также осуществляются научно-исследовательские, опытно-конструкторские и опытно-технологические работы [6].

Взаимовыгодное сотрудничество позволяет создать благоприятную деловую среду и достичь устойчивого социально-экономического развития, что оказывает положительное влияние на экономический рост обеих стран.

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ARTIFICIAL INTELLIGENCE TECHNOLOGY FOR EVALUATING SOLAR ENERGY RESOURCES AND ITS APPLICATION IN HARBIN

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Summary. *In terms of economy, electricity is a commodity capable of being bought, sold and traded. Electricity is difficult to store, and it has to be available on demand. Consequently, unlike other products, it's impossible, under normal operating conditions, to keep it in stock, to ration it, or to have customers queue for it. The solar energy generating system, whether grid-connected or stand-alone, is most commonly used in places when possible to install solar equipment (roofs, pollutes areas, closed rubbish dumps, rural and suburban areas). It is based on converting solar radiation (i.e., photons that are sent from the sun) to produce electricity. The PV system has a lot of ways of applications. For example, in developing countries, PV is used for basic life needs, such as heating and cooking, while in developed countries, the system is used to supply electricity for homes and grids. Due to its importance in the solar energy field, global solar radiation data (GSR) forecasting has become more popular to facilitate solar system installation. This paper investigates the method of prediction of global solar radiation in Harbin by the artificial neural network (ANN) approach. Solar radiation prediction and forecasting carry out considering global weather solar radiation data.*

Keywords. *energy forecasting; solar energy prediction; artificial neural network; global solar radiation; average air temperature.*

1. Introduction

There are many spheres computers can do better than human-calculate square roots or retrieve a web page instantaneously. However, incredible brain of human is still a step ahead when it comes to common sense, imagination and inspiration. Inspired by the strategy of actions of the brain, artificial neural networks are the way of making computers more human-like and help machines be more like humans [1].

In this paper, neural networks are used to design forecasting models, using four steps, such as collecting data, initiating network, training data, and simulating data. Location of investigation: Harbin, Heilongjiang province, the People's Republic of China (*Latitude* 45.7448, *Longitude* 126.6299) is selected as the case study.

2. Methods

The core unit of an artificial neural network is neurons, which use the transfer function to create output. Each input (p) is multiplied by a weight (w), which serves as a connection between an input and a neuron as well as between the various layers of neurons. In the next stage, weight inputs are combined, after which a bias (b) is added to the sum of the weight inputs. The neuron applies a transfer function (n) to this result, from which the output (a) is obtained. Figure1 illustrates a simplified flow chart of the artificial neural network.

In this study, 4 types of weather data are considered for appropriate parameter settings.

1. Massive from September 2014 till September 2018.
2. Massive from September 2009 till September 2018.
3. Massive from September 2004 till September 2018.
4. Massive from September 1999 till September 2018.

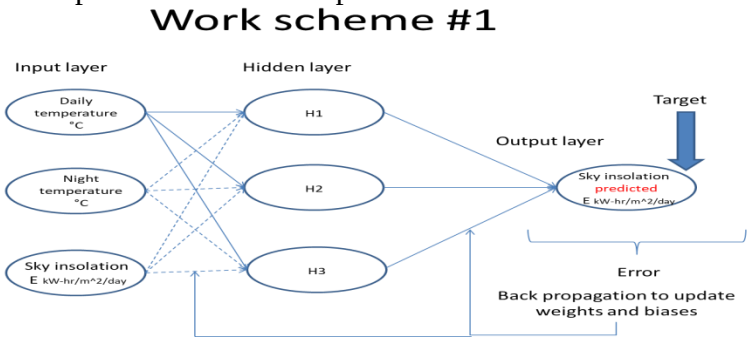

Fig.1 Work scheme #1. Input: Daily temperature, night temperature and solar sky insolation. Output-solar insolation

3. Results and discussion.

Figure 3 describes the comparison of original solar radiation and predicted solar radiation between 2014-2018 years. The deviation observed between the original radiation and the predicted one could be attributed to the errors. Some places have technical errors. Moreover, original solar radiation data and predicted solar radiation data for 5 years is shown in Figure 8; 9.

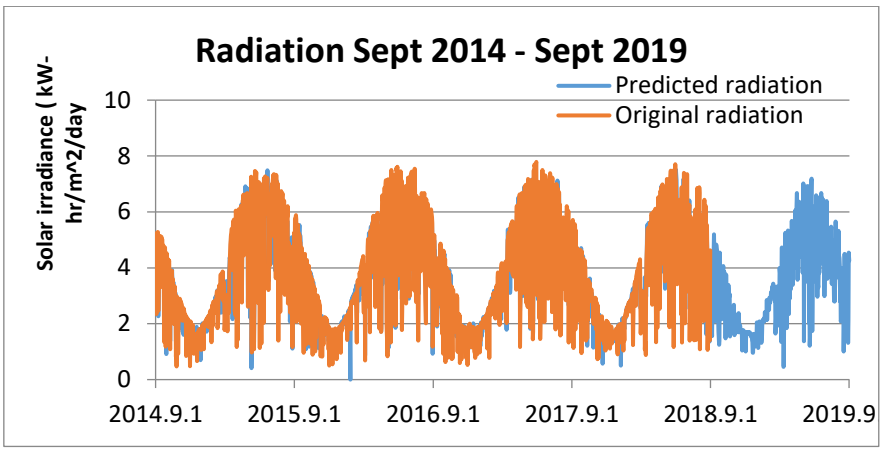

Fig.2 Predictions of period from September 2014 till September 2019: red color massive is our Original solar irradiance data kW-hr/m^2/day (data which was taken from weather resource). Blue color massive is our Predicted solar irradiance data (which was predicted by ANN technology)

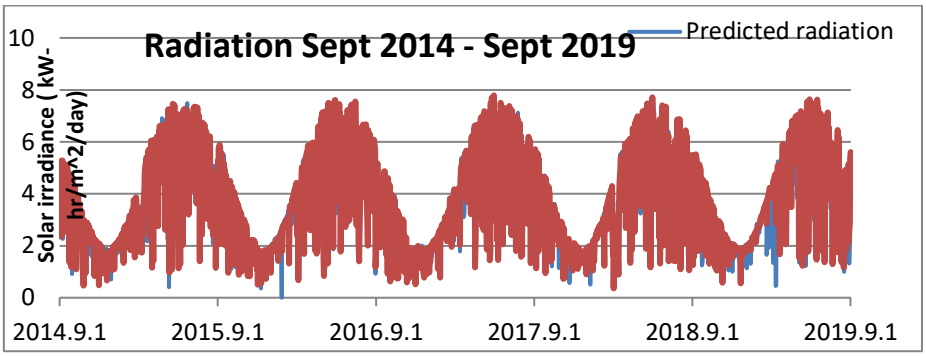

Fig.3 Predicted data (Blue) Vs. Original data (red); stratification

"Figure3" shows comparison of original solar radiation and predicted solar radiation between 2018-2019. As can be seen in "Figure10", we can detect a form of 2018-2019-years solar radiation prediction. It is almost similar to the previous year's parts. It gives us insight that our prediction is plausible. Peaks of the graph are only in the summer. The peak of predicted part is the summer period too. "Figure 5" shows the original solar radiation data and predicted solar radiation data for 5 years. It doesn't have any extreme vertical drops.

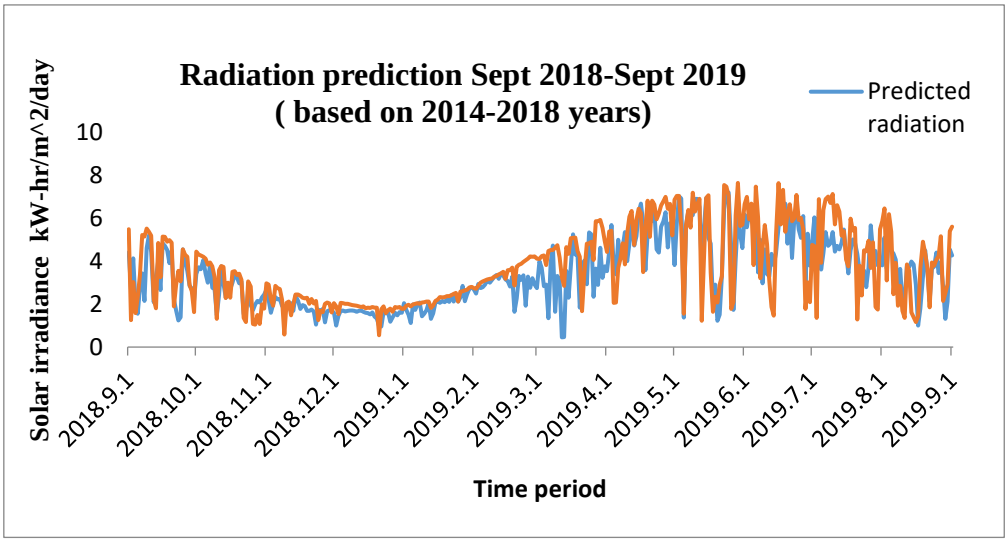

Fig.4 Original solar radiation (red) (2018-2019) and predicted solar radiation (blue) data (2018-2019)

Solar energy is an inexhaustible and renewable source of energy. The main necessary conditions for the development of solar energy are: long daylight hours, the prevalence of sunny weather in the daytime and a high angle of incidence of sunlight [5].

On this basis, the most favorable development regions are countries in tropical and subtropical climatic zones. However, for industrial sphere use, a major drawback is that the intensity of solar radiation is dependent on weather conditions and the time of day.

Due to the impermanent nature of renewable energy sources, the task of forecasting the volumes of generated solar energy is relevant.

The forecasting task is one of the most complex tasks of data analysis and requires careful analysis of the source data, identifying patterns in them, as well as selecting informative features. The initial data for the task of forecasting solar energy is long-term statistics containing information on weather conditions and the daily solar irradiance data.

The goal of the research was to find accurate method of predictions solar radiation, to predict the daily average of global solar radiation in Harbin, China. This research discusses **the** results obtained from the ANN model. Solar radiation is an essential parameter for implementing solar energy systems.

The proposed method has ability to do future solar energy forecasting according to collected data:

• Method is fully informative and based on the current instrumentation of Artificial Intelligence.

• Application is simple and understandable for engineers.

• It has a big research backup for improving our method (increase input, decrease error, add new algorithms of predictions, etc.)

Conclusion

Global solar radiation forecasting plays a significant role in the design of solar power systems. In this work, the method was employed to predict daily average solar radiation. This section provides conclusions of the results obtained along with suggestions for future work. In this study, the goal was to find a method that accurately predicts global solar radiation, to predict the daily average of global solar radiation in the area of Harbin, China. This research discusses the results obtained from the ANN model used four types of weather data. Artificial neural networks, in collaboration with solar energy, are good basis for implementing and exploiting effective solar power generation systems.

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