Centre for European Master's Programmes

Master in Artificial Intelligence for Healthcare

Module 1 Activity

Rapid diagnosis of injuries via AI on mobile devices

Iryna Ryhaylo

October 2024

CENTRO EUROPEO DE MASTERS Y POSTGRADOS

Table of Contents

CENTRO
EUROPEO
DE MASTERS
Y POSTGRADOS

1. List of Figures

2. List of Tables

3. Abreviations

AI	Artificial Intelligence
CT	Computed Tomography
MRI	Magnetic Ressonance Imaging
CNN	Convolutional neural network
RNN	Recurrent neural network
GAN	Generative adversarial networks
PET	Positron Emission Tomography
DGX	Deep Learning System with Extreme performance
IBM	International Business Machines
GDPR	General Data Protection Regulation
EHR	Electronic Health Record

4. Introduction

4.1. Background

Despite advances, the medical field still has a lot of problems to solve. One of them is a lack of quick and accurate tools for the diagnosis of visible injuries in patients, especially in emergency situations or in rural areas with limited access to specialists.

Statistics show that rural emergency medical services take approximately double of the time to respond compared to urban areas. As a result, we can see a lot of consequences, one of which is increasing mortality rates[1].

By this way, geographical accessibility to healthcare services is a critical issue. In Portugal, the average travel time to reach the hospital rounds about 25 minutes[2]. Although this number has improved since the last decades, in some scenarios it's still not enough.

Introducing predictive Artificial Intelligence (AI) starts a new era of medicine. Predictive AI provides cutting-edge technology which focuses on processing and analyzing large volumes of data. This tool has revolutionized the diagnosis of visible injuries by significantly intensifying the speed and accuracy of image analysis. This approach has impacted all the medical field, but especially radiology. In radiology, deep learning[3] models[a] are created to process different medical images and detect abnormal patterns. It is possible through previous training on large datasets of different types of injuries[5].

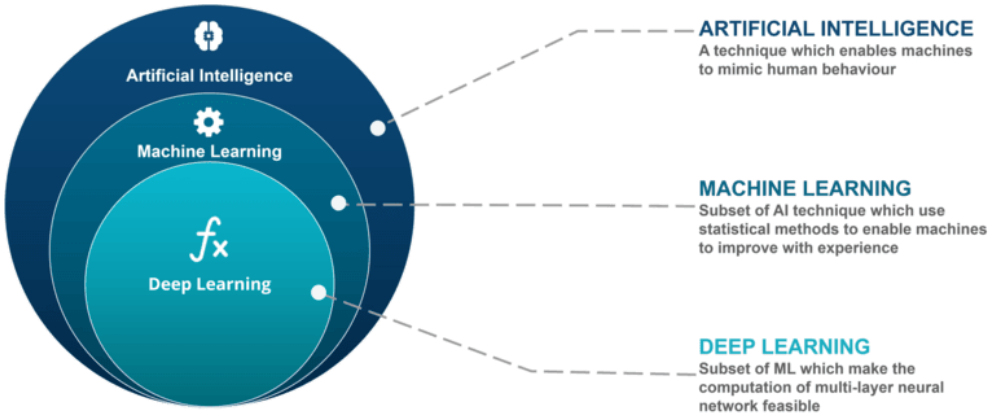

Figure 1 - Differences between artificial intelligence, machine learning and deep learning[3]

a. Deep learning models - multilayered neural networks which simulate the complex decision-making power of the human brain[4]

In essence, predictive AI seems to be a powerful diagnostic assistant by ensuring that patients receive timely and accurate help.

So, the next step is to scale up the power of this tool by introducing the mobile app which can permit each patient equal access to medical care in the shorter time possible.

4.2. General and specific objectives

4.2.1. General objective

The general objective of this project is to develop a mobile app that uses AI to diagnose visible injuries in patients.

4.2.1 Specific Objectives

- Describe the types of data needed, such as images of injuries, and the possible sources of these data;

- Detail how these images would be processed to improve their quality and make them suitable for the AI model;

- Research and justify which type of AI is most suitable for this problem (image analysis) and why;

- Explain how the mobile app works and how it can provide quick diagnosis of injuries.

4.3. Methodology and work plan

4.3.1. Literature review

Diagnostic imaging models created through AI could be a game-changer in the field of medical image analysis, specially in diagnosis of visible injuries. These models use deep learning techniques to interpret complex images like CT scans, MRI and X-rays. Some of these models are the next:

- Convolutional Neural Networks (CNNs). Convolutional neural networks use three-dimensional data for image classification and object recognition tasks. This model is used in detection of lung diseases and immune response abnormalities. CNNs have also dominated the area of COVID-19 detection using chest X-rays/CT scans[6].

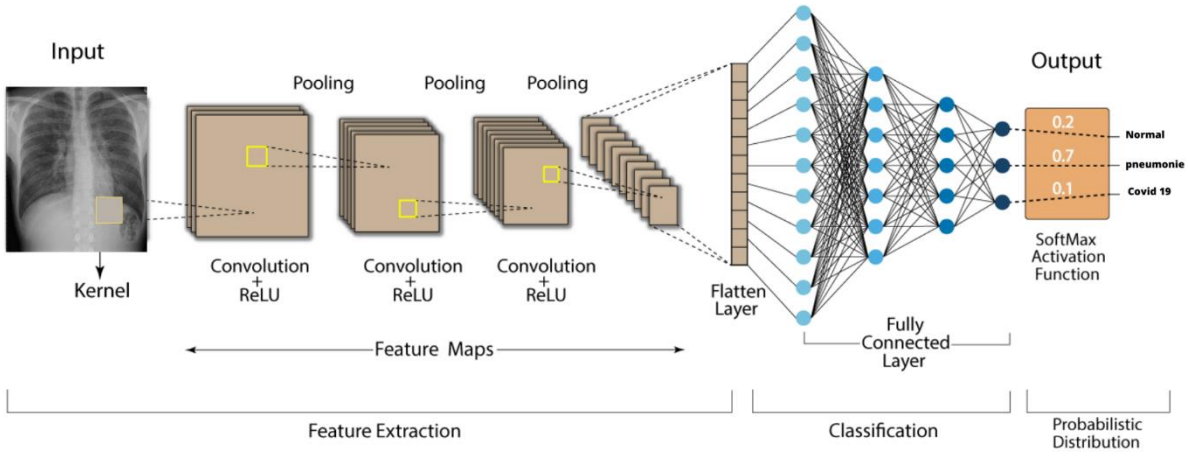

Figure 2 - Convolutional Neural Network[7]

- Recurrent Neural Network (RNN). It is a type of neural network where the output from the previous step is fed as input to the current step. In traditional neural networks, all the inputs and outputs are independent of each other[8]. Recurrent neural networks are effective for predicting a future diagnosis of heart failure and appears to continue to improve in direct relation to training set size[9].

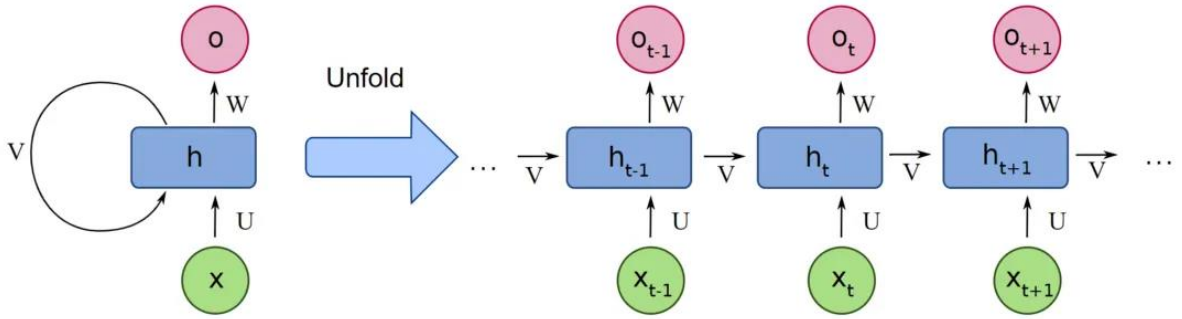

Figure 3 - Recurrent Neural Network[10]

- Generative Adversarial Networks (GANs). It is a part of deep neural network that stands out in data augmentation, data synthesis, and design automation. GANs are made up of two components, a generator and a discriminator pair. The generator attempts to generate samples that will pass the scrutiny of the discriminator, and the discriminator tries to distinguish the synthetic samples from the real samples. During training, the generator and the discriminator pit against each other in a zero-sum game, each trying to outperform the other.

Eventually, a state of equilibrium is reached, and the generator could produce synthetic samples indistinguishable from the ground truth by the discriminator[11]. This model is used in enhancing image quality, particularly in PET, MRI, CT and breast ultrasound[12].

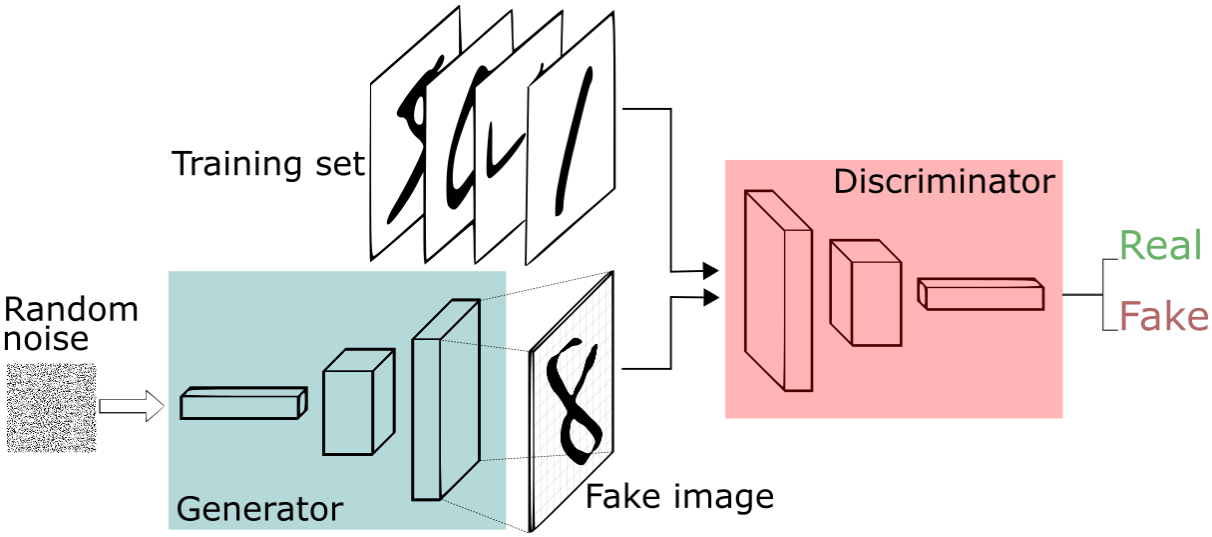

Figure 4 - Generative Adversarial Networks[13]

- Hybrid Models. This approach combines the strengths of multiple types of machine learning models mentioned above to improve performance in medical image analysis. Hybrid model is particularly useful for brain tumor imaging multi-classification[14].

4.3.2. Plan of action

A project schedule is a timetable that organizes tasks, resources and due dates in an ideal sequence so that a project can be completed on time. Thus, a schedule was developed (*Table 1*) outlining the different phases of the project and their distribution over the period of the investigation. It is important to mention that these phases remain as estimates.

Research Phases	October	November	December	January	February	March	April	May	June	July	August	September
The Conceptual Phase												
Selecting the topic												
Formulating the clinical problem												
Formulating the clinical problem and justification												
Defining general and specific objectives												
Determinate the research purpose												
Reviewing the literature												
The Methodology Phase												
Selecting a research design												
Developing study procedures												
Determining the sampling and data collection plan												
Risk analysis and contingency plan												
Ethical and legal considerations												
The Empirical Phase												
Collecting data												
Preparing data for analysis												
The Analytic Phase												
Analyzing the data												
Interpreting the results												
The Dissemination Phase												
Communicating results to appropriate audience												

Table 1 - Project schedule

4.3.3. Risk analysis and contingency plan

In any AI-driven healthcare project, the analysis of potential risks and developing of contingency plans are crucial to guarantee the success of the activity[15].Thus, the following table shows the potential pitfalls that can hinder the effectiveness of the app and possible solutions for each problem.

	Risks	Solutions
The Conceptual Phase	○ Unclear Objectives ○ Over-promising capabilities	✓ Have well-defined scope ✓ Start with basic version
The Methodology Phase	○ Poor-quality medical images ○ Lack of diverse datasets ○ Problems with training the AI	✓ Collaborate with diverse health institutions ✓ Select suitable AI model for each task
The Empirical Phase	○ Model bias ○ Model cannot generalize results	✓ Make sure that the model training has enough variety of data with different characteristics ✓ Test models performance
The Analytic Phase	○ Incorrect AI diagnoses ○ Difficulties to analyze complex injuries	✓ Let human doctors to have a final word to prevent potential harm ✓ Optimize the app to by using additional information to support heavy tasks
The Dissemination Phase	○ User trust issues ○ Regulatory challenges (GDPR)	✓ Provide clear and accessible information about how app works ✓ Ensure app meets all regulatory standards

Table 2 – Risks at each phase and possible solutions

By addressing risks specific to each phase, it is possible to ensure that app is not only feasible but also reliable, user-friendly, and compliant with healthcare standards.

4.4. Required Infrastructure

To turn this project into reality there are some steps to be done. One of them is a selection of servers for data processing and AI model training. They could be NVIDIA DGX Systems[16], Amazon Web Services[17], Google Cloud Platform[18], Microsoft Azure[19], IBM Watson studio[20] and others. To choose the best one to use for healthcare app it is

necessary to consider factors such as computational requirements of models to be used, scalability needs and ease of integration with existing data sources.

Also, selecting the analysis and modeling software is crucial. In case of health mobile app, the most suitable software seems to be Python due to its versatility, accessibility and powerful libraries. Another important point about Python is that it easily integrates with various databases and healthcare systems, which is essential to develop mobile healthcare app[21].

5.Expected impact of the Results

5.1. Scientific-Technical Impact

Once the developed app is going to enable analysis of images of visible injuries quickly, is going to provide immediate preliminary diagnoses. As the result, the app is going to reduce time needed to give first aid, especially in emergency situations where every second counts. It will be possible thanks to pattern recognition provided by machine learning models which have trained on vast datasets of injury images.

Also, the app will allow the remote diagnosis of injuries by analyzing uploaded images of injury. Thus, the app will provide explication about the injury, classify its severity and suggest the next steps to do. By this way, more people would have access to quality healthcare, which is very useful in situations when patients may not have access to immediate medical help.

Another advantage of this app is continuous learning from new data and improvement over time. By this way, the model can be updated to rectify its errors.

To guarantee that the app will be shared with the scientific and technical community, a multi-channel dissemination strategy is crucial. Participating in webinars or workshops can serve as a platform for real-time engagement. In this way it would be easy do explain how the app works, how to use it and receive some observations on how to turn it better.

The presentation in conference is also an option to divulgate about the app and meet other researchers from data sharing initiatives.

5.2. Social and economic impact

The mobile app will revolutionize healthcare by enhancing speed, precision, availability and effectiveness. By providing quicker diagnosis, this tool will prevent unnecessary trips to hospitals with associated costs and enable fast treatment decisions in emergency situations. Efficient use of time enables healthcare providers to attend to more patients in less time, reducing waiting time, which leads to financial savings. Once app will be capable of analyzing multiple factors about the patient, it could offer personalized treatment plans based on individual needs. All these factors are going to transform nowadays reality and improve significantly healthcare quality.

5.3. Ethical and regulatory impact

The mobile app for rapid diagnosis of visible injuries involves important ethical and regulatory considerations. To start, the app must ensure patient privacy and data security by applying data protection laws like GDPR[22], approached during this module. Processing of personal data shall be processed lawfully, fairly and in a transparent manner in relation to the data subject (‘lawfulness, fairness and transparency’). Thus, it is crucial to follow Article 32 and Article 35 from GDPR about security of processing and data protection impact assessment whereas other Articles from GDPR are important to follow as well.

Bias in AI has ethical consequences, particularly in healthcare, where misdiagnoses can have serious effects. The app must guarantee that every patient, regardless of their background, receives an accurate and reliable diagnosis[23].

Also, it will be necessary to assess the interaction between the development of the AI-based application and the GDPR during the entire life cycle of the system, from its genesis to its discarding, identifying different stages common to all technological developments. Another requirement to mentioned app is determining who is responsible if the AI provides incorrect diagnoses.

Only after all the below issues are solved, the app could be implemented, guaranteeing its safe and legal use in healthcare setting.

6.Deployment and daily use

To implement the AI-based mobile app for rapid diagnosis of visible injuries, a well-structured plan is essential to ensure its trouble-free launch, proper staff training and full integration into the healthcare system. The first step is installation of the AI ap on mobile devices used by healthcare professionals to ensure its integration with Electronic Health Record (EHR). All of this is only possible after ensuring compliance with privacy regulations like GDPR mentioned above. The next step is to start with staff training program. It includes teaching healthcare workers how to navigate the app, input relevant injury data and interpret AI-generated diagnostic suggestions. The pilot testing is another vital action. Its main objective is to guarantee that the app is working effectively, detect possible bugs and identify difficulties staff may face while using the system. Once the pilot phase is successfully completed, the app can initiate full-scale deployment which includes promoting the app across relevant hospitals or clinic departments. Of course, all the mentioned steps are going to be always associated with monitoring and support with regular updates and other functionalities which will maintain system accuracy and reliability.

The usage of this app will be quite simpler. After having any injury, the patient will use the app to capture the injury. Then AI model will process this photo and provide preliminary diagnosis or suggest plan of action in each case. If it is necessary to go to the hospital, app will share the injury with the hospital and help in triage situations. When access to specialist might not be available, like in rural areas, the app will also assist in remote healthcare settings. It is particularly important for healthcare providers who may have limited resources or training. Moreover, the AI system can facilitate telemedicine consultations by this capability which allows for real-time collaboration and discussion about patient cases. By this way, the app can significantly improve the efficiency and effectiveness of injury diagnosis and management.

7. Bibliography

1. Adeyemi, O. J., Paul, R., DiMaggio, C., Delmelle, E., & Arif, A. (2022). The association of crash response times and deaths at the crash scene: A cross-sectional analysis using the 2019 National Emergency Medical Service Information System. *Journal of Rural Health*, *38*(4), 1011–1024. https://doi.org/10.1111/JRH.12666

2. Costa, C., Tenedório, J. A., & Santana, P. (2020). Disparities in Geographical Access to Hospitals in Portugal. *ISPRS International Journal of Geo-Information 2020, Vol. 9, Page 567*, *9*(10), 567. https://doi.org/10.3390/IJGI9100567

3. *How Deep Learning is Different from Machine Learning? - DataWider*. (n.d.). Retrieved October 24, 2024, from https://datawider.com/how-deep-learning-is-different-from-machine-learning/

4. *What Is Deep Learning? | IBM*. (n.d.). Retrieved October 24, 2024, from https://www.ibm.com/topics/deep-learning

5. *Artificial Intelligence Improves Orthopedic Diagnosis - Mass General Advances in Motion*. (n.d.). Retrieved October 24, 2024, from https://advances.massgeneral.org/ortho/article.aspx?id=1330

6. *What are Convolutional Neural Networks? | IBM*. (n.d.). Retrieved October 24, 2024, from https://www.ibm.com/topics/convolutional-neural-networks

7. Rguibi, Z., Hajami, A., Zitouni, D., Elqaraoui, A., & Bedraoui, A. (2022). CXAI: Explaining Convolutional Neural Networks for Medical Imaging Diagnostic. *Electronics 2022, Vol. 11, Page 1775*, *11*(11), 1775. https://doi.org/10.3390/ELECTRONICS11111775

8. *Introdução à Rede Neural Recorrente - GeeksforGeeks*. (n.d.). Retrieved October 24, 2024, from https://www.geeksforgeeks.org/introduction-to-recurrent-neural-network/

9. Chen, R., Stewart, W. F., Sun, J., Ng, K., & Yan, X. (2019). Recurrent neural networks for early detection of heart failure from longitudinal electronic health record data: Implications for temporal modeling with respect to time before diagnosis, data density, data quantity, and data type. *Circulation: Cardiovascular Quality and Outcomes*, *12*(10). https://doi.org/10.1161/CIRCOUTCOMES.118.005114/SUPPL_FILE/CIRCCVQO_CIRCCQO-2018-005114_SUPP1.PDF

10. *Recurrent Neural Networks: A Comprehensive Overview*. (n.d.). Retrieved October 24, 2024, from https://www.analyticsvidhya.com/blog/2022/03/a-brief-overview-of-recurrent-neural-networks-rnn/

11. Wu, A. N., Stouffs, R., & Biljecki, F. (2022). Generative Adversarial Networks in the built environment: A comprehensive review of the application of GANs across data types and scales. *Building and Environment*, *223*, 109477. https://doi.org/10.1016/J.BUILDENV.2022.109477

12. *Overview of GAN Use in The Medical Field | by Aysen Çeliktaş | Medium*. (n.d.). Retrieved October 24, 2024, from https://medium.com/@aysenceliktas/overview-of-gan-use-in-the-medical-field-23cb90adf51d

13. *A Short Introduction to Generative Adversarial Networks - Thalles' blog*. (n.d.). Retrieved October 24, 2024, from https://sthalles.github.io/intro-to-gans/

14. Srinivasan, S., Francis, D., Mathivanan, S. K., Rajadurai, H., Shivahare, B. D., & Shah, M. A. (2024). A hybrid deep CNN model for brain tumor image multi-classification. *BMC Medical Imaging*, *24*(1), 1–21. https://doi.org/10.1186/S12880-024-01195-7/TABLES/11

15. Smith, J., & Doe, A. (2020). "Risk Analysis and Contingency Planning in AI-Driven Healthcare Projects." *Journal of Healthcare Management*, 65(3), 123-135

16. *DGX Platform | NVIDIA*. (n.d.). Retrieved October 24, 2024, from https://www.nvidia.com/en-us/data-center/dgx-platform/

17. *Machine Learning (ML) on AWS - ML Models and Tools - AWS*. (n.d.). Retrieved October 24, 2024, from https://aws.amazon.com/ai/machine-learning/

18. *Cloud AI*. (n.d.). Retrieved October 24, 2024, from https://research.google/teams/cloud-ai/

19. *Azure Machine Learning - ML as a Service | Microsoft Azure*. (n.d.). Retrieved October 24, 2024, from https://azure.microsoft.com/en-us/products/machine-learning/

20. *IBM Watson Studio*. (n.d.). Retrieved October 24, 2024, from https://www.ibm.com/products/watson-studio

21. *Python Dev Create Disruptive AI App for Healthcare - DZone*. (n.d.). Retrieved October 24, 2024, from https://dzone.com/articles/python-developers-are-creating-disruptive-ai-appli

22. *General Data Protection Regulation (GDPR) – Legal Text*. (n.d.). Retrieved October 24, 2024, from https://gdpr-info.eu/

23. *Understanding Bias and Fairness in AI Systems | by Mary Reagan PhD | Towards Data Science*. (n.d.). Retrieved October 24, 2024, from https://towardsdatascience.com/understanding-bias-and-fairness-in-ai-systems-6f7fbfe267f3