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REVIEW ARTICLE

"Solving" Cancer: The Use of Artificial Neural Networks in Cancer Diagnosis and Treatment

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Recent advances in both the biological and computer sciences have spurred researchers to pay greater attention to the role of computational methods in the broad sphere of cancer research. Specific focus has been given to the demonstrated benefits of artificial intelligence (AI) and machine learning approaches when compared to current methods for the diagnosis and treatment of cancer. An artificial neural network is a form of AI based on algorithms that mimic human brain function. Neural networks are especially useful in the interpretation of nonlinear data, which is commonly encountered in biological research studies. Neural networking technologies may be used to diagnose cancer more easily and effectively than traditional methods as they decrease the need for invasive procedures and interpreting the results of imaging methods. Additionally, neural networks have been trained to analyze individual prognoses and treatment plans with an accuracy comparable to that of experienced physicians. Advances such as these aid both medical professionals and patients in making optimal health care decisions. As large-scale computing initiatives – such as the recent Microsoft project aiming to "solve" cancer with computer science – move forward, it has become increasingly apparent that the future of medical research will involve technologies such as neural networking and other forms of AI.

INTRODUCTION

In recent years, significant research focus and funding has been directed towards the application of powerful computational techniques for cancer diagnosis and treatment. While these technologies have been researched for many years, their applications for cancer have only now begun to garner attention from both the corporate sector as well as the area of academia. In September of 2016, Microsoft announced an initiative to "solve" cancer by approaching the study of the disease and its treatment through a novel computational lens. One key technology in their approach is artificial intelligence (AI), which now plays a rapidly expanding role in the medical field. This review examines one specific form of AI – artificial neural networking – and its current applications to cancer diagnosis and treatment, with the intent of providing perspective on where initiatives such as Microsoft's are heading in the pursuit of solving the so-called "cancer problem."

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Artificial Neural Networks

Artificial Neural Networks (ANNs) are computer systems that operate by using algorithms based on human brain functions to interpret nonlinear data, which does not follow a sequential pattern. ANNs are composed of many smaller units called neurons, which are organized into multiple layers between the input of data and the output of results. In the same fashion as biological neurons, the connections and patterns between these units determine the behavior of the network, and this behavior may be learned through a process called backpropagation (Drew & Monson, 2000). In backpropagation, a data set for which the correct output is already known is input into the network. The output of the ANN is then continuously compared to the known output, and adjustments are made to the pattern of network components to minimize the least mean square difference over the entire set. After a sufficient number of repetitions, the network adjusts to a higher level of accuracy, and can perform complex tasks without requiring the as many computing resources as traditional methods (Drew & Monson, 2000). Researchers are now discovering that biomedical systems must increasingly be represented by nonlinear systems, making ANNs a valuable computing resource for biological research. ANNs have been applied to various aspects of cancer medicine for decades. Yet, more recent research efforts in this field have been accompanied by new knowledge about the biological aspects of cancer (Cruz & Wishart, 2006). As a result, computational methods are becoming significantly more effective than ever before.

Applications to Cancer Diagnosis

Even before an individual develops cancer, this technology may provide insight into his or her susceptibility to the disease; Naushad et al. (2016) developed an ANN-based model which analyzes the interaction of genes, nutrients, and demographic indicators to predict the likelihood of an individual developing breast cancer. This model proved to be very precise – displaying 94.2% accuracy – and identified several variables which contributed to breast cancer risk, including folate deficiency and estrogen exposure (Naudshad et al., 2016). For many years it has been known that ANNs have diagnostic utility, with an early review concluding that AI methods are more effective than traditional statistical approaches, particularly for large data sets (Abbod et al., 2007). Many of these technologies have their roots in biological processes beyond neural networking. For example, an ANN developed by He et al. (2009) to diagnose breast cancer at a sufficient level was modeled after the producer-scrounger model of animal searching behavior and group. Similarly, another study presents a method for evolving ANNs using genetic algorithms so that the networks adapt much in the same way that natural evolution occurs, so that eventually said network can be used in computer-aided mammographic mass detection (Tan et al., 2014). Methods such as those mentioned have shown high accuracy rates comparable to those of humans, including a particular ANN system for malignant melanoma screening which displays a classification accuracy of 93% (Premaladha & Ravichandran, 2016).

Applications to Cancer Treatment

After a diagnosis has been made, ANNs may be used to improve treatment plans in ways that even trained medical professionals cannot; as early as fifteen years ago, artificial intelligence was shown to predict relapse in bladder cancer with an accuracy rate of 88-95%, a level which is significantly more reliable than standard logistic regression techniques (Catto et al., 2003). A systematic review published in 2006 concluded that out of 27 clinical and randomized control trials involving ANNs in cancer research, 21 exhibited increased benefit from using the technology, and none presented any decreased benefit (Lisboa & Taktak, 2006). These methodologies are effective because they can model the nonlinear relationships that are necessary for an accurate prognosis, something that is cannot be done by the standard statistical regression techniques that were used previously (Abbod et al., 2007). In recent years, the application of machine learning to cancer disease modeling has become a fast-growing trend in research due to the ability of AIs to decipher complex datasets for both disease recurrence and patient survival (Kourou et al., 2015). With increased availability of public data, these techniques have the potential to become even more useful. In another study, an ANN was used to categorize women with cervical abnormalities, based on clinical information, into one of three diagnostic categories – each of which reflected a varying degree of severity – in order to develop a decision-support scoring system (Kyrgiou et al., 2016). Studies such as this one reflect a current trend: as more research centers around individualized treatment plans, many of the strategies used to determine those plans may be assisted by ANN technologies.

An additional capability of ANNs, which may contribute to the creation of individualized treatment plans is their skill at predicting treatment outcomes. A study by Francis et al. (2015) analyzing post-op data from colorectal cancer surgery patients with a neural network yielded results compliant with standard regression methods and identified two factors behind readmission within the first thirty days after surgery. Another recent study using ANNs to model treatment outcome data for radiotherapy in cancer patients displayed computation advantages for ANN time-series modeling over traditional techniques with applications in quality assurance research (Li et al., 2016). One possible benefit of ANNs over regressions in this area is that while complex statistical knowledge is necessary to run a proper regression, ANNs are easy to operate with little-to-no knowledge of their function, thus making it so more hospitals could take advantage of such technologies (Francis et al., 2015). Clearly, as research continues to progress in the intersection of medicine and technology, there is room for AI in predicting disease progression both before and after treatment - an initiative which has undeniably great clinical utility for cancer patients.

DISCUSSION

This review of research involving ANNs and cancer validates Microsoft's claims that advancements in computer science will contribute similar advancements to cancer research. Neural networks are one of many different computational techniques that may be applied to cancer diagnostics and treatment, and as more funding is now being awarded to computer science research through efforts such as that of Microsoft, it is entirely possible that the next cancer breakthrough may take place in a CPU instead of a test tube. Many of these advances could realistically be applied to research in other areas of medicine as well, as they represent a pragmatic approach to tackling increasingly complex research problems. In conclusion, cancer research literature supports the claim that ANNs are effective tools in cancer diagnosis and treatment, and suggests that there is an expanding role for computer technologies in the future of medicine.

REFERENCES

Abbod, M. F., Catto, J. W., Linkens, D. A., & Hamdy, F. C. (2007). Application of artificial intelligence to the management of urological cancer. *The Journal of Urology, 178*(4), 1150-1156. doi:10.1016/j.juro.2007.05.122

Catto, J., Linkens, D., Abbod, M., Chen, M., Meuth, M., & Handy, F. (2003). The application of artificial intelligence in predicting outcome of bladder cancer: a comparison of neuro-fuzzy modelling and artificial neural networks. *European Urology Supplements, 2*(1), 66. doi:10.1016/s15699056(03)80262-2

Cruz, J. A., & Wishart, D. S. (2006). Applications of machine learning in cancer prediction and prognosis. *Cancer Informatics, 2*, 59–77.

Drew, P. J., & Monson, J. R. (2000). Artificial neural networks. *Surgery, 127*(1), 3-11. doi:10.1067/msy.2000.102173

Francis, N. K., Luther, A., Salib, E., Allanby, L., Messenger, D., Allison, A. S., & Ockrim, J. B. (2015). The use of artificial neural networks to predict delayed discharge and readmission in enhanced recovery following laparoscopic colorectal cancer surgery. *Techniques in Coloproctology, 19*(7), 419-428. doi:10.1007/s10151-015-1319-0

He, S., Wu, Q., & Saunders, J. (2009). Breast cancer diagnosis using an artificial neural network trained by group search optimizer. *Transactions of the Institute of Measurement and Control, 31*(6), 517-531. doi:10.1177/0142331208094239

Kourou, K., Exarchos, T. P., Exarchos, K. P., Karamouzis, M. V., & Fotiadis, D. I. (2015). Machine learning applications in cancer prognosis and prediction. *Computational and Structural Biotechnology Journal, 13,* 8–17. doi:10.1016/j.csbj.2014.11.005

Kyrgiou, M., Pouliakis, A., Panayiotides, J. G., Margari, N., Bountris, P., Valasoulis, G., … Paraskevaidis, E. (2016). Personalised management of women with cervical abnormalities using a clinical decision support scoring system. *Gynecologic Oncology, 141*(1), 29-35. doi:10.1016/j.ygyno.2015.12.032

Li, Q., & Chan, M. F. (2016). Predictive time-series modeling using artificial neural networks for Linac beam symmetry: an empirical study. A*nnals of the New York Academy of Sciences.* doi:10.1111/nyas.13215

Lisboa, P. J., & Taktak, A. F. (2006). The use of artificial neural networks in decision support in cancer: a systematic review. *Neural Networks, 19*(4), 408-415. doi:10.1016/j.neunet.2005.10.007

Naushad, S. M., Ramaiah, M. J., Pavithrakumari, M., Jayapriya, J., Hussain, T.,

Alrokayan, S. A., … Kutala, V. K. (2016). Artificial neural network-based exploration of gene-nutrient interactions in folate and xenobiotic metabolic pathways that modulate susceptibility to breast cancer. *Gene, 580*(2), 159-168. doi:10.1016/j.gene.2016.01.023

Premaladha, J., & Ravichandran, K. S. (2016). Novel approaches for diagnosing melanoma skin lesions through supervised and deep learning algorithms. *Journal of Medical Systems, 40*(4). doi:10.1007/s10916-016-0460-2

Tan, M., Pu, J., & Zheng, B. (2014). Optimization of network topology in computer-aided detection schemes using phased searcing with NEAT in a time-scaled framework. *Cancer Informatics, 13*(1), 17–27. doi:10.4137/CIN.S13885