International Journal of Data Warehousing and Mining
Volume 20 • Issue 1

Research on Multi-Parameter Prediction of Rabbit Housing Environment Based on Transformer

Feiqi Liu, School of Information Science and Engineering, Hebei North University, China
Dong Yang, School of Information Science and Engineering, Hebei North University, China
Yuyang Zhang, College of Robotics Science and Engineering, Northeastern University, China
Chengcai Yang, Zhuolu County Animal Husbandry and Fishery Service Center, China
Jingjing Yang, School of Information Science and Engineering, Hebei North University, China*
https://orcid.org/0000-0003-2751-2930

ABSTRACT

The rabbit breeding industry exhibits vast economic potential and growth opportunities. Nevertheless, the ineffective prediction of environmental conditions in rabbit houses often leads to the spread of infectious diseases, causing illness and death among rabbits. This paper presents a multi-parameter predictive model for environmental conditions such as temperature, humidity, illumination, CO2 concentration, NH3 concentration, and dust conditions in rabbit houses. The model adeptly distinguishes between day and night forecasts, thereby improving the adaptive adjustment of environmental data trends. Importantly, the model encapsulates multi-parameter environmental forecasting to heighten precision, given the high degree of interrelation among parameters. The model's performance is assessed through RMSE, MAE, and MAPE metrics, yielding values of 0.018, 0.031, and 6.31% respectively in predicting rabbit house environmental factors. Experimentally juxtaposed with Bert, Seq2seq, and conventional transformer models, the method demonstrates superior performance.

KEYWORDS

Attention Mechanism, Multi-Parameter, Prediction, Rabbit House Environment, Time Series

INTRODUCTION

The expansion and optimization of the livestock industry provide significant prospects for agricultural development, poverty reduction, food security, and human nutrition (Hernandez-Patlan et al., 2023). The rabbit industry is a significant contributor to economic development due to factors such as brief breeding cycles, minimal start-up capital, and easy entry (Bolster & Wireless News, 2023). The demand for animal products is continuously increasing in many countries (Cullere et al., 2018). However, as people's understanding of the connection between diet and health has deepened, food safety and public health have become important areas of concern (Pavan et al., 2022). Rabbit meat, known for its high

DOI: 10.4018/IJDWM.336286
*Corresponding Author

protein content, low fat, and low cholesterol, has gained popularity among the public, in recent years (Dalle Zotte & Szendrő, 2011). Consequently, there is a higher demand for rabbit meat that meets the standards of hygiene, health, and safety. However, the environmental conditions profoundly affect the physiological functions, health status, and feed conversion rates of livestock, including rabbits (Agea et al., 2019). Rabbits, in particular, are highly sensitive to environmental changes, necessitating stable conditions for optimal growth and development (Shawna et al., 2023). Parameters such as temperature, humidity, light, carbon dioxide, and ammonia concentrations, along with dust levels, are critical in rabbit housing. Research indicates that low humidity can incur respiratory diseases in rabbits, while high humidity could expedite the spread of infectious diseases (Li et al., 2023). Lower temperatures may reduce food intake, impair reproductive capabilities, and increase susceptibility to diseases such as rabbit fever, whereas high temperatures may induce heatstroke in rabbits, leading to infections that could affect reproduction or even cause death. Moreover, the quality of environmental air notably impacts the health of rabbits. Rabbit waste and urine, combined with polluted bedding straw, generate harmful gases such as ammonia and carbon dioxide (Xia et al., 2022). The accumulation of these gases along with dust can elevate the likelihood of disease outbreak among rabbits. Thus, fluctuations in environmental parameters pose substantial problems in rabbit housing, impacting health, growth, and survival rates. Therefore, accurate control of environmental parameters in rabbit houses is crucial for healthy breeding, intensive farming, and large-scale rabbit production. Predicting the changing trends and impacts of these environmental parameters is a necessary step towards achieving accurate environmental regulation.

Traditional regulation techniques for the rabbit-house environment have relied on the accumulation of experience and manual monitoring. However, the complexity and uncertainty of environmental parameters make this method limited. Problems include significant errors in manual monitoring, high costs, and difficulties managing large data volumes, yielding inaccurate environmental parameter predictions. Changes in environmental parameters significantly impact the growth and health status of rabbits. Addressing the monitoring needs of rabbit-house environments, Chandra et al. (2023) suggested a livestock environmental management system for measuring CO_2 concentration in barns, enabling remote control of barn environments. Xinrui et al. (2023) developed an approach to modulate total atmospheric ammonia emissions concerning space and time by updating high-resolution crop maps and animal housing location databases. They created an agricultural ammonia emission model, enabling better control decisions for indoor farmhouse environments. Shin et al. (2023) proposed an optimal mechanical ventilation system for outdoor air cooling based on weather forecast data. They tackled barn interior environmental quality and thermal insulation issues– thereby optimizing ventilation control strategies to ensure uniform air distribution and enhance barn indoor environment quality. However, the time-lag characteristics of changes in various environmental factors in rabbit houses pose challenges. If a rabbit house's environmental parameter predictions are not effective or timely, inability to control the environment changes may lead to rabbit illnesses or deaths, thus impeding the development of the rabbit industry.

Artificial intelligence has made great strides, and machine learning algorithms are now applied prevalently in environmental prediction. Recurrent neural networks (RNNs) are frequently used algorithms that can identify correlations within sequence data. However, RNNs face challenges in the prediction of long-sequence environmental data due to issues related to gradient explosion and vanishing gradients. To overcome these shortcomings, Hochreiter and Schmidhuber (1997) proposed the long short-term memory (LSTM) network, which adds gate units to RNNs, effectively circumventing long-term dependency problems and enhancing modeling capacity for sequence data. However, when the sequence length increases, it limits the LSTM network's memory capacity, affecting its predictive efficacy. Researchers have recently applied the transformer model, a deep learning architecture specifically designed for sequence modeling, to environmental prediction. Compared to the LSTM, the transformer excels at handling long-sequence data and can autonomously learn the relevance of environmental data through a self-attention mechanism, thereby capturing key features