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Integrated models for carbon emission prediction: Combining epidemiology models and statistical forecasting

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Abstract. The topic of our article is Integrated Models for Carbon Emission Prediction: Combining Epidemiology Models and Statistical Forecasting. In this work, we need to combine various epidemiological models from different perspectives, including evolution, application and statistics, to simulate and predict carbon emissions and obtain the results we need. The following content is about the results we have obtained, and its significance lies in predicting and analyzing when and how much carbon emissions will peak in various possible scenarios. Predict the most likely peak time and peak volume from a regional and industry perspective, providing decision-making basis and reference for scientifically and reasonably formulating emission reduction policies. Also, some application in real life of the integrated models is shown in this paper. In addition, the limitations and challenges we face are provided in the article, we are able to consider how to improve the prediction by analyzing these limitations. This article includes a case study about energy which allows us to better have a more comprehensive and vivid image and understanding of the models. All the actions in this work will be meaningful in our life because carbon play an important role in environment like greenhouse effect and biological carbon cycle.

Keywords: statistical forecasting, epidemiology model, carbon emission prediction, integrated models, Artificial Neural Network (ANN)

1. Introduction

This paper presents a method which use the combination of epidemiology model and statistical forecasting for carbon emission prediction.

Carbon emissions generally refer to greenhouse gas emissions, which cause the greenhouse effect and make the global temperature rise. However, as our technology continuously developing, more and more greenhouse gas was produced during the industrial process. Global warming has become a serious problem to the whole world. Correspondingly, many words were created to describe different phases. For example, peak carbon emissions and carbon neutral.

Epidemiology model is a set of mathematical equations that describe how a disease spreads through a population. These equations are based on numerous assumptions and simplifications in order to produce predictions about the number of future cases, trends in the virus. Epidemiologists use these models to analyze the spread of disease, to deduce the characteristics of disease transmission, and to look into future pathological trends.

In general, we have four classic epidemiological models - natural growth model, SI model, SIS model, SIR Model. In these models, S stands for susceptible (potentially infectable people), E stands for exposed (people who have been infected but do not show it), I stands for infectives (people who show symptoms of infection), and R stands for resistances (people who have acquired resistance after an infected person has recovered).

The natural growth model is mostly used under ideal conditions without too much outside interference. The SI model is applicable to the total number of people in the examined area during the transmission period, regardless of life and death and migration. When the sick person has effective contact with the healthy person, the healthy person becomes infected and becomes sick. The SIS model adds the condition that the infected can be cured and become susceptible to infection to the SI model. In the SIR Model, the infected person will acquire immunity after being cured and will not be infected, thus becoming a removed, which is different from the SIS model.

The impact of carbon emissions on global climate is a pressing concern for our planet. Accurately predicting these emissions is crucial for policymakers to make informed decisions. This thesis explores an innovative approach to forecast carbon emissions by integrating methods from two distinct fields: epidemiology and statistical forecasting. At first glance, epidemiology, the study of diseases, might seem unrelated. However, its models, which track and predict the spread of diseases, can offer unique insights when applied to carbon emissions. When combined with traditional statistical forecasting techniques, which rely on past data to predict future outcomes, we aim to develop a more comprehensive and precise model for predicting carbon emissions. This integrated model could enhance our ability to foresee emission trends, informing better climate policy and action.

2. Carbon Emission Prediction Model

2.1. Evolution of Carbon Emission Prediction Models

There have been a lot of carbon emission prediction models in the history. For example, using Artificial Neural Network (ANN) to model carbon emission intensity [1]. Different from previous models, this model not only focuses on economic growth and population, but also includes other variables such as energy consumption. Moreover, ANN can model a non-linear system which makes the results become more reliable.

Nowadays, some people try to combine other models with ANN model to make the results more accurate. For instance, combining the ARIMA and ANN models can make predictions with both linear system and non-linear system [2]. Researches have shown that the new combination model is more effective than earlier methodologies [3]. The results' accuracy has also been greatly improved by merging the models [4].

It is obvious that people are trying to use a mix of models to make more accurate predictions nowadays.

2.2. Applications of Epidemiological Models in Carbon Emission Prediction

The mathematical models can also contribute to forecasting carbon emissions. In mathematical models, we consider about the rate of any subjects according to the time using differential equations [5]. There are several epidemiology models which we can use in carbon emissions prediction. For example, the

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SIS epidemic model, the SEIR disease model, the SIR epidemic model, etc. These models show that the relationship between the object and the environment.

For example, the SIS model is used to show the relationships of natural births-deaths and diseases related with time [6].

We may combine the traditional models with the epidemiological models to gain some new results. The SIR model has been used to solve a novel vehicle routing problem for vaccine distribution [7]. So it is clear that these epidemiological models can greatly help the prediction of carbon emission in the future.

2.3. Statistical Forecasting in Carbon Emission Prediction

Pao et al. conducted an experiment and proposed a new improved GM model called the Nonlinear Grey Bernoulli Model (NGBM) [8]. It is very practical, used to predict three indicators related to China: carbon emissions, consumption of energy and output. The study concludes different relevant data such as consumption of energy, carbon dioxide emissions, energy intensity, carbon intensity, and actual GDP. This is very meaningful for certain related fields. After comparing different data, it makes relevant predictions and satisfies some groups with different needs for such data in the future. In order to measure their relevant abilities, three different evaluation statistical quantities are used to calculate, in order to test whether the prediction has a certain degree of accuracy.

According to relevant experimental results, different data showed different changes between 2011 and 2020, especially the following three data: China's annual composite emissions, energy consumption, and actual GDP growth rate were 4.47%, 0.06%, and 6.67%, respectively. This result indicates that the above three indicator data demonstrate that there is an equilibrium relationship between them and it has been maintained for a considerable period of time. Pau et al. used the grey prediction model (GM) to study the dynamic relationship between Brazilian variables, including energy consumption, CO_2 emissions, and actual GDP [9]. It means an important relationship among the three.2.4 Challenges and Limitations in Existing Models.

2.4. Challenges and Limitations in Existing Models

Around 2010, the world problem about carbon emission and attracted widespread attention. The large-scale smoke caused by carbon dioxide emissions has gradually become a problem, causing concern from relevant personnel in various fields. The existing relevant models have encountered many challenges and limitations. Removing nitrogen restrictions will lead to an underestimation about carbon emission. Though there are many challenges, we still need to meet the challenges and overcome the limitations to change the current situation.

3. Methodology for Integration.

3.1. Overview of Epidemiology Models Used in the Integration

The overview of epidemiology models is comprehensive. First, literature from both epidemiology and demography provide clear evidence for generally health-promoting effects of personal social relationships and individual social characteristics [10]. Most of the evidence is associated with the mortality rate, but in these two areas the study of other physical health, including cognitive, behavioral and disease outcomes had begun. This integration plays a role in the study of how diverse social conditions promote the difference between people's health status and poor distribution.

Moreover, agent-based modelling provided a specific focus for structured discussion about integrating ethnographic and epidemiological methods and data [11]. Data on ethnic epidemiology are provided on the use of mental stimulants(psychostimulant) to test the potential impact of specific methods between additional drug-related drawbacks. In addition, there is a framework for cooperation between research disciplines, which focuses on analysing different types of data to create new knowledge about drug risk change.

Also, epidemiological game theoretic model of HPV integrated vaccination epidemiology, psychology, and economics to achieve HPV vaccination targets [12]. Comparing common cognitive based vaccines to optimal values to maximize community effectiveness is the goal of this model. The results show that respondents believe that the vaccines obtained are far lower than those that maximize overall health effects.

3.2. Overview of Statistical Forecasting Techniques

There have been several statistical forecasting techniques. First of all, statistical hybrid wind power forecast technique is created for estimation of wind. The proposed model groups weather events based on the most important weather forecast parameters [13]. It also combines performance predictions from three different numerical weather prediction (NWP) sources and generates a mixed final forecast.

Also, earthquake forecasting techniques play a role in statistical forecasting techniques. Comparing previous methods, statistical techniques such as epidemic-type aftershock sequence models improved the forecast capability-gain more in shorter time [14]. These latest developments will help to explain the intrinsic importance of different time scale seismic processes and the importance of high qualified seismic data to accurately quantify the time related seismic risk.

In addition, there are still some issues on forecasting techniques. The first problem is associated with electricity and load forecasting. The other issue is the variability and non-schedulable nature of wind generation [15]. Currently, the solution of these issue is called ANFIS-application of an adaptive neural fuzzy inference system which address short-term wind forecasting problem [16].

3.3. Proposed Integration Methods.

This new method is called quadratic integration. This method has two innovations. (a) By introducing additional state variables, the equations in the nonlinear system model (differential or differential algebra) are reassigned to a completely equivalent second-order system of equations. (b) If the system state is the second time within an hour, the equations in the system model are integrated (quadratic integration) [17].

The proposed method creates an implicit integrated circuit that exhibits better convergence characteristics. The most important thing is making the solution more precise. Compared with conventional methods such as trapezoidal integration rules, this method also exhibits excellent performance in terms of accuracy and numerical stability, especially in switching systems. This method does not have artificial numerical fluctuations [18]. The numerical properties of this method are discussed in detail.

The proposed methodology and its characteristics include: (a) R-L-C linear circuits; (b) Testing has been conducted on multiple testing systems, including nonlinear detection systems and (C) electrical and electronic circuits (switch systems) [19]. It is expected that this method is very suitable for systems with electrical and electronic equipment and nonlinear equipment, such as saturation transformers/reactors and lightning arresters.

3.4. Comparison with Existing Methods

Useful multi-stage methods for predicting current carbon emissions include energy consumption and economic growth, clustering Based on two key variables: predictive technology for machine learning and degradation. To this end, a self-mapping clustering algorithm is used to collect the data, adaptive neural fuzzy inference system with artificial networks is used to create models on all self-mapping clusters. Emissions forecasting considered several import parameters such as economic growth and energy consumption of the G20. In addition, singular value decomposition was used to reduce missing values in the dimension and prediction dataset. After analyzing the actual data set, it was found that the developed multi-stage method can predict carbon dioxide emissions based on two indicators. It turns out that the consequences were compared with the methods we have so far to validate the proposed method. The results showed that the technology in combination with spontaneous mapping and SVD technology 0.065 provided an average error accuracy [20]. Compared to the method 0.104, the method of SVD offers spontaneous mapping adaptive neural fuzzy inference system precise results in the

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prediction of CO_2 emissions. In addition, multiple linear retrogression provides the worst results (0.522) in comparation with artificial neural networks and adaptive neural fuzzy inference system technologies. G20 from the perspective of national energy and economic policy, it is crucial to analyze the link between economic development, carbon dioxide emissions and energy consumption [21]. The focus of this group is on global economic governance.

4. A Case Study

Energy: Some experiments that overly focused on green energy and economic growth have resulted in a lack of timely attention to the connection between green energy and environmental conditions in the form of carbon emissions. So it is very necessary for us to study the causal relationship between renewable energy and environmental degradation. At first, natural gas consumption may have a negative effect. After many studies, we believe that the most effective way to help reduce carbon dioxide emissions is to use renewable energy.

5. Conclusion and Main Point

5.1. Conclusion

This paper studies and reviews statistical forecasting models and classical epidemiological models respectively. It also discusses the feasibility and importance of combining the two in the statistical prediction of carbon emissions, as well as its future prospects. By making use of the epidemiological model in the mathematical model of the differential equation for time and the classic model and method of statistical prediction, we can greatly improve the accuracy of the results, which is of great benefit to solving global carbon dioxide emissions and delaying the greenhouse effect.

5.2. A Main point

a) A number of studies have shown that the integrated models can help improve the accuracy of the prediction of carbon dioxide. (For example, combining the linear and non-linear model) So we should pay attention to the importance of the integrated models.The differential equations can help us to learn a model over a long time, and that is how epidemiological models help the statistical forecasting.

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