

# Artificial Intelligence in *Cancer*

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# Artificial Intelligence in Cancer

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### EDITORIAL

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**ABOUT COVER**

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The primary aim of *Artificial Intelligence in Cancer* (AIC, *Artif Intell Cancer*) is to provide scholars and readers from various fields of artificial intelligence in cancer with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

AIC mainly publishes articles reporting research results obtained in the field of artificial intelligence in cancer and covering a wide range of topics, including artificial intelligence in bone oncology, breast cancer, gastrointestinal cancer, genitourinary cancer, gynecological cancer, head and neck cancer, hematologic malignancy, lung cancer, lymphoma and myeloma, pediatric oncology, and urologic oncology.

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## How can artificial intelligence and humans work together to fight against cancer?

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### Abstract

This editorial will focus on and discuss growing artificial intelligence (AI) and the utilization of AI in human cancer therapy. The databases and big data related to genomes, genes, proteins and molecular networks are rapidly increasing all worldwide where information on human diseases, including cancer and infection resides. To overcome diseases, prevention and therapeutics are being developed with the abundant data analyzed by AI. AI has so much potential for handling considerable data, which requires some orientation and ambition. Appropriate interpretation of AI is essential for understanding disease mechanisms and finding targets for prevention and therapeutics. Collaboration with AI to extract the essence of cancer data and model intelligent networks will be explored. The utilization of AI can provide humans with a predictive future in disease mechanisms and treatment as well as prevention.

**Key Words:** Artificial intelligence; Cancer; Cancer therapy; Database; Molecular network; Network data analysis

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**Core Tip:** The utilization of artificial intelligence (AI) is important for analyzing abundant data on diseases in the big data era. The genomic and molecular data in cancer have been accumulated in databases worldwide. Collaboration with AI in human cancer research is explored in this editorial.

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## INTRODUCTION

Artificial intelligence (AI) has been emphasized since the application of AI expanded into the analysis and prediction of cancer data. The abundant digital cancer data have been accumulated in open-sourced databases worldwide. It is anticipated that new breakthroughs in AI-oriented analysis for utilizing crowd space for big data will predict the treatment of diseases. To explore the coordination in AI and humans, the evolution of AI and the history of supercomputers is summarized, and AI in data analysis and the utilization of AI in the interpretation of cancer data and the predictive role of AI in cancer therapy are overviewed<sup>[1]</sup>. Many studies related to AI have been conducted for identifying cancer, which are emerging to produce another data field to be interpreted. Machine learning-based models are being actively applied for predicting the toxic outcome of radiotherapy<sup>[2]</sup>. It is clear that AI can be utilized in data analysis, but they require orientation toward the desired goal. The future perspective of AI applications in cancer will also be discussed.

Recent advances in AI have enabled AI-based clinical prediction in medicine<sup>[3-5]</sup>. In many cases, machine learning techniques are utilized to learn from data related to diagnosis, prognosis or treatment to predict and support medical decisions<sup>[5,6]</sup>. Additionally, there is a growing demand for targeting cancer with novel technology such as nanomedicines<sup>[7]</sup>. Deep-learning methods for image recognition can predict and classify cancer<sup>[8]</sup>. The utilization of AI is greatly in need in this “big data” era to bridge new technologies and cancer treatment.

## EVOLUTION OF AI

The modern history of AI begins in the 1950s<sup>[1,9,10]</sup>. Turing<sup>[1]</sup> proposed thinking about whether machines think to compute machinery and intelligence. New languages have been created to communicate with AI<sup>[10]</sup>. To think deeply about AI, three key words may exist: Machine learning, deep neural networks and supercomputers. Machine learning can be considered as an *in silico* method that includes databases, quantitative structure-activity relationships, pharmacophores, homology models and other molecular modeling approaches, and data analysis that uses a computer such as network analysis<sup>[11]</sup>. Deep neural networks have been developed by mimicking “networks of neurons” in the human brain. In 2006, further evolution in AI occurred, where data were translated into codes<sup>[12]</sup>. The data translation and coding in neural networks conferred AI to image recognition and interruption<sup>[12]</sup>. Deep learning with newly developed functions such as rectified linear units (ReLU) has also produced computational speech translation<sup>[13]</sup>. AI is utilized in image recognition based on deep neural networks<sup>[14]</sup>. Deep learning of cancer tissue can predict individual risk, such as the probability of 5-year disease-specific survival<sup>[15]</sup>. Outstanding advances in the neural network field have achieved a multimodel neural network approach for emotion recognition<sup>[16]</sup>.

Supercomputing has been developed worldwide in multiple fields from black hole exploration to biology research<sup>[17]</sup>. The development of supercomputers is rapid, and the top supercomputer in performance changes every year in the TOP500 (<https://top500.org/Lists/top500/2020/06/>). Supercomputer Fugaku, which is named from the Japanese traditional name of Mt. Fuji, the highest mountain in Japan, achieved a calculation speed of 415.5 petaflops/sec, followed by Summit, Sierra, Sunway TaihuLight, and Tianhe, as of June 2020 (<https://top500.org/Lists/top500/2020/06/>). New supercomputers will be developed in the near future, which will be accompanied by AI as well.

## AI IN DATA ANALYSIS

Recent advances in AI have promoted digital approaches in which pathological images are analyzed in deep learning, and machine learning is utilized for diagnosis<sup>[18]</sup>. AI is also utilized in human genetics and genomics data, such as nucleic sequence differences in medical applications<sup>[19]</sup>. AI is utilized for big data analysis for precision medicine<sup>[20]</sup>. Genome medicine data are analyzed with AI to explore new therapeutic targets<sup>[21]</sup>. AI might be utilized to diagnose nanomaterial engineering with image recognition<sup>[22]</sup>. A deep neural network is utilized for data in games to create a specialized AI such as AlphaGo<sup>[23]</sup>. Deep-learning technology has enabled live-cell superresolution imaging<sup>[24]</sup>. AI is applied in clinical radiology, such as thoracic



imaging, abdominal and pelvic imaging, colonoscopy, mammography, brain imaging, and radiation oncology<sup>[25]</sup>. AI, including machine learning and natural language processing, has been optimized for decision-making in health intelligence and precision medicine<sup>[26]</sup>. Abundant machine learning algorithms have been developed to build prediction models in digital medicine fields, which allows us to predict and proactively intervene in healthcare with AI companions<sup>[26-28]</sup>. Digital therapeutics where symptoms, disease progression and medication adherence are monitored need AI integration in controlling data and appropriate feedback<sup>[29]</sup>. AI has been utilized in digital pathology in a wide variety of fields<sup>[30]</sup>. Careful consideration for AI utilization is also essential for the safe contribution of AI in digital health<sup>[31]</sup> (Figure 1).

## UTILIZATION OF AI IN THE INTERPRETATION OF CANCER DATA

AI, which includes machine learning and deep learning, has been utilized in cancer data analysis, such as The Cancer Genome Atlas and the Catalogue of Somatic Mutations in Cancer<sup>[21,32-34]</sup>. In the 2000s, the AI concept became popular for classifying cancer stages with abundant data<sup>[35]</sup>. The increasing data in the oncology field will be suitable for machine learning to predict cancer prognosis<sup>[34]</sup>. AI utilization in cancer variants and mutation data for cancer drug discovery has been developed in integration with computational biology<sup>[36]</sup>. Currently, AI is applied in quantitative imaging to predict the future risk of cancer development<sup>[37]</sup>. Genomics data obtained from next-generation sequencing can be analyzed by AI for precision medicine<sup>[38]</sup>. Molecular mechanisms and digital biomarkers can be analyzed with AI to build a disease knowledge network<sup>[39]</sup>. Deep-learning methods with convolutional neural networks successfully classified liver tumors in magnetic resonance imaging (MRI) images<sup>[40]</sup>. Machine learning of MRI image data showed significant performance in the detection of prostate cancer<sup>[41]</sup>.

## PREDICTIVE ROLE OF AI IN CANCER THERAPY

Since the 1990s, cancer therapy has been assisted by computational methods<sup>[42-44]</sup>. The analysis of genomic features and quantitative radiomic phenotypes through gene-set enrichment analysis has revealed integrated relationships between cancer-related genetic pathways and radiomic phenotypes in cancer diagnosis<sup>[45]</sup>. The in silico profiling of microRNA networks enabled the classification of cancer phenotypes<sup>[46]</sup>. The relationships between complex molecular pathways and cancer phenotypes may be predicted by AI. In fact, deep-learning methods and modeling with manually defined features are combined in the radiomics pipeline for application in cancer diagnosis, prognosis and treatment evaluation<sup>[47]</sup>. Furthermore, the morphology of cancer stem cells can be predicted by AI with a conditional generative adversarial network<sup>[48]</sup>. Cancer image data are deep-learned by AI with convolutional neuronal networks to predict lung cancer subtypes<sup>[49]</sup>. Prediction of immunotherapy targets in lung cancer by AI was successful in some models, while the need for further validation has also been noted<sup>[50]</sup> (Table 1).

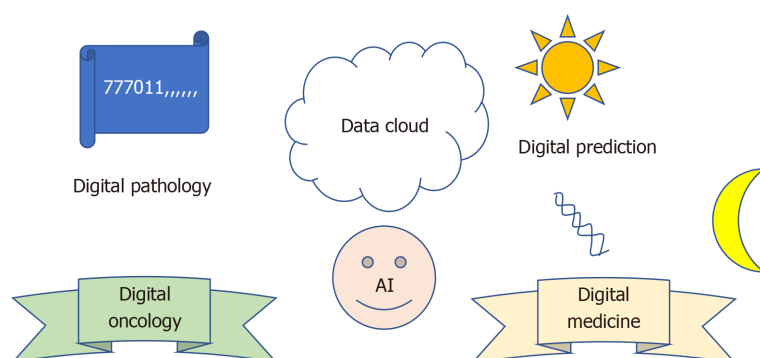
## CONCLUSION

AI application in cancer therapy is rapidly increasing. The expanding computational technology has conferred AI with the capacity to interpret and predict cancer data. As image recognition by AI is becoming precise and accurate, digital cancer captures will advance in more predictably. There remain challenges for AI to overcome, where human knowledge and ambitiously mining data maximize AI performance.

**Table 1** The various roles of artificial intelligence in cancer therapy

Role of AI	Prediction object	Application in cancer therapy
Deep learning of cancer images	Cancer subtypes	Diagnosis
Conditional generative adversarial network	Morphology of cancer stem cells	Prediction of cancer drug resistance
Modeling of cancer immunology	Immunotherapy targets	Prediction of therapeutic targets
In silico profiling of microRNA networks	Cancer phenotypes	Classification of cancer and identification of therapeutic targets

AI: Artificial intelligence.

**Figure 1** Artificial intelligence in medicinal data analysis. Artificial intelligence is utilized for big data analysis in the digital era. AI: Artificial intelligence.

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