DEEP LEARNING ANALYSIS IN HEALTH CARE
ANÁLISE DO DEEP LEARNING EM CUIDADOS DE SAÚDE
ANÁLISIS DEL DEEP LEARNING EN ATENCIÓN MÉDICA

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ABSTRACT

Objective: to analyze the applicability and benefits of Deep Learning in health care. **Method:** this is a descriptive study, reflective analysis, with articles from 2014 to 2019, published in English and peer-reviewed, in the CAPES Journal Portal, with the search equation ("Deep Learning" AND ("Health Care" OR Health-care OR Healthcare)). The results were presented in figure form followed by descriptive analysis. **Results:** it is revealed that 15 articles describe the applicability of Deep Learning in the health care area. This article analyzed the use of Deep Learning in different areas related to health care, highlighting the benefits found by the authors of those selected through the literature review. **Conclusion:** it is suggested the use of Deep Learning in health care in view of the benefits identified in the articles selected as: the prediction of disease stages; precise identification of pathological mutations and support to doctors and nurses in their daily activities. **Descriptors:** Benefits; Deep Learning; Health Care; Diseases; Physicians; Nurses.

RESUMO

Objetivo: analisar a aplicabilidade e os benefícios do *Deep Learning* na área de cuidados de saúde. **Método:** trata-se de um estudo descritivo, tipo análise reflexiva, com consulta a artigos entre os anos de 2014 a 2019, publicados em inglês e revisado por pares, no Portal de Periódicos da CAPES, com a equação de busca ("*Deep Learning*" AND ("*Health Care*" OR *Health-care* OR *Healthcare*)). Apresentaram-se os resultados em forma de figura seguida da análise descritiva. **Resultados:** revela-se que 15 artigos descrevem a aplicabilidade do *Deep Learning* na área de cuidados de saúde. Analisou-se, por este artigo, o emprego do *Deep Learning* em diferentes áreas referentes aos cuidados de saúde, destacando os benefícios encontrados pelos autores dos selecionados por meio da revisão de literatura. **Conclusão:** sugere-se o emprego do *Deep Learning* na área de cuidados de saúde diante dos benefícios identificados nos artigos selecionados como: a previsão dos estágios das doenças; a identificação precisa de mutações patológicas e o suporte aos médicos e aos enfermeiros em suas atividades diárias. **Descritores:** Benefícios; *Deep Learning*; Cuidados de Saúde; Doenças; Médicos; Enfermeiros.

RESUMEN

Objetivo: analizar la aplicabilidad y los beneficios del *Deep Learning* en la atención médica. **Método:** se trata de un estudio descriptivo, tipo análisis reflexivo, con artículos de 2014 a 2019, publicados en inglés y revisados por pares, en el Portal de la revista CAPES, con la ecuación de búsqueda ("*Deep Learning*" Y ("*Health Care*" O *Health-care* O *Healthcare*)). Los resultados se presentaron en forma de figura seguida de un análisis descriptivo. **Resultados:** se revela que 15 artículos describen la aplicabilidad del *Deep Learning* en el área de la atención médica. Este artículo analizó el uso del *Deep Learning* en diferentes áreas relacionadas con la atención de la salud, destacando los beneficios encontrados por los autores de los seleccionados a través de la revisión de la literatura. **Conclusión:** se sugiere el uso de *Deep Learning* en la atención de la salud en vista de los beneficios identificados en los artículos seleccionados como: la predicción de las etapas de la enfermedad; identificación precisa de mutaciones patológicas y apoyo a médicos y enfermeros en sus actividades diarias. **Descriptor:** Beneficios; *Deep Learning*; Cuidados de la Salud; Enfermedades; Médicos; Enfermeros.

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INTRODUCTION

Many scientists have been known to have attempted to create a program over the past few decades that apparently thinks and processes data like humans by observing behavior. This idea began by analyzing how neurons transmit electrical information to each other by releasing neurotransmitters into the space known as synaptic cleft, trying to replicate this format of transmissions to computers, giving rise to the term Deep Learning (DL).¹

DL represents, in other words, the steps the computer takes to try to figure out certain things. It is a technology inspired by the functioning of the human brain where artificial neural networks analyze large data sets to automatically discover underlying patterns without human intervention.²

It is reported that DL is a subgroup of Machine Learning (ML) which, in turn, is a strand of Artificial Intelligence (AI). DL has been applied, as well as Big Data (BD), the Internet of Things (IoT) and itself (ML), in the area of health frequently. Therefore, it can be said that it is part of electronic health (e-Health) that, according to the World Health Organization,³ is the use of health communication and information technologies. It is also stated by World Health Organization,⁴ e-Health solutions are designed to make life easier for its users.

The term "deep" is derived from the numerous hidden layers in the structure of the Artificial Neural Network (ANN). The ANN algorithm models the functionality of a biological brain and its nerve cells.⁵ It consists of an axon nerve cell (output), dendrites (input), a node (sum), nucleus (activation function) and synapses (weights).⁶ The activation function in the artificial neuron acts as the nucleus of a biological neuron, while the input signals and their respective weights shape the dendrites and synapses, respectively.

DL methods are powerful tools that complement traditional ML and allow computers to learn from data so they can create ways to produce smarter applications. In addition, these approaches have already been used in a variety of applications, especially for computer vision and natural language processing. For all available literature results, DL's capabilities for analyzing health care data are also illustrated.⁷

It is explained, as described earlier, that PD is a subgroup of ML, so in order to better understand the idea of DL, it is important to know the goal of ML. The goal of ML is to enable a system to learn from the past or present and use that knowledge to make predictions or decisions about unknown future events, and its overall focus is on representing input data and generalizing learned patterns for use on future unseen data.⁸

It is inferred that probably the most well-known health care ML software is Watson Health (WH)

from International Business Machines (IBM). WH is fed with everything that has been written in any language and at any time related to cancer diagnoses and their treatments. WH still continues to ingest all new data as it is published. WH, when presented to a specific cancer patient, will recommend the treatment test most likely to cure that individual patient's cancer, considering their genome, history, image, and pathology, along with all known information on the treatment of this cancer, because the more information WH has about the patient, the more accurate it will be. It's basically IBM's vision for AI that it will support the physician's decision-making rather than replace it by doing what she does best: managing, handling large amounts of data, and presenting only the relevant information to the doctor.⁹

It is detailed, as described in the introduction ML and DL, that the central theme of this article are strands of AI, which is defined by science as the study of intelligent agents, which are devices that perceive their environment and take actions to maximize their chance of success in some goal.¹⁰

There are many examples of AI in our lives, and Apple's Siri is one such example; another is Alexa from Amazon. Natural language processing technology, a form of artificial intelligence, is used to translate languages in Google Translate. Approximately \$ 30 billion was invested in AI in 2017 and research and development by companies like Google and Microsoft.¹¹

It is clear that AI has been around for some time. The term was coined by John McCarthy in a lecture at Dartmouth College in 1956,¹² however, it took some time for technology to reach the promise of AI and the hopes of computer science experts. It was predicted by Moore's Law, defined in 1965 by Intel co-founder Gordon E. Moore, that the number of transistors in integrated circuits would double approximately every two years.

OBJECTIVE

- To analyze the applicability and benefits of deep learning in healthcare.

METHOD

This is a descriptive study, reflective analysis, with research in the CAPES Journal Portal (PPC).¹³

The following steps were followed: 1) formulation of the problem; 2) determination of the inclusion and exclusion criteria of the studies according to the sampling criteria; 3) data evaluation; 4) analysis of information and 5) analysis and interpretation of results and review presentation.

The guiding question was "What benefits can be obtained through the applicability of Deep Learning in health care?"

For the search, the descriptors in Health Sciences (DeCS) and the Medical Subject Headings (MeSH) were used with the following search equation: (“Deep Learning” AND (“Health Care” OR Health-care OR Healthcare)), resulting in 421 peer-reviewed articles published from January 2014 to January 2019.

The following selection and exclusion criteria were used: English articles describing the use of DL in health care; articles published in the last five years; peer reviewed articles; articles that presented search descriptors only in the title, using, as Boolean operators, AND and OR; limitation of results by using quotes and hyphens.

As an aid for the selection and exclusion of articles, PPC filter tools were used and 30 articles were selected for full reading.

It is detailed from the results of this search that 15 articles describe the applicability of DL in the health care area.

RESULTS

Figure 1 describes the articles included in this study, as well as the specifications concerning the title / authors, field of application, year and the main benefits highlighted.

Study code	Title/authors	Field of application	Year	Highlighted benefits
E1	Introduction to the special issue on deep learning for biomedical and healthcare applications. Tong, Medsker, Cheng, Jafari, Wang ¹⁵	Biomedicine	2016	Important examples include using Deep Learning for image classification and drug discovery.
E2	Predicting healthcare trajectories from medical records: A deep learning approach. Pham, Tran, Phung, Venkatesh ¹⁶	Predictive Medicine	2017	Deep Learning reads medical records, remembers disease pathways and care processes, estimates current disease states and predicts future risks, and opens a new, principled approach to predictive medicine.
E3	Using Deep Learning for Classification of Lung Nodules on Computed Tomography Images. Song, Zhao, Luo, Dou ¹⁷	Medical Imaging	2017	Deep Learning has proven to be a popular and powerful method in many areas of medical imaging diagnosis.
E4	A deep inference learning framework for healthcare. Dai, Wang ¹⁸	Medical assistance	2018	This paper demonstrates the effectiveness of the closed loop process and illustrates the promising perspective of deep learning in health.
E5	Socialized healthcare service recommendation using Deep Learning. Yuan, Li, Guan, Han, Khattak ¹⁹	Health services	2018	Deep Learning based model can achieve high performance even for novice users with limited knowledge.
E6	Deep Learning versus Professional Healthcare Equipment: A Fine-Grained Breathing Rate Monitoring Model. Liu, Dai, Gong, Guo, Liu, Wang, et al. ²⁰	M-Health (Mobile health)	2018	Results show good accuracy of respiration rate monitoring. Thus, Deep Filter, a Deep Learning based low-granular respiration rate monitoring algorithm that works on the smartphone, is proposed.
E7	Applying Deep Learning in Medical Images: The Case of Bone Age Estimation. Lee, Kim ²¹	Medical Imaging (X-rays)	2018	The Deep Learning-based neural network can be used to estimate a subject's age from hand-held x-ray images, which eliminates the need for tedious atlas searches in clinical settings and should improve process time and cost of the estimation process.
E8	Benchmarking deep learning models on large healthcare datasets. Purushotham, Meng, Che, Liu ¹	ICU	2018	The results show that the Deep Learning model consistently outperforms all other approaches, especially when "raw" clinical time series data is used as input to the models.
E9	Voice Pathology Detection Using Deep Learning on Mobile Healthcare Framework. Alhussein, Muhammad ²²	Telemedicine	2018	The result, based on Deep Learning, is promising because it surpasses some of the previous results reported in the literature using another approach.
E10	Deep learning for healthcare: review, opportunities and challenges. Miotto, Wang, Wang, Jiang, Dudley ⁷	Medicine	2018	Deep Learning can pave the way for the next generation of predictive healthcare systems that can include many millions to billions of patient records.
E11	Human Action Monitoring for Healthcare Based on Deep Learning. Gao, Xiang, Xiong, Huang, Lee, Alrifai, et al. ²³	Healthcare	2018	The Deep Learning-based method for recognizing human action showed a significant difference from traditional methods. This method is effective and discriminative for recognizing human actions.
E12	A guide to deep learning in healthcare. Esteve, Robicquet, Ramsundar, Kuleshov, Depristo, Chou, et al. ²⁴	Medical Imaging	2019	In the near future, models that integrate external modalities and additional sources of biological data, medical imaging and other intermediate phenotypes may also benefit from Deep Learning.
E13	Improving Accuracy of Lung Nodule Classification Using Deep Learning with Focal Loss. Tran, Nghiem, Nguyen, Luong, Burie ²⁵	Computerized tomography	2019	The experiments showed that the focal loss Deep Learning method is a high quality classifier with 97.2% accuracy, 96.0% sensitivity and 97.3% specificity.
E14	Recent Deep Learning Techniques, Challenges and Its Applications for Medical Healthcare System: a review. Pandey, Janghel ²⁶	Medical assistance	2019	The findings present some of the most fundamental and recent applications in the healthcare system and also identified some of the challenges and opportunities of deep learning techniques.
E15	Automatic Tissue Image Segmentation Based on Image Processing and Deep Learning. Kong, Li, Luo, Xu ²⁷	Multimodal Imaging	2019	Deep Learning approaches have greatly reduced processing time compared to manual and semi-automatic segmentation, and are of great importance for improving speed and accuracy as more and more samples are being learned.

Figure 2. Articles searched in the review. Rio de Janeiro (RJ), Brazil, 2019.

DISCUSSION

This article analyzed the use of DL in different areas related to health care. It was proposed in the first study (E1) to bring articles on theoretical and model development along with innovative applications of DL. This study showed the effectiveness of DL in its use for image classification and drug discovery. This study highlights the contribution of DL to imaging and the pharmaceutical industry, as discovering new drugs represents the hope of finding a cure for many diseases.¹⁵ The importance of researching other sectors in which they can employ DL is highlighted, as mentioned in study E1.

In the second study (E2), the efficacy of DL for modeling disease progression, intervention recommendation and future risk prediction was shown. It was identified through this study that DL opens a new approach based on principles for predictive medicine, highlighting, in turn, that predictive medicine can be defined as the ability to make predictions about the possibility of a person develops any disease.¹⁶

The third study (E3) analyzed both types of deep neural networks, known as convolution neural network (CNN) and deep neural network (DNN). DL's popularity and power observed in many areas of medical imaging.¹⁷

In the fourth study (E4), a structure of DL inferences for health care was presented. The promising perspective of DL in health care has been demonstrated due to the effectiveness of the closed-loop process.¹⁸

In the fifth study (E5), a new DL-based socialized health service recommendation model was demonstrated. The importance of DL regarding the ease of use of this method was highlighted, as it can achieve high performances, even when used by novice users and with a limited number of knowledge.¹⁹

In the sixth study (E6), the DL model was introduced as a high-resolution respiratory rate monitoring technique for smartphones for people's daily sleep quality monitoring. The results of this study show good accuracy of respiration rate monitoring.²⁰

In the seventh study (E7), we presented a way to apply the DL technique to medical image analysis using bone age estimation as an example. The high accuracy of DL has been identified by allowing the estimation of a subject's age from hand-held x-ray images, which eliminates the need for tedious atlas searches in clinical settings and should improve time and cost of the estimation process.²¹

In the eighth study (E8), benchmarking results for various clinical prediction tasks and the publicly available data set at the Intensive Care Medical Information Center were demonstrated. It has thus been shown that DL consistently

outperforms all other approaches, especially when "raw" clinical time series data is used as input to the models.¹

In the ninth study (E9), a transfer learning technique was used to use the existing robust models of Convolutional Neural Networks. It was found from the results obtained in this study that DL is a promising approach because it surpasses some of the previous results reported in the literature where other types of approach were used.²²

In the tenth study (E10), the recent and future applications of Deep Learning in Medicine were discussed, highlighting the key aspects to significantly impact health care. Deep Learning can pave the way for the next generation of predictive healthcare systems that can include many millions to billions of patient records.⁷

In the eleventh study (E11), a feed-forward artificial neural network class was presented to remotely monitor human action for smart health, which is the first attempt to integrate the 3D convolutional network. There was a significant difference from traditional methods in human voice recognition.²³

In the twelfth study (E12), Deep Learning techniques for health care were implemented, focusing the Deep Learning discussion on computer vision, natural language processing and generalized methods. It has been shown in this study that the benefits of DL can reach models that integrate external modalities and additional sources of biological data, medical imaging and other intermediate phenotypes.²⁴

In the thirteenth study (E13), a new Deep Learning method was reported to improve the accuracy of lung nodule classification on computed tomography (CT). (E13) This study highlighted the high quality of the DL method, even with focal loss.²⁵

In the fourteenth study (E14), all Deep Learning techniques and their experimental analysis with advantages and disadvantages were described. Through the results, we presented some of the most fundamental and recent applications in the medical health system and also identified some of the challenges and opportunities of Deep Learning techniques.²⁶

Preprocessing methods such as wavelet denoisation were used to extract the precise contours of different tissues such as skull, cerebrospinal fluid (CSF), gray matter (GM) and white matter (WM) in five sets of images of the head MRI. Just as in (E6), a good precision was identified in the DL model, also highlighting the reduction of processing time compared to manual and semi-automatic segmentation.²⁷

CONCLUSION

It is concluded that DL systems can be effectively used to improve accuracy and increase

health care efficiency. DL can help health professionals with those tasks in which they have some difficulty, because the proposal of “deep learning”, the way in which DL can be translated, seeks to learn from human difficulties through the identification of errors in certain steps, always seeking to correct them and to avoid them in later steps.

There is a need to address more topics linking health care and Big Data, the Internet of Things and Machine Learning itself, as DL is a subgroup of Machine Learning, which in turn is a strand of AI.

This study seeks to encourage health professionals to implement Deep Learning in health care and to disseminate their respective results obtained through this implementation and to cite the main challenges that may arise along the way.

It is understood that the analysis of these benefits may contribute to future research and identification of others that were not identified in this study. It is identified the need for more national publications, due to the significant difference between the number of national and international articles, since most of the literature based on the theme of this study focuses on publications outside Brazil and in the English language, based on results presented in this article.

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