Research on the Construction of Teacher's Classroom Speech Portrait in Classroom Based on Mathematical Modeling Based on Deep Learning

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Abstract. Teacher's classroom speech has a significant impact on students' learning experience and teaching effect, and is the key to connect mathematical knowledge with practical problems. Firstly, the traditional analysis method of teachers' classroom speech, the application status of deep learning in education, the research progress of teacher portrait and the text classification research based on deep learning are summarized. Then, according to the role function of teacher speech, the classroom speech is divided into eight dimensions, and the convolutional neural network (CNN) and recurrent neural network (RNN) model are used for classification research. By collecting and preprocessing the recorded data of multiple mathematical modeling classes, the classification model based on deep learning and training was researched and trained, and the effectiveness of the model was verified through experiments. Finally, the research also discusses how to use the obtained speech classification data to generate teachers 'classroom speech portrait, and shows the distribution of different teachers' speech through visual means.

Keywords: deep learning; teacher classroom speech; mathematical modelling; classroom speech portrait

1. Introduction

In today's rapidly developing information society, mathematical modeling, as a bridge connecting mathematical theory and practical application, is becoming more and more important. Mathematical modeling teaching can not only cultivate students 'mathematical literacy, but also exercise students' logical thinking, innovation ability and the ability to solve complex problems. Teachers 'speech in the mathematical modeling class is the key factor affecting students' learning experience and teaching effectiveness. Effective classroom speech can not only convey knowledge, but also stimulate students' thinking, guide students to explore the unknown, and promote the communication and

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cooperation between students. In mathematical modeling teaching, teachers' words need to be more enlightening and guiding, and to help students to establish the connection between mathematical knowledge and practical problems. In addition, the teacher's words can also affect the classroom atmosphere, to mobilize the enthusiasm of students to establish a positive interactive relationship between teachers and students. Therefore, it is of great significance to study the role of teachers 'classroom speech in mathematical modeling teaching to improve the teaching quality and students' learning effect.

In order to deeply understand and optimize the teacher's speech behavior in the mathematical modeling classroom, this study proposes the goal of constructing the classroom speech portrait of the mathematical modeling teachers based on deep learning. By applying deep learning technology, we can automatically analyze and classify teachers' classroom speech, so as to reveal the patterns and characteristics of speech behavior. This research objective can not only help us to more accurately evaluate the teaching effect of teachers, but also provide teachers with personalized suggestions for teaching improvement. In addition, the construction of teacher classroom speech portrait can also promote the professional development of educational decision-makers and teachers, and promote the innovation of mathematical modeling teaching methods and the improvement of teaching quality.

2. Research review

2.1. The traditional analysis method of teachers' classroom speech

Traditional teacher classroom speech analysis methods include linguistics, discourse, functional and situational analysis. However, these methods suffer from some drawbacks. First, they are often limited to a specific analytical perspective, ignoring important information in other aspects, resulting in a comprehensive understanding of teachers' words. Secondly, the subjective experiences and preferences may influence the analysis results, leading to subjectivity and one-sidedness. In addition, in order to simplify the analysis process, the complexity of teachers' speech is often simplified, ignoring its rich connotation and multiple functions. Finally, some methods lack sufficient empirical support, making the reliability and validity of the analytical conclusions questionable. In the 1990s, with the rise of artificial intelligence, machine learning-based algorithms focused more on improving the promotion of algorithms compared with traditional rule-based algorithms (Gonzalez-Carvajal & GarridoMerchan, 2020).

2.2. Current application status of deep learning in the education field

As an important branch of artificial intelligence, deep learning has been widely used in education in recent years. Deep learning technology has the ability to process

large amounts of data and automatically learn features from them, giving it great potential in text analysis, speech recognition, image processing, and more. In educational research, deep learning is used to analyze learners' interactive data, predict learning outcomes, and personalized recommend learning resources, etc. In particular, in classroom speech analysis, deep learning models such as convolutional neural network (CNN) and recurrent neural network (RNN) are used to automatically classify and identify teachers' speech patterns.

2.3.Progress in the research on teacher portraits

Teacher portrait aims to construct a model of teachers 'teaching characteristics by collecting and analyzing teachers' teaching behavior data. With the development of big data technology, teacher portrait research began to integrate a variety of data sources, such as teaching video, learning management system data, student evaluation, etc., in order to comprehensively describe the teaching style and effect of teachers. The application of deep learning technology makes it possible to extract teacher portraits from complex data, which improves the accuracy and practicability of the portraits. Yu Fang and Liu Yanshen (2019) use mathematical statistics, classification, clustering, class, association and regression algorithms to establish teacher portraits, and the dimensions of the portrait mainly focus on personal characteristics, teaching level, research interest, academic circle and research track. Dong-ping liu (2022) collected the classroom teaching video data, using TPACK-Map method, lag sequence analysis, cognitive network analysis to build the teacher portrait, the portrait visualization presents the teachers 'professional learning situation, further enrich and develop the knowledge visualization theory, make it more accurate and effectively provide reference for teachers' professional learning. In general, the research of teacher classroom speech portrait based on deep learning has made many attempts. Deep learning has become an important booster for the application of technology, and artificial intelligence technology provides support and conditions for the formation of teachers' speech portraits.

2.4.Text classification research based on deep learning

In education, text classification based on deep learning has been widely used. Kim (2014) combined the convolutional neural network (CNN) model with short text information and proposed the Text CNN model. Although the convolution and pooling layer of this model were only monolayer, it showed ideal results in the classification experiment of short text. Liu, Qiu, and Huang (2016) integrated the recurrent neural network (RNN) model into the multi-task framework, improved the long and short-term memory network (LSTM) method through the information sharing mechanism, and proposed a typical Text RNN model. The model integrates all relevant tasks into a joint system and achieves high accuracy in extracting the semantics of short text. However,

the study found that a single algorithm model does not cover all disciplines in the educational field. Therefore, the CNN, model and RNN model were selected for this study to construct a teacher classroom speech classification system based on deep learning.

3.Mathematics teacher classroom speech classification

Each teacher shows a unique teaching style, so their speech content presents a diversity. In order to analyze the teacher's classroom speech, we need to classify speech. In past studies, Wu Kangning et al. (1994) divided teachers' classroom speech into five types: "question, reply, request, evaluation and other" based on the role function of speech. Liang Xingjing (2007) divided teachers' classroom speech into five categories: descriptive, narrative, descriptive, explanatory and evaluative, based on the interaction between teachers and students. Liu Junjun (2014) divided teachers' classroom speech into six categories: feedback, motivation, inspiration, questions, statements and instructions. Ye Lijun and Zhao Yating (2022) selected classroom teaching behavior, teachers 'teaching speech behavior, teacher's classroom teaching feedback behavior and classroom teaching waiting behavior as the starting point, and divided teachers' classroom speech into six categories: commitment, imperative, affirmation, inquiry, announcement and expression. Therefore, from different perspectives, there are differences in the types of teachers' classroom speech from different perspectives. In this study, when constructing the classification model of teachers 'classroom speech, the classification of teachers' speech in relevant literature can be divided into eight dimensions: Encouragement, Inspiration, Explanatory, Explanatory, Logicacity, Inquiry, Summary,Management and Structure. As shown in Figure 1.

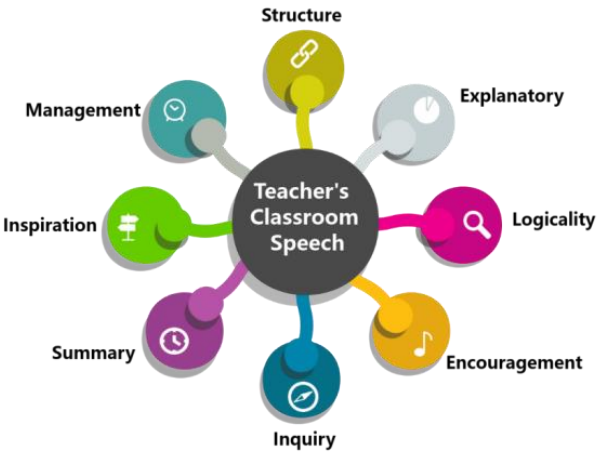


Figure1. Eight dimensions of teachers' classroom speech

4. The generation of the teacher's classroom speech portrait

4. 1. Construct teachers' classroom speech classification model

For these eight dimensions, deep learning technology is used to automatically classify teachers 'classroom speech, with deep learning as the core, and comprehensively analyzing teachers' speech behavior. The framework will include the steps of the collection, preprocessing, feature extraction, model building, and evaluation of classroom speech. First, the objectives and classification criteria of classroom speech analysis were clarified to ensure the direction and systematization of the research. Secondly, the feature extraction method of classroom speech is designed to capture the key information of teachers' speech. Finally, an evaluation system was constructed to quantify the performance of the analytical model.

4.2. Collection and pre-processing of mathematical modeling class records

This study will collect transcript data from multiple mathematical modeling classes, including video, audio, and text recordings. The collected data will be strictly preprocessed to improve the accuracy and efficiency of the subsequent analysis. Preprocessing steps include noise removal, text transcription, statement segmentation, vocabulary standardization, etc. Furthermore, all data will be anonymized to protect privacy. More than 8000 statements were generated, and the data sets were manually annotated according to the classification criteria.

4.3. Classroom speech classification model based on deep learning

Based on the pre-processed data, this study will construct a classroom speech classification model based on deep learning.

(1) Convolutional Neural Network (CNN) model

The CNN model will be used to extract and classify the local features of classroom speech. Through the stacking of convolutional layer and pooling layer, the model can automatically learn n-gram features and part of speech features in classroom speech, providing support for classification.

(2) Cyclic neural network (RNN) model

RNN model, especially its variants LSTM (long and short-term memory network) and GRU (gated cycle unit), will be used to process the time series characteristics of classroom speech (Hou Xueliang, Shan Tengfei Shan, Xue Jingguo, 2022). The RNN model can capture the long-distance dependencies in speech and help to understand the dynamic changes in teacher speech.

4.4. Experiments

(1) Experimental design: model training, verification and testing

Experimental design will follow a strict scientific approach. Training of the model will be performed on the pre-processed dataset using cross-validation to assess the stability and generalization ability of the model. During training, the hyperparameters of the model such as learning rate, batch size, and iterations will be adjusted to achieve optimal performance. The validation set will be used for model selection and hyperparameter tuning, and the test set will be used to ultimately evaluate the performance of the model. The evaluation index will include the accuracy, the recall rate, the F1 score, etc., to comprehensively measure the classification effect of the model.

(2) Data preprocessing: text cleaning, word segmentation, and feature extraction

The first step in research implementation is pre-processing the collected transcript text of mathematical modeling. Text cleaning involves removing irrelevant characters, punctuation marks, and stop words, as well as correcting transcription errors to ensure the quality of the data. Subsequently, the word segmentation technology is used to cut the continuous text into meaningful word sequences to lay a foundation for feature extraction. In the feature extraction stage, methods such as word bag model, TF-IDF weight, and word embedding vector are used to transform the text into numerical feature vectors that can be used for deep learning models. In addition, considering the context relevance of classroom speech, techniques such as N-gram model and part-of-speech annotation are also used to capture richer language features.

(3) Model training: the training process of CNN and RNN model

After feature extraction, the next work is to train the CNN and RNN models. The training of CNN model focuses on automatically extracting the local features of classroom speech through the convolutional layer, and reducing the spatial dimension of the features through the help of the pooling layer and enhancing the generalization ability. During model training, the hyperparameters such as the number, size and step size are adjusted to achieve the best classification effect. The RNN model, especially LSTM and GRU, effectively avoids the gradient disappearance problem in long sequence training through its gating mechanism and maintains sensitivity to classroom speech time series. When training the RNN model, the paper focuses on adjusting the number of neurons, learning rate, and sequence length in the hidden layer, and the temporal data of teacher speech is used for supervised learning.

4.5. Experimental results and analysis

(1) Experimental results and analysis

Teachers can stimulate students' potential and learning enthusiasm through a variety of verbal teaching strategies. For example, teachers can enhance students' confidence and activate the classroom atmosphere by expressing appreciation and encour-

agement. In addition, teachers can ask guiding and enlightening questions to help students deepen their understanding of knowledge. Teachers can also encourage students to work in groups and actively communicate in class to increase their interest in learning. At the end of the course, teachers can summarize the knowledge they have learned and help students establish a clear knowledge system. In the course of teaching, the teacher's explanation is the key link to help the students master the knowledge. At the same time, teachers can also use logical language to reveal the essence of concepts through definitions and principles, so as to help students to build a mathematical knowledge structure in their thinking. In terms of classroom management, teachers need to properly maintain the classroom order to ensure the smooth progress of teaching activities. Finally, the teacher's words should also reflect the connection between the knowledge points, which is in line with the requirements of the new curriculum standard for the knowledge structure, and helps to strengthen the coherence of the course content. After text training, the drawing accuracy (Accuracy) of CNN model is 83.89%, and the drawing accuracy of RNN model is 81.86%. The specific classification results are shown in Figure 2 and Figure 3.

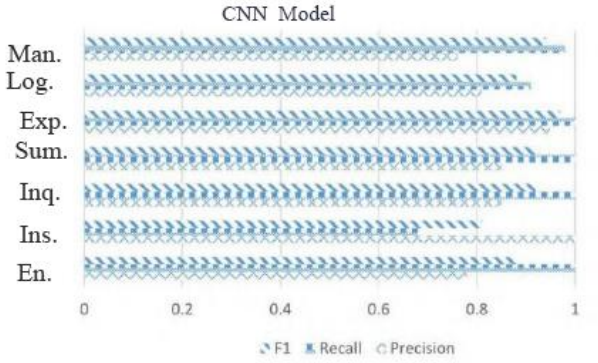


Figure2. Experimental classification results of CNN model

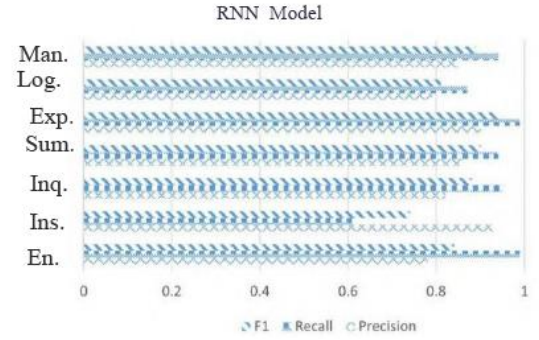


Figure3. Experimental classification results of RNN model

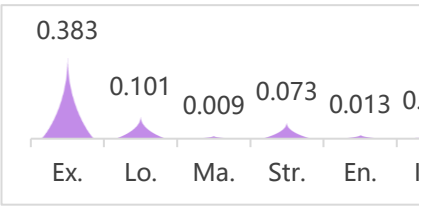
In the comparison of model accuracy, the CNN model showed high accuracy in multiple classification tasks, especially when distinguishing between explanatory and logical speech. In contrast, the RNN model performs better in identifying time-series features of speech, especially in analyzing coherent enlightening and exploratory speech. The difference in accuracy between the two models suggests that the combined use of CNN and RNN models allows a more comprehensive analysis of teacher classroom speech.

(2) Portrait generation

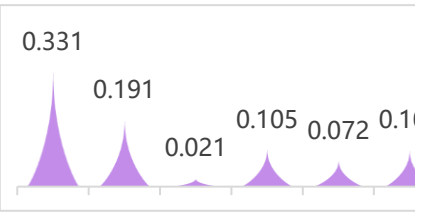
The core driver of portrait visualization comes from a series of data generated by teachers in the classroom, which needs to show the specific speech distribution of teachers through a matching visual interface. A class speech corpus was randomly selected from 10 mathematical modeling teachers from Double Top University, 211 University, General And Private University, and then CNN and RNN models were used to automatically classify the speech of the teachers in these 10 classes（Table 12 shows this）. In order to more clearly present the distribution of speech more clearly, these data will show the specific proportion of each dimension of speech in the form of cluster map. Specific distribution structure (see Figure 4).

Table1 The proportion of each dimension of teachers' classroom speech

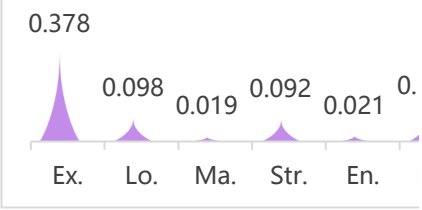
Name	Dimensions							
	Exploratory	Logicality	Management	Structure	Encouragement	Inspiration	Inquiry	Summary
Portrait 1 (Double top University)	0.383	0.101	0.009	0.073	0.013	0.033	0.109	0.279
Portrait 2 (211 University)	0.331	0.191	0.021	0.105	0.072	0.103	0.011	0.166
Portrait 3 (211 University)	0.378	0.098	0.019	0.092	0.021	0.105	0.063	0.224
Portrait 4 (Private University)	0.424	0.128	0.037	0.011	0.105	0.011	0.008	0.276
Portrait 5 (General University)	0.347	0.163	0.034	0.056	0.058	0.097	0.053	0.192
Portrait 6 (Private University)	0.424	0.008	0.066	0.023	0.121	0.004	0.067	0.287
Portrait 7 (General University)	0.299	0.191	0.027	0.058	0.021	0.095	0.087	0.222
Portrait 8 (Private University)	0.434	0.008	0.074	0.062	0.076	0.026	0.088	0.232
Portrait 9 (Double top University)	0.294	0.235	0.002	0.065	0.016	0.099	0.193	0.096
Portrait: 10 (General University)	0.394	0.072	0.038	0.092	0.041	0.043	0.113	0.207



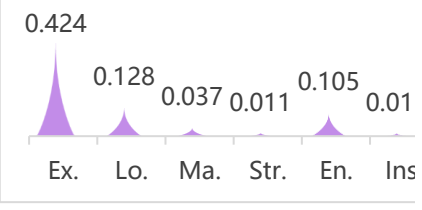
Portrait 1 (Double top University)



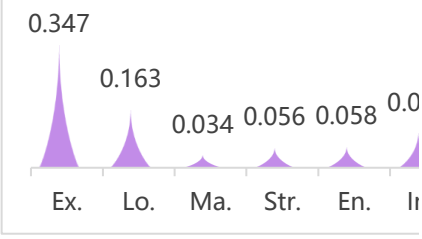
Portrait 2 (211 University)



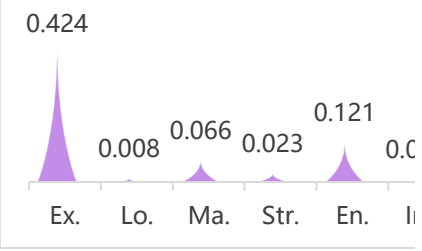
Portrait 3 (211 University)



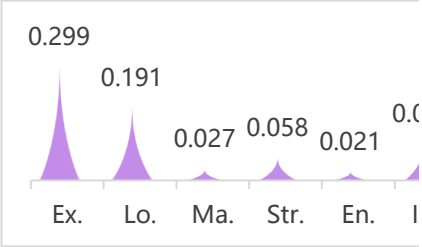
Portrait 4 (Private University)



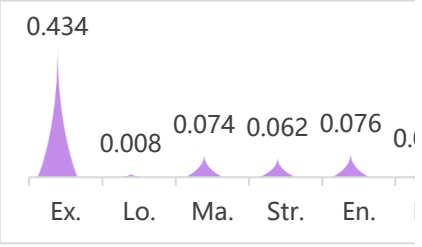
Portrait 5 (General University)



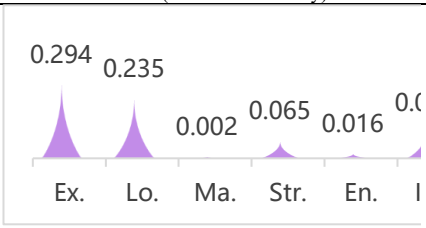
Portrait 6 (Private University)



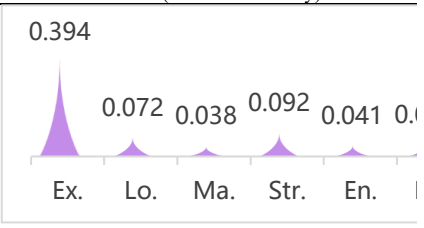
Portrait 7 (General University)



Portrait 8 (Private University)



Portrait 9 (Double top University)



Portrait: 10 (General University)

Figure 4. Cluster diagram of class speech category distribution of 10 mathematical modeling teachers

From the above 10 teachers on the distribution of speech profile dimensions, double first-class university less use classroom management words, and private university use classroom management language more, at the same time private university explaining language and summative words, classroom to the teacher explanation and summarized directly to students as the main line, and double top university more logical speech and inspiring words to guide students to thinking and induction. In terms of encouraging language, private college students should be encouraged, while most students in 211 universities and first-class universities can learn and think independently, and do not need verbal encouragement from teachers.

5. Conclusion

Teacher speech portrait provides a new perspective and tool for teaching practice. By analyzing teachers' verbal behavior, educators can better understand the dynamic changes in the teaching process, thus adjust teaching strategies and improve teaching quality. Deep learning models, particularly the CNN and RNN, have been shown to be effective in teacher classroom language analysis. These models are able to process large amounts of classroom speech data and from which learn features that contribute to classification. The overall accuracy of convolutional neural network model (CNN) and recurrent neural network (RNN) is 83.89% and 81.86%, respectively, and the accuracy of both models is more than 81%, which proves that the method of using deep learning algorithm to analyze teachers' classroom speech can be promoted. By constructing teachers 'classroom speech portrait, we get the distribution of teachers' speech in class, which provides a reference for teachers to use speech more standardized in the future. Despite the modest results of this study, some limitations remain. For example, current models may need to be adapted and optimized for a specific discipline or teaching settings. Future research can be explored in the following directions: first, to further optimize the classification performance of the model, especially when processing larger and more diverse data sets, and second, to study how to better link teacher speech portrait with students' learning results.

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