Klasifikasi Emosi Kalimat pada Percakapan Chat Berbasis Transformer Melalui Fine-Tuning BERT

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Abstract - Percakapan pada media sosial dan aplikasi chat sering kali memuat ekspresi emosi yang penting untuk dipahami, baik dalam konteks komunikasi interpersonal maupun dalam pengembangan sistem kecerdasan buatan yang mampu merespons secara lebih manusiawi. Namun, klasifikasi emosi pada teks berciri informal memiliki tantangan tersendiri, seperti variasi bahasa, struktur kalimat yang tidak teratur, serta ketidakseimbangan distribusi label emosi, terutama dominasi kelas neutral. Penelitian ini mengusulkan pendekatan fine-tuning BERT untuk tugas klasifikasi multi-label emosi pada percakapan chat dengan menerapkan serangkaian strategi peningkatan performa. Tahapan penelitian mencakup pembersihan teks, normalisasi, serta reduksi distribusi pure neutral melalui downsampling terkontrol untuk mengatasi ketidakseimbangan label. Selain itu, penelitian ini memodifikasi classification head BERT melalui integrasi mekanisme representasi yang lebih kaya, yaitu cross-layer fusion, gabungan empat teknik pooling (CLS, mean, max, dan attention pooling), normalisasi RMSNorm, feed-forward network berbasis aktivasi SwiGLU, serta multi-sample dropout untuk meningkatkan stabilitas dan kemampuan generalisasi. Penelitian ini juga memperkenalkan label-wise attention sehingga setiap label emosi memperoleh representasi token yang lebih relevan secara kontekstual. Selama pelatihan, pendekatan pos_weight digunakan untuk menangani ketidakseimbangan label, sedangkan optimasi ambang prediksi dilakukan secara terpisah untuk setiap label. Evaluasi dilakukan menggunakan metrik akurasi, precision, recall, dan F1-score. Hasil eksperimen menunjukkan bahwa arsitektur classification head yang ditingkatkan pada model BERT mampu menghasilkan performa yang lebih baik dibandingkan konfigurasi BERT standar, terutama pada label berfrekuensi rendah, sebagaimana ditunjukkan oleh peningkatan nilai F1 makro. Temuan ini menunjukkan bahwa fine-tuning BERT dengan modifikasi classification head, integrasi mekanisme representasi multi-level, serta penanganan ketidakseimbangan yang tepat mampu meningkatkan efektivitas sistem klasifikasi emosi pada percakapan berbasis chat.

Keywords - Transformer, BERT, Emotion Classification, Multi-Label Learning, Imbalanced Data

1. INTRODUCTION

Perkembangan teknologi digital dan penggunaan media komunikasi berbasis teks telah menghasilkan volume percakapan daring yang semakin besar. Interaksi melalui aplikasi chat, media sosial, dan platform pesan instan sering kali memuat ekspresi emosi yang penting untuk dipahami, baik dalam konteks komunikasi interpersonal, layanan pelanggan, maupun dalam pengembangan sistem kecerdasan buatan yang lebih responsif. Kemampuan untuk mengidentifikasi emosi secara otomatis menjadi aspek yang semakin relevan, terutama pada sistem pendukung keputusan, analisis sentimen, chatbot, serta aplikasi pemantauan kesehatan mental.

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Meskipun memiliki potensi yang luas, klasifikasi emosi pada teks percakapan merupakan tugas yang kompleks. Teks percakapan umumnya bersifat pendek, informal, tidak terstruktur, dan dipengaruhi oleh variasi bahasa yang tinggi, termasuk penggunaan singkatan, kesalahan ketik, serta ekspresi nonverbal. Tantangan tersebut diperparah oleh ketidakseimbangan distribusi label emosi, terutama dominannya kelas neutral dibandingkan kelas emosi lainnya, sehingga model cenderung bias dan kurang mampu mengenali kategori emosi berfrekuensi rendah. Permasalahan ini menuntut adanya pendekatan yang mampu mempelajari representasi konteks secara lebih mendalam.

Model berbasis transformer, khususnya BERT (Bidirectional Encoder Representations from Transformers), telah terbukti efektif dalam memahami konteks linguistik melalui mekanisme self-attention. Berbagai penelitian menunjukkan bahwa fine-tuning BERT dapat meningkatkan performa klasifikasi pada tugas analisis teks. Namun, penerapan BERT standar pada data multi-label yang tidak seimbang masih menghadapi keterbatasan. Representasi yang hanya mengandalkan token [CLS] belum sepenuhnya memanfaatkan kekayaan informasi lintas-layer dalam arsitektur BERT, sementara classification head sederhana sering tidak mampu menangkap variasi emosional yang kompleks dalam percakapan pendek.

Untuk mengatasi permasalahan tersebut, penelitian ini mengusulkan pendekatan fine-tuning BERT yang diperkuat dengan mekanisme classification head berbasis representasi multi-layer. Pendekatan ini memanfaatkan cross-layer fusion untuk menggabungkan informasi dari beberapa lapisan BERT, serta menerapkan kombinasi pooling yang lebih komprehensif melalui gabungan CLS, mean pooling, max pooling, dan attention pooling. Selain itu, normalisasi RMSNorm diterapkan untuk meningkatkan stabilitas pelatihan, sementara feed-forward network berbasis aktivasi SwiGLU digunakan untuk memperkaya kapasitas non-linearitas. Penggunaan multi-sample dropout ditujukan untuk meningkatkan kemampuan generalisasi model. Pada tahap prapengolahan, distribusi kelas neutral yang dominan ditangani melalui strategi downsampling terkontrol, kemudian dilanjutkan dengan penerapan pos_weight selama pelatihan untuk menyeimbangkan kontribusi setiap label emosi. Strategi ini diperkuat dengan optimasi ambang keputusan khusus untuk setiap label agar prediksi lebih sesuai dengan karakteristik masing-masing emosi.

Pendekatan yang digunakan dalam penelitian ini memberikan kontribusi dalam penguatan representasi emosi melalui integrasi informasi lintas-layer, peningkatan arsitektur classification head agar lebih adaptif terhadap variasi ekspresi emosional, serta perancangan strategi pelatihan yang lebih stabil untuk data multi-label yang tidak seimbang. Evaluasi menggunakan metrik akurasi, precision, recall, dan F1-score menunjukkan bahwa metode yang diusulkan menghasilkan performa yang lebih baik dibandingkan dengan fine-tuning BERT standar, terutama pada label berfrekuensi rendah. Temuan ini menunjukkan bahwa pemodelan emosi pada percakapan chat dapat ditingkatkan secara signifikan dengan memanfaatkan representasi mendalam dan mekanisme penanganan ketidakseimbangan yang tepat.

2. RESEARCH METHOD

Explaining research chronological, including research design, research procedure (in the form of algorithms, Pseudocode or other), how to test and data acquisition [1], [3]. The description of the course of research should be supported references, so the explanation can be accepted scientifically [2], [4].

2.1. Figures and Tables

Position figures and tables at the tops and bottoms of pages, when possible. Avoid placing them in the middle of columns. Figure captions should be centered below the figures; table captions should be centered above. Avoid placing figures and tables before their first mention in the text.

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Figure axis labels are often a source of confusion. Use words rather than symbols. For example, write "Magnetization," or "Magnetization, M," not just "M." Put units in parentheses. Do not label axes only with units. In the example, write "Magnetization (A/m)" or "Magnetization (A · m^1)." Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)," not "Temperature/K."

Multipliers can be especially confusing. Write "Magnetization (kA/m)" or "Magnetization (10^3 A/m)." Figure labels should be legible, about 11-point type.

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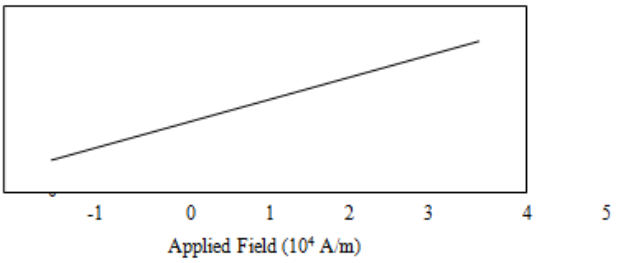

Figure 1. Magnetization as a function of applied field.

2.2. References

Number citations consecutively in square brackets [1]. Punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]. Use "Ref. [3]" or Reference [3]" at the beginning of a sentence: "Reference [3] was the first …"

Give all authors' names; use "et al." if there are six authors or more. Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been accepted for publication should be cited as "in press" [5]. In a paper title, capitalize the first word and all other words except for conjunctions, prepositions less than seven letters, and prepositional phrases.

For papers published in translated journals, first give the English citation, then the original foreign-language citation [6].

2.3. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even if they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title unless they are unavoidable.

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2.4. Equations

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use an en dash (–) rather than a hyphen for a minus sign. Use parentheses to avoid ambiguities in denominators. Punctuate equations with commas or periods when they are part of a sentence, as in

$$a + b = c \qquad (1)$$

Symbols in your equation should be defined before the equation appears or immediately following. Use "(1)," not "Eq. (1)" or "equation (1)," except at the beginning of a sentence: "Equation (1) is …"

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Use a zero before decimal points: "0.25," not ".25." Use "cm^3," not "cc." Do not mix complete spellings and abbreviations of units: "Wb/m^2" or "webers per square meter," not "webers/m^2." Spell units when they appear in text: "…a few henries," not "…a few H." If your native language is not English, try to get a native English-speaking colleague to proofread your paper.

3. RESULTS AND DISCUSSION

In this section, it is explained the results of research and at the same time is given the comprehensive discussion. Results can be presented in figures, graphs, tables and others that make the reader understand easily [2], [5]. The discussion can be made in several sub-chapters.

4. CONCLUSION

Provide a statement that what is expected, as stated in the "Introduction" chapter can ultimately result in "Results and Discussion" chapter, so there is compatibility. Moreover, it can also be added the prospect of the development of research results and application prospects of further studies into the next (based on result and discussion).

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