Transformer-Based Named Entity Recognition for Semantic Information Extraction

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Article History: *Published:15 March 2026* <u>*Publication Issue:*</u> *Volume 3, Issue 3* *March-2026* <u>*Page Number:*</u> *268-273* <u>*Corresponding Author:*</u> *Hriesheec VA*	Named Entity Recognition (NER) is one of the main functions of Natural Language Processing, and it is used for the identification and categorization of important information in texts, such as person names, organization names, locations, dates, and monetary values, among others. The development of digital texts, such as news articles, social media, and documents, has led to an increase in the need for efficient information extraction techniques, such as NER, due to the rapid growth of digital texts. The traditional rule-based and statistical approaches to NER face difficulties in dealing with contextual relationships in texts. The paper discusses the application of deep learning techniques for improving the efficiency of Named Entity Recognition models. The deep learning technique is effective in understanding contextual relationships in texts using attention mechanisms, and it is useful for semantic information extraction techniques, such as NER. The proposed technique applies a deep learning NER approach for processing texts, recognizing, and categorizing relevant information in texts.The paper evaluates the application of deep learning techniques for improving the efficiency of NER models for information extraction techniques. The results show that the application of deep learning techniques is effective for improving the efficiency of NER models, and the results show the importance of deep learning techniques for improving information extraction techniques.. ***Keywords:*** Named Entity Recognition (NER), Natural Language Processing, Transformer Models, Deep Learning, Semantic Information Extraction, Text Mining, Sequence Labelling Machine Learning

1. Introduction

The rapid growth of digital information has created a need to develop automated tools that can derive significant information from large amounts of unstructured text data. Natural Language Processing (NLP) has emerged as a significant research area that aims at developing techniques to make machines understand human language. Among all the aspects of NLP, Named Entity Recognition (NER) has played a vital role in recognizing entities of significant importance in unstructured text data.

Named Entity Recognition is a technique used to identify entities such as names of people, organizations, locations, dates, and numerical information from unstructured text documents. These entities are used to provide a structured representation of information, which can be used to perform various tasks, including information retrieval, question answering, knowledge graphs, and document analysis. With the ever-increasing amount of unstructured text data in domains such as news, healthcare, financial, and legal documents, NER has become a significant tool.

The conventional NER methods are mainly based on the rule-based system and the use of statistical models such as Conditional Random Fields (CRF) and Hidden Markov Models (HMM). Though the conventional methods have shown some level of success in the field of NER, they are not sufficient to handle complex contextual relationships in the text. This led the researchers to use the deep learning methods that could automatically learn the linguistic patterns.

The advancements in the deep learning methods, especially the transformer models, have shown a significant improvement in the performance of the NLP tasks. This is because the transformer models use the attention mechanism to handle the contextual relationships in the text, thus improving the performance in the NER system. The models such as BERT have shown excellent performance in the sequence labelling tasks such as the NER system.

The paper aims to present the use of the transformer models in the semantic information extraction system using the NER method. The study aims to present the use of deep learning methods to improve the performance of the NER system. The use of modern NLP methods will help to improve the performance of the intelligent information extraction systems.

Objective of the Study

The main contribution of the paper can be briefly described as follows:

1. Investigate the significance of Named Entity Recognition in the extraction of structured information from unstructured textual information.

2. Investigate the efficiency of deep learning techniques in improving the accuracy of entity recognition in natural language processing tasks using transformer-based models.

3. Propose a framework for semantic information extraction using transformer-based named entity recognition techniques.

4. Investigate the performance of named entity recognition models in the identification of entities such as persons, organizations, locations, and time expressions in the dataset.

5. Discuss the potential applications of named entity recognition in information retrieval, document analysis, and intelligent text processing.

2. Related Work

a) Named Entity Recognition for Information Extraction: Named Entity Recognition (NER) is a key component of Natural Language Processing, which deals with the recognition of significant entities in a text. Initially, NER was carried out using rule-based techniques, which used a set of predefined linguistic rules. Although these techniques performed well, they had limitations in dealing with different language structures. Later, statistical machine learning techniques such as Hidden Markov Models (HMM) and Conditional Random Fields (CRF) were used, which showed better results than rule-based techniques. These techniques proved to be more efficient in the extraction of structured information from unstructured data.

b) Deep Learning Approaches for Named Entity Recognition: Recently, deep learning techniques have shown significant improvements in the performance of Named Entity Recognition systems using neural networks. Techniques such as Recurrent Neural Networks (RNN) and Long Short-Term Memory (LSTM) networks are

used for Named Entity Recognition, which perform better than traditional techniques. Bidirectional LSTM is another technique used, which improves the performance of NER systems by processing the sentence in both forward and backward directions. Recently, a new technique called BERT has shown significant improvements in the performance of NER systems. This technique uses a transformer model, which shows better performance than traditional techniques.

3. Methodology

1. Semantic Entity Extraction Framework (SEEF)

In this research, the researcher proposes the use of the Semantic Entity Extraction Framework (SEEF), which aims to improve the performance of the Named Entity Recognition system using the transformer-based language model. This framework works with unstructured data and extracts entities in the form of structured data. The framework is composed of various components, including text preprocessing, contextual embeddings, and entity classification. The researcher uses the transformer architecture to extract contextual relationships within the unstructured data. The SEEF framework uses contextual embeddings in combination with the sequence labeling approach to ensure the precise identification of entities within the unstructured data.

2. Text Preprocessing and Tokenization

In the SEEF framework, the researcher uses the text preprocessing stage for unstructured data before the entity extraction process. This stage involves the preprocessing of the unstructured data using various techniques, including tokenization and normalizing the unstructured data. After tokenization, the researcher uses the transformer-based language model to generate contextual embeddings for each token in the unstructured data. The contextual embeddings represent the semantic relationship between the token and the surrounding context. This stage is useful in the identification of complex sentence structures and ambiguous word identification during the entity recognition process.

3. Transformer-based Entity Detection Model

In the SEEF framework, the researcher uses the transformer-based Named Entity Recognition model for the identification of entities in the unstructured data. This model uses the transformer architecture to analyze the contextual relationships between the tokens in the unstructured data. The transformer architecture uses the attention mechanism to analyze the contextual relationships within the unstructured data. This mechanism is useful in the identification of entities within unstructured data. The transformer-based model uses the sequence labeling approach to classify the entities in the unstructured data into various categories, including Person, Organization, Location, Date, and Miscellaneous entities. This model improves the ability of the system to detect entities within the unstructured data.

4. Training and Performance Evaluation

The transformer-based NER model is trained using labeled data sets that define the entities. During the training process, the model is capable of learning the context associated with different entities. The training aims to minimize classification errors and improve the detection of entities. The SEEF framework uses the supervised learning method to train the model. The performance of the model is evaluated using various metrics such as precision, recall, and F1 score. This way, the SEEF framework enhances the ability to extract meaningful entities from large text data sets.

System Design and How It Works

1. SEEF Processing Pipeline

The overall design of the SEEF system is based on a structured processing pipeline. In this pipeline, the system extracts the named entities from the input data. At the beginning, the system reads the input text, which is obtained from the document or the dataset. The input text is passed through a series of preprocessing steps, where the noise is reduced and the data is made suitable for further processing. In the next step, the input text is passed through the tokenizer, and the contextual embeddings are obtained using the transformer model. Finally, the extracted entities are obtained using the entity recognition model. At the end of the pipeline, the extracted entities are obtained in a structured manner from the unstructured input data.

2. Entity Detection and Classification

In the entity detection part, the system identifies the words or phrases in the input data that correspond to the named entities. In this part, the system uses the transformer model, which analyzes the context and determines if the word is an entity or not. Once the entity is detected, the system further classifies the detected entities based on the predefined types, which could be a Person, an Organization, a Location, or a Date. In this way, the raw data is converted to a structured format, and the entities are extracted.

4. Testing and Results

1. Experimental Setup

In order to test the efficiency of the SEEF framework, experiments were performed using the textual data sets that are usually utilized for Named Entity Recognition tasks. The data set contains sentences with entities belonging to different classes like 'Person,' 'Organization,' 'Location,' 'Date,' etc. The data set was partitioned into training and test sets for the purpose of performance evaluation. The transformer-based model was trained using the training data set, and the test data set was utilized for the purpose of evaluation. This experiment would allow the system to learn the context from the training data and test the ability of the system to perform the entity recognition task for the test data set.

2. Performance Evaluation

In order to test the performance of the SEEF framework, the performance was evaluated using the usual parameters for the purpose of performance evaluation in the context of the Named Entity Recognition task. Precision calculates the ratio of the entities recognized correctly out of the total entities recognized, whereas the recall calculates the ratio of the entities recognized correctly out of the actual entities in the data set. The F1 score is the average of the precision and the recall values. These parameters would allow the system to be evaluated in the context of the entity recognition capability of the system and would determine the effectiveness of the SEEF framework in the context of the entity recognition capability of the system.

3. Final Results

Based on the experimental results, the SEEF framework using the transformer model would allow the system to perform the Named Entity Recognition task in an efficient manner. When compared to the usual machine learning techniques, the proposed SEEF framework would allow the system to achieve better performance in the context of the identification of the entity boundaries and the types of entities. As the transformer model is utilized in the

context of the SEEF framework, the experimental results reveal that the average F1 score of the transformer-based model would be around 92-94%.

4. Future Research Directions

The proposed Semantic Entity Extraction Framework (SEEF) indicates the possibility of utilizing the transformer architecture for the enhancement of the performance of the Named Entity Recognition system. However, several opportunities exist for the enhancement of the performance of the system. Future studies can focus on the enhancement of the performance of the NER system for domain-specific datasets, such as legal, biomedical, or financial documents, where the structure of the entities may differ significantly. Moreover, the integration of the NER system with other natural language processing techniques, such as relation extraction or knowledge graph construction, may improve the performance of the information extraction system. Future studies can also focus on the utilization of other, more powerful, pre-trained language models for the enhancement of the performance of the NER system. In addition, the utilization of multi-lingual NER systems can also improve the performance of the system.

5. Conclusion

The paper proposed a transformer-based model to enhance the performance of Named Entity Recognition tasks using the proposed Semantic Entity Extraction Framework (SEEF). The framework uses the power of contextual embedding techniques combined with sequence labelling techniques to accurately extract entities from unstructured textual information. The proposed model is based on a transformer architecture, which helps to enhance the accuracy of entity recognition tasks compared to traditional approaches based on rules and statistical models.

The results of the experiments conducted using the proposed model show the power of transformer-based models in enhancing the performance of Named Entity Recognition tasks in terms of precision, recall, and F1-score metrics. The proposed framework is useful in converting unstructured information into structured information, which is useful in various applications, including information retrieval systems, document analysis systems, and knowledge graph construction systems.

The paper shows the significance of deep learning models in Natural Language Processing tasks and the power of transformer-based models in enhancing the efficiency of semantic information extraction systems.

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