SADLE: Services and Applications Based on Deep Learning for eHealth

Special track along with eTelemed 2020
https://www.iaria.org/conferences2020/eTELEMED20.html

Javier Civit-Masot, and Satur Vicente-Diaz
Robotics and Computer Technology Lab
Avda. Reina Mercedes s/n, E.T.S. Ingeniería Informática, Universidad de Sevilla, Sevilla, Spain
Email: { jcivit, satur}@atc.us.es

***Abstract*—Recently, Machine Learning techniques and more specifically Deep Learning-based solutions have been applied successfully in many fields. Deep Learning-based systems and applications have been performing well for image-based tasks such as object or face recognition and for Natural Language Processing. Many possibilities have become feasible and attractive for medical applications. Deep Learning has been applied to many eHealth fields: imaging (tele)diagnosis tools, health analytics, pervasive sensing for user monitoring and assistance, predictive diagnosis or explainabling deep learning. The Sadle track main object is discussing the opportunities and challenges that deep learning-based eHealth applications and services face. The topics finally covered in the track are Diagnosis tools in medical imaging, Internet of Things (IoT)-based medical data collection and analysis, Deep learning-based ambient assisted living tools and services and explainable deep learning based eHealth systems.**

Deep learning, Medical diagnostic Aids, Ambient Assisted Living, Explainable AI

I. Introduction

In the last decade the availability of a wide variety of medical data has made many machine learning based applications possible. The possibility of finding common factors between information from widely different data sets is a fundamental for providing widely available, acceptable and reliable machine learning based medical diagnosis and support tools. A very important difficulty lays in the heterogenity and inconsistency of many data sources.

The traditional aproach to the development of medical diagnostic and support aid during most of the 20th century was to create rule based human expert specified expert systems. These approach scales very badly and is not able to find any aspect not specifically defined by the human expert. Modern supervised and unsupervised machin learning methods can discover the characteristics that will permit to make predictions from new data. Deep learning methods use multiple representation stages and increase the meaning of the available characteristics as we go deeper in the network. This approach has had important successes in a wide range of application areas such as natural language processing (NLP), speech recognition, computer vision and automatic driving among many other possible uses.

These main stream successes together with the fast theoretical and methodological developments represent a very significant opportunity for medical AI applications. Many areas of application have already been analyzed in research papers (e.g. medical image analysis including X-Ray, CT, RM, ultrasound, etc. or patient support aids for many chronic deceases). Deep learning approaches have not been extensively evaluated in many realistic medical situations for a wide range of problems and, in many cases, the results come from very limited data. The deep learning research approach must still address many challenges relating to the characteristics of health care data (i.e. sparse, noisy, heterogeneous, time-dependent) and also requires new methodologies to integrate with established health care information workflows and clinical decision support.

In this track our idea is to analyze current and future approaches to a wide range of medical problems tha can have an important impact on medical diagnostic and care quality., we discuss recent and forthcoming applications of deep learning in medicine, highlighting the key aspects to significantly impact health care. A very important, not widely discussed aspect of deep learning based medical tools is their acceptability by healthcare professionals. One of the reasons that decreases the acceptability of this type of systems is their ”oracle” approach. The healthcare professional needs to understand the reasons for a diagnosis sugestion and this is not easy to implement with deep learning technology.

II. Submitions

The received papers cover a wide variety of applications related to medical applications of Deep Learning technologies. Application include inteligent assistive techonlogy, medical diagnosis aid, ambient assisted living and explainable deep learning systems.

The first paper [1] is related to possibility of using an AI enabled embedded device for the detection and prevention of fall in older users. Accidental falls are one of the most common causes of early disability and even mortality related to unnatural causes. Fall happend mainly to the elderly population and, thus, considering the growing aging population, the rate of accidental falls is increasing significantly. Computer based systems for gait analysis and assistance in ubiquitous environments can be effective tools to prevent these accidents. In the first article the authors present the advances in the creation of an intelligent device for detecting falls and risk situations based on accelerometer signals registered on the user's ankle. The method uses Gated Recurrent Neural Networks. The results show that the presented model is a viable alternative to detect falls and fall risk using low power devices. The results also open the possibility of combining fall detection with a biomechanical analysis system to identify gait deficiencies and help improve the user's mobility. Many factors related to falls have an important influence on the person's gait. Thus,it is possible study the gait in order to predict the future probability of falling [2]. It would be interesting to study the capability of wearable devices to perform both gait analysis [3] and fall detection tasks [4][5].

The second paper [6] is related to glaucoma diagnosis aids. Color fundus image segmentation is a required first step in many glaucoma diagnosis techniques. Traditionally automated Fundus image segmentation is implemented in the image acquisition instrument and, thus, it only needs to be able to segment data from this specific acquisition source. With the advent of multi GPU and TPU virtual machines by different Cloud providers cloud-based segmentation has become an interesting possibility. To implement this ideait is needed to make correct predictions for images coming from different sources. In the presented paper the authors study the possibility of building a web base segmentation service using incremental training, i.e, initially training the system using data from a single source and, later, performing retraining with data from other acquisition sources.

For this article the authors use a generalized U-Net. U-Net, a type of deconvolutional network, [7] has become popular for many medical segmentation problems including glaucoma [8] and diabetic macular edema [9]. In this type of networks a set of convolutional layers outputs a deep small more meaningful representation of the original image. This highly encoded representation is then decoded to the original image size using a set of upsampling layers. Its structure has been widely modified by many researchers (e.g. [8]).

Many medical diagnostics are currently based, at least, in part on imaging technologies. Currently the interpretation of these images is, in most cases done almost directly by medical professionals. The great development of machine learning (ML) based image processing applications in the last decade has significantly increased the research on diagnostic support aids based on these technologies.

The third paper [10] deals with the acceptability of deep learning tools by medical professionals. The authors indicate that Medical image processing will experiment a breakthrough when this type of ML based diagnostic assistance tools became widely available and accepted by the medical community. Clearly one of the problems regarding the adoption of this type of systems is related to the lack of understandability of their diagnostic suggestions due to their Black-box nature. This aspect is especially relevant in the case of medical diagnostic aids. This fact has been recently highlighted by several recent articles [11]. In a recent presentation[12] Carlos Guestrin, Senior Director of AI and Machine Learning at Apple considers the transition from black box to inclusivity as one of the four challenges of ML systems for the next few years. In all these cases medical systems are considered the paradigmatic case where understandability is of out-most importance. Some authors even consider that GDPR [13] includes the requirement that companies should be able to give users an explanation for decisions that this type of systems produce. However, in the medical case no real automatic decision making is envisioned as the tools are just diagnostic assistance and are never responsible for any final decision.

The third paper [14] deals with intelligent prosthetic devices.Today, bionics is the application of biological solutions to systems technologies in architecture, design, engineering and modern technology [15]. There is also bionic engineering that covers several disciplines with the aim of concatenating (making biological and electronic systems work together), for example, to create prostheses activated by robots controlled by a biological signal or also to create artificial models of things that only exist in nature, for example, artificial vision and artificial intelligence also called cybernetics [16]. One could even consider bionics as that branch of cybernetics that tries to simulate the behavior of living beings by making them better in almost all branches by means of mechanical instruments.

The main objective of the third paper work is the creation of cheap non-invasive active prosthesis. Its user will be able to use it thanks to a bracelet, which has several integrated sensors (gyroscope, accelerometer and EMG (electromyographic signal sensors)). This bracelet will be placed on the user's arm and will read the parameters of the resident muscular terminations of the user's residual limb, transmitting them to a microprocessor that will move the specific motor in the prosthesis.

To achieve this purpose, the authors apply the "Divide and Win" technique,i.e., the main aim of this work is split into smaller objectives, which can be carried out individually, to finally bring them together and obtain the final goal.

III. Conclusions

In the Sadle track papers we see that a wide range of deep learning based medical technologies are becoming widely available for solving a wide range of practical everyday problems. This tools can be directed to help professionals in their diagnosis, patient in their daily life or even both cases simulataneously.

From the presented work it should become clear that these tecnologies will become more and more part of our life in the near future.

Acknowledgments

We would like to thank the organizers of eTelemed 2020 for their tireless efforts and for accepting Sadle as a special track. I also thank the members of the program committee for their hard work with the reviews and feedback. Last, but not least, I am very thankful to the authors for their very interesting contributions.

References

[1] F. Luna-Perejon, L. Muñoz-Saavedra, J. Civit-Masot, J. M. Montes-Sanchez, and M. D.-M. A. Civit, "Lower-limb falling detection system using gated recurrent neural networks," in *eTELEMED 2020, The Twelfth International Conference on eHealth, Telemedicine, and Social Medicine*. IARA XPS Press, 2020.

[2] L. Wolfson, R. Whipple, P. Amerman, and J. N. Tobin, "Gait assessment in the elderly: a gait abnormality rating scale and its relation to falls," *Journal of gerontology*, vol. 45, no. 1, pp. M12–M19, 1990.

[3] J. Pineda-Gutiérrez, L. Miró-Amarante, M. Hernández-Velázquez, F. Sivianes-Castillo, and M. Domínguez-Morales, "Designing a wearable device for step analyzing," in *2019 IEEE 32nd International Symposium on Computer-Based Medical Systems (CBMS)*. IEEE, 2019, pp. 259–262.

[4] F. Luna-Perejon *et al.*, "An automated fall detection system using recurrent neural networks," in *Conference on Artificial Intelligence in Medicine in Europe*. Springer, 2019, pp. 36–41.

[5] F. Luna Perejón *et al.*, "Sampling frequency evaluation on recurrent neural networks architectures for iot real-time fall detection devices," in *IJCCI 2019: 11th International Joint Conference on Computational Intelligence (2019), p 536-541*. ScitePress Digital Library, 2019.

[6] J. Civit-Masot, L. Muñoz-Saavedra, F. Luna-Perejon, J. M. Montes-Sanchez, and M. Dominguez-Morales, "Incremental learning for fundus image segmentation," in *eTELEMED 2020, The Twelfth International Conference on eHealth, Telemedicine, and Social Medicine*. IARA XPS Press, 2020.

[7] O. Ronneberger, P. Fischer, and T. Brox, "U-net: Convolutional networks for biomedical image segmentation," in *International Conference on Medical image computing and computer-assisted intervention*. Springer, 2015, pp. 234–241.

[8] B. Al-Bander, B. Williams, W. Al-Nuaimy, M. Al-Taee, H. Pratt, and Y. Zheng, "Dense fully convolutional segmentation of the optic disc and cup in colour fundus for glaucoma diagnosis," *Symmetry*, vol. 10, no. 4, p. 87, 2018.

[9] C. S. Lee, A. J. Tyring, N. P. Deruyter, Y. Wu, A. Rokem, and A. Y. Lee, "Deep-learning based, automated segmentation of macular edema in optical coherence tomography," *Biomedical optics express*, vol. 8, no. 7, pp. 3440–3448, 2017.

[10] L. M.-S. Juan Manuel Montes-Sanchez, F. Luna-Perejon, J. Civit-Masot, S. Vicente-Diaz, and A. Civit, "An approach to explainable ai for digital pathology," in *eTELEMED 2020, The Twelfth International Conference on eHealth, Telemedicine, and Social Medicine*. IARA XPS Press, 2020.

[11] W. Knight, "The dark secret at the heart of al," *Technology Review*, vol. 120, no. 3, pp. 54–61, 2017.

[12] A. Lauterbach, "Artificial intelligence and policy: quo vadis?" *Digital Policy, Regulation and Governance*, 2019.

[13] F. Pesapane, C. Volonté, M. Codari, and F. Sardanelli, "Artificial intelligence as a medical device in radiology: ethical and regulatory issues in europe and the united states," *Insights into imaging*, vol. 9, no. 5, pp. 745–753, 2018.

[14] J. Civit-Masot, A. Perez-Rodriguez, F. Luna-Perejon, L. Muñoz-Saavedra, M. Dominguez-Morales, and A. Civit, "Emg-controlled robotic prosthetic arm with neural network training," in *eTELEMED 2020, The Twelfth International Conference on eHealth, Telemedicine, and Social Medicine*. IARA XPS Press, 2020.

[15] M. H. Dickinson, "Bionics: Biological insight into mechanical design," *Proceedings of the National Academy of Sciences*, vol. 96, no. 25, pp. 14 208–14 209, 1999.
[16] K. Krippendorff, "The cybernetics of design and the design of cybernetics," in *Design Cybernetics*. Springer, 2019, pp. 119–136.