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**Cancer recognition of artificial intelligence**

Tanabe S*.* Cancer recognition of AI

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**Abstract**

The recognition mechanism of artificial intelligence (AI) is an interesting topic in understanding AI neural networks and their application in therapeutics. A number of multilayered neural networks can recognize cancer through deep learning. It would be interesting to think about whether human insights and AI attention are associated with each other or should be translated, which is one of the main points in this editorial. The automatic detection of cancer with computer-aided diagnosis is being applied in the clinic and should be improved with feature mapping in neural networks. The subtypes and stages of cancer, in terms of progression and metastasis, should be classified with AI for optimized therapeutics. The determination of training and test data during learning and selection of appropriate AI models will be essential for therapeutic applications.

**Key Words:** Artificial intelligence; Cancer; Network; Recognition; Therapeutic application

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**Core Tip:** Recently, rapidly growing advances in deep learning have enabled cancer recognition by artificial intelligence (AI). Differences between human insights and AI attention may exist, and the interpretation of the modeling would lead to the further progression of AI-oriented therapeutics. The massive ability of AI is useful for cancer recognition.

**INTRODUCTION**

The automatic detection of cancer has already been in practice and will become generalized[1]. Computer-aided diagnosis (CAD) is growing, and the detection and classification of cancer has been achieved in the identification of the subtypes of leukemia with dense convolutional neural networks and residual convolutional neural networks[1]. A CAD system with a massive artificial neural network based on the soft tissue technique detected lung cancer in X-ray images[2]. Infection of *Helicobacter pylori* was predicted with endoscopic images by artificial intelligence (AI)[3]. A faster region-based convolutional neural network was applied to diagnose the T stage of gastric cancer in enhanced computed tomography (CT) images of gastric cancer[4]. Digital images of pathological data in cancer have been utilized in cancer diagnosis[5]. Digital pathology using whole-slide images may contribute into the “remote” assessment[6]. Automated image analysis and AI applications are increasing in the field of thyroid pathology[7]. Cancer recognition by AI has become more accurate and precise, accompanied by the progress of neural networks and calculation capacity[8]. It is time to think of ways to manage teaching AI in cancer therapeutics[9].

**RECOGNITION AND AI APPLICATION**

It may be possible that deep learning approaches such as a pretrained biomedical text mining model in natural language corpora apply to the recognition of cancer by AI[10]. The concept of the adversarial nets framework has advanced the field of recognition[11]. The recognition mechanism of AI application can be translated to human language *via* the indication of attention[12]. Future perspectives on cancer recognition in AI may need to focus on the translation of AI and human languages. Liver cancer survival can be predicted with deep learning-based multiomics integration[13]. Autoencoder architecture was used to integrate RNA sequencing (RNA-Seq) data, DNA methylation data and microRNA sequencing (miRNA-Seq) data of hepatocellular carcinoma in the cancer genome atlas (TCGA) database[13,14]. Data coordination with TCGA-Assembler was the first step to provide proper data for AI[14]. A similarity network fusion approach predicted cancer subtypes and survival[15]. A gene signature for the metastasis-related recurrence of hepatocellular carcinoma was identified with a classifier model consisting of class prediction algorithms, support vector machine (SVM), nearest centroid, 3-nearest neighbor, 1-nearest neighbor, linear discriminant analysis, and compound covariate prediction, to assess the risk of cancer recurrence in the early stage[16]. Gene mutation sets were identified in liver cancers, including hepatitis-positive samples[17]. SVM learning is useful for classifying and subtyping cancer[18]. Tumor pathology, such as subtyping, grading and staging, can be predicted by deep learning-based AI[19]. Clustering and machine learning methods have been used to classify immunotherapy-responsive triple-negative breast cancer patients[20]. Progressive non-muscle-invasive bladder cancer and muscle-invasive bladder cancer were classified based on the molecular subtype of immunotherapy responsiveness[21]. An interesting classifier model called cancer of unknown primary-AI-Dx predicted the tumor primary site and molecular subtype in RNA profiling[22].

**APPLICATION OF AI TECHNOLOGY IN CANCER TREATMENT**

Enhanced clinical workflow with AI interventions has been suggested in cancer treatment, which includes AI-guided detection and characterization, AI-guided treatment planning and monitoring, and AI-oriented optimization of the outcome[23]. AI tools can be used in detection of abnormalities, characterization of suspected lesion, and determination of prognosis or response to the treatment[23]. AI technology provides robust tumor descriptors in segmentation, diagnosis, staging and imaging genomics[23]. Radiomic feature extraction from CT images of lung cancer patients was successful to show association with gene expression and prognostic performance[24]. CT-based radiomic features may predict distant metastasis for lung adenocarcinoma patients[25]. The approach in evaluation and validation of novel biomarkers incorporates modified criteria in image data into Response Evaluation Criteria in Solid Tumours in cancer therapy[26]. The results of clinical study in metastatic non-small- cell lung cancer demonstrated that the treatment of pembrolizumab in combination with chemotherapy showed longer overall survival and progression-free survival than chemotherapy alone in the patients without epidermal growth factor receptor or anaplastic lymphoma kinase mutations[27]. The AI application in medical fields such as early detection, diagnosis, and treatment of diseases is expanding[28]. Clinical data is processed with natural language processing and machine learning of AI, which would be important components in clinical decision making on treatment strategy[28,29] (Figure 1, Table 1).

**CONCLUSION**

The utilization of AI for cancer recognition is rapidly increasing. The traditional approach may evolve with AI neural networks to create a future field for the planet. The recognition of image data, as well as translated and untranslated transcripts of genes in cancer, will deepen the AI universe.

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**REFERENCES**

1 **Bibi N**, Sikandar M, Ud Din I, Almogren A, Ali S. IoMT-Based Automated Detection and Classification of Leukemia Using Deep Learning. *J Healthc Eng* 2020; **2020**: 6648574 [PMID: 33343851 DOI: 10.1155/2020/6648574]

2 **Rajagopalan K**, Babu S. The detection of lung cancer using massive artificial neural network based on soft tissue technique. *BMC Med Inform Decis Mak* 2020; **20**: 282 [PMID: 33129343 DOI: 10.1186/s12911-020-01220-z]

3 **Bang CS**, Lee JJ, Baik GH. Artificial Intelligence for the Prediction of Helicobacter Pylori Infection in Endoscopic Images: Systematic Review and Meta-Analysis Of Diagnostic Test Accuracy. *J Med Internet Res* 2020; **22**: e21983 [PMID: 32936088 DOI: 10.2196/21983]

4 **Zheng L**, Zhang X, Hu J, Gao Y, Zhang X, Zhang M, Li S, Zhou X, Niu T, Lu Y, Wang D. Establishment and Applicability of a Diagnostic System for Advanced Gastric Cancer T Staging Based on a Faster Region-Based Convolutional Neural Network. *Front Oncol* 2020; **10**: 1238 [PMID: 32850373 DOI: 10.3389/fonc.2020.01238]

5 **Brunelli M**, Beccari S, Colombari R, Gobbo S, Giobelli L, Pellegrini A, Chilosi M, Lunardi M, Martignoni G, Scarpa A, Eccher A. iPathology cockpit diagnostic station: validation according to College of American Pathologists Pathology and Laboratory Quality Center recommendation at the Hospital Trust and University of Verona. *Diagn Pathol* 2014; **9 Suppl 1**: S12 [PMID: 25565219 DOI: 10.1186/1746-1596-9-S1-S12]

6 **Eccher A**, Neil D, Ciangherotti A, Cima L, Boschiero L, Martignoni G, Ghimenton C, Chilosi M, Giobelli L, Zampicinini L, Casartelli M, Brunelli M. Digital reporting of whole-slide images is safe and suitable for assessing organ quality in preimplantation renal biopsies. *Hum Pathol* 2016; **47**: 115-120 [PMID: 26547252 DOI: 10.1016/j.humpath.2015.09.012]

7 **Girolami I**, Marletta S, Pantanowitz L, Torresani E, Ghimenton C, Barbareschi M, Scarpa A, Brunelli M, Barresi V, Trimboli P, Eccher A. Impact of image analysis and artificial intelligence in thyroid pathology, with particular reference to cytological aspects. *Cytopathology* 2020; **31**: 432-444 [PMID: 32248583 DOI: 10.1111/cyt.12828]

8 **Govind D**, Jen KY, Matsukuma K, Gao G, Olson KA, Gui D, Wilding GE, Border SP, Sarder P. Improving the accuracy of gastrointestinal neuroendocrine tumor grading with deep learning. *Sci Rep* 2020; **10**: 11064 [PMID: 32632119 DOI: 10.1038/s41598-020-67880-z]

9 **Tanabe S**. How can artificial intelligence and humans work together to fight against cancer? *Artif Intell Cancer* 2020; **1**: 45-50 [DOI: 10.35713/aic.v1.i3.45]

10 **Lee J**, Yoon W, Kim S, Kim D, Kim S, So CH, Kang J. BioBERT: a pre-trained biomedical language representation model for biomedical text mining. *Bioinformatics* 2020; **36**: 1234-1240 [PMID: 31501885 DOI: 10.1093/bioinformatics/btz682]

11 **Goodfellow IJ**, Pouget-Abadie J, Mirza M, Xu B, Warde-Farley D, Ozair S, Courville A, Bengio Y. Generative adversarial nets. In: Ghahramani Z, Welling M, Cortes C, Lawrence ND, Weinberger KQ, editors. Proceedings of the 27th International Conference on Neural Information Processing Systems - Volume 2; 2014 Dec 8-13; Montreal, Canada. Cambridge: MIT Press, 2014: 2672-2680

12 **Vaswani A**, Shazeer N, Parmar N, Uszkoreit J, Jones L, Gomez AN, Kaiser L, Polosukhin I. Attention is all you need. In: von Luxburg U, Guyon I, Bengio S, Wallach H, Fergus R, editors. Proceedings of the 31st International Conference on Neural Information Processing Systems; 2017 Dec 4-9; Long Beach, United States. New York: Curran Associates Inc., 2017: 6000-6010

13 **Chaudhary K**, Poirion OB, Lu L, Garmire LX. Deep Learning-Based Multi-Omics Integration Robustly Predicts Survival in Liver Cancer. *Clin Cancer Res* 2018; **24**: 1248-1259 [PMID: 28982688 DOI: 10.1158/1078-0432.CCR-17-0853]

14 **Zhu Y**, Qiu P, Ji Y. TCGA-assembler: open-source software for retrieving and processing TCGA data. *Nat Methods* 2014; **11**: 599-600 [PMID: 24874569 DOI: 10.1038/nmeth.2956]

15 **Wang B**, Mezlini AM, Demir F, Fiume M, Tu Z, Brudno M, Haibe-Kains B, Goldenberg A. Similarity network fusion for aggregating data types on a genomic scale. *Nat Methods* 2014; **11**: 333-337 [PMID: 24464287 DOI: 10.1038/nmeth.2810]

16 **Roessler S**, Jia HL, Budhu A, Forgues M, Ye QH, Lee JS, Thorgeirsson SS, Sun Z, Tang ZY, Qin LX, Wang XW. A unique metastasis gene signature enables prediction of tumor relapse in early-stage hepatocellular carcinoma patients. *Cancer Res* 2010; **70**: 10202-10212 [PMID: 21159642 DOI: 10.1158/0008-5472.CAN-10-2607]

17 **Fujimoto A**, Furuta M, Totoki Y, Tsunoda T, Kato M, Shiraishi Y, Tanaka H, Taniguchi H, Kawakami Y, Ueno M, Gotoh K, Ariizumi S, Wardell CP, Hayami S, Nakamura T, Aikata H, Arihiro K, Boroevich KA, Abe T, Nakano K, Maejima K, Sasaki-Oku A, Ohsawa A, Shibuya T, Nakamura H, Hama N, Hosoda F, Arai Y, Ohashi S, Urushidate T, Nagae G, Yamamoto S, Ueda H, Tatsuno K, Ojima H, Hiraoka N, Okusaka T, Kubo M, Marubashi S, Yamada T, Hirano S, Yamamoto M, Ohdan H, Shimada K, Ishikawa O, Yamaue H, Chayama K, Miyano S, Aburatani H, Shibata T, Nakagawa H. Whole-genome mutational landscape and characterization of noncoding and structural mutations in liver cancer. *Nat Genet* 2016; **48**: 500-509 [PMID: 27064257 DOI: 10.1038/ng.3547]

18 **Huang S**, Cai N, Pacheco PP, Narrandes S, Wang Y, Xu W. Applications of Support Vector Machine (SVM) Learning in Cancer Genomics. *Cancer Genomics Proteomics* 2018; **15**: 41-51 [PMID: 29275361 DOI: 10.21873/cgp.20063]

19 **Jiang Y**, Yang M, Wang S, Li X, Sun Y. Emerging role of deep learning-based artificial intelligence in tumor pathology. *Cancer Commun (Lond)* 2020; **40**: 154-166 [PMID: 32277744 DOI: 10.1002/cac2.12012]

20 **He Y**, Jiang Z, Chen C, Wang X. Classification of triple-negative breast cancers based on Immunogenomic profiling. *J Exp Clin Cancer Res* 2018; **37**: 327 [PMID: 30594216 DOI: 10.1186/s13046-018-1002-1]

21 **Song BN**, Kim SK, Mun JY, Choi YD, Leem SH, Chu IS. Identification of an immunotherapy-responsive molecular subtype of bladder cancer. *EBioMedicine* 2019; **50**: 238-245 [PMID: 31735557 DOI: 10.1016/j.ebiom.2019.10.058]

22 **Zhao Y**, Pan Z, Namburi S, Pattison A, Posner A, Balachander S, Paisie CA, Reddi HV, Rueter J, Gill AJ, Fox S, Raghav KPS, Flynn WF, Tothill RW, Li S, Karuturi RKM, George J. CUP-AI-Dx: A tool for inferring cancer tissue of origin and molecular subtype using RNA gene-expression data and artificial intelligence. *EBioMedicine* 2020; **61**: 103030 [PMID: 33039710 DOI: 10.1016/j.ebiom.2020.103030]

23 **Bi WL**, Hosny A, Schabath MB, Giger ML, Birkbak NJ, Mehrtash A, Allison T, Arnaout O, Abbosh C, Dunn IF, Mak RH, Tamimi RM, Tempany CM, Swanton C, Hoffmann U, Schwartz LH, Gillies RJ, Huang RY, Aerts HJWL. Artificial intelligence in cancer imaging: Clinical challenges and applications. *CA Cancer J Clin* 2019; **69**: 127-157 [PMID: 30720861 DOI: 10.3322/caac.21552]

24 **Aerts HJ**, Velazquez ER, Leijenaar RT, Parmar C, Grossmann P, Carvalho S, Bussink J, Monshouwer R, Haibe-Kains B, Rietveld D, Hoebers F, Rietbergen MM, Leemans CR, Dekker A, Quackenbush J, Gillies RJ, Lambin P. Decoding tumour phenotype by noninvasive imaging using a quantitative radiomics approach. *Nat Commun* 2014; **5**: 4006 [PMID: 24892406 DOI: 10.1038/ncomms5006]

25 **Coroller TP**, Grossmann P, Hou Y, Rios Velazquez E, Leijenaar RT, Hermann G, Lambin P, Haibe-Kains B, Mak RH, Aerts HJ. CT-based radiomic signature predicts distant metastasis in lung adenocarcinoma. *Radiother Oncol* 2015; **114**: 345-350 [PMID: 25746350 DOI: 10.1016/j.radonc.2015.02.015]

26 **Schwartz LH**, Seymour L, Litière S, Ford R, Gwyther S, Mandrekar S, Shankar L, Bogaerts J, Chen A, Dancey J, Hayes W, Hodi FS, Hoekstra OS, Huang EP, Lin N, Liu Y, Therasse P, Wolchok JD, de Vries E. RECIST 1.1 - Standardisation and disease-specific adaptations: Perspectives from the RECIST Working Group. *Eur J Cancer* 2016; **62**: 138-145 [PMID: 27237360 DOI: 10.1016/j.ejca.2016.03.082]

27 **Gandhi L**, Rodríguez-Abreu D, Gadgeel S, Esteban E, Felip E, De Angelis F, Domine M, Clingan P, Hochmair MJ, Powell SF, Cheng SY, Bischoff HG, Peled N, Grossi F, Jennens RR, Reck M, Hui R, Garon EB, Boyer M, Rubio-Viqueira B, Novello S, Kurata T, Gray JE, Vida J, Wei Z, Yang J, Raftopoulos H, Pietanza MC, Garassino MC; KEYNOTE-189 Investigators. Pembrolizumab plus Chemotherapy in Metastatic Non-Small-Cell Lung Cancer. *N Engl J Med* 2018; **378**: 2078-2092 [PMID: 29658856 DOI: 10.1056/NEJMoa1801005]

28 **Jiang F**, Jiang Y, Zhi H, Dong Y, Li H, Ma S, Wang Y, Dong Q, Shen H, Wang Y. Artificial intelligence in healthcare: past, present and future. *Stroke Vasc Neurol* 2017; **2**: 230-243 [PMID: 29507784 DOI: 10.1136/svn-2017-000101]

29 **Komorowski M**, Celi LA, Badawi O, Gordon AC, Faisal AA. The Artificial Intelligence Clinician learns optimal treatment strategies for sepsis in intensive care. *Nat Med* 2018; **24**: 1716-1720 [PMID: 30349085 DOI: 10.1038/s41591-018-0213-5]

**Footnotes**

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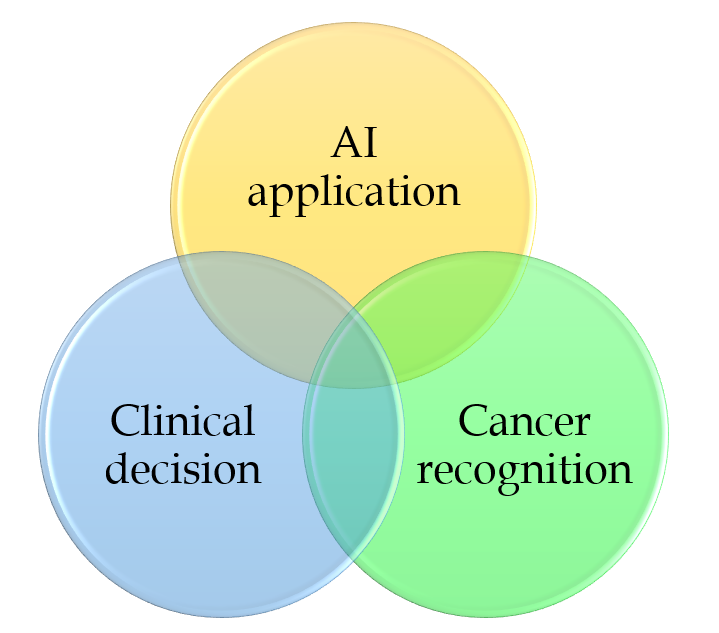
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**Figure Legends**



**Figure 1 Artificial intelligence application and cancer recognition in clinic.** Artificial intelligence is utilized for cancer recognition, which contributes in clinical decision such as the treatment strategy. AI: Artificial intelligence.

**Table 1 Artificial intelligence application in cancer recognition and treatment**

|  |  |  |
| --- | --- | --- |
| Step | AI application | Recognition/treatment |
| Early | Natural language processing | Clinical data in human language are translated into AI language to allow AI to recognize cancer |
| Middle | Machine learning | AI learns the feature of the data to generate the recognition model |
| Late | Deep learning | AI modeling is further evaluated and modified. Human interprets the results of the AI modeling prediction and decides the clinical treatment strategy |

AI: Artificial intelligence.