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Insolation Forecasting by a Multi-Stage Neural Network

SHINICHIROU ORITA, YOSHISHIGE KEMMOKU, and TATEKI SAKAKIBARA
Toyohashi University of Technology, Japan
SHIGEYASU NAKAGAWA
Maizuru College of Technology, Japan

SUMMARY

A single-stage neural network has been proposed to forecast next day insolation. In this paper, a multi-stage neural network is developed to reduce forecasting error further. A first-stage neural network forecasts average atmospheric pressure for the next day from atmospheric pressure data of the previous day. A second-stage neural network forecasts insolation level for the next day from the average atmospheric pressure and weather data of the previous day. A third-stage neural network forecasts next day insolation from the insolation level and weather data of the previous day. Meteorological data of Omaezaki, Shizuoka at April 1994 were chosen as input data. The insolation values forecasted by the multi-stage and the single-stage neural networks are compared with the measurement values. The results show that the forecasting error is reduced to 24% (by the multi-stage) from 33% (by the single-stage). ©1998 Scripta Technica, Electr Eng Jpn, 125(4): 26–33, 1998

Key words: Neural network; multi-stage; atmospheric pressure forecasting; insolation level forecasting; insolation forecasting; forecasting error.

1. Introduction

Gas hot-water supplying equipment and petroleum boilers have been used conventionally for domestic hot-water supply. In recent years, however, in replacing these systems, heat pump (HP) hot-water supply systems, in which energy saving is high at primary energy level, are being introduced. In solar-heat/HP hot-water supply systems in which a HP hot-water supply system and a solar-heat collector are combined together, much higher energy saving is expected [1].

From an economical viewpoint, it is desirable that the HP hot-water supply system is operated using nighttime electricity whose energy charge is one third of that during the daytime. When a solar-heat/HP hot-water supply system is operated similarly, the hot-water storage tank can be heated by solar heat alone without using nighttime electricity if the solar heat that can be obtained the next day is sufficient. On the other hand, if the solar heat is not sufficient, the system must be operated in such a way that the temperature of the hot-water storage tank is adequately raised by using nighttime electricity and the setting temperature is reached, at hot-water supply time in the evening, by applying the solar heat obtained during the daytime. In this way, the electric charges can be greatly reduced by suppressing the utilization of nighttime electricity and effectively utilizing solar energy.

In order to carry out an operation of this kind of system, the authors have proposed an operation method based on a system in which the use of nighttime electricity is suppressed and the solar energy is effectively utilized by forecasting the all-day insolation for the next day and raising the hot-water storage tank to setting temperature at the hot-water supply time with nighttime electricity and solar heat [2]. This operation method suggests that it is important to forecast insolation with good accuracy.

Neural networks have been used in next day insolation forecasting. At present, neural networks are applied in the forecasting of the next day power demand and the forecasting with considerable accuracy have become possible [3–5]. However, if the severe variation such as insolation is forecast by using a single neural network, high-accuracy forecasting cannot be achieved [2].

In replacing conventional insolation forecasting methods by a single neural network (single-stage type), we propose in this paper a method in which the rough range (level) of the insolation is forecast first, and then the insolation is forecast at each level by using separate neural networks (multi-stage type).

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