A New Perspective on the Treatment of Ovarian Cancer: Deep Learning Algorithms-Based Prediction

Yan Yan[a]
Intelligent Medical Engineering, Nankai University, Tianjin, China

Keywords: Deep Learning, Ovarian Cancer, Medical Diagnosis, Precision Oncology.

Abstract: Ovarian cancer is one of the most common gynaecological cancers worldwide, because the initial symptoms are not obvious, they are often discovered in the late stages, resulting in poor treatment effects and poor prognosis. This paper explores various applications of deep learning (DL) in early detection and personalized treatment of ovarian cancer. The construction process of the deep learning model including data collection, preprocessing, model training and evaluation is introduced in detail. In the application of Convolutional Neural Network (CNN), this paper discusses how to reduce and learn parameters through image enhancement and feature mapping, and how to use SoftMax and cross-entropy loss functions in the later stages of data preprocessing and classification to improve the recognition accuracy of the model. For Long Short Term Memory (LSTM), this paper analyses its significant advantages in handling irregular time series data, especially in handling missing value patterns and complex time dependencies. In addition, this study also explored the clinical challenges of DL models when dealing with ovarian cancer-related issues, such as the "black box" nature of decision-making, generalization capabilities, and privacy issues of sensitive data. The comprehensive results indicate that the DL method will become an effective way to advance the development of the oncology field.

1 INTRODUCTION

Ovarian cancer is one of the most common gynecological cancers worldwide, its mortality rate ranks first among the three major malignant tumors of the reproductive system, so it is called the "silent killer" (Wang, 2019). It is difficult to detect in the early stages of the disease, and there is no effective and reliable screening method for early-stage ovarian cancer, therefore clinical surgical treatment, radiotherapy, and chemotherapy have poor efficacy, has seriously threatened women's health and lives.

Ovarian cancer occurs in the ovarian tissue deep in the pelvic cavity. Early symptoms are vague and easily misdiagnosed. More than 75% of ovarian cancer patients are diagnosed in stages III-IV (late stage). When diagnosed, patients already have typical symptoms such as pelvic pain, abdominal distension, abdominal distension, or loss of appetite. At this time, the tumor cells have spread, and the five-year relative survival rate is only 29% (Gao, 2022). Mortality rates from ovarian cancer are particularly concerning, so it is crucial to find effective treatment strategies and diagnostic methods, and thus more effective monitoring indicators and interventions.

In recent years, the application of deep learning has become more and more widespread and has demonstrated its unique advantages in various fields (Liu, 2021; Qiu, 2022; Zhao, 2023), which is particularly significant in medical applications. Deep learning, through its complex multi-level computing structure, ability to deeply analyze image data and capture its core features (Thompson, 2018). Based on this, deep learning can learn these features and make more intelligent, accurate and personalized decisions for image analysis, early diagnosis, and drug treatment. As a model that is efficient, accurate, and does not completely rely on doctors' subjective judgment, deep learning shows great potential in the diagnosis and treatment of ovarian cancer.

The combination of deep learning and ovarian cancer research is currently showing huge advantages.

[a] https://orcid.org/0009-0003-9945-1230

Yan, Y.
A New Perspective on the Treatment of Ovarian Cancer: Deep Learning Algorithms-Based Prediction.
DOI: 10.5220/0012939300004508

In *Proceedings of the 1st International Conference on Engineering Management, Information Technology and Intelligence (EMITI 2024)*, pages 417-421
ISBN: 978-989-758-713-9

Based on the advantages of artificial intelligence and machine learning algorithms, deep learning algorithms can independently mine key features from medical images. It then identifies and differentiates potential pathological variations that are difficult to detect by clinicians, greatly improving the accuracy and efficiency of early diagnosis in the process (Sadeghi, 2024). This facilitates earlier and more accurate diagnosis. This model is more efficient and accurate than traditional methods such as ultrasound, Computed Tomography (CT), and Magnetic Resonance Imaging (MRI), greatly improving the efficiency of tumor detection and feature analysis. Taken together, deep learning, as a transformative technology, can assist clinicians in making more informed decisions, thereby promoting progress in the field of ovarian cancer treatment, and ultimately improving patients' treatment effects and quality of life (Sadeghi, 2024).

The core goal of this study is to deepen the understanding of the application of deep learning in the field of ovarian cancer and explore new possibilities for intelligent treatment. It will provide an in-depth exploration of how deep learning methods can improve diagnostic efficiency, improve the efficiency and accuracy of medical imaging, and provide a basis for identifying new therapeutic targets. It also provides new perspectives and strategies for the diagnosis and treatment of ovarian cancer, brings new hope to patients, and provides experience and methods for the research of other types of tumors. This review provides an in-depth exploration of deep learning methods in the field of ovarian cancer (Section 2), including key steps such as data collection, preprocessing, and model training, and introduces different models used in ovarian cancer research through examples, including convolutional neural networks (CNN), long short-term memory networks (LSTM) and other technologies. Next, in Section 3, this paper discusses the limitations of existing research in deep learning research on ovarian cancer and provides solutions to these problems. Finally, in Section 4, this paper summarizes the main contents of this review and provide ideas for future research. This article highlights the unique potential of deep learning in the field of ovarian cancer and explores its application prospects in clinical practice.

2 METHODS

2.1 Framework of Deep Learning-Based Ovarian Cancer Prediction

Deep learning processes complex data by simulating the working mechanism of the human brain. In ovarian cancer prediction research, it can autonomously learn from pathological images, genetic information, and patients' electronic medical records to identify key disease indicators.

The effectiveness of deep learning technology depends largely on the quality and quantity of data. Ideally, high-quality data should include ovarian cancer images and corresponding clinical information from different perspectives and times. At the same time, in real life, different ethnic groups and different types of lesions will affect the adaptability of the model, so the diversity of data is particularly important. In published studies, multiple research groups have used different data collection methods to obtain data for ovarian cancer prediction. For instance, Gao et al. (Gao, 2022) extracted data from the ultrasound image database of 10 hospitals in their study. They classified the data according to whether women were single or not and used rectal ultrasound and transvaginal ultrasound images separately; Thomas et al. (Buddenkotte, 2023) used 451 scan data from four different institutions and two countries. Although the sources of these data are very wide, considering that most of the data (380 samples) come from the United Kingdom, they chose to use this part of the data for model training and evaluation.

In the process of establishing and evaluating deep learning models, data preprocessing, model selection, training, evaluation, and testing are closely related. In the data preprocessing stage, the data is processed to adapt to the requirements of the model, including standardization, denoising and enhancement of images, and processing of missing data; for non-image data, it needs to be converted into a structured format and normalized. Depending on the characteristics of the data and the prediction task, select an appropriate deep learning model, such as a CNN for image recognition, a LSTM for sequence data. In the model training stage, a large amount of labeled data is used to adjust the weights of the network to minimize the gap between the predicted output and the actual output, and appropriate loss functions and optimizers are used. Finally, the performance of the model is evaluated on an independent test set, and the generalization ability of the model is verified through indicators such as accuracy, recall, and F1 scores, and is visualized through qualitative analysis such as Gradient-weighted Class Activation Mapping (Grad-CAM) technology for model decision-making process.

Finally, the developed deep learning model can be deployed in clinical settings to assist doctors in more accurate diagnosis and treatment planning. When deployed, ensure that the model can integrate seamlessly with existing healthcare record systems and maintain accuracy and efficiency while protecting patient privacy.

2.2 CNN-Based Ovarian Cancer Prediction

Among deep learning methods, CNN, is one of the commonly used architectures. Convolutional neural network (CNN) is a very broad structure in deep learning technology. CNN consists of different types of processing layers, including convolutional layers, fully connected layers (FC), and pooling layers. Among them, the convolution layer generates an output feature map through a 2D convolution kernel operation with the input feature map, which is the core part of CNN. The pooling layer downsamples the feature map after the convolutional layer and selects the average or maximum value to summarize the characteristics of each block. Finally, the fully connected layer performs the classification task, which is similar to traditional artificial neural networks (ANN) (Banerjee, 2019; Ghoniem, 2020). The rapid development of deep learning models such as CNN is of great significance in the field of medical diagnosis and has gradually shown outstanding potential (Ghoniem, 2021).

In previous studies, many scholars have studied the application of CNN-based methods in ovarian cancer prediction. For example, Ziyambe et al. (Ziyambe, 2023) proposed a novel CNN algorithm for prediction and diagnosis of ovarian cancer. This study used a dataset consisting of 200 images of serum ovarian cancer and non-cancer samples, extended to 11,040 images by augmentation methods for use with deep learning architectures. After preprocessing the data set, it is processed using a convolution operation. After preprocessing the data, convolution operation is used for preliminary processing. The data is then further processed through the ReLU nonlinear activation function, and on this basis, the pooling layer is used for data simplification. Through this process, the size of the feature map and the number of future learning parameters are reduced. The data is then flattened and transformed into a one-dimensional vector in preparation for data input to the fully connected layer. In the final stage, the author uses SoftMax as the classifier and cross-entropy as the loss function. After training, the CNN model showed an accuracy of up to 94% and was able to identify cancer samples with an accuracy of 95.12%, it can also distinguish healthy cells with an accuracy of 93.02%.

2.3 LSTM-Based Ovarian Cancer Prediction

Long short-term memory network is an extension of the basic recurrent neural network (RNN) and aims to solve the gradient disappearance and gradient explosion problems of traditional RNN (Ghoniem, 2020; Datta, 2020). The LSTM network introduces memory units (cells) and gating mechanisms to effectively process time series data. In this process, it is necessary to control the memory unit (c) of the long short-term memory network (LSTM) by using a set of gate control networks, including the forget gate (f), the input gate (i) and the output gate (o) (Ghoniem,2021). This built-in gating mechanism can also avoid computational problems of vanishing or exploding gradients. It can be adapted to handle irregular time series data with missing values, inconsistent time intervals and complex time dependencies. Based on these advantages of LSTM and being very suitable for TM data containing missing data and irregular intervals between sequence tests, this method has become an ideal algorithm for processing actual data sets (Wu,2022).

Researchers such as Wu et al. (Wu,2022) applied the LSTM model to an incomplete large-scale TM data set to create a tool for predicting cancer risk, which is undoubtedly a pioneering act. This tool adopts simple missing value processing strategies including directly filling gaps with 0 or KNN, MICE interpolation technology, etc. The design includes a hidden layer configured with 100 units. On this basis, a standard S-shaped activation function was used, and a 10-round training cycle was carried out. This study highlights the potential ability of the LSTM model to handle irregular time series problems including missing values, varying time intervals, and complex dependencies. It also avoids the limitations of gradient disappearance or excessive growth. Through single-point verification of TM test data, the model showed higher accuracy than single threshold analysis, with an AUROC value of 0.831. And in another model, by analyzing data at up to four time points, the AUROC value increased to 0.931. This series of tools greatly improves the efficiency of the further screening process for individuals and helps to detect potential tumor risks at an early stage.

3 DISCUSSIONS

3.1 Limitations and Challenges

1) Transparency and Explainability: The potential of deep learning models to improve the accuracy of ovarian cancer diagnosis cannot be ignored, however, their use in clinical decision-making processes has been severely limited, in part due to the so-called "black box" problem. This means that the model's decision-making process is opaque, although the model can make predictions by learning patterns in large amounts of data, its internal logic is invisible, which is a fatal problem in cancer diagnosis. Medical decision-making requires a high degree of accuracy and interpretability, if doctors and patients have difficulty understanding how the model derives a specific diagnosis from the input data, trust in the model will be reduced, this limits the application of deep learning tools in clinical practice. **2) Limitations on Generalization Ability:** Ideally, a good model can not only perform well on the training set, but also show good prediction capabilities on unseen data sets, which is the generalization ability of the model. In practical applications, deep learning models often have difficulty achieving this. For ovarian cancer, the data comes from a wide range of sources, including different populations, geographic locations, and devices, so the data may vary significantly, the diversity of data, differences in data quality between different devices, and the complexity of the model itself make it challenging for the model to maintain performance on new data. Such problems may cause the model to overfit the distribution of training data and fail to fully cover all potential situations. **3) Private issues:** Deep learning models require large amounts of data to train and optimize. In the medical field, this means collecting and analyzing sensitive information such as patients' personal records, pathology images, and genetic information. As a gynecological disease, ovarian cancer will be more serious. Therefore, if not handled properly, it may result in unauthorized privacy disclosure. In addition, existing regulations and laws may not be able to keep up with the development of science and technology, making privacy protection measures insufficient and leading to more serious consequences. For healthcare organizations, data breaches can result in reputational damage, financial losses, and legal liability. For individuals, it may lead to social discrimination, insurance fraud and even security risks. Such leaks may also erode public trust in the field of smart healthcare and affect the further development of future research projects.

3.2 Solution Strategy

For interpretability, by utilizing techniques such as Shapely Additive Explanations (SHAP) and Local Interpretable Model-agnostic Explanations (LIME) to quantify the contribution of each input feature to model prediction, it can provide more intuitive use of the model. In addition, visualizing networks in key regions using activation maps and Class Activation Mapping (CAM) techniques is particularly useful for medical image analysis; For limitations on generalization capabilities, data enhancement and transfer learning can be used to increase the diversity and breadth of model training. Furthermore, regularization techniques can reduce overfitting, thereby improving model performance on unseen data; As a distributed machine learning method, federated learning allows models to be trained on local devices, which means that only the weights and biases of the model are shared during the training process, rather than the training data itself. This is an effective method to reduce data transmission and protect data privacy, especially suitable for handling sensitive medical information in diseases such as ovarian cancer. With the continuous advancement of deep learning technology and the deepening of artificial intelligence in the medical field, in the future, the application of deep learning in early diagnosis of ovarian cancer, treatment plan formulation, and patient prognosis assessment will become more and more extensive and accurate.

4 CONCLUSIONS

This review highlights the challenges posed by ovarian cancer as a common gynecological malignancy and the revolutionary role of deep learning in early diagnosis and treatment. In it, this paper elaborates on the architecture of deep learning in ovarian cancer diagnosis and discuss the process of training and validating models on different datasets. Additionally, the application of deep learning techniques was explored, specifically CNN and LSTM, to ovarian cancer prediction and diagnosis, and how these models can learn from medical images and genetic data and assist clinical decision-making. Although deep learning models achieve remarkable accuracy and performance in experiments, this paper also identify and discuss the limitations of these methods in real-world applications. At the same time, it can be foreseen that with the maturity and advancement of explainable artificial intelligence technology and the strengthening of privacy protection measures, the application of deep learning in the field of ovarian cancer will become more extensive and efficient. Future work will need to focus on more reliable model evaluation tools and algorithms for handling diverse and irregular data sets.

REFERENCES

Banerjee, I., Ling, Y., Chen, M. C., Hasan, S. A., Langlotz, C. P., Moradzadeh, N., ... & Lungren, M. P. 2019. Comparative effectiveness of convolutional neural network (CNN) and recurrent neural network (RNN) architectures for radiology text report classification. Artificial intelligence in medicine, 97, 79-88.

Buddenkotte, T., Rundo, L., Woitek, R., Escudero Sanchez, L., Beer, L., Crispin-Ortuzar, M., ... & Schönlieb, C. B. 2023. Deep learning-based segmentation of multisite disease in ovarian cancer. European radiology experimental, 7(1), 77.

Datta, S., Si, Y., Rodriguez, L., Shooshan, S. E., Demner-Fushman, D., & Roberts, K. 2020. Understanding spatial language in radiology: Representation framework, annotation, and spatial relation extraction from chest X-ray reports using deep learning. Journal of biomedical informatics, 108, 103473.

Gao, Y., Zeng, S., Xu, X., Li, H., Yao, S., Song, K., ... & Gao, Q. 2022. Deep learning-enabled pelvic ultrasound images for accurate diagnosis of ovarian cancer in China: a retrospective, multicentre, diagnostic study. The Lancet Digital Health, 4(3), e179-e187.

Ghoniem, R. M. 2020. A novel bio-inspired deep learning approach for liver cancer diagnosis. Information, 11(2), 80.

Ghoniem, R. M., Algarni, A. D., Refky, B., & Ewees, A. A. 2021. Multi-modal evolutionary deep learning model for ovarian cancer diagnosis. Symmetry, 13(4), 643.

Liu, Y., Liu, L., Yang, L., Hao, L. and Bao, Y., 2021. Measuring distance using ultra-wideband radio technology enhanced by extreme gradient boosting decision tree (XGBoost). Automation in Construction, 126, p.103678.

Qiu, Y., Wang, J., Jin, Z., Chen, H., Zhang, M., & Guo, L. 2022. Pose-guided matching based on deep learning for assessing quality of action on rehabilitation training. Biomedical Signal Processing and Control, 72, 103323.

Sadeghi, M. H., Sina, S., Omidi, H., Farshchitabrizi, A. H., & Alavi, M. 2024. Deep learning in ovarian cancer diagnosis: a comprehensive review of various imaging modalities. Polish Journal of Radiology, 89, e30.

Thompson, R. F., Valdes, G., Fuller, C. D., Carpenter, C. M., Morin, O., Aneja, S., ... & Thomas Jr, C. R. 2018. Artificial intelligence in radiation oncology: a specialty-wide disruptive transformation?. Radiotherapy and Oncology, 129(3), 421-426.

Wang, S., Liu, Z., Rong, Y., Zhou, B., Bai, Y., Wei, W., ... & Tian, J. 2019. Deep learning provides a new computed tomography-based prognostic biomarker for recurrence prediction in high-grade serous ovarian cancer. Radiotherapy and Oncology, 132, 171-177.

Wu, X., Wang, H. Y., Shi, P., Sun, R., Wang, X., Luo, Z., ... & Wang, Y. 2022. Long short-term memory model–a deep learning approach for medical data with irregularity in cancer predication with tumor markers. Computers in Biology and Medicine, 144, 105362.

Zhao, F., Yu, F., Trull, T., & Shang, Y. 2023. A new method using LLMs for keypoints generation in qualitative data analysis. In 2023 IEEE Conference on Artificial Intelligence (CAI) (pp. 333-334). IEEE.

Ziyambe, B., Yahya, A., Mushiri, T., Tariq, M. U., Abbas, Q., Babar, M., ... & Jabbar, S. 2023. A deep learning framework for the prediction and diagnosis of ovarian cancer in pre-and post-menopausal women. Diagnostics, 13(10), 1703.