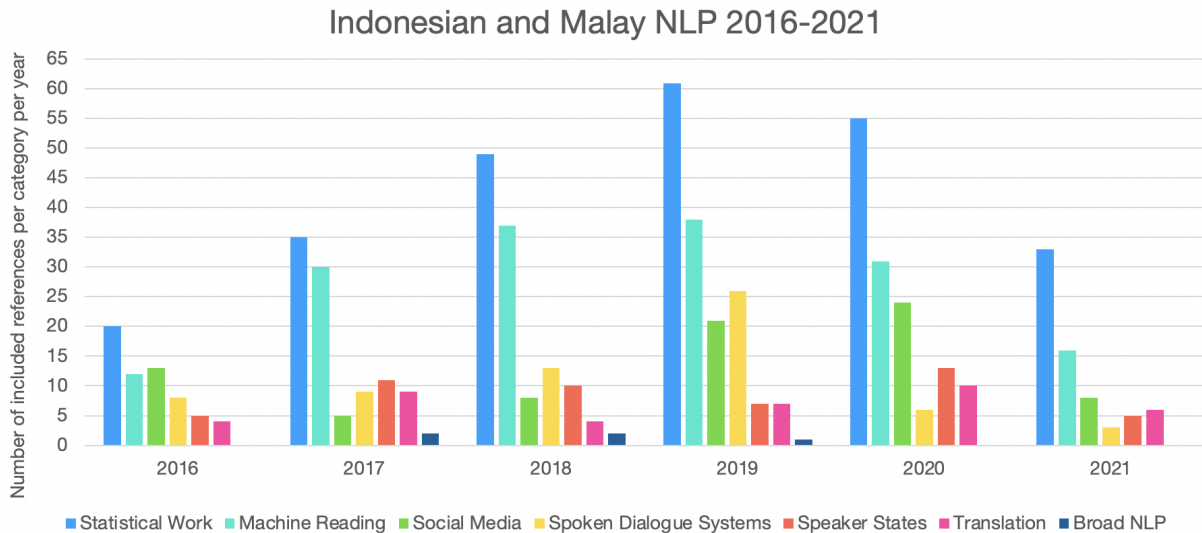
Figure 4: Categorisation of Indonesian and Malay NLP Research in 2016–2021 by Year

However, as "country-specific variables play a significant role" (Abramo et al., 2022) in pandemic publication trends, this is very difficult to determine.

As noted by Hirschberg and Manning in 2015, machine reading research makes use of the vast quantities of text available in the modern world while the mining of text from social media has "revolutionized the amount and types of information available today to NLP researchers". The presence of work in all classifications indicates Indonesian and Malay NLP has advanced from its 2015 state, when Hirschberg and Manning said it had "no such resources or systems available" (2015). To complement the quantitative picture in Figures 3 and 4, we identified existing reviews and provide a summary below. A detailed full-text review of all articles identified in a given classification is needed to fully investigate progress in each respective field.

3.1 Existing Reviews

Of the included studies, 15 were identified as reviews and read in full-text. Lan and Logeswaran (2020) discussed NLP in Indonesian/Malay in general. They did not identify their search methods nor their inclusion criteria, and their reference list had a strong focus on Malaysian research. Their description of statistical work on morphological and lexical analysis, the development of stop word lists, text normalization and named entity recognition concluded that "most researchers have no choice but to resort to compile their own corpus specific to their domain" (Lan and Logeswaran, 2020). According to their discussion, applications of NLP,

such as those for machine translation, sentiment analysis, sarcasm and spam detection, as well as text summarization, were hampered by an absence of language-specific tools and resources. For example, they stated that the Jawi Malay script (which is based on Arabic) appeared to be missing characters, lemmatizers for translation seemed to struggle with affixes as they were loaned from English NLP, and sentiment analysis tended to rely on translated sentiment lexicons.

A 16th review article — "An Overview of Natural Language Processing for Indonesian and Malay" by Jiang et al. (2020), written in Mandarin — was identified at the screening stage. It fell outside the scope of this study but we did note that it provided a detailed overview of Indonesian/Malay NLP. The authors characterized the field as "widely distributed, covering stemming, part-of-speech tagging, syntactic analysis, semantic analysis, and other underlying technologies, as well as upper-level applications such as machine translation, spell checking, sentiment analysis, named entity recognition" (Jiang et al., 2020). However, similarly to Lan and Logeswaran (2020), they noted that "the basic resources, open data platforms and open-source language processing tools for these two languages are also lacking, and there are few mature and available text analysis systems" (Jiang et al., 2020).

Statistical or corpus based NLP is important to further the field; however, only 2 reviews had a special focus on corpora and these were specific to Malay (Awang Abu Bakar et al. (2018) and Nasharuddin et al. (2018)). These reviews provided

some insight into Malay resources, and Nasharuddin et al. (2018) suggested document alignment as an avenue to overcome parallel corpus scarcity in cross and bilingual information retrieval, however, a thorough picture of existing corpora was lacking.

A further review by Kassim et al. (2016b) discussed morphology related challenges in stemming tools for Malay as perceived by the authors. However, this review did not fully address the complex steps necessary to uncover lemmas. As later described by Nomoto (2020), what has been "thought of as stemming and lemmatization [···] is in fact 'root'-ing, that is, undoing all morphological processes to get a root". Future work needs to make use of the sort of stem and lemma information in MALINDO Morph to create Indonesian/Malay stemmers.

Machine translation was discussed in a single review of Indonesian translation by Rahutomo et al. (2019)[6], who identified that many researchers had created their own web-crawled parallel corpora. They described a range of techniques used in Indonesian translation, noting that Moses was commonly used and that attention-based approaches were improving neural machine translation. Their list of studies spanned languages: Sundanese, Javanese, Lampung, as well as English, Japanese, and Korean — a very limited list given there are between 652–701 languages in use in Indonesia (Zein, 2020). Thereby translation needs are yet to be met.

Machine reading was the focus of 5 reviews. Gunawan and Amalia (2018) reviewed single document text summarization and identified evaluation methods as a significant concern among 10 papers reporting research into extractive text summarization. They concluded that a text-summary dataset created by experts is needed to advance the field and to calibrate the diverse results reported in the literature.

Looking only at Malay, Mohemad et al. (2020b) suggested relatively poor results across the field. They found summaries were often longer than the original text and Malay anaphora proved difficult to condense, resulting in poor comprehensibility.[7]

In 2021, Widodo et al. remained concerned with evaluation measures in text summarization. Their review of 6 studies found all text summarization work was in extractive summarization — as opposed to abstractive — and that it was dominated by single document summarization of online news. To expand the usability and scope of these tools for Indonesian, they suggested that journal articles should be used as data to support multi-document summarization, as existing summaries of these documents could be used to enhance results.

Malay named entity recognition and classification (NERC) was carefully reviewed by Mohemad et al. (2020a), finding that differences in Malay morphology and textual ambiguities, as well as limitations on corpora and annotated data, are difficult challenges affecting both rule-based and machine learning methods. In addition, they found that the "majority of the systems developed [were] based on manually predefined dictionaries by a human" (Mohemad et al., 2020a) and that deep learning methods were yet to be studied with Malay NERC.

All 4 reviews of sentiment analysis were primarily concerned with social media in the Malaysian context (see both 'Speaker States' and 'Social Media' in Appendix B). Abdullah et al. (2017) found hybrid approaches of lexicon based and supervised machine learning were most common, while Handayani et al. (2018) added a more detailed discussion of techniques and datasets found in 10 carefully selected studies. Abu Bakar et al. (2020) foregrounded the 'noise' of social media data to confront the more complex language often found on the Internet. Abdullah and Rusli (2021) pushed this further, examining literature on multilingual sentiment analysis to inform the development of sentiment analysis for the Malaysian social media context, which they described as characterized by the multilingual use of English, Malay, and Chinese.

No reviews of spoken dialogue systems, such as automated speech recognition (ASR) or Text To Speech (TTS) toolkits (which are typically considered later-generation NLP), were found. This is not surprising given text-based NLP (e.g., machine reading) dominated the research agenda (Figure 4).

3.2 Notable Work Responding to the Lack of Data and Evaluation Methods, and Other Recent Contributions

Common to all reviews was a scarcity of freely available NLP resources, and subsequently the creation of custom datasets, loaned preprocessing tools from NLP in English, and difficulties in benchmarking performance without reliable eval-

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[6]see also Septarina et al. (2019)

[7]Providing a brief reference to Malay language corpora, Omar et al. (2021) outlined advances in text summarization techniques.

uation techniques and reference datasets. In this context, we note the growing use of zero and few shot methods which are supported by pipelines such as HuggingFace[8]. We also note four projects and respective papers that develop benchmarking and open access corpora for:

- language modelling; Indonesian Language Evaluation Montage (IndoLEM) and Indonesian Bidirectional Encoder Representations from Transformers (IndoBERT);

- Indonesian Natural Language Understanding (IndoNLU); as well as

- Indonesian Natural Language Generation (IndoNLG) and Indonesian Natural Language Inference (IndoNLI).

Recently available, but not included in our study as it was published after our analysis was complete, Aji et al. (2022) provide a detailed discussion of NLP for the 700+ languages spoken in Indonesia. They outline challenges for NLP in Indonesia, describing limited resources, language diversity, orthography variation, and societal challenges such as the poor distribution of technology and education across Indonesia.

3.3 Highly Active Researchers and Research Hubs

Highly active researchers in the field are identified in Figure 5. While we made substantial efforts to ensure author publications were grouped accurately, name variations appeared to be prevalent in this field. We concentrated our efforts on normalizing the raw list of the top 50 authors. In contrast to broader trends (Mohammad, 2020), we note that 7 of the 11 authors in Figure 5 are female, though some are not first authors on many papers.

Research hubs in Indonesia and Malaysia are illustrated in Figure 6. The affiliations of the 25 authors with the most publications were used to identify these hubs. All affiliated universities listed by these 25 authors (as indicated in their most recent publication which met our inclusion criteria) were in either Malaysia or Indonesia. While there was an even spread between the two countries, overall Malaysia dominated with a ratio of 14:11 affiliations in Malaysia and Indonesia, respectively.

3.4 Education Specific Studies

The number of education specific studies was 41 (see Appendix A), based on the title and abstract. Of these 41 studies, 15 focused on assessment, with an emphasis on expediting and improving the efficiency of grading and providing feedback. Earlier studies (2016–2018) tended to focus on word-level error correction and short-answer grading while later studies (2019–2021) seemed to address whole of text evaluation, assessment task design (particularly questioning techniques), and providing feedback. Within the limited time frame of our study, we tentatively noted a shift from micro language level applications and their intrinsic evaluations to more macro, holistic language use applications that proceed to extrinsic or broader NLP evaluations.

A portion of education studies considered teaching practices and teacher training. Generally the studies reflected the design of our search-terms to target Indonesian language teaching; 10 papers were geared towards using NLP to improve the teaching and learning of Indonesian/Malay for non-background language learners. Bahasa Indonesia bagi Penutur Asing (BIPA — *Indonesian language for Foreign Learners*) and the Malay equivalent were discussed separately. Two studies were related to using NLP to improve the training of teachers of Indonesian as a foreign language. Another 2 studies focused on NLP for improving the teaching of translation for local students (i.e., Indonesian background speakers). Beyond studies from a language teaching setting, a further 6 studies related to instruction in general or other areas of the curriculum such as Mathematics, study skills, and values education.

Overall the body of work indicates a need for greater resourcing generally, and greater resourcing in education, with a shift towards more sophisticated language concerns and potential uses for these methods. Pleasingly, researchers identified for a high number of publications in Figure 5, such as Amalia, A[9] were also identified among those developing NLP for education (Amalia et al., 2019a), indicating high profile NLP researchers are invested in education sector applications.

4 Discussion

This study sheds significant light on the state of play and progress of Indonesian and Malay NLP.

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[8]See, for example, Cahya Wirawan's pre-trained Wikipedia model.

[9](see also name variant: *Amalia, Amalia* and Google Scholar profile *Amalia, Mahdi*)
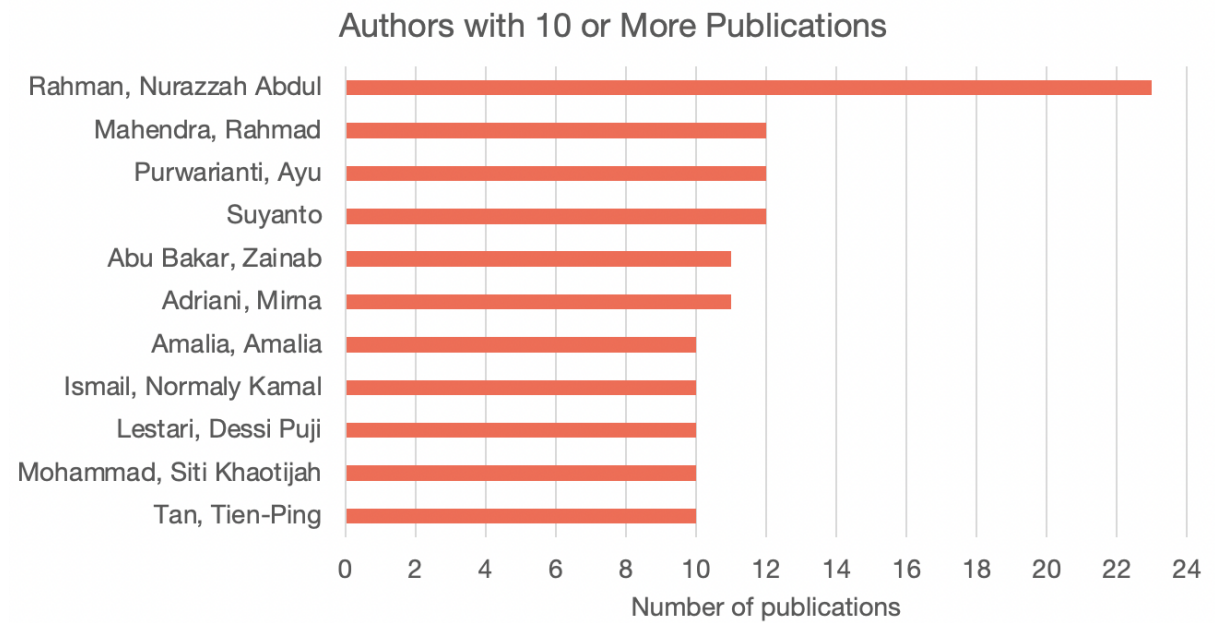
Figure 5: Authors with 10 or More Publications

Figure 6: Author Affiliation of the Top 25 Authors with Most Publications

We make the following 7 recommendations and outline our related contributions to encourage collaboration and support appropriate investment in the development of Indonesian and Malay NLP, and its application in education.

4.1 Recommendations

1. Broader adoption of best-practices for findable, open, sustainable, and future-proof data. All 15 reviews raised the difficulty of locating data, tools, and existing work as a significant problem.

Our study responds to this problem and is unique in that Appendix B offers a catalogue of recent work, identifies a variety of openly shared datasets and tools, and locates research hubs. Our results complement reviews such as Lan and Logeswaran (2020) and Jiang et al. (2020) by providing an empirical picture of published research on Indonesian and Malay NLP. While our study was not specifically focused on corpora like Awang Abu Bakar et al. (2018), over 50 of the papers listed at the top of 'Statistical Work' in Appendix B point to

datasets which may be useful to future projects.

Useful advice to implement the FAIR Principles (Findable, Accessible, Interoperable, Reusable) and further advice for individual researchers/teams to develop metadata, choose file formats, and think beyond their immediate plans for linguistic data is set out by Janda (2022) and Mattern (2022), respectively. Funding requirements that encourage data reuse (given ethics restraints) and which provide financial support for adequate digital stewardship are recommended.

2. Expanded evaluation methods and datasets, and negative result publication

As identified by Gunawan and Amalia (2018) and Widodo et al. (2021), evaluation of Indonesian and Malay NLP is poorly supported due to a lack of clear methods and few reference datasets. Open, accessible data from studies can assist with this, but to encourage further efficiency in the field, we also recommend authors consider the publication of 'unsuccessful' experiments in venues such as Workshop on Insights from Negative Results in NLP and organize or participate in evaluation challenges (a.k.a. shared tasks) and their workshops, for example, as part of ACL conferences.

3. Collaboration and connection between Indonesian and Malay NLP research and projects to speed development and allow cross-fertilisation

Many of the reviews discussed in our results focused on Malaysian research specifically looking at Malay NLP. By using both Indonesian and Malay in our search terms we connect these reviews to the work of Indonesian authors. To illustrate, Handayani et al. (2018), Abu Bakar et al. (2020), and Abdullah et al. (2021) examine one study which included Malay in the application of multilingual sentiment analysis. Our findings connect this work in Malay to more recent work by Tho et al. (2021), who looked at Indonesian and Javanese code-mixed sentiment analysis.

Indonesian and Malay are closely related (Sneddon, 2003). With a caveat that corpus metadata must clearly describe which languages are present, and that projects must clearly state how Indonesian and Malay are used in training data, we recommend future work seek out synergies that could be leveraged by using both languages.

4. Flexible author name formats and consistent author name use

Many authors of studies we included had only one name, but appeared to double this name in some publications but not others, perhaps to suit forms built with an (eurocentric) expectation of family names. Similarly, many authors with lengthy names used various forms.

We recommend publishers adapt their submission forms to accommodate diverse name traditions and support existing unique author identifiers (e.g., the ORCID system). We also recommend authors choose a publication name and use it as consistently as possible to increase the findability of their work.

5. Investment in spoken language data and transcription protocols

Our findings indicate only modest developments of 'later-generation' NLP in Indonesian and Malay. Significant investment is needed to give users of these languages access to a broader gamut of NLP applications, including applications in the education sector.

In this space it is also essential to recognise differences in the actual usage of these languages in real-life, spoken situations. Transcription which records code-mixed and often diglossic use of spoken varieties of Indonesian and Malay in a machine readable format needs to be investigated and scrutinised (Maxwell-Smith et al., 2020).

6. Investment in other languages of Indonesia and Malaysia

As a necessary endeavour for equitable access to advances in NLP for speakers, and to limit the further endangerment of many languages as a consequence of the expansion of Indonesian (Zein, 2020), we recommend simultaneous investment in other languages of Indonesia and Malaysia. Linked to Recommendation 5, to reflect actual usage and to allow NLP to be useful in real-world contexts where code-mixing is the norm, investment in other languages is also likely crucial.

7. Education and NLP researchers should consider the use of datasets by researchers outside their field

A research project such as ours, investigating teacher-speech and teaching materials for Indonesian language teaching (Maxwell-Smith et al., 2020) should take advantage of human language technologies. This article contributes a language-specific characterization of the field which will help scope future projects.

Education researchers should be aware that computational methods such as data normalization scripts and stemming tools are yet to be fully de-

veloped for their use with the Indonesian language. If working with spoken language, ASR toolkits for working on low resource languages are suitable for consideration but may require significant investment of time and training before they are capable of managing complex code-switching behaviours common in education settings.

For education researchers and teachers to use NLP resources they need clear information about the profile of language/s in corpora and also about what data has been used when training models/tools. This allows proper assessment of the cultural and political suitability of NLP resources.

Education researchers also need to consider the possible use of datasets by researchers outside their field. Ensuring data they collect is recorded in 'future-proof' formats and prepared with consideration of the FAIR principles (see Recommendation 1 — Janda (2022) and Mattern (2022)) is an investment which encourages NLP applications specifically built for or amenable to education settings.

4.2 Limitations and Future Work

With regard to the limitations of this study, we employed a 'light-touch', subjective coding method with a discrete set of class labels to scope relevant literature; we did not undertake the act of synthesis (Peters et al., 2015). We screened only the title and abstract for the vast majority of references. Unintentional misinterpretation could have taken place. Our analysis provides an approximate area within NLP for each reference to assist researchers studying an NLP application or use-case. Researchers interested in a particular algorithm (e.g., Random Forest Decision Trees or Transformers), or the use of a particular performance indicator (e.g., F1 or Word Error Rate), might not find our work as useful, but we encourage them to scan related categories in Appendix A for work relevant to their interest. Most references were labelled as belonging to multiple categories, with the identification of the first category an educated but ultimately subjective decision. Reading every study carefully beyond title and abstract was beyond the scope of this study.

Future studies to target Indonesian and Malay language publications may identify further literature on Indonesian and Malay NLP. Unfortunately, our initial searches through databases such as the University of Indonesia's Research Portal, produced varied results, with a large proportion of returned studies not necessarily having been as rig-

orously peer-reviewed (encompassing for example many 'skripsi' or honours dissertations). Indonesia's national library service OneSearch has grown dramatically, and with over 3748 libraries affiliated in February 2022, it should also be included in future reviews of Indonesian and Malay NLP.

Since we conducted our review, Aji et al. (2022) have proposed potential research directions in the Indonesian context such as data-efficient and compute-efficient NLP. Given the low number of studies in our *Speaker Dialogue Systems* class, we support their call for "NLP Beyond Text". The 'superglossic' translanguaging practices of Indonesia (Zein, 2020), and language classrooms (Maxwell-Smith et al., 2020), correspond with their call for "Robustness to Code-mixing and Non-Standard Orthography". Applications of Indonesian NLP necessitate involvement with other languages of Indonesia and inevitably impact many at-risk languages. There is an ethical obligation for "careful assessment of individual usage scenarios of language technology, so they are implemented for the good of the local population" (Aji et al., 2022).

5 Conclusion

Overall, this scoping study provides a baseline picture of Indonesian and Malay NLP. It shows an emerging research community engaged with the wide range of NLP advances identified in 2015 by Hirschberg and Manning. Researchers in the field continue to experience difficulties in benchmarking performance without reliable evaluation techniques and reference datasets, re-engineering of loaned preprocessing tools from English NLP, and thankless tasks such as the creation of custom datasets and resources. NLP applications in education are limited, as are tools for language which is not in text format. Our results highlight the importance of creating and releasing well-described and maintained resources openly and fostering collaboration. IndoLEM-IndoBERT, IndoNLU, IndoNLG, and IndoNLI are notable releases that are already helping to orientate researchers and future projects using Indonesian and Malay NLP.

Acknowledgements

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A Appendix

A more accessible table will be available here.

Table 1

Education Specific Studies		
Title	Author	Year
The Development of an Audible Pattani Malay-Thai Electronic Phrasebook for Military Purposes	Boonkwan et al.	2016
A corpus platform of Indonesian academic language	Kwary	2019
U-tapis: Automatic spelling filter as an effort to improve Indonesian language competencies of journalistic ...	Mediyawati et al.	2021
Word level auto-correction for latent semantic analysis based essay grading system	Ratna et al.	2017
The development of Indonesian POS tagging system for computer-aided independent language learning	Muljono et al.	2017c
A morphophonemic analysis on the affixation in the Indonesian Language	Ampa et al.	2019
Learning Indonesian Frequently Used Vocabulary from Large-Scale News	Lin et al.	2019b
Towards developing colloquial Indonesian language pedagogy: A corpus analysis	Nataprawira and Carey	2020
Pengajaran bahasa dan pemerolehan bahasa kedua dalam pembelajaran BIPA (Bahasa Indonesia Penutur ...	Rosiyana	2020
Cross-corpus native language identification via statistical embedding	Rangel et al.	2018
Acquiring Extended Units of Meaning: The Role of Learner Corpus in Teaching Indonesian as A Foreign	Suhardijanto and Putra	2019
Designing Phonetic Alphabet for Bahasa Indonesia (PABI) for the teaching of intelligible English pronun ...	Karlina et al.	2020
Indonesian essay grading module using Natural Language Processing	Ajitiono and Widyani	2017
Automated Bahasa Indonesia essay evaluation with latent semantic analysis	Amalia et al.	2019a
Exploiting Syntactic Similarities for Preposition Error Corrections on Indonesian Sentences Written by ...	Irmawati et al.	2016
Vocabulary Load on Two Mainstream Indonesian Textbooks for Foreign Learners: A Comparative Study	Destiani et al.	2018a
Perbandingan Deiksis pada Dua Buku Ajar: Analisis Kontrastif BIPA dan Bahasa Inggris	Destiani et al.	2018b
Pengembangan kamus pemelajar Bahasa Indonesia bagi penutur asing tingkat dasar di Universitas Muham ...	Fadly	2018
Teaching Specific Purpose Translation: Utilization of Bilingual Contract Document as Parallel Corpus	Siregar	2017
Theme markedness in the translation of student translators	Sofyan and Tarigan	2018
Strategi Pengukuran Upaya Berbahasa Menerusi Kesantunan Berbahasa sebagai Indikator Profesionalisme ...	Redzwan et al.	2020
Generating artificial error data for Indonesian preposition error corrections	Irmawati et al.	2017b
Menangani Kekaburan Kemahiran Prosedur dan Terminologi Awal Matematik: Pendekatan Leksis ...	Anida et al.	2019
Environmental awareness content for character education in grade 10 in Indonesian language student ...	Rahmawati et al.	2020
Inquisitive semantic analysis of Malay language proverbs	Subet and Md Nasir	2019
An experimental study of text preprocessing techniques for automatic short answer grading in Indonesian	Hasanah et al.	2018

Title	Author	Year
N-Gram Keyword Retrieval on Association Rule Mining for Predicting Teenager Deviant Behavior from …	Setiawan et al.	2018
Semi-supervised learning self-training for Indonesian motivational messages classification	Wulan and Supangkat	2018
Evaluating rnn architectures for handling imbalanced dataset in multi-class text classification in Bahasa …	Christianto et al.	2020
A comparison of supervised text classification and resampling techniques for user feedback in Bahasa …	Dhammajoti et al.	2020
Automatic Indonesia's questions classification based on Bloom's taxonomy using Natural Language …	Kusuma et al.	2016
Answer categorization method using K-means for Indonesian language automatic short answer grading …	Ratna et al.	2019
Knowing Right from Wrong: Should We Use More Complex Models for Automatic Short-Answer …	Septiandri et al.	2020
WPS: Application for Generating Answer of Word Problem in Bahasa Indonesia	Oktavia et al.	2021
Question generation model based on key-phrase, context-free grammar, and Bloom's taxonomy	Wijanarko et al.	2021
Developing Question Generation System for Bahasa Indonesia Using Indonesian Standard Language …	Wisnu Prabowo et al.	2021
Applications of natural language processing in bilingual language teaching: An Indonesian-English case …	Maxwell-Smith et al.	2020
Developing an online self-learning system of Indonesian pronunciation for foreign learners	Muljono et al.	2016
Automatic Pronunciation Generator for Indonesian Speech Recognition System Based on Sequence-to- …	Hoesen et al.	2019
Anita: Intelligent Humanoid Robot with Self-Learning Capability Using Indonesian Language	Andreas et al.	2019
A novel model and implementation of humanoid robot with facial expression and natural language …	Budiharto et al.	2021

End of Table

B   Appendix

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Table 2

Broad NLP		
Title	Author	Year
IndoLEM and IndoBERT: A Benchmark Dataset and Pre-trained Language Model for Indonesian NLP	Koto et al.	2020b
Unstructured Malay Text Analytics Model in Crime	Mohemad et al.	2020c
A new framework for information system development on instant messaging for low cost solution	Sukarsa et al.	2018
An overview of BPPT's Indonesian language resources	Gunarso et al.	2016
Challenges and development in Malay natural language processing	Lan and Logeswaran	2020
Statistical and Corpus Work		
Title	Author	Year
The Development of an Audible Pattani Malay-Thai Electronic Phrasebook for Military Purposes	Boonkwan et al.	2016
Linking the TUFS Basic Vocabulary to the Open Multilingual Wordnet	Bond et al.	2020
Hypernym-Hyponym Relation Extraction from Indonesian Wikipedia Text	Nityasya et al.	2019
Linguistik Korpus Kuantitatif dan Kajian Semantik Leksikal Sinonim Emosi Bahasa Indonesia	Rajeg	2020
Characteristics of Malay translated hadith corpus	Sazali et al.	2020
Syllabification Model of Indonesian Language Named-Entity Using Syntactic n-Gram	Fanani and Suyanto	2021
A corpus platform of Indonesian academic language	Kwary	2019
Examining the writing genre in journal articles of natural science and social science	Wiratno and Dzakiria	2016
An annotated news corpus of Malaysian Malay	Chung and Shih	2019
Introduction of the Asian Language Treebank	Riza et al.	2017
Information extraction: Evaluating named entity recognition from classical Malay documents	Sazali et al.	2017
Comparative study on corpus development for Malay investment fraud detection in website	Din et al.	2017
Building the Pornography Corpus for Bahasa Indonesia Based on TRUST+™ Positif Database	Gunawan et al.	2019c
Building a Malay-English code-switching subjectivity corpus for sentiment analysis	Kasmuri and Basiron	2019
IndoNLU: Benchmark and Resources for Evaluating Indonesian Natural Language Understanding	Wilie et al.	2020
Development of a retrieval system for Al Hadith in Bahasa (case study: Hadith Bukhari)	Aulia et al.	2017b
An Ontological Approach towards Dialogue based Information Visualization System: Quran Corpus for . . .	Mohd Yunus et al.	2017
Co-occurrence technique and dictionary based method for Indonesian thesaurus construction	Sholikah et al.	2017
Penentuan Fitur bagi Pengekstrakan Tajuk Berita Akhbar Bahasa Melayu (Determining Features of News . . .	Shahrul Azman Mohd et al.	2018a

Title	Author	Year
The Development of the Malaysian Hansard Corpus: A Corpus of Parliamentary Debates 1959-2020	Abdullah et al.	2021
Rancang bangun aplikasi web scraping untuk korpus paralel Indonesia-Inggris dengan metode html dom	Mitra et al.	2017
NUWT: Jawi-specific buckwalter corpus for Malay word tokenization	Bakar et al.	2016
Towards Computational Linguistics in Minangkabau Language: Studies on Sentiment Analysis and . . .	Koto and Koto	2020
Indonesia Language Sphere: an ecosystem for dictionary development for low-resource languages	Murakami	2019
Designing a collaborative process to create bilingual dictionaries of Indonesian ethnic languages	Nasution et al.	2019
Tufs asian language parallel corpus (talpco)	Nomoto et al.	2018b
Sentence segmentation and phrase strength estimation in Malay continuous speech	Hanum and Bakar	2016b
Evaluation of Energy and Duration on Malay Phrase Breaks	Hanum and Bakar	2016a
Prosodic breaks on Malay speech corpus: Evaluation of pitch, intensity and duration	Hanum et al.	2017
Demarcating and highlighting in Papuan Malay phrase prosody	Kaland and Baumann	2020
Repetition Reduction Revisited: The Prosody of Repeated Words in Papuan Malay	Kaland and Himmelmann	2020
Stress predictors in a Papuan Malay random forest	Kaland et al.	2019
Lexical analyses of the function and phonology of Papuan Malay word stress	Kaland et al.	2021
Development of under-resourced Bahasa Indonesia speech corpus	Cahyaningtyas and Arifianto	2018
Generative Indonesian Conversation Model using Recurrent Neural Network with Attention Mechanism	Chowanda and Chowanda	2018
An evaluation of sentence selection methods on the different phone-sized units for constructing Indonesian . . .	Muljono et al.	2020
Indonesian Affective Word Resources Construction in Valence and Arousal Dimension for Sentiment . . .	Hulliyah et al.	2019
Analysis of Indonesian sentiment text based on affective space model (ASM) using electroencephalogram . . .	Hulliyah et al.	2017
An integrated semi-automated framework for domain-based polarity words extraction from an unannotated . . .	Kaity and Balakrishnan	2020
BMBI: A Development of a Special Corpus on Homonyms for Multi-Lingual Sentiment Analysis	Rumaisa et al.	2020
Sentiment analysis in Indonesian and French by SentiSAIL	Shalunts et al.	2018
Preliminary Research Design on Sensor Data Gathering for Air Quality Text Generation	Aulia et al.	2020
Review on the Role of Social Media for Dengue Prevention and Monitoring	Kannan et al.	2019
Twitter corpus creation: The case of a Malay Chat-style-text corpus (MCC)	Saloot et al.	2016
An Application that Invites Users to Participate in Developing Repository of Bahasa Indonesia	Thamrin et al.	2019b
A publicly available Indonesian corpora for automatic abstractive and extractive chat summarization	Koto	2016
Development of multilingual social media data corpus: Development and evaluation	Rumaisa et al.	2019
Bahasa Indonesia text corpus generation using web corpora approaches	Amalia et al.	2019b
WatsaQ: Repository of Al Hadith in Bahasa (Case study: Hadith Bukhari)	Aulia et al.	2017a
Malay Online Virtual Integrated Corpus (MOVIC): A Systematic Review	Awang Abu Bakar et al.	2018

Title	Author	Year
The Development of an Integrated Corpus for Malay Language	Bakar	2020
Building Corpus in Bahasa Indonesia for Pornographic Indicated Website Content	Chandra et al.	2019
Building a web-based application for language resources in Indonesia	Dinakaramani and Suhardijanto	2019
Development of a Web-based Jahai-Malay Language Repository	Mohtar et al.	2021
A Review on Building Bilingual Comparable Corpora for Resource-limited Languages	Nasharuddin et al.	2018
Linguistic studies using large annotated corpora: introduction	Nomoto and Moeljadi	2019
Introducing the Asian language treebank (ALT)	Thu et al.	2016
Bahasa Melayu sebagai Bahasa Ilmu (BMBI) di ruang siber: Suatu analisis sosiologi tehadap pembangu . . .	Yusof et al.	2017
A dependency annotation scheme to extract syntactic features in Indonesian sentences	Irmawati et al.	2017a
Domain-specific stop words in Malaysian parliamentary debates 1959 - 2018	Rahman et al.	2021a
Transforming semi-structured indigenous dictionary into machine-readable dictionary	Ranaivo-Malançon et al.	2017
Rule-based text normalization for Malay social media texts	Ariffin and Tiun	2020
Evaluating the use of word embeddings for part-of-speech tagging in Bahasa Indonesia	Abka	2017
Information Retrieval System to Find Articles and Clauses in UUD 1945 Using Vector Space Model Method	Sulaeman et al.	2020
U-tapis: Automatic spelling filter as an effort to improve Indonesian language competencies of journalistic . . .	Mediyawati et al.	2021
Building the Application to Identify Incorrect Capital Letters Writing in Bahasa Indonesia	Gunawan et al.	2019a
Feature extraction using regular expression in detecting proper noun for Malay news articles based on . . .	Sulaiman et al.	2017
Incorporating Knowledge Base in Unsupervised Approach of Word Sense Disambiguation of Malay . . .	Rifin and Hamzah	2017
Movie Summarization based on Indonesian Subtitles with Restricted Boltzmann Machine	Situmeang et al.	2019
Semantic similarity measures for Malay-English ambiguous words	Mahadzir et al.	2018
Recognizing and normalizing temporal expressions in Indonesian texts	Mirza	2016
Automatic Grammar Checking System for Indonesian	Rahutomo et al.	2018
Rapid Heteronym Disambiguation for Text-to-Speech System	Samsudin and Rahim	2019
Identification Of Features In Predicting Prominent Malay Words Using Decision Tree	Tiun and Hong	2020
An Enhancement of Malay Social Media Text Normalization for Lexicon-Based Sentiment Analysis	Bakar et al.	2019
Text Normalization Algorithm on Twitter in Complaint Category	Hanafiah et al.	2017
Pre-processing Tasks in Indonesian Twitter Messages	Hidayatullah and Ma'arif	2017
Proposal: A Hybrid Dictionary Modelling Approach for Malay Tweet Normalization	Nor Azlizawati Binti et al.	2017
Normalization of Indonesian-English code-mixed Twitter data	Barik et al.	2019
Review and Visualization of Facebook's FastText Pretrained Word Vector Model	Young and Rusli	2019
Bidirectional encoder representations from transformers for cyberbullying text detection in Indonesian . . .	Candra et al.	2021

Title	Author	Year
Categorization of Malay social media text and normalization of spelling variations and vowel-less words	Maskat and Rahman	2020
Exploring Edit Distance for Normalising Out-of-Vocabulary Malay Words on Social Media	Raja et al.	2019
An automatic construction of Malay stop words based on aggregation method	Chekima and Alfred	2016
Word Sense Disambiguation in Bahasa Indonesia Using SVM	Faisal et al.	2018
Cross-Lingual and Supervised Learning Approach for Indonesian Word Sense Disambiguation Task	Mahendra et al.	2018b
Enhancing Latent Semantic Analysis by Embedding Tagging Algorithm in Retrieving Malay Text Documents	Rahman et al.	2017
Word level auto-correction for latent semantic analysis based essay grading system	Ratna et al.	2017
Evaluating Word Embeddings for Indonesian–English Code-Mixed Text Based on Synthetic Data	Rizal and Stymne	2020
Designing and implementing parsing for ambiguous sentences in Indonesian language	Soyusiawaty and Aribowo	2016
Word Embedding for Small and Domain-specific Malay Corpus	Tiun et al.	2020a
Resolving Malay word sense disambiguation utilizing cross-language learning sources approach	Yahaya et al.	2017a
Morphological Analysis of Malay Words for Resolving Ambiguity	Yahaya et al.	2018
Evaluation on knowledge extraction and machine learning in resolving Malay word ambiguity	Yahaya et al.	2017b
Naïve Bayes implementation into Bahasa Indonesia stemmer for content based webpage classification	Jodhinata and Hartanti	2016
Analyzing Malay Stemmer Performance Towards Fuzzy Logic Ranking Function on Malay Text Corpus	Rodzman et al.	2018
Information Retrieval Technique for Indonesian PDF Document with Modified Stemming Porter Method ...	Riza et al.	2020
Stemmer and phonotactic rules to improve n-gram tagger-based Indonesian phonemicization	Suyanto et al.	2021
Analysis of Stemming Influence on Indonesian Tweet Classification	Hidayatullah et al.	2016
Towards stemming error reduction for Malay texts	Kassim et al.	2019
Enhanced Text Stemmer with Noisy Text Normalization for Malay Texts	Kassim et al.	2020b
Design Consideration of Malay Text Stemmer Using Structured Approach	Kassim et al.	2020a
Malay word stemmer to stem standard and slang word patterns on social media	Kassim et al.	2016b
Enhanced rules application order to stem affixation, reduplication and compounding words in Malay texts	Kassim et al.	2016a
Word stemming challenges in Malay texts: A literature review	Kassim et al.	2016c
Non-formal affixed word stemming in Indonesian language	Putra et al.	2018a
Accuracy measurement on Indonesian non-formal affixed word stemming with levenhstein	Putra et al.	2019
Improving stemming techniques for non-formal Indonesian sentences using incorbiz	Rianto et al.	2021
Comparison of stemming algorithms on Indonesian text processing	Rizki et al.	2019
Improvement on stemmer algorithm for Indonesian language with spellchecker	Syawanodya and Huda	2018
The development of Indonesian POS tagging system for computer-aided independent language learning	Muljono et al.	2017c
Semantic Role Labeling in Conversational Chat using Deep Bi-Directional Long Short-Term Memory ...	Rachman et al.	2018a

Title	Author	Year
POS-Tagging for informal language (study in Indonesian tweets)	Suryawati et al.	2018
Part-of-speech tagger for Malay social media texts	Ariffin and Tiun	2018
A comparison of different part-of-speech tagging technique for text in Bahasa Indonesia	Amrullah et al.	2017
Indonesian part of speech tagging using hidden markov model - Ngram viterbi	Cahyani and Vindiyanto	2019
Part-of-speech (pos) tagger for Malay language using naïve bayes and k-nearest neighbor model	Gaber et al.	2020
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Morphology analysis for Hidden Markov Model based Indonesian part-of-speech tagger	Muljono et al.	2017a
POS-tagging for non-English tweets: An automatic approach: (Study in Bahasa Indonesia)	Munandar et al.	2017
An evaluation of MorphInd's morphological annotation scheme for Indonesian	Prihantoro	2021
Rule-based Part of Speech Tagger for Indonesian Language	Purnamasari and Suwardi	2018
Evaluating lstm networks, hmm and wfst in Malay part-of-speech tagging	Tan et al.	2017b
Time Series Neural Network Model for Part-of-Speech Tagging Indonesian Language	Tanadi	2018
Implementation of ontology-based on Word2Vec and DBSCAN for part-of-speech	Togatorop et al.	2020
Utilizing Morphological Features for Part-of-Speech Tagging of Bahasa Indonesia in Bidirectional LSTM	Trisna et al.	2020
On Empirical Evaluation of Deep Architectures for Indonesian POS Tagging Problem	Yuwana et al.	2019
On part of speech tagger for Indonesian language	Yuwana et al.	2018
Identifying Sentence Structure in Bahasa Indonesia by Using POS Tag and LALR Parser	Gunawan et al.	2019d
Breakdown film script using parsing algorithm	Wahana et al.	2020
Algorithm for simple sentence identification in Bahasa Indonesia	Anggraini et al.	2018
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The effectiveness of bottom up technique with probabilistic approach for a Malay parser	Fairuzz Hiloh et al.	2018
Warning and Suggestion System on Syntax Tree Maker Application	Haris et al.	2019
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Modification of Chu-Liu/Edmonds algorithm and MIRA learning algorithm for dependency parser on . . .	Nizami and Purwarianti	2017
Sentence boundary disambiguation for Indonesian language	Putra et al.	2017
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Ensemble technique utilization for Indonesian dependency parser	Rahman and Purwarianti	2017
How Similar is Similar: A Comparison of Bahasa Indonesia and Bahasa Malaysia	Basuki and Antaputra	2020a
New tools for old tasks: A new approach to the investigation of Malay	Don and Knowles	2020

Title	Author	Year
Identifying and Exploiting Definitions in Wordnet Bahasa	Moeljadi and Bond	2016
A morphophonemic analysis on the affixation in the Indonesian Language	Ampa et al.	2019
A study of education-related Chinese words used in Malaysia-based computer corpus	Kia and Su'Ad	2019
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An identification of authentic narrator's name features in Malay hadith texts	Abd Rahman et al.	2016
The process of forming a more complex idiomatic meaning using a principle of integration metaphors	Ismail et al.	2021
Exploring Lexical Differences Between Indonesian and Malay	Lin et al.	2019c
A Corpus Driven Analysis of Representations Around the Word 'ekonomi' in Malaysian Hansard Corpus	Nor Fariza Mohd et al.	2019
Exploiting Malay corpus on islamic issue using sketch engine	Setik et al.	2018
English legalese translation into Indonesian	Dewi et al.	2021
A corpus-based analysis of English core modal verbs and their counterparts in Indonesian	Oktavianti	2019
Comparison of Personal Pronoun between Arabic and Its Indonesian Translation of Koran	Markhamah Abdul et al.	2017
Prosody analysis of Malay language storytelling corpus	Ramli et al.	2016
Code-switching in Bruneian online retail transactions	Henry and Ho	2016
Comparison of the themes of Malaysian Friday sermons between the year 2010 and 2015	Aasim Asyafi'Ie bin Ahmad et al.	2017
Where is the Head Positioned in Indonesian Language?: A Corpus Study of Head Directionality from a . . .	Ansari and Suhardijanto	2019
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Conceptual structure representation of causative verb in Malay language and relation with syntax	Binti Yusof and Binti Rosly	2018
A new look at Pattani Malay Initial Geminates: a statistical and machine learning approach	Burroni et al.	2020
The particle pun in modem Indonesian and Malaysian (La particule pun en indonésien et malaisien modernes.)	Chambert-Loir	2019
Lagi in standard Malaysian Malay: Its meaning conceptualization	Chung	2019
The Indonesian prefixes PE- and PEN-: A study in productivity and allomorphy	Denistia and Baayen	2019
Similar southeast asian languages: Corpus-based case study on Thai-Laotian and Malay-Indonesian	Ding et al.	2016
The Design of Lexical Database for Indonesian Language	Gunawan and Amalia	2017
Automatic extraction of multiword expression candidates for Indonesian language	Gunawan et al.	2017b
The Observation of Bahasa Indonesia Official Computer Terms Implementation in Scientific Publication	Gunawan et al.	2018a
Utterance-final particles in Klang Valley Malay	Hoogervorst	2018
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Compilation of Malay criminological terms from online news	Lee et al.	2019
Exploring Letter's Differences between Partial Indonesian Branch Language and English	Lin et al.	2019a
Hedging in the discussion sections of English and Malay educational research articles	Loi and Lim	2019
Formation of health science terminology by users in general Malay language texts	Mohamad et al.	2020c
Politeness in communication through local children's animated film	Mohamad Nor et al.	2019
Translation and Markedness	Ni et al.	2018
Frequency of Verbs in Lifestyle Column in the Jakarta Post and the Relation to Text Characteristics: A ...	Oktavianti and Pramesti	2019
The influence of students' L1 and spoken English in English writing: A corpus-based research	Prihantoro	2016
Sketching the Semantic Change of Jahanam and Hijrah: A Corpus Based Approach to Manuscripts of ...	Puspita and Yusuf	2020
Vector Space Models and the usage patterns of Indonesian denominal verbs: a case study of verbs with ...	Rajeg et al.	2019
Cross-corpus native language identification via statistical embedding	Rangel et al.	2018
Imbuhan meN- dengan Kata Nama Konkrit Unsur Alam: Analisis Teori Relevans (Prefix meN- with ...	Saad and Jalaluddin	2020
Ideational Grammatical Metaphors in Doctrinal Verses of The Bible in Indonesian Version	Saragih et al.	2017
Collocation analysis of variants of intensifies in classical Malay texts	Sarudin et al.	2020a
Discourse functions of the two non-active voices in Indonesian: based on the web corpus in MALINDO Conc	Shiohara et al.	2019
The Framework of Multiword Expression in Indonesian Language	Suhardijanto et al.	2020
Acquiring Extended Units of Meaning: The Role of Learner Corpus in Teaching Indonesian as A Foreign	Suhardijanto and Putra	2019
Bila dan Mengapa 'You' Menjadi 'Kita': Satu Analisis Perbandingan Inggeris-Melayu (When and Why ...	Sulaiman and Bin Mohamad Yusoff	2020
Frasa Topik Dan Fokus Dalam Bahasa Melayu: Analisis Program Minimalis (Topic And Focus Phrase In ...	Sultan and Othman	2021
Prestige of products and code-switching in retail encounters	Ting et al.	2020
Quantifying semantic shift visually on a Malay domain-specific corpus using temporal word embedding ...	Tiun et al.	2020b
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'Sampai Di' Vs 'Sampai Ke': Accomplishment or achievement verb?	Yusof et al.	2016
Diachronic Corpora as a Tool for Tracing Etymological Information of Indonesian-Malay Lexicon	Yusuf and Puspita	2020
Representatif Leksikal Ukuran sebagai Metafora Linguistik berdasarkan Teks Klasik Melayu (Representa ...	Zaini et al.	2020b
Designing Phonetic Alphabet for Bahasa Indonesia (PABI) for the teaching of intelligible English pronun ...	Karlina et al.	2020
Indonesian essay grading module using Natural Language Processing	Ajitiono and Widyani	2017
Automated Bahasa Indonesia essay evaluation with latent semantic analysis	Amalia et al.	2019a
Exploiting Syntactic Similarities for Preposition Error Corrections on Indonesian Sentences Written by ...	Irmawati et al.	2016
Vocabulary Load on Two Mainstream Indonesian Textbooks for Foreign Learners: A Comparative Study	Destiani et al.	2018a

Title	Author	Year
Perbandingan Deiksis pada Dua Buku Ajar: Analisis Kontrastif BIPA dan Bahasa Inggris	Destiani et al.	2018b
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Fossicking in dominant language teaching: Javanese and Indonesian 'low'varieties in language teaching . . .	Maxwell-Smith	2021
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Theme markedness in the translation of student translators	Sofyan and Tarigan	2018
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Environmental awareness content for character education in grade 10 in Indonesian language student . . .	Rahmawati et al.	2020
Development of Malay word materials for auditory-cognitive training for older adults	Yusof et al.	2019
Exploring gender issues associated with wanita/woman and perempuan/woman in Malaysian parliamen . . .	Aziz	2019
"Happiness" in Bahasa Indonesia and its implication to health and community well-being	Effendi and Muchammadun	2018
Defying the global: The cultural connotations of "islam" in Malaysia	Hashim and Rahim	2016
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"Is Selangor in Deep Water?": A Corpus-driven Account of Air/water in the Malaysian Hansard Corpus . . .	Norsimah Mat et al.	2019
Linguistic Representation of Violence in Judicial Opinions in Malaysia	Othman et al.	2019
Text mining of online job advertisements to identify direct discrimination during job hunting process: A . . .	Panggih Kusuma et al.	2020
Inquisitive semantic analysis of Malay language proverbs	Subet and Md Nasir	2019
Spotlight on LGBT in Malaysian online newspapers: Insights from textual analytics	Ting et al.	2021
The polarity of war metaphors in sports news: A corpus-informed analysis	Hua et al.	2021
Communicating insults in cyberbullying	Hua et al.	2019
Analisis korpus terhadap idiom Bahasa Indonesia yang berbasis nama binatang	Paramarta	2018
Conceptual metaphor and linguistic manifestations in Malay and French: A cognitive analysis	Saad et al.	2018b
The relationship between astronomy and architecture as an element of Malay intelligentsia	Sarudin et al.	2020b
Beyond the closet? The trends and visibility of homosexuality coverage in Malaysian newspapers, 1998 - . . .	Subir	2019
Trend Penggunaan Bahasa Samar dalam Persidangan Parlimen Malaysia (Trend of Adjunctive and Dis . . .	Tan et al.	2017a
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House building tips (HBT) corpus dataset as a resource to discover Malay architectural ingenuity and identity	Zaini et al.	2021
Understanding quotation extraction and attribution: towards automatic extraction of public figure's . . .	Purnomo W.P et al.	2020

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An automatic health surveillance chart interpretation system based on Indonesian language	Aulia and Barmawi	2016
A text representation model using Sequential Pattern-Growth method	Alias et al.	2018b
Relationship analysis of keyword and chapter in Malay-translated tafseer of Al-Quran	Chua and Nohuddin	2017
Relation extraction using dependency tree kernel for Bahasa Indonesia	Esperanti and Purwarianti	2016
An experimental study of text preprocessing techniques for automatic short answer grading in Indonesian	Hasanah et al.	2018
Relation Detection for Indonesian Language Using Deep Neural Network - Support Vector Machine	Hasudungan and Purwarianti	2019
Classification of short possessive clitic pronoun nya in Malay text to support anaphor candidate determination	Noor et al.	2020
Assessing Suitable Word Embedding Model for Malay Language through Intrinsic Evaluation	Phua et al.	2020
Experiments on coreference resolution for Indonesian language with lexical and shallow syntactic features	Suherik and Purwarianti	2017
Malay manuscripts transliteration using statistical machine translation (SMT)	Razak et al.	2019
Transliteration engine for union catalogue of Malay manuscripts in Malaysia: E-JAWI version 3	Razak et al.	2018
SMVS: A Web-based Application for Graphical Visualization of Malay Text Corpus	Ahmat Baseri et al.	2020
Exploring Multilingual Syntactic Sentence Representations	Liu et al.	2019a
Transfer Building of Multiword Expression Resource from Indonesian to Malay	Liu and Wang	2020
Reclassification of the Leipzig Corpora Collection for Malay and Indonesian	Nomoto et al.	2018a
Learning Indonesian-Chinese Lexicon with Bilingual Word Embedding Models and Monolingual Signals	Qiu and Zhu	2016

Machine Reading

Title	Author	Year
Towards corpus and model: Hierarchical structured-attention-based features for Indonesian named entity …	Fu et al.	2021
Towards a Standardized Dataset on Indonesian Named Entity Recognition	Khairunnisa et al.	2020
Semi-supervised learning approach for Indonesian Named Entity Recognition (NER) using co-training …	Aryoyudanta et al.	2017
Named entity recognition for extracting concept in ontology building on Indonesian language using end-…	Santoso et al.	2021
Rule-based Approach on Extraction of Malay Compound Nouns in Standard Malay Document	Zamri Abu et al.	2017
A review of named entity recognition and classification on unstructured Malay data	Mohemad et al.	2020a
Detecting proper nouns in Indonesian-language translation of the Quran using a guided method	Raharjo et al.	2020
Named entity recognition on Indonesian tweets using hidden markov model	Azarine et al.	2019
Named entity recognition on Indonesian Twitter posts using long short-term memory networks	Rachman et al.	2018b
An enhanced Malay named entity recognition using combination approach for crime textual data analysis	Asmai et al.	2018
Named entity recognition using fuzzy c-means clustering method for Malay textual data analysis	Salleh et al.	2018
Named entity recognition on Indonesian microblog messages	Taufik et al.	2017
DBpedia entities expansion in automatically building dataset for Indonesian NER	Alfina et al.	2017

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Entity annotation WordPress plugin using TAGME technology	Aprilius et al.	2017
Developing name entity recognition for structured and unstructured text formatting dataset	Azzahra et al.	2020
Detection of compound word with combination noun and adjective using rule based technique in Malay ...	Bakar et al.	2017
Identification of Noun + Verb Compound Nouns in Malay Standard document based on rule based	Bakar et al.	2018a
Automatic detection of compound word in Malay standard document using rule based technique	Bakar et al.	2018b
Named-Entity Recognition for Indonesian Language using Bidirectional LSTM-CNNs	Gunawan et al.	2018c
A Concise Review of Named Entity Recognition System: Methods and Features	Ikhwan Syafiq et al.	2019
Empirical Evaluation of Character-Based Model on Neural Named-Entity Recognition in Indonesian ...	Kurniawan and Louvan	2018
A Semi-supervised Algorithm for Indonesian Named Entity Recognition	Leonandya et al.	2016
Malay name entity recognition using limited resources	Noor et al.	2016
Medical Named Entity Recognition for Indonesian Language Using Word Representations	Rahman	2018
Pendekatan Teknik Pengecaman Entiti Nama Bagi Capaian Berita Jenayah Bahasa Melayu (Named Entity ...	Saad and Mohamed Kamil	2018
A Malay named entity recognition using conditional random fields	Salleh et al.	2017
Low Complexity Named-Entity Recognition for Indonesian Language using BiLSTM-CNNs	Sukardi et al.	2020
Building Low-Resource NER Models Using Non-Speaker Annotations	Tsygankova et al.	2021
Hate speech detection in the Indonesian language: A dataset and preliminary study	Alfina et al.	2018
Developing Indonesian corpus of pornography using simple NLP-text mining (NTM) approach to support ...	Andriansyah et al.	2018
Bahasa Indonesia pre-trained word vector generation using word2vec for computer and information ...	Putri et al.	2021
Indonesian text document similarity detection system using rabin-karp and confix-stripping algorithms	Sinaga and Hansun	2018
N-Gram Keyword Retrieval on Association Rule Mining for Predicting Teenager Deviant Behavior from ...	Setiawan et al.	2018
The Effectiveness of Using Malay Affixes for Handling Unknown Words In Unsupervised HMM POS Tagger	Mohamed et al.	2018
Author-Topic Modelling for Reviewer Assignment of Scientific Papers in Bahasa Indonesia	Kusumawardani and Khairunnisa	2019
Benchmarking Mi-AR: Malay anaphora resolution	Xian et al.	2016
Fake news identification characteristics using named entity recognition and phrase detection	Al-Ash and Wibowo	2018
Graph-based text representation for Malay translated hadith text	Alias et al.	2017a
Building automatic mind map generator for natural disaster news in Bahasa Indonesia	Yulianto and Mariyah	2017
Neural sequence-to-sequence learning of internal word structure	Ruzsics and Samardzic	2017
Classification of user comment using word2vec and deep learning	Kurnia and Girsang	2021
Short Message Service (SMS) Spam Filtering using Machine Learning in Bahasa Indonesia	Theodorus et al.	2021
Analysis and implementation of cross lingual short message service spam filtering using graph-based k- ...	Dewi et al.	2018
Long short-term memory for hate speech and abusive language detection on Indonesian YouTube comment ...	Salim and Suhartono	2021

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Semi-supervised learning self-training for Indonesian motivational messages classification	Wulan and Supangkat	2018
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Hoax analyzer for Indonesian news using rnns with fasttext and glove embeddings	Adipradana et al.	2021
An evolutionary-based term reduction approach to bilingual clustering of Malay-English corpora	Alfred et al.	2017
Assessing factors that influence the performances of automated topic selection for Malay articles	Alfred et al.	2016
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Optimizing Deep Learning for Detection Cyberbullying Text in Indonesian Language	Anindyati et al.	2019
Evaluating rnn architectures for handling imbalanced dataset in multi-class text classification in Bahasa...	Christianto et al.	2020
A comparison of supervised text classification and resampling techniques for user feedback in Bahasa...	Dhammajoti et al.	2020
Classifying Medical Document in Bahasa Indonesia using Semi-Supervised Learning	Dhomas Hatta and Kiki Purnama	2021
Using naïve bayes classifier for application feedback classification and management in Bahasa Indonesia	Ferdino and Rusli	2019
The identification of pornographic sentences in Bahasa Indonesia	Gunawan et al.	2019e
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Building a question classification model for a Malay question answering system	Puteh et al.	2019
Age Group Based Document Classification in Bahasa Indonesia	Putra et al.	2020
Hoax web detection for news in bahasa using support vector machine	Rahmat et al.	2019
Indonesian news classification using convolutional neural network	Ramdhani et al.	2020
Answer categorization method using K-means for Indonesian language automatic short answer grading...	Ratna et al.	2019
Identifying fake news in Indonesian via supervised binary text classification	Rusli et al.	2020
Indonesian news classification based on NaBaNA	Septian et al.	2017
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Enhancing text classification performance by preprocessing misspelled words in Indonesian language	Setiabudi et al.	2021
Text Classification Services Using Naïve Bayes for Bahasa Indonesia	Setiani and Ce	2018

Title	Author	Year
Argument annotation and analysis using deep learning with attention mechanism in Bahasa Indonesia	Suhartono et al.	2020
Semi-supervised Category-specific Review Tagging on Indonesian E-Commerce Product Reviews	Sun et al.	2020
Short Message Service Filtering with Natural Language Processing in Indonesian Language	Tandra et al.	2021
Implementation of Naïve Bayes Classifier Algorithm to Categorize Indonesian Song Lyrics Based on Age	Thirafi and Rahutomo	2018
Research on Pseudo-label Technology for Multi-label News Classification	Wang et al.	2021
Efficient Implementation of Dirty Words Detection in Decision Tree Model	Yao et al.	2020
A Study of Text Classification for Indonesian News Article	Yovellia Londo et al.	2019
Developing the COVID-19 Malay Corpus Using WordPress Content Management System (CMS)	Hakimi and Rahman	2021
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Performance Evaluation of Inverted Files, B-Tree and B+ Tree Indexing Algorithm on Malay Text	Rosnan et al.	2019
Word prediction algorithm in resolving ambiguity in Malay text	Sazali et al.	2016
Implementation of LSI method on information retrieval for text document in Bahasa Indonesia	Pardede and Barmawi	2016
A document recommendation system of stemming and stopword removal impact: A web-based application	Parwita	2020
Weighted inverse document frequency and vector space model for hadith search engine	Pratama et al.	2020
Cross Language Information Retrieval Using Parallel Corpus with Bilingual Mapping Method	Rahmanda et al.	2019
Machine Learning Approach for Sentiment Analysis in Crime Information Retrieval	Mantoro et al.	2020
Natural Language Interface to Database (NLIDB) for Decision Support Queries	Anisyah et al.	2019
A Survey on Context-Aware Information Retrieval Research	Bin Rodzman et al.	2018a
The implementation of fuzzy logic controller for defining the ranking function on Malay text corpus	Bin Rodzman et al.	2018b
Experiment with text summarization as a positive hierarchical fuzzy logic ranking indicator for domain . . .	Bin Rodzman et al.	2019b
Indonesian document retrieval using vector space method	Fitriasari et al.	2017
Access to Relational Databases Using Interrogative Sentences in Indonesian Language	Ghassani and Widagdo	2018
Automatic open domain information extraction from Indonesian text	Gultom and Wibowo	2018
Open Text Ontology Mining to Improve Retrievals of Information	Hamzah and Kamaruddin	2021
Multi-word similarity and retrieval model for a refined retrieval of quranic sentences	Hanum et al.	2019
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Information Retrieval for Malay Text: A Decade Review of Research (2008-2019)	Kamaruddin et al.	2021
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Content-based Filtering Model for Recommendation of Indonesian Legal Article Study Case of Klinik . . .	Putri et al.	2019b

Title	Author	Year
Fabricated and Shia Malay translated hadith as negative fuzzy logic ranking indicator on Malay informa...	Rodzman et al.	2020
Domain specific concept ontologies and text summarization as hierarchical fuzzy logic ranking indicator...	Rodzman et al.	2019
Rule-based Indonesian Open Information Extraction	Romadhony et al.	2018
A Statistical Linguistic Terms Interrelationship Approach to Query Expansion Based on Terms Selection...	Yusuf et al.	2021
A Survey: Framework of an Information Retrieval for Malay Translated Hadith Document	Zulkefli et al.	2017
Crowdsourcing in developing repository of phrase definition in Bahasa Indonesia	Thamrin et al.	2019a
Single document keywords extraction in Bahasa Indonesia using phrase chunking	Trisna and Nurwidyantoro	2020
Topic modeling on Indonesian online shop chat	Hidayatullah et al.	2019
Indonesian abstractive text summarization using bidirectional gated recurrent unit	Adelia et al.	2019
Topic labeling towards news document collection based on Latent Dirichlet Allocation and ontology	Adhitama et al.	2017
MYTextSum: A Malay Text Summarizer Model Using a Constrained Pattern-Growth Sentence Compres...	Alias et al.	2018a
A Malay text corpus analysis for sentence compression using pattern-growth method	Alias et al.	2016
Extract, compress and summarize–An experiment using Malay news article	Alias et al.	2017c
A Malay text summarizer using pattern-growth method with sentence compression rules	Alias et al.	2017b
Understanding Human Sentence Compression Pattern for Malay Text Summarizer	Alias et al.	2018c
Bilingual extractive text summarization model using textual pattern constraints	Alias et al.	2020
A Syntactic-based Sentence Validation Technique for Malay Text Summarizer	Alias et al.	2021
Indonesian Automatic Text Summarization Based on A New Clustering Method in Sentence Level	Cai et al.	2019
Summarizing Indonesian news articles using Graph Convolutional Network	Garmastewira and Khodra	2019
Review of the recent research on automatic text summarization in Bahasa Indonesia	Gunawan and Amalia	2018
Multi-document Summarization by using TextRank and Maximal Marginal Relevance for Text in Bahasa...	Gunawan et al.	2019b
Automatic Text Summarization for Indonesian Language Using TextTeaser	Gunawan et al.	2017a
Liputan6: A Large-scale Indonesian Dataset for Text Summarization	Koto et al.	2020a
Peringkasan dokumen berita Bahasa Indonesia menggunakan metode cross latent semantic analysis	Mandar and Gunawan	2017
The purpose of bellman-ford algorithm to summarize the multiple scientific Indonesian journal articles	Maylawati et al.	2020
Sequential pattern mining and deep learning to enhance readability of Indonesian text summarization	Maylawati et al.	2019
Technique on Malay text summarization: A review	Mohemad et al.	2020b
Generation of news headline for Malay language based on term features	Noah et al.	2018
Text simplification for Malay corpus: A Review	Omar et al.	2021
Automatic Text Summarization for Malay News Documents Using Latent Dirichlet Allocation and...	Rahman et al.	2021b
Towards product attributes extraction in Indonesian e-commerce platform	Rif'at et al.	2018

Title	Author	Year
Multidocument Abstractive Summarization using Abstract Meaning Representation for Indonesian Language	Severina and Khodra	2019
Penjanaan Ringkasan Isi Utama Berita Bahasa Melayu berdasarkan Ciri Kata (Generation of News . . .	Shahrul Azman Mohd et al.	2018b
Terrorism domain corpus building using Latent Dirichlet Allocation (LDA) and its ontology relationship . . .	Suhendra et al.	2018
Topic Modelling for Malay News Aggregator	Weiying et al.	2018
A comparative review of extractive text summarization in Indonesian language	Widodo et al.	2021
Indonesian Abstractive Summarization using Pre-Trained Model	Wijayanti et al.	2021
A Conceptual Framework for Malay-English Mixed-language Question Answering System	Lim et al.	2021
Design of Ontology-based Question Answering System for Incompleted Sentence Problem	Yunmar and Wayan Wiprayoga Wisesa	2019
Corpus development for Indonesian consumer-health question answering system	Hakim et al.	2018
Towards question identification from online healthcare consultation forum post in bahasa	Mahendra et al.	2018a
WPS: Application for Generating Answer of Word Problem in Bahasa Indonesia	Oktavia et al.	2021
Automated question generating method based on derived keyphrase structures from Bloom's taxonomy	Wijanarko et al.	2020
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Developing Question Generation System for Bahasa Indonesia Using Indonesian Standard Language . . .	Wisnu Prabowo et al.	2021
Developing an adaptive language model for Bahasa Indonesia	Hidayatullah and Suyanto	2019
Pembangunan Taksonomi dari Teks Melayu Menggunakan Algoritma Kunang-Kunang Pembahagi Dua . . .	Mohd Zakree Ahmad et al.	2018
Document Similarity Detection Using Indonesian Language Word2vec Model	Ramadhanti and Mariyah	2019
Paraphrase construction of Al Quran in Indonesian language translation	Hutami et al.	2019
Rude-Words Detection for Indonesian Speech Using Support Vector Machine	Novitasari et al.	2019
Taxonomy development from Malay text using firefly bisection algorithm	Ahmad Nazri et al.	2018
Cross-Language Plagiarism Detection System Using Latent Semantic Analysis and Learning Vector . . .	Anak Agung Putri et al.	2017
Plagiarism Detection for Indonesian Language using Winnowing with Parallel Processing	Arifin et al.	2018
Knowledge representation system for copula sentence in Bahasa Indonesia based on Web Ontology . . .	Cahyani et al.	2016
Keyword extraction from scientific articles in Bahasa Indonesia using textrank algorithm	Gunawan et al.	2020
Extracting disease-symptom relationships from health question and answer forum	Halim et al.	2018
Segregation of Code-Switching Sentences using Rule-Based Technique	Kasmuri and Basiron	2020
Automated verbalization of ORM models in Malay and Mandarin	Lim and Halpin	2016
Noun phrases extraction using shallow parsing with C4.5 decision tree algorithm for Indonesian Language . . .	Santoso et al.	2016
Implementing Graph Based Rank on Online News Media Keyword Extraction	Syafiandini et al.	2019

Translation

Title	Author	Year

Title	Author	Year
A framework for English and Malay cross-lingual document alignment method	Nasharuddin et al.	2019
User participation in building language repository: the case of Google Translate	Thamrin et al.	2018
Google vs. Instagram Machine Translation: Multilingual Application Program Interface Errors in Trans . . .	Larassati et al.	2019
Neural Machine Translation model for University Email Application	Aneja et al.	2020
Quality translation enhancement using sequence knowledge and pruning in statistical machine translation	Ayu et al.	2018
Meaning preservation in Example-based Machine Translation with structural semantics	Chua et al.	2017
English-Indonesian Neural Machine Translation for Spoken Language Domains	Dwiastuti	2019
Benchmarking multidomain English-Indonesian machine translation	Guntara et al.	2020
A Neural Machine Translation Approach for Translating Malay Parliament Hansard to English Text	Low et al.	2020
IIT Bombay's English-Indonesian submission at WAT: Integrating Neural Language Models with SMT	Singh et al.	2016
Source language adaptation approaches for resource-poor machine translation	Wang et al.	2016
Hybrid machine translation with multi-source encoder-decoder long short-term memory in English-Malay . . .	Yeong et al.	2018
Using Dictionary and Lemmatizer to Improve Low Resource English-Malay Statistical Machine Transla . . .	Yeong et al.	2016
Semi-Supervised Low-Resource Style Transfer of Indonesian Informal to Formal Language with Iterative . . .	Wibowo et al.	2020
Morphological analysis of speech translation into Indonesian sign language system (SIBI) on android . . .	Nurilman Baehaqi et al.	2019
Pengaruh Pennambahan Korpus Paralel pada Mesin Penerjemah Statistik Bahasa Indonesian ke Bahasa . . .	Abidin and Permata	2021
Effect of mono corpus quantity on statistical machine translation Indonesian-Lampung dialect of nyo	Abidin et al.	2021
Peningkatan Mesin Penerjemah Statistik dengan Menambah Kuantitas Korpus Monolingual (Studi Kasus: . . .	Darwis et al.	2019
Peningkatan Akurasi Penerjemah Bahasa Daerah dengan Optimasi Korpus Paralel	Sujaini	2018
Translation Learning Tool for Local Language to Bahasa Indonesia using Knuth-Morris-Pratt Algorithm	Warnars et al.	2021
Leveraging additional resources for improving statistical machine translation on asian low-resource languages	Trieu et al.	2019
Rule-based Reordering and Post-Processing for Indonesian-Korean Statistical Machine Translation	Mawalim et al.	2017
A novel Hadith authentication mobile system in Arabic to Malay language translation for android and . . .	Fadele et al.	2020
Translation of idioms from Arabic into Malay via Google Translate: What needs to be done?	Abidin et al.	2020
Multiple pivots in statistical machine translation for low resource languages	Budiwati and Aritsugi	2019
A Parallel Evaluation Data Set of Software Documentation with Document Structure Annotation	Buschbeck and Exel	2020
A Comprehensive Analysis of Bilingual Lexicon Induction	Irvine and Callison-Burch	2017
Malay-corpus-enhanced Indonesian-Chinese neural machine translation	Liu and Wang	2019
Language Resource Extension for Indonesian-Chinese Machine Translation	Liu et al.	2019b
Development of mobile application for Malay translated hadith search engine	Rahman et al.	2020
Enhancing Pivot Translation Using Grammatical and Morphological Information	Trieu and Nguyen	2018

Title	Author	Year
Translating Malay Compounds into Arabic Based on Dynamic Theory and Arabization Method	Wahiyudin and Romli	2021
Generating image description on Indonesian language using convolutional neural network and gated . . .	Nugraha et al.	2019
Visual question answering for monas tourism object using deep learning	Siregar and Chahyati	2020
Learning translations via images with a massively multilingual image dataset	Hewitt et al.	2018
Adaptive Attention Generation for Indonesian Image Captioning	Mahadi et al.	2020
Cross-lingual projection for class-based language models	Gfeller et al.	2016
Extremely Low-Resource Neural Machine Translation for Asian Languages	Rubino et al.	2020
Machine translation of Indonesian: A review	Septarina et al.	2019
See also - A review on Indonesian machine translation	Rahutomo et al.	2019

Spoken Dialogue Systems

Title	Author	Year
Malay speech corpus of telecommunication call center preparation for ASR	Draman et al.	2017
Detection of Malay phrase breaks using energy and duration	Mohamed Hanum and Abu Bakar	2016
A hybrid approach for single channel speech enhancement using deep neural network and harmonic . . .	Jamal et al.	2020
Developing ASR for Indonesian-English Bilingual Language Teaching	Maxwell-Smith and Foley	2021
Applications of natural language processing in bilingual language teaching: An Indonesian-English case . . .	Maxwell-Smith et al.	2020
Robust Feature Extraction Based On Spectral And Prosodic Features For Classical Arabic Accents . . .	Ibrahim et al.	2019
Transfer learning with bottleneck feature networks for whispered speech recognition	Lim et al.	2016
Cross-Lingual Machine Speech Chain for Javanese, Sundanese, Balinese, and Bataks Speech Recognition . . .	Novitasari et al.	2020
Comparing statistical classifiers for emotion classification	Hamzah et al.	2017
Influences of age in emotion recognition of spontaneous speech: A case of an under-resourced language	Jamil et al.	2017
Influences of languages in speech emotion recognition: A comparative study using Malay, English and . . .	Rajoo and Aun	2016
Voice-Based Malay Commands Recognition by Using Audio Fingerprint Method for Smart House Appli . . .	Abu et al.	2020
Automatic Transcription and Captioning System for Bahasa Indonesia in Multi-Speaker Environment	Andra and Usagawa	2020
Improved Transcription and Speaker Identification System for Concurrent Speech in Bahasa Indonesia . . .	Andra and Usagawa	2021
Speech-to-Text Conversion in Indonesian Language Using a Deep Bidirectional Long Short-Term Memory . . .	Dwijayanti et al.	2021
Comparison of feature extraction MFCC and LPC in automatic speech recognition for Indonesian	Endah et al.	2017
Development of language identification system using MFCC and vector quantization	Gunawan et al.	2018b
Voiced and unvoiced separation in Malay speech using zero crossing rate and energy	Hanifa et al.	2019
Wavelet based feature extraction for the vowel sound	Hidayat et al.	2016
Shared-hidden-layer deep neural network for under-resourced language the content	Hoesen et al.	2018

Title	Author	Year
Classification and clustering to identify spoken dialects in Indonesian	Ibrahim and Lestari	2018
Automatic phoneme identification for Malay dialects	Khaw et al.	2017
Speech to Text of Patient Complaints for Bahasa Indonesia	Laksono et al.	2019
Malay language speech recognition for preschool children using Hidden Markov Model (HMM) system ...	Maseri and Mamat	2019
Indonesian audio-visual speech corpus for multimodal automatic speech recognition	Maulana and Fanany	2018a
Sentence-level Indonesian lip reading with spatiotemporal CNN and gated RNN	Maulana and Fanany	2018b
Sphinx4 for Indonesian continuous speech recognition system	Muljono et al.	2017b
Indonesian graphemic syllabification using a nearest neighbour classifier and recovery procedure	Parande and Suyanto	2019
Rule-Based Pronunciation Models to Handle OOV Words for Indonesian Automatic Speech Recognition ...	Putri et al.	2019a
Speech to Text Translation for Malay Language	Rami Ali and Rini	2017
Assessing automatic speech recognition in measuring speech intelligibility: a study of Malay speakers ...	Rosdi et al.	2017
Hybrid methods of Brandt's generalised likelihood ratio and short-term energy for Malay word speech ...	Seman and Norazam	2019
Incorporating syllabification points into a model of grapheme-to-phoneme conversion	Suyanto	2019b
Flipping onsets to enhance syllabification	Suyanto	2019a
Phonological similarity-based backoff smoothing to boost a bigram syllable boundary detection	Suyanto	2020
End-to-End Speech Recognition Models for a Low-Resourced Indonesian Language	Suyanto et al.	2020
Indonesian syllabification using a pseudo nearest neighbour rule and phonotactic knowledge	Suyanto et al.	2016
Recognizing Five Major Dialects in Indonesia Based on MFCC and DRNN	Tawaqal and Suyanto	2021
Specific acoustic models for spontaneous and dictated style in Indonesian speech recognition	Vista et al.	2018
Cloud-based automatic speech recognition systems for southeast asian languages	Wang et al.	2018
Smart presentation system using hand gestures and Indonesian speech command	Wardhany et al.	2016
Leveraging Text Data Using Hybrid Transformer-LSTM Based End-to-End ASR in Transfer Learning	Zeng et al.	2021
Indonesian Corpus Constructing and Text Processing for Speech Synthesis	Kong and Yang	2018
Utilizing Indonesian Allophones and Intraword Short Pauses Handling to Improve Performance of Indone ...	Uliniansyah et al.	2019
Developing an online self-learning system of Indonesian pronunciation for foreign learners	Muljono et al.	2016
Automatic Pronunciation Generator for Indonesian Speech Recognition System Based on Sequence-to- ...	Hoesen et al.	2019
Multi Speaker Speech Synthesis System for Indonesian Language	Budiman and Lestari	2020
A Bilingual Speech Synthesis System of Standard Malay and Indonesian Based on HMM-DNN	Chen et al.	2020
Poetry visualization in digital technology	Noh et al.	2019
The first Malay language storytelling text-to-speech (TTS) corpus for humanoid robot storytellers	Ramli et al.	2017
An Iterated Two-Step Sinusoidal Pitch Contour Formulation for Expressive Speech Synthesis	Ramli et al.	2021

Title	Author	Year
A Tool to Solve Sentence Segmentation Problem on Preparing Speech Database for Indonesian Text-to- . . .	Uliniansyah et al.	2016
Enhancing Prosodic Features by Adopting Pre-trained Language Model in Bahasa Indonesia Speech . . .	Zhao et al.	2020
Anita: Intelligent Humanoid Robot with Self-Learning Capability Using Indonesian Language	Andreas et al.	2019
A novel model and implementation of humanoid robot with facial expression and natural language . . .	Budiharto et al.	2021
Teach your robot your language! trainable neural parser for modeling human sentence processing: . . .	Hinaut and Twiefel	2020
The Architecture of Speech-to-Speech Translator for Mobile Conversation	Santosa et al.	2019
Development of text and speech corpus for an Indonesian speech-to-speech translation system	Teduh Uliniansyah et al.	2018
Chatbot Application on Internet of Things (IoT) to Support Smart Urban Agriculture	Gunawan et al.	2019f
Virtual assistant using lstm networks in Indonesian	Mirwan et al.	2018
Forming of Dyadic Conversation Dataset for Bahasa Indonesia	Tho et al.	2018
Development of Indonesian Language Speech Recognition Algorithm Model in Knowledge Database	Yossy et al.	2020
GMM based automatic speaker verification system development for forensics in Bahasa Indonesia	Stefanus et al.	2017
Recurrent Neural Network to Deep Learn Conversation in Indonesian	Chowanda and Chowanda	2017
Virtual phone discovery for speech synthesis without text	Nayak et al.	2019

Speaker States

Title	Author	Year
An automatic lexicon generation for Indonesian news sentiment analysis: A case on governor elections in . . .	Ayu et al.	2019
Minimally-supervised sentiment lexicon induction model: A case study of Malay sentiment analysis	Darwich et al.	2017
Extraction Sentiment Analysis Using naive Bayes Algorithm and Reducing Noise Word applied in . . .	Jaka Harjanta and Herlambang	2020
Automatic Semantic Orientation of Adjectives for Indonesian Language Using PMI-IR and Clustering	Riyanti et al.	2018
Enhanced Malay sentiment analysis with an ensemble classification machine learning approach	Al-Moslmi et al.	2017
Aspect and Opinion Extraction of Indonesian Lipsticks Product Reviews using Conditional Random Field . . .	Kun Indarta and Romadhony	2021
Identifying deception in Indonesian transcribed interviews through lexical-based approach	Warnita and Lestari	2017
Aspect Extraction for Tourist Spot Review in Indonesian Language using BERT	Yanuar and Shiramatsu	2020
Framework of sentiment annotation for document specification in Indonesian language base on topic . . .	Sutabri and Ardiansyah	2017
Evaluation of support vector machine and decision tree for emotion recognition of Malay folklores	Saad et al.	2018a
Sentiment analysis for low resource languages: A study on informal Indonesian tweets	Le et al.	2016
Indonesian Lexicon-Based Sentiment Analysis of Online Religious Lectures Review	Kurniawan et al.	2021
A Simplified Method to Identify the Sarcastic Elements of Bahasa Indonesia in Youtube Comments	Wijaya et al.	2020
Experiment with lexicon based techniques on domain-specific Malay document sentiment analysis	Bin Rodzman et al.	2019a
Implementation of a Machine Learning Algorithm for Sentiment Analysis of Indonesia's 2019 Presidential . . .	Buntoro et al.	2021

Title	Author	Year
Sentiment Analysis of Malay Social Media Text	Chekima and Alfred	2018
Random forest approach fo sentiment analysis in Indonesian language	Fauzi	2018
Word embedding comparison for Indonesian language sentiment analysis	Imaduddin et al.	2019
Text Mining and Support Vector Machine for Sentiment Analysis of Tourist Reviews in Bangkalan Regency	Imamah et al.	2020
Unsupervised aspect-based sentiment analysis on Indonesian restaurant reviews	Sasmita et al.	2018
Elman recurrent neural network for aspect based sentiment analysis	Widiastuti and Ali	2021
Multilingual sentiment analysis: A systematic literature review	Abdullah and Rusli	2021
Polarity classification tool for sentiment analysis in Malay language	Abu Bakar et al.	2019b
Long short term memory convolutional neural network for Indonesian sentiment analysis towards touristic . . .	Af'idah et al.	2020
Malay sentiment analysis based on combined classification approaches and Senti-lexicon algorithm	Al-Saffar et al.	2018
An analysis of Malay language emotional speech corpus for emotion recognition system	Apandi and Jamil	2017
Aspect-Based Sentiment Analysis Using Convolutional Neural Network and Bidirectional Long Short- . . .	Cahyadi and Khodra	2018
Rule-Based Model for Malay Text Sentiment Analysis	Chekima et al.	2018
Speech-Emotion Detection in an Indonesian Movie	Fahmi et al.	2020
A comparative study of sentiment analysis using SVM and Senti Word Net	Fikri and Sarno	2019
Sentiment analysis for Malay language: systematic literature review	Handayani et al.	2018
Sentiment analysis using recurrent neural network-lstm in Bahasa Indonesia	Kurniasari and Setyanto	2020a
Sentiment Analysis using Recurrent Neural Network	Kurniasari and Setyanto	2020b
Aspect-based Opinion Mining on Beauty Product Reviews	Mahfiz and Romadhony	2020
Aspect-Based Sentiment Analysis on Candidate Character Traits in Indonesian Presidential Election	Manik et al.	2020
Sentiment Analysis Using Word2vec and Long Short-Term Memory (LSTM) for Indonesian Hotel Reviews	Muhammad et al.	2021
English and Malay cross-lingual sentiment lexicon acquisition and analysis	Nasharuddin et al.	2017
Word2vec for Indonesian sentiment analysis towards hotel reviews: An evaluation study	Nawangsari et al.	2019
The Influence of Negation Handling on Sentiment Analysis in Bahasa Indonesia	Ningtyas and Herwanto	2018
Sentiment analysis system for movie review in Bahasa Indonesia using naive bayes classifier method	Nurdiansyah et al.	2018
An experimental study of lexicon-based sentiment analysis on Bahasa Indonesia	Pamungkas and Putri	2017
A comparison of the use of several different resources on lexicon based Indonesian sentiment analysis on . . .	Pratama et al.	2019
Pair Extraction of Aspect and Implicit Opinion Word based on its Co-occurrence in Corpus of Bahasa . . .	Setiowati et al.	2019
Sentiment analysis of application user feedback in Bahasa Indonesia using multinomial naive bayes	Wiratama and Rusli	2019
Sentiment analysis of economic news in Bahasa Indonesia using majority vote classifier	Zamahsyari and Nurwidyantoro	2017
Indonesia Hate Speech Detection Using Deep Learning	Sutejo and Lestari	2019

Title	Author	Year
Criminality recognition using machine learning on Malay language tweets	Malim et al.	2019
Personality Measurement Design for Ontology Based Platform using Social Media Text	Alamsyah et al.	2020
A preliminary study on hybrid sentiment model for customer purchase intention analysis in social commerce	Eshak et al.	2018
A Progress on the Personality Measurement Model using Ontology based on Social Media Text	Alamsyah et al.	2019
Speech Emotion Recognition for Indonesian Language Using Long Short-Term Memory	Lasiman and Lestari	2019

Social Media

Title	Author	Year
Opinion QA-Pairs Generation from Indonesian Twitter	Suwarningsih and Nuryani	2019
Preprocessing for crawler of short message social media	Ariestya et al.	2018
Pola Penggunaan Bahasa Melayu dalam Twitter Mantan Perdana Menteri Ke-enam, Dato' Seri Najib …	Khalid and Rahim	2021
Cyberbullying through intellect-related insults	Sood et al.	2020
Formal and Non-Formal Indonesian Word Usage Frequency in Twitter Profile Using Non-Formal Affix Rule	Utami et al.	2019b
Ten-year compilation of #savekpk Twitter dataset	Rahutomo et al.	2020
Word Cloud Result of Mobile Payment User Review in Indonesia	Dewi et al.	2020
Ensemble method for Indonesian Twitter hate speech detection	Fauzi and Yuniarti	2018
Event detection in Twitter: A keyword volume approach	Hossny and Mitchell	2019
Multi-label Hate Speech and Abusive Language Detection in Indonesian Twitter	Ibrohim and Budi	2019a
Identification of hate speech and abusive language on Indonesian Twitter using the Word2vec, part of …	Ibrohim et al.	2019
Classification of Radicalism Content from Twitter Written in Indonesian Language using Long Short …	Idris et al.	2019
Hierarchical multi-label classification to identify hate speech and abusive language on Indonesian Twitter	Prabowo et al.	2019
Topic classification and clustering on Indonesian complaint tweets for bandung government using super …	Pratama and Purwarianti	2017
Twitter Topic Modeling on Football News	Hidayatullah et al.	2018
Topic Summarization of Microblog Document in Bahasa Indonesia using the Phrase Reinforcement …	Jiwanggi and Adriani	2016
Negation handling in sentiment classification using rule-based adapted from Indonesian language syntactic …	Amalia et al.	2018
A Framework for Sentiment Analysis Implementation of Indonesian Language Tweet on Twitter	Asniar and Aditya	2017
Social Media Analytics using Sentiment and Content Analyses on The 2018 Malaysia's General Election	Balakrishnan et al.	2021
Multi-Classes Emotion Detection for Unbalanced Indonesian Tweets	Farsiah et al.	2020
Twitter sentiment analysis in under-resourced languages using byte-level recurrent neural model	Ferdiana et al.	2019
Corpus Usage for Sentiment Analysis of a Hashtag Twitter	Herlawati et al.	2019
Sentiment analysis on Bahasa Indonesia tweets using Unibigram models and machine learning techniques	Iswanto and Poerwoto	2018
Social tension and crime related events detection method on Twitter	Jamil et al.	2019

Title	Author	Year
Bilingual sentiment detection - Investigating impact of tweet translation	Kaur and Balakrishnan	2016
Comparison of SVM Naïve Bayes Algorithm for Sentiment Analysis Toward West Java Governor Candi ...	Kristiyanti et al.	2019
Indonesian Twitter Sentiment Analysis Using Word2Vec	Kurniawan and Maharani	2020
Aspect-level Sentiment Analysis for Social Media Data in the Political Domain using Hierarchical ...	Kusumawardani and Maulidani	2020
Sentiment Analysis Using Weighted Emoticons and SentiWordNet for Indonesian Language	Maulidiah Elfajr and Sarno	2018
Employ Twitter data to perform sentiment analysis in the Malay language	Mohamad et al.	2020b
Classification of Twitter data by sentiment analysis in the Malay language	Mohamad et al.	2020a
Detecting candidates of depression, anxiety and stress through Malay-written tweets: A preliminary study	Nasrudin et al.	2019
Naive Bayes as opinion classifier to evaluate students satisfaction based on student sentiment in Twitter ...	Permana et al.	2017
Sentiment Analysis of BPJS Kesehatan's Services Based on Affective Models	Rasyada et al.	2020
When Homecoming is not Coming: 2021 Homecoming Ban Sentiment Analysis on Twitter Data Using ...	Sandra and Lumbangaol	2021
Aspect-Based Sentiment Analysis for Posts on Friday Prayer during MCO in Malaysia	Setik et al.	2021
Applying Opinion Mining Technique on Tourism Study Case: Lake Toba	Situmorang et al.	2019
Does it make you sad? A lexicon-based sentiment analysis on COVID-19 news tweets	Suryadi	2021
Emotion analysis using self-training on Malaysian code-mixed Twitter data	Tan et al.	2020
Sentiment analysis for telco popularity on Twitter big data using a novel Malaysian dictionary	Tan et al.	2016
Hate speech classification in Indonesian language tweets by using convolutional neural network	Taradhita and Putra	2021
Sentiment Analysis of Indonesians Response to Influencer in Social Media	Tauhid and Ruldeviyani	2020
Code-mixed sentiment analysis of Indonesian language and Javanese language using Lexicon based approach	Tho et al.	2021
Simulation of marketplace customer satisfaction analysis based on machine learning algorithms	Turdjai and Mutijarsa	2017
Hashtag Global Surgery: The Role of Social Media in Advancing the Field of Global Surgery	Vervoort and Luc	2020
School from home situation in Indonesia: An exploratory data analysis of Indonesian tweet data	Wahyuni et al.	2020
Measuring happiness in large population	Wenas et al.	2016
Sentiment analysis of informal Malay tweets with deep learning	Ying et al.	2020
Developing cross-lingual sentiment analysis of Malay Twitter data using lexicon-based approach	Zabha et al.	2019
Automatic Labelling of Malay Cyberbullying Twitter Corpus using Combinations of Sentiment, Emotion ...	Maskat et al.	2020
Personality prediction based on Twitter information in Bahasa Indonesia	Ong et al.	2017
Personality Modelling of Indonesian Twitter Users with XGBoost Based on the Five Factor Model	Ong et al.	2021
Profiling analysis of DISC personality traits based on Twitter posts in Bahasa Indonesia	Utami et al.	2019a
Supervised learning and resampling techniques on DISC personality classification using Twitter informa ...	Utami et al.	2021
D-Loc Apps: A Location Detection Application Based on Social Media Platform in the Event of A Flood ...	Fitrianah et al.	2020

Title	Author	Year
Music interest classification of Twitter users using support vector machine	Yusra et al.	2017
Lexical based sentiment analysis - Verb, adverb & negation	Shamsudin et al.	2016
Construction of the Malay language psychometric properties using LIWC from Facebook statuses	Ahmad et al.	2017
Hate speech detection in Indonesian language on Instagram comment section using deep neural network ...	Bunga Batara et al.	2019
Hate speech detection in Indonesian language on Instagram comment section using maximum entropy ...	Erizal et al.	2019
Hate speech detection on Indonesian Instagram comments using FastText approach	Pratiwi et al.	2019
Hate speech detection in Indonesian language Instagram	Putra and Nurjanah	2020
Hate speech detection in Indonesian language on Instagram comment section using K-nearest neighbor ...	Briliani et al.	2019
Recognizing the sarcastic statement on WhatsApp Group with Indonesian language text	Afiyati et al.	2018
Construction of Malay abbreviation corpus based on social media data	Omar et al.	2017
Context-sensitive normalization of social media text in Bahasa Indonesia based on neural word embeddings	Kusumawardani et al.	2018
A taxonomy of Malay social media text	Maskat and Munarko	2019
Detecting opinion spams through supervised boosting approach	Hazim et al.	2018
The development of Bahasa Indonesia corpora for machine learning model in combating cyber bullying: ...	Jambak and Setiawan	2018
Review on sentiment analysis approaches for social media data	Abdullah et al.	2017
Sentiment Analysis of Noisy Malay Text: State of Art, Challenges and Future Work	Abu Bakar et al.	2020
Emotion detection of tweets in Indonesian language using LDA and expression symbol conversion	Cahyaningtyas et al.	2017
Bias aware lexicon-based Sentiment Analysis of Malay dialect on social media data: A study on the ...	Hijazi et al.	2017
Translated vs non-translated method for multilingual hate speech identification in Twitter	Ibrohim and Budi	2019b
Classification and quantification of user's emotion on Malay language in social network sites using Latent ...	Jamaluddin et al.	2017
A hybrid model for social media sentiment analysis for Indonesian text	Putra et al.	2018b
Natural language processing based features for sarcasm detection: An investigation using bilingual social ...	Suhaimin et al.	2017
Modified framework for sarcasm detection and classification in sentiment analysis	Suhaimin et al.	2019
Concerns of thalassemia patients, carriers, and their caregivers in Malaysia: Text mining information ...	Phang et al.	2021

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