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Research on Optimizing the Language and Culture Communication Path of Chinese International Education Platform Using Deep Neural Network Algorithm in New Media Framework

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Abstract The rapid development of new media technology has increased the complexity of predicting the communication effects of language and culture in Chinese international education. This paper combines the Necessary Condition Analysis (NCA) and Qualitative Comparative Analysis (QCA) methods to identify the necessary conditions and combinations of conditional factors that affect the dissemination effect of short videos on language and culture in Chinese international education. A temporal convolutional network (TCN) is constructed to realize the prediction of communication effects of short videos in the new media framework. A multilayer deep time convolutional extended residual network network structure (MDTCNet) is proposed to optimize the prediction accuracy with respect to the prediction lag of TCN. The results show that the condition of "content theme" simultaneously satisfies the efficiency measure d > 0.2, with a p-value of <0.05, and the consistency index is 0.848, close to 0.85, which is a necessary condition for the high-quality dissemination of short videos about language and culture in Chinese international education. The existence of three combinations of conditional factors has strong explanatory strength for the dissemination effect. The improved MDTCNet model propagates heat prediction error of no more than 0.1 with an R^2 score of 0.88 for its prediction. The value is closer to the real value. Using the MDTCNet model to process the short video related condition data can effectively improve the prediction accuracy of the dissemination effect of language and culture short videos in Chinese international education.

Index Terms necessary condition analysis, qualitative comparative analysis, multilayer deep time convolutional network, dissemination effect prediction, Chinese international education

I. Introduction

The discipline of Chinese language international education has been developing rapidly, promoting Chinese language and culture to the world, becoming an important way of language and culture exchange at home and abroad, and exposing numerous Chinese learners to the rich content of Chinese language and Chinese culture [1], [2]. Chinese language international education is a communication activity that spreads Chinese language and Chinese culture to Chinese learners in the international arena by means of various communication media, Chinese language teaching and Chinese cultural activities, etc., and ultimately achieves a certain effect [3]-[5]. Nowadays, there are still some problems in the communication process of Chinese language international education, such as unsatisfactory communication effect of Chinese language international education, obsolete content of some communication, insufficient utilization of communication media, etc., which affect the healthy development of Chinese language international education [6]. In addition, under the background of the new era, in the face of the increasing demand for Chinese language learning, Chinese language international education needs to provide a higher level of language teaching, carry out richer language and culture communication activities, and enhance the influence of Chinese language international education [7], [8]. In this context, the use of media technology in education can meet the needs of students to receive targeted teaching services and make full use of the fragmented time outside the classroom for effective learning.

New media has become one of the main communication media in modern times by virtue of its efficient transmission rate and convenient use, and has been widely used in various fields, among which the application of new media to the field of teaching plays a driving role in the change of teaching methods [9]-[12]. The application of new media in Chinese language international education has enriched the teaching content of Chinese language international majors, deepened students' understanding and learning of specialized contents, and provided great assistance for the cultivation of composite bilingual talents [13]-[15]. At the same time, with the help of the new

media platform, Chinese international teachers can break the time and space limitations that exist in traditional teaching, make the teaching time more flexible, meet the students' demand for learning with fragmented time, so that students can listen to the difficult points and key points of the course repeatedly and better understand the professional content [16]-[19]. Along with the increasingly wide application of new media in teaching, its various auxiliary teaching functions have been gradually developed, and the majority of students have gradually accepted and like to use new media to search for learning materials and learning [20], [21].

This paper integrates causal inference methods and deep learning techniques to systematically optimize the accuracy of effect prediction of language and culture short video dissemination on Chinese international education platform. A hybrid method of Necessary Condition Analysis (NCA) and Qualitative Comparative Analysis (QCA) is used to find the laws of necessary conditions and condition combinations that affect the dissemination effect. Based on the results of causal condition analysis, the traditional TCN model is introduced to predict the communication trend and effect. Aiming at the lag problem of TCN model in prediction, MDTCNet model is proposed to improve the accuracy and timeliness of prediction. Specifically, the long time-series dependency capturing ability is enhanced by introducing multilayer null convolution with residual jump connection. And the multilayer perceptron is used instead of linear regression to enhance the efficiency of nonlinear feature fusion. Comparing the model prediction effect before and after the improvement, we analyze the optimization of the prediction effect of MDTCNet model.

II. Research methodology and variable setting

This chapter mainly analyzes two research methods, the New Method of Necessary Condition Analysis (NCA) and the Qualitative Comparative Analysis (QCA) method. It also sets appropriate conditional variables for the characteristics of the two methods as well as the linguistic and cultural communication features of the Chinese international education platform under the new media framework.

II. A. Research methodology and data construction

II. A. 1) Hybrid NCA and QCA approach

Necessary and sufficient causation are two emerging explanations of causation; necessary conditional causation means that the outcome does not occur in the absence of a particular antecedent, while sufficient conditional causation means that the antecedent (combination) is sufficient to produce the outcome. In order to better analyze the necessary and sufficient causation in this study, this study integrates the new method of necessary condition analysis (NCA) and complements the qualitative comparative analysis (QCA) method, which is superior in sufficient causation analysis. For one thing, the use of the NCA method can identify the necessary insufficient conditions that affect the linguistic and cultural communication effects of Chinese international education platforms. Compared with QCA, which only qualitatively identifies the necessary relationship between antecedents and outcome variables, NCA not only identifies, but also quantitatively demonstrates the extent to which antecedents are necessary for the outcome variables. Secondly, the qualitative comparative analysis (QCA) method is based on the idea of grouping, and one of the main methods is Boolean algebra and set theory, i.e., it assumes that the variables are interdependent and play a role in each other, and it is capable of exploring the “chemical reaction” formed by the combination of the independent variables instead of the independent effect, which combines the advantages of both qualitative analysis and quantitative analysis.

II. A. 2) Data sources

This paper takes the 15 journals related to language and culture communication of the Chinese International Education Platform included in 2022-2023 as samples, and the basic data are all derived from the WeChat public number data of the 15 academic journals, and the statistical starting and ending time is from January 1, 2022 to December 31, 2023, and the impact factor of this paper (the impact factor referred to in the text is TIF impact factor) is selected from the “2022 Chinese The impact factors of this paper (all the impact factors mentioned in the text are TIF impact factors) are selected from the “2022 Annual Report of Impact Factors of Chinese Academic Journals (Humanities and Social Sciences).

II. B. Design of study variables

II. B. 1) Design of Conditional Variables

There are many factors affecting the communication effect of short videos on Chinese international education language and culture, both internal factors of short videos and external factors such as science and technology and cultural policies. Considering that the number of condition variables of QCA method should be appropriate to the number of samples and the availability of research data. In this study, we choose the internal factors of short videos for research, i.e., to study the influencing factors of the communication effects of Chinese international education language and culture short videos from the quality of short videos itself.

At present, there is no fixed analytical framework for the content production of Chinese international education language and culture short videos, and it is impossible to carefully categorize the secondary indicators in the process of selecting conditional variables, which is due to the fact that the theories are broader than the traditional theories of various disciplines that are difficult to cover the emerging social phenomena individually.

After preliminary validation and comprehensive consideration, this study chooses the domestic qualitative comparative analysis methods of "literature induction" and "phenomenon summarization" to complement each other in the design of condition variables for the dissemination effect of short videos on Chinese language and culture in international education. These two methods belong to the "five main methods for determining conditions in QCA research", in which the "literature induction method" refers to selecting and summarizing the main conditions from existing literature or research, and the "phenomenon summarization method" refers to selecting and summarizing the main conditions from the phenomenon itself, while the "phenomenon summary method" refers to selecting and summarizing the main conditions from the phenomenon itself. The "Phenomenon Summarization Method" refers to forming or obtaining credible conditions from the phenomenon itself, which is suitable for the research of such emerging things as short videos. Specifically for this study, by reviewing the relevant studies on short videos, language and culture communication, and qualitative comparative analysis method, we draw on the referable experiences, observe and investigate the specific short video category of short videos on Chinese language and culture for international education, and further refine and summarize the influencing factors of the communication effect of short videos on Chinese language and culture for international education in the framework of new media.

It should be noted that the QCA method requires that the conditional variables should maintain a certain ratio with the number of cases to avoid the complication of the interpretation of the research results. Since the finalized number of cases of Chinese international education language and culture short videos in this paper is 30, considering that the number of conditional variables should be appropriate to the number of samples, the Chinese international education language and culture short videos are divided into 2 levels of short video structure performance and short video intrinsic elements to be analyzed, two QCA operations are carried out, and the relevant connotations in the conditional variables are interpreted with the combination of theoretical experience and relevant literature. Finally, this paper selects the condition variables into 2 categories of short video structure performance and short video intrinsic elements totaling 10 condition variables, including 5 variables of short video structure performance and 5 variables of short video intrinsic elements. Table 1 shows the specific condition variables. In Table 1, the five variables of short video structure performance are: video duration, screen direction, subtitle text, interactive behavior, and release timing; and the five variables of short video intrinsic elements are content theme, emotional connotation, character subject, background music, and narrative technique.

Table 1: Condition variable details

Serial number	Dimensionality	Variable name	Dimensionality	Variable name
1	Short video structure performance	Video duration	Short video intrinsic elements	Content topic
2		Picture direction		Release timeal connotation
3		Caption text		Character subject
4		Interactive behavior		Background music
5		Release time		Narrative technique

II. B. 2) Design of outcome variables

The current research on the dissemination effect of short videos mainly evaluates the dissemination effect of short videos with the data of the number of likes, comments, favorites and retweets of short videos respectively.

The theme of this paper is communication effect, and the cases point to specific short videos rather than short video accounts. The data that visually quantify the communication effect in short videos include the number of likes, comments, favorites, and retweets, and these four playback data of the case samples of short videos on Chinese international education, language and culture belong to the public data, which further ensures the transparency of this study. Therefore, these four data were used to calculate the dissemination effect of Chinese international education language and culture short videos, and as the outcome variables to examine the factors influencing the dissemination effect of Chinese international education language and culture short videos.

From the academic research on the dissemination effect of short videos and its influencing factors, the research on using data to comprehensively evaluate the dissemination effect of short videos adopts methods such as the subjective assignment method and the objective assignment method. Considering the subjective components of the research results, this study chooses the entropy weight method to objectively assign the data weights. The basic idea of entropy weighting method is to determine the data weights according to the magnitude of the variability of

the indicators. By calculating the magnitude of the information entropy, the amount of information contained in a certain assessment indicator can be measured; the smaller the entropy value of the indicator is, the more information it provides, and the greater the objective weights should be assigned; if the entropy value of the indicator is larger, the result is just the opposite. Using the entropy weight method to determine the weights of the indicators for evaluating the dissemination effect of short videos on Chinese language and culture in international education can fully tap the information of objective data, make the evaluation results more accurate and realistic, and avoid the bias brought by human subjective factors. The four indicators of the number of likes, comments, favorites and retweets of 30 short videos on Chinese international education language and culture are calculated according to the steps of the entropy weight method. Firstly, the units of the four data of Chinese international education language and culture short videos were unified, and the original evaluation index matrix was established, i.e., the specific data of the four indexes for each case. Subsequently, the indicator data are standardized and the standardized matrix is converted into a probability matrix. And then the information entropy of each indicator of the number of likes, comments, favorites and retweets is calculated based on the probability matrix after the processing of the indicators. Table 2 shows the information entropy value and information utility value of the four indicators of the case sample. Combining the data in Table 2, it is found that the smallest value of information entropy is the amount of forwarding, 0.786854394, and the largest is the amount of likes, 0.904342340; accordingly, the largest value of information utility is the amount of forwarding, 0.213145606, and the smallest is the amount of likes, 0.095657658.

Table 2: Information entropy and information utility values of samples

Index item	Information entropy	Information utility value
Number of likes	0.904342340	0.095657658
Number of comments	0.873890552	0.126109449
Number of collections	0.835540886	0.164459115
Number of forwarding	0.786854394	0.213145606

Ultimately, the weight of each index is calculated through information entropy, and Table 3 shows the results of the weight coefficients of the amount of likes, comments, favorites, and retweets of the short videos of Chinese international education language and culture. From Table 3, it can be seen that the largest weight is the amount of forwarding, which reaches 0.35561497, and the smallest weight is 0.159596520. From the practical cognitive point of view, the user's forwarding of a certain short video can generally indicate that the content of the user's short video is more recognized, and therefore the dissemination effect is better, with a larger weight. The recognition represented by the number of likes, on the other hand, is the lowest of the four outcome variables.

Table 3: Short video 4 data weights

	Number of likes	Number of comments	Number of collections	Number of forwarding
Weight coefficient Wi	0.159596520	0.210402691	0.274385792	0.35561497

III. Requirements analysis and modeling

This chapter analyzes the conditions affecting the dissemination of language and culture on Chinese international education platforms under the two research methods and the relationship between the conditions and the results. A multilayer deep time convolution model is constructed and improved, and the effectiveness of the model in predicting the effect of language and culture short video dissemination on Chinese international education platform is verified through experiments.

III. A. NCA-based analysis of necessary conditions

The NCA method is able to analyze whether each influencing factor is necessary for the outcome and calculate the effect size of the necessary condition. In this case, the effect size, also called the bottleneck level, represents the minimum level of the necessary conditions required to produce a particular outcome. "The effect sizes (d-values) are between 0 and 1, with larger values representing higher levels, with $0 \leqslant d < 0.2$ indicating a low level of effect, $0.2 \leqslant d < 0.4$ indicating a medium level of effect, and $0.4 \leqslant d < 0.5$ indicating a high level of effect." The results of the analysis also need to refer to the significance P-value, i.e., the Monte Carlo simulation permutation test results show that the effect size is significant. The NCA method can be used with the upper bound regression method (CR) to deal with continuous variables, or discrete and greater than or equal to 5 variables; and the upper bound envelopment analysis method (CE) for discrete variables where both the condition variable and the outcome

variable are dichotomous variables and less than 5 levels. In this paper, two estimation methods, upper bound regression and upper bound envelope analysis, are used to calculate the effect sizes of the 10 conditioning variables.

Table 4 shows the specific analysis results. Taken together, video duration, screen direction, subtitle text, interactive behavior, release timing, emotional connotation, character subject, background music, and narrative technique cannot simultaneously satisfy the efficiency quantity d > 0.2, P value < 0.05, and do not constitute the necessary conditions for producing high-quality communication effects. Only the content theme (d-value of CR method is 0.256, P = 0.009, and d-value of CE method is 0.271, P = 0.004) can simultaneously satisfy the amount of effect d > 0.2, with a P-value of < 0.05, and thus, the content theme is a necessary condition for producing high-quality communication effects. Reflecting that the quality of the pushed content and the chosen theme are still necessary factors to promote the dissemination of Chinese international education language and culture when adopting short-video dissemination, particular attention should be paid to the combination of high-quality content and personalized theme, so as to attract the attention of more viewers.

Table 4: Analysis of necessary conditions based on NCA

Conditions	Method	Precision/%	Upper limit area	Radius	Effect size (d)a	P-value b
Video duration	CR	76.915	183.708	1263.874	0.146	0.028
	CE	100	128.590	1263.874	0.100	0.097
Picture direction	CR	100	1226.552	4985.973	0.243	0.092
	CE	100	2 453.108	4985.973	0.494	0.087
Caption text	CR	100	0.000	586.612	0.000	1
	CE	100	0.000	586.612	0.000	1
Interactive behavior	CR	84.620	334.372	3 109.081	0.109	0.090
	CE	100	389.875	3 109.081	0.124	0.027
Release time	CR	79.884	357.810	339.507	0.133	0.031
	CE	100	339.751	339.507	0.127	0.037
Character subject	CR	100	326.783	589.560	0.106	0.110
	CE	100	355.624	589.560	0.155	0.098
Background music	CR	100	193.701	715.634	0.136	0.074
	CE	100	188.650	715.634	0.157	0.052
Narrative technique	CR	95.221	208.314	636.582	0.124	0.061
	CE	100	215.673	636.582	0.131	0.029
Release timeal connotation	CR	100	1203.335	721.630	0.202	0.071
	CE	100	1307.486	721.630	0.213	0.079
Content topic	CR	69.28	3360.715	5035.267	0.256	0.009
	CE	100	2423.916	5035.267	0.271	0.004

III. B. QCA-based analysis of necessary conditions

III. B. 1) Univariate necessity analysis

In QCA qualitative comparative analysis, whether each condition variable will individually have an effect on the outcome variable, whether it is a sufficient or necessary condition to produce the outcome, etc., is usually measured by Consistency, which here is similar to significance in regression analysis, and is calculated by the following formula:

$$Consistency\left(X_i \le Y_i\right) = \sum\left[\min\left(X_i, Y_i\right)\right] - \sum X_i \tag{1}$$

Firstly, we assess whether the condition constitutes a sufficient condition for the outcome, i.e. if the conditional variable X is a subset of the outcome Y, then the corresponding consistency index should be greater than 0.85, which indicates that the appearance of the conditional variable can lead to the appearance of the outcome; secondly, we assess whether the condition constitutes a necessary condition for the outcome, i.e. if the outcome Y is a subset of the conditional variable X, then the corresponding consistency index should be greater than 0.95. In addition, Coverage reflects the strength of explanation of the given condition or combination of conditions for the outcome. In addition, Coverage is a measure of how well a given condition or combination of conditions explains the outcome, and is given by the following formula:

$$Coverage\left(X_i \le Y_i\right) = \sum\left[\min\left(X_i, Y_i\right)\right] - \sum Y_i \tag{2}$$

Table 5 shows the results of the univariate necessity analysis of the heat of language and culture dissemination in Chinese international education. Analyzing the data in Table 5, the consistency of all the causal variables is less than 0.85, indicating that none of the 10 conditional variables is sufficiently necessary to promote the linguistic and cultural dissemination of the Chinese international education platform. The consistency index of the conditional variable “content theme” is 0.848, which is very close to 0.85, indicating that “content theme” can promote the dissemination of language and culture in international Chinese language education to a certain extent; however, the other causal variables are lower than 0.85, indicating that none of the other variables is sufficient to promote the dissemination of language and culture in international Chinese language education. However, all other variables are lower than 0.85, indicating that the other variables are not enough to promote language and culture dissemination in Chinese international education, and also indicating that a single variable cannot lead to the dissemination results, i.e., the dissemination of language and culture in Chinese international education is often the result of the joint action of a variety of factors rather than a single conditional factor, so it is necessary to analyze the combination of factors to refine the factors contributing to the dissemination of language and culture in Chinese international education through further analysis. Therefore, it is necessary to refine the factors contributing to the spread of language and culture in Chinese international education through further factor combination analysis.

Table 5: Univariate necessity analysis of propagation heat

Variable name	Consistency	Coverage rate
Video duration	0.619	0.459
Picture direction	0.578	0.467
Caption text	0.616	0.456
Interactive behavior	0.539	0.468
Release time	0.537	0.388
Content topic	0.848	0.615
Release timeal connotation	0.697	0.627
Character subject	0.696	0.701
Background music	0.670	0.734
Narrative technique	0.785	0.849

III. B. 2) Conditional factor combination analysis

Based on the above univariate necessity results, fsQCA 3.0 software was utilized to conduct conditional factor combination analysis. Conditional factor combination analysis is similar to univariate necessity analysis in that it also utilizes consistency and coverage to measure the degree to which each combination of conditional factors explains the outcome variable. Based on the results of the analysis, three different sets of solutions were obtained, namely, simple, intermediate and complex solutions. Among the three different analysis results, the complex solution was obtained by analyzing only the grouping of the actual observed instances and did not take into account the logical residuals, therefore, the article analyzes the complex solution.

Table 6 shows the specific results of the complex solution. The original coverage in Table 6 is the proportion of resultant cases covered by that combination of factors, including the coverage of the part explained by overlap between the combinations; the net coverage is the proportion of cases for which the result can only be explained by that combination, after removing the common parts with other combinations; "*" indicates the logical "and", that is, it exists at the same time; "~" indicates that the logical "not", that is, the cause variable does not exist. From Table 6, it can be seen that the complex solution can explain the 30 cases selected in this paper well, because its overall consistency and overall coverage are both 1.0, which is greater than 0.85 and 0.95, indicating that the factor combinations obtained from the selection of the complex solution explain the results strongly. In addition, the consistency of all 10 factor combinations of the complex solution is 1.0. Among them, three more typical factor combinations explain the results more strongly than others. Based on this, this paper obtains three micro-factor combinations that can lead to the spread of language and culture in Chinese international education platforms:

1) Video duration*Picture direction*Content topic*Character subject* Background music*Narrative technique;

2) Picture direction*Content topic*Interactive behavior*Character subject* Background music*Narrative technique;

3)~Video duration*~Picture direction*Content topic*~Interactive behavior* Release time*Character subject*media index.

Table 6: Combination analysis of complex solution condition factors

Serial number	Factor combination	Primary coverage	Net coverage	Consistency
1	Video duration*Picture direction*Content topic*Character subject*Background music*Narrative technique	0.165	0.133	1.000
2	Picture direction*Content topic*Interactive behavior*Character subject*Background music*Narrative technique	0.165	0.129	1.000
3	~Video duration*~Picture direction*Content topic*~Interactive behavior*Release time*Character subject*media index	0.143	0.117	1.000
4	~Video duration*~Picture direction*~Interactive behavior*Release time*Character subject*~Background music*Narrative technique	0.064	0.109	1.000
5	Video duration*~Picture direction*~Caption text*Interactive behavior*Character subject*Background music*~Narrative technique	0.064	0.100	1.000
6	Video duration*Picture direction*Caption text*~Interactive behavior*Release time*Character subject*Background music	0.064	0.095	1.000
7	Video duration*Picture direction*Caption text*Interactive behavior*~Release time*Character subject*Background music	0.105	0.084	1.000
8	Video duration*Picture direction*Caption text*Interactive behavior*Release time*Character subject* Narrative technique	0.105	0.079	1.000
9	~Picture direction*~Caption text*Interactive behavior*~Release time*Character subject*Background music*Narrative technique	0.075	0.077	1.000
10	~Video duration*~Picture direction*~Caption text*~Interactive behavior*~Release time*~Character subject*~Background music*Narrative technique	0.050	0.077	1.000

III. C. Multi-layer deep time-convolution model design

III. C. 1) Multi-Layer Deep Time Convolution Models

Recurrent neural networks and variants are commonly used for temporal sequences, but suffer from gradient explosion/vanishing or memory shortage when dealing with sequences. Temporal Convolutional Network (TCN) is a specialized architecture that has advantages over recurrent networks in prediction tasks.TCN is capable of extracting long-term patterns using dilated causal convolutions and residual blocks and can be more efficient in terms of computation time.The model is constructed based on the convolutional network, which avoids the shortcomings in the recursive model at the same time and allows parallel output, which largely improves the efficiency of sequence processing. Introducing the TCN model into the language and culture communication field of the Chinese international education platform in this study can realize the prediction of the communication effect of related short videos under the new media framework.

The usual idea of time series prediction is to model through historical information and then use it for the prediction of future data. The specific form can be described in mathematical form as:

$$y_{t+1} = f\left(x_1, x_2, \ldots, x_{t-1}, x_t\right) \tag{3}$$

where x_t is a one-dimensional vector containing n features, and y_{t+1} denotes the value of the variable at the next time period to be predicted. The goal of the prediction is to use the historical data information: ($X:\{x_1,\ldots,x_t\}$ and $Y:\{y_1,\ldots,y_t\}$) to fit a relationship function with the f function as optimal as possible to predict the value of the variable in the next time period, then the characteristics of the historical data information determine the

relationship function f with the optimal function. The characteristics of the historical data information determine the optimization relationship between the relation function f and the optimal relation function, and the amount of historical information and the model's ability to learn the historical information directly determine the prediction effect. In this paper, through experiments, it is found that the TCN model has serious lag in predicting the spread of language and culture on the Chinese international education platform, and the prediction accuracy is not satisfactory, and it is found that the reason for the lag is that the model's ability to learn the features is not enough, and for this reason, this paper proposes a multilayered deep temporal convolutional network, and the decomposition of the TCN network is found that it can be roughly decomposed as follows:

$$TCN = 1DFCN + Dilated\ causal\ Conv \tag{4}$$

1) One-dimensional full convolution (1DFCN)

1DFCNN ensures that the input and output sequences are of equal length and maintain equal time steps. Convolutional networks have a better recognition effect on data with simple patterns, especially when the positions in the data segments have a low degree of correlation. 1DCNN can be well applied to analyze signal data with a fixed length of the cycle, such as audio signals, but in the face of the Chinese Language and Culture Dissemination Time Series Data of Chinese Language International Education Platform with complex patterns and uncertainty it is difficult to exert its Recognition effect, so that the extraction of features is insufficient.

2) Null Causal Convolution (DCC)

On the one hand, although the causal convolution in the TCN structure ensures the orderliness of the sequence, it limits its ability to learn long history information, although the expansion causal convolution is used in the TCN structure to solve the problem of learning long history information. The problem of information loss is caused when the expansion convolution kernel is superimposed multiple times: loss of information continuity - not all information is involved in the computation, resulting in the loss of information continuity, which is fatal for sequential data with strong continuity; non-correlation of the data - the For some sequence data with a fixed length of the cycle of the problem can be experimentally selected by the appropriate expansion rate. However, for sequence data with uncertainty or randomness, too large an expansion rate will cause the network to learn non-correlated data features, and too small an expansion rate will cause correlated features to be insufficiently learned, both of which will directly affect the prediction effect.

On the other hand, the hysteresis may also be due to the characteristics of convolutional neural network (CNN) in the TCN structure, because CNN has a restricted sensory field, which makes it difficult to capture long-distance features, and is locally sensitive and globally insensitive. Although the introduction of inflated causal convolution in TCN networks seems to solve this limitation, it only achieves a certain range of global feature learning, and is not as effective in predicting time series in the presence of noise, data fluctuations, or with uncertainty.

In order to maintain the efficiency of CNN in processing sequences, this paper addresses the above problem by improving the learning ability of features in order to reduce the lag of TCN in predicting the spread of language and culture in Chinese international education platform. Inspired by the ResNet network structure, this paper improves the TCN structure to propose a multilayer deep time convolution network structure: a multilayer deep time convolution extended residual network network structure (MDTCNet). Figure 1 shows the specifics of the improved TCN structure. The structure deepens the null causal convolutional layers between hidden layers, improving the ability to extract information between each hide to obtain relatively longer-range and deeper temporal features. This is done for time series with complex patterns, which improves the feature extraction ability to obtain deeper temporal features and dependencies for each time series convolutional segment, and improves the ability to express nonlinear features in non-stationary time series. To solve the problems of insufficient feature extraction in one-dimensional full convolution and loss of continuity and non-correlation of data information in null causal convolution, thus reducing the lag of prediction, and to prevent the gradient from disappearing due to the depth of the network, a jump connection is introduced between each hidden layer.

III. C. 2) Feature Fusion Networks

In this paper, through the decomposition of the TCN network, it is found that: the use of linear regression as the output part of the prediction results in the TCN model, and the use of linear regression as the output part of the prediction results after feature extraction cannot effectively utilize the features extracted by the time convolution network, and especially may cause loss of nonlinear features, resulting in unsatisfactory fitting accuracy for non-smooth time series. In this paper, a multilayer perceptron is used to replace linear regression in MDTCNet to further improve the fusion output of features extracted by multilayer deep time convolutional networks, and to improve the representation of nonlinear features and the ability to deal with the features of non-smooth and uncertain sequence data.

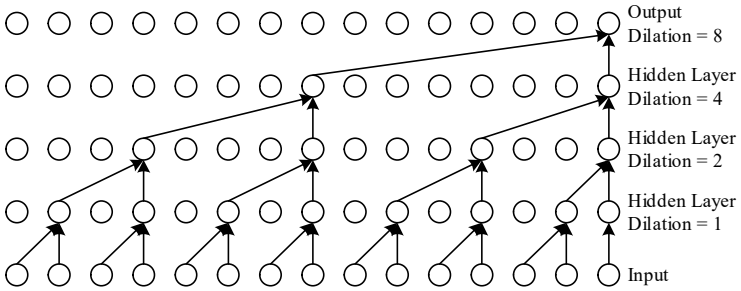

Figure 1: Concrete situation of improving TCN structure

III. D. Analysis of prediction results before and after model improvement

In this paper, the experimental environment is Windows 10 operating system, IntelCorei5-10210U CPU, 2.11 GHz, 16.0 GB RAM. The experimental model is built using Pytorch framework, and the parameters of the MDTCNet model are set: the learning rate lr is 0.002, the kernel size is 6, the dropout is 0.15, the number of iteration cycles is 500, and ReLU is used as the activation function. The experimental data are in daily units, totaling 300 groups after removing outliers and other preprocessing, and the ratio of the training set to the test set is set at 7:3, with 210 groups selected as the training set and 90 groups as the test set according to the principle of randomization. In order to fully verify the superiority of MDTCNet model, TCN and MDTCNet models were trained on the same training set respectively.

Figure 2 shows the TCN model prediction results. Figure 3 shows the MDTCNet model prediction results. On the training set of 300 sets of propagation data, the predicted value curve of the single model TCN is poorly fitted to the true value curve, and the prediction heat error is large. While the MDTCNet model fitting effect is more obvious, and the prediction heat error is not more than 0.1. It shows that the MDTCNet model has better memorization of the information dependence of the long time series, and the information grasping ability is stronger. It verifies the ability of MDTCNet to extract the intrinsic logical relationship of multidimensional data, and the simplified low-dimensional data can more clearly predict the linguistic and cultural dissemination of the Chinese international education platform.

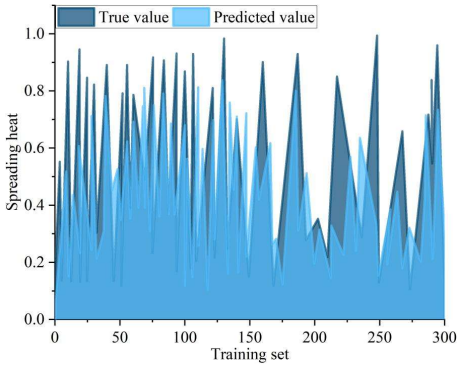

Figure 2: Prediction results of TCN model

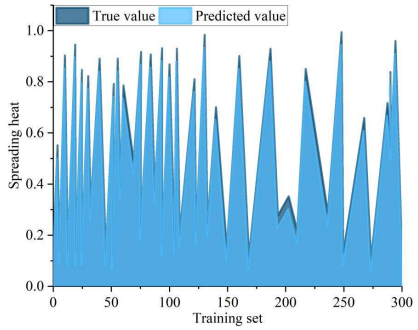

Figure 3: Prediction results of MDTCNet model

To further refine the comparison between the prediction performance of MDTCNet model and TCN model, prediction is performed on the test set. Figure 4 shows the results of the performance evaluation metrics. Figure 4 Performance evaluation results show that MDTCNet has an R^2 score of 0.88 and its prediction value is closer to the true value. Compared with the single model TCN and the improved model MDTCNet, the MAE and RMSE are reduced from 22.08 and 40.19 to 6.17 and 8.96, indicating the effectiveness of the structural improvement.MDTCNet can significantly improve the utilization of communication data, and further achieve the improvement of the accuracy of the prediction of the communication effect of language and culture of the Chinese international education platform.

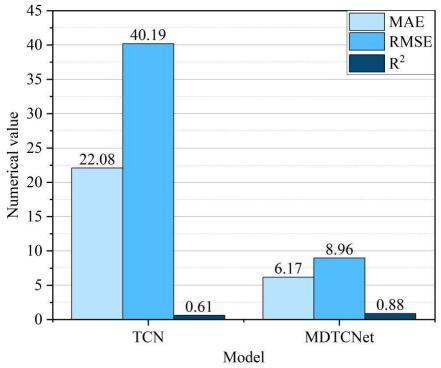

Figure 4: Results of performance evaluation indicators

IV. Conclusion

In this paper, we constructed a hybrid causal analysis and deep learning model to improve the prediction accuracy of the dissemination effect of language and culture short videos on Chinese international education platforms. “Content theme” is a necessary condition for high-quality communication of short videos ($P<0.01$), and the consistency index of the 10 conditional variables does not exceed 0.85, which cannot be taken as a factor to promote high-quality communication of short videos. However, the consistency index of “content theme” is 0.848, which is closer to 0.85, further indicating that this condition plays a very important role in the dissemination of short videos about language and culture on the Chinese international education platform. The prediction error of the improved MDTCNet on the dissemination effect does not exceed 0.1, which has a higher prediction accuracy and alleviates the prediction lag of the TCN model. In the future, we can integrate real-time user feedback data to construct a dynamic communication prediction system to improve the timeliness of prediction.

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