Artificial Intelligence in Medicine

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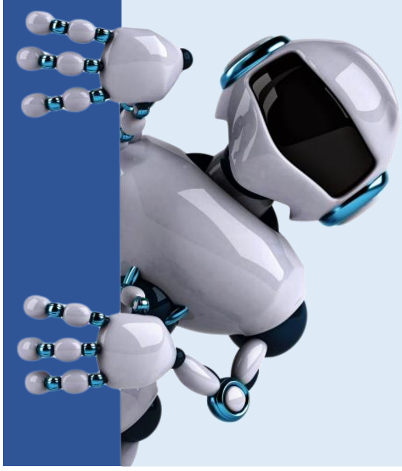

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Introduction

Have you ever thought about how people used to look up into the night sky, before knowing the earth rotated around the sun and not the other way around? They thought everything was about them, about Earth, and it must have been mind-blowing when they realized, after years of filtration of course, that we are only a ridiculously small part of a very vast universe. The ratio of us to the rest of the universe (Somewhere near 1 to 6.68×10^77) is smaller than the ratio of ants to us (Somewhere near 1 to 180).

That is how I feel when I look at the papers before the coronavirus pandemic about AI in medicine. They did not know what was going to happen and most of the papers liked the idea of using various aspects of Artificial Intelligence in the healthcare system. Some of them had proposed a model and had trained and evaluated them in a controlled environment successfully, and then they were considering expanding their experiments. It felt like they were testing the waters with Artificial Intelligence and healthcare. We all know that just because it is working alright, doesn't mean it can't become better.

However, it feels like after the start of the pandemic, AI scientists were bored while sitting at home and thought to themselves: “Why not? What could go wrong? My algorithm can detect a car from a dog, it will probably see the difference between a healthy lung, and one affected by something, right? If it goes right, I can publish it. If it goes wrong, nobody must know! How would they know? They would not know!” and one by one, they started using different algorithms with different data to see *"who is the smartest and fastest and most accurate them of all!”*

We will see the effect of using larger databases that became available after COVID-19 on the process of bringing more Artificial Intelligence into medicine. The way that collaboration evolved between people over time and how everyone’s attitude is different after observing how beneficial AI can be in the healthcare system. We will cover shortcomings and challenges everyone faced during their experiments. The cherry on top is the impressive results of each research and experiment. Sounds better than a fairy tale to me!

But before we do that, tell me, what do we usually imagine when it comes to Artificial Intelligence and the healthcare system? You might imagine a huge scanning device that you'd lay down and go through, the way you do a CT scan. Or even scan you while you're standing up in a certain position. Then it'll map your body and tell you about everything that is wrong with you and give you your medication. Like going to the supermarket on your way from work and buying milk. You might even imagine a robot wearing a white coat and smiling at you while scanning your body with his glowing eyes. Sounds cool, right? Unfortunately, that's not on the market yet. Maybe in the future, but not right now. Right now, we have AI with amazing results that can help doctors in their everyday work. It's still cool. I promise!

Come along with me on this adventure as we uncover who did what, and when, and look into their thoughts at the time. Our journey begins in 1996, then leaps forward to 2008, followed by a leap to 2019, and finally diving into more recent research papers.

Pre-covid

I chose the oldest paper to be a review paper, so we can get a good grasp of how people viewed this topic then. Published in 1996, "AI in Medicine: Overview and Challenges" by E W Coiera dove into the hybrid nature of Artificial Intelligence in Medicine (AIM), merging AI with medical practices. Coiera highlighted three interaction modes between AI and medicine: technology-driven, problem-driven, and technical issues related to AI, which, while significant, were not the primary concern for clinicians.

The impact of AIM's success in healthcare was highlighted, prioritizing its impact on clinical outcomes and cost-effectiveness over computational complexities. Coiera's paper offered a reflective overview of AIM's evolution and challenges without delving into specific research methods or datasets, urging AIM to embrace healthcare issues and realign its goals with evidence-based medicine for transformative solutions.

In the end, the author emphasizes the need for AIM to adopt healthcare problems as its own, redefine goals, and work towards solutions that line up with evidence-based medicine.

One thing that was amusing to me, was the fact that in the paper, the author encouraged scientists to use the Internet for communication and managing clinical guidelines. See what I am saying about not knowing the Earth rotated around the sun? Now imagine going back a couple of centuries and telling a scientist that you read their paper and they ask: "Where? How did you?" How could you explain Google when there was no Google? You can't google it!

Now, fast forward to 2008, when Fariba Shadabi and Dharmendra Sharma explored the area of "Artificial Intelligence and Data Mining Techniques in Medicine – Success Stories". Their study introduced the novel RIDC-ANNE hybrid-learning model, a fusion of neural networks and decision trees. They applied them to three distinct databases: the Kidney Transplant Dataset, the Wisconsin Breast Cancer Dataset, and the Pima Indian Diabetes Dataset.

In this paper, the researchers said that one challenge in the application of AI and data mining in medicine is ensuring the interpretability and transparency of the generated models so that medical professionals can understand and trust the output of these models. Also, the researchers emphasized that obtaining enormous amounts of high-quality training data for accurate model building can be difficult due to technical and economic constraints. High-quality training data is essential for developing accurate classifiers. They stressed the importance of the need for uniform standards in technological development for adding these technologies to clinical decision-making processes.

Their comprehensive study dived into various datasets, methods, and results. For instance, in the Pima Indian Diabetes Dataset, they achieved an 80% accuracy using 93% of data points, eventually increasing accuracy to 87% with a reduced dataset. Similarly, in the Wisconsin Breast Cancer Dataset, their model showed 98.6% accuracy with an agreement among networks after removing a minimal percentage of data points. In the Kidney Transplant Dataset, the researchers used 19% of data points, achieving 70.2% accuracy and identifying crucial factors like donor state and age for transplant success, along with a short rule set stating 97% of cases.

The study highlighted several challenges inherent in applying AI and data mining in medicine, like the complexity of clinical data, the fragility of symbolic data mining algorithms, data quality and availability concerns, interpretability, transparency, rule-based knowledge acquisition, integration into clinical decision-making, and also, ethical considerations regarding patient data privacy and consent.

Shadabi and Sharma's work emphasized the potential of AI and data mining in enhancing diagnostic patterns and predictive power in medical tests, highlighting the pressing need for collaboration across diverse fields to optimize these technologies' effectiveness in healthcare.

Now let's look at another paper that found the idea of AI in medicine fascinating.

Jumping again to July 2019, we bump into Samira Yeasmin's paper, "Benefits of Artificial Intelligence in Medicine" where she used a survey. This paper stands out as a rarity in its area, using a survey, an uncommon approach in this field. We will return to this later; however, it appears that not many scientists thought about asking patients or medical people about their feelings on this topic.

Yeasmin's survey gathered opinions from medical professionals and students, revealing overwhelmingly positive experiences with AI in their professional lives and collective hope for adding AI into the future of medicine. The majority expressed confidence in AI's potential to aid in diagnoses and even replace doctors to some extent. Concerns include the financial investment required for AI but believe it is valuable and relevant to future medicine.

The insights disclosed a positive sentiment toward AI's contributions to medicine, particularly in advancing and enhancing medical diagnosis, resulting in reduced mortality rates. Notable examples include AI's role in quickly and accurately diagnosing skin tumors, and diseases through image analysis, and its ability in radiology to distinguish between healthy and cancerous tissues, then alerting doctors about worsening patient conditions.

Furthermore, Yeasmin's research detailed AI's significant impact on medical treatments. It highlighted how AI can significantly reduce treatment duration while offering personalized therapies that aim to minimize medication side effects and enable precise treatment decisions. Additionally, Artificial Intelligence's potential assistance to Alzheimer's patients and its role in drug delivery through micro-sized robots swimming through bodily fluids were among the discussed innovations.

The paper also highlighted the wider implications of AI in healthcare by addressing the reduction of human errors in diagnosis, leading to a decrease in treatment expenses. Yeasmin emphasized the concept of AI's virtual presence, illustrating its application through remote presence robots, medication adherence reminders, and the provision of continuous medical assistance, available 24/7, through smartphone applications, to function as pocket doctors.

The survey, encompassing sixty-eight participants, brought to light the overwhelmingly positive reception of AI among medical professionals and students, with a shared vision of AI as a pivotal player in the future of healthcare. It underscored certain concerns about financial investment in AI implementation and the need for further research to gauge AI's capacity to take risks within medical tasks. On the other hand, Yeasmin's work highlighted the transformative potential of AI in medicine, shaping a future where AI is deeply embedded in diagnosis, treatment, and patient care.

As you can see, or read for that matter, there has not been a lot of implementation and use of Artificial Intelligence in medicine in real life, and it was mostly about how cool it sounds to use it.

I always imagined AI to be something like a calculator. Not literally of course, but like a tool that can be employed. We have several types of calculators, and they can be used in various places. But it sometimes feels like even though we have made scientific calculators, we’re afraid to use them in the places they can be used, even though they haven’t let us down yet. We’re still doing the calculations by hand and *sometimes* using the hand-calculated results to compare them with the results by scientific calculators and if we’re brave enough, we will use simple calculators when doing simple mathematical equations. Sounds weird, right? That is how I feel too!

But let us take a look at the brave people who used this beautiful tool to make some cool systems in those years.

Wan-Jung Chang authored a paper titled “A Deep Learning Based Wearable Medicines Recognition System for Visually Impaired People”. This research introduced a novel system tailored for visually impaired individuals, employing a pair of smart glasses, a waist-mounted device for drug recognition, a mobile application, and a cloud-based management platform. The innovation targeted the accurate identification of medications, displaying a remarkable 90% success rate in helping users.

Chang's study dived into the methodology behind this innovative system. By using deep learning techniques, such as Faster R-CNN and Google Inception V3 modules, the system utilized image recognition techniques to process images of drug pills. The embedded AI computing module, NVidia Jetson TX2, enabled deep learning operations in the waist-mounted drug recognition device.

The experimental findings detailed in the paper highlighted the system's efficacy, explaining an impressive 90% accuracy rate in identifying various drug pills. Addressing a critical concern, the paper highlighted the potential dangers faced by visually impaired individuals in taking incorrect medications. Nevertheless, prior drug recognition systems failed to cater specifically to the needs of this population. Chang's system aimed to fix this issue by employing cutting-edge deep learning technology integrated into wearable devices.

To learn more about what were other ways of using AI in medicine in those days, we can go through this paper called 'Deep Neural Networks Improve Radiologists' Performance in Breast Cancer Screening.' It is a really nice head-turner. Isn't it? I can imagine it on a newspaper title, first page, in huge font. Or a news reporter talking about it on TV, in a very 80s-90s style, reading the script like:

In October 2019, Nan Wu published a significant paper titled "Deep Neural Networks Improve Radiologists' Performance in Breast Cancer Screening", claiming that they designed a system that could work like an experienced radiologist! This research introduced a custom ResNet-based network specially optimized for high-resolution medical images, trained and evaluated on an extensive database containing over one million mammographic images taken from 229,426 screening exams. The study accurately explored ways to combine data from various mammographic views, enhancing the accuracy of breast cancer screening.
Now, what do we think about that, John?

The core approach involved a two-stage architecture utilizing convolutional neural networks (CNNs), incorporating both patch-level networks and macroscopic breast-level labels. By designing a specialized ResNet-based network and pretraining it on screening BI-RADS classification, Wu's team achieved a remarkable Area Under the Curve (AUC) of 0.895 in predicting cancer presence in breast screenings.

Moreover, in a reader study involving fourteen human radiologists and comparing their performance to the model, the results showed the model's accuracy matched that of experienced radiologists when exposed to the same data. The research did not stop there; it introduced innovative heatmaps pinpointing suspicious findings, significantly enhancing interpretability.

Despite the limitations of traditional computer-aided detection (CAD) programs in mammography, the paper emphasized the need to minimize potential harms such as falsepositive recalls and associated biopsies in routine breast cancer screenings. The study also highlighted the importance of balancing benefits and risks in breast cancer screening.

Regardless of these impressive findings, the paper addressed concerns regarding the relatively small test set used in experiments, stressing the need for further clinical validation. It also noted that the model, while strong in the specific task evaluated, might not fully replicate radiologists' typical workflow, suggesting avenues for further improvement. *So, I think the radiologist's job is still safe for now, Julia!*

Post-Covid

Up until now, we were looking at papers from before the Coronavirus pandemic and it looked like we were only selling the idea of using AI and if we look at the people who worked on it, we can see that it is mostly computer scientists. As we've seen, the only place where medical staff have been asked for their opinion was on the survey, and depending on the project and the topic they were working on some radiologists who worked on cancer. To me, that is concerning because like every other technology, Artificial Intelligence will affect the relationship between people who are working with and around it. There are no surveys documenting how would the patients feel if their data were used for medical advancements or how they would feel about artificial intelligence helping with their diagnostics or treatments. Also, there are no studies on how medical staff, doctors, nurses, radiologists, etc., would feel comfortable using this. What would it take for them to trust AI systems and how using AI will affect their communication and relationships? There are so many unanswered questions.

But after 2019, things picked up a bit of pace and got more exciting. If we look at the papers after 2020 it is obvious that the usage of COVID-related databases helped to train different algorithms more accurately. We can see there are more papers about this, and more doctors and people from medical facilities are helping with those studies. So, it's a good sign to see if we can get answers to more of our questions.

In 2020, Di Dong's paper, "The Role of Imaging in the Detection and Management of COVID-19: A Review" discussed how using larger datasets and AI has significantly elevated the accuracy of COVID-19 diagnoses. By combining deep learning models with patient information, physicians gained a sharper ability to identify high-risk patients better. These advanced tools not only help personalize treatments but also enhance overall patient care.

Dong's comprehensive review, focused on the critical role of imaging techniques, especially computed tomography (CT), in the detection and management of COVID-19. It emphasized the importance of imaging characteristics, particularly in situations where reverse-transcription polymerase chain reaction (RT-PCR) results had no clarity.

The article discussed some important aspects related to COVID-19 diagnosis. It explored the emergence of COVID-19 and emphasized the crucial role of imaging, particularly chest CT scans, in complementing RT-PCR tests for accurate diagnosis and disease management. Additionally, it detailed the diverse CT characteristics used in diagnosing COVID-19, outlining common findings, and explaining how CT helps in patient classification while differentiating it from other forms of pneumonia. The paper also explored a range of imaging techniques, such as PET/CT, lung ultrasound (LUS), and MRI, assessing their efficacy in both the diagnosis and monitoring of COVID-19 and highlighting their advantages and limitations. Then, it addressed concerns about RT-PCR sensitivity, pointing out the importance of follow-up imaging and considering various imaging techniques for comprehensive patient care and accurate disease assessment.

Dong also talked about recent advancements that have driven the combination of Artificial Intelligence (AI) into CT-based diagnosis. AI models like UNet and ResNet have shown excellent accuracy in detecting COVID-19 lesions and classifying the disease based on lung regions or whole lung analysis.

Additionally, newer AI models such as UNet++ and radio-mics analysis have a high level of both sensitivity and specificity in recognizing COVID-19 lesions from other pulmonary conditions. These advancements, mixed with AI's predictive capabilities, allow clinicians to predict disease severity and personalize treatment strategies effectively.

This mixture of innovative imaging technologies, particularly CT scans, with AI, has led to a revolutionary era in diagnosing and managing COVID-19. While these advancements have vast potential, validating these findings through large-scale multi-centre studies remains a crucial step.

I do not know about you, but talking about available huge databases to use to train the AI got me tingling with excitement. To look further into the data and its nurture, we can look at what I call the triplets of 2020! These were published online in the same month and printed in the same article. Looks like someone was doing what I am doing right now.

In the dark days of 2020, when COVID and quarantine had filled our lives, three similar papers were published, each contributing distinct approaches to combat the challenges of accurate diagnosis, treatment, and prediction of the big bad coronavirus.

First, the paper titled “Deep Learning COVID-19 Features on CXR Using Limited Training Data Sets” by Yujin Oh, prioritized the usage of Chest X-ray (CXR) images for COVID-19 detection. They utilized various datasets, including public CXR datasets, JSRT dataset, and USNLM dataset, to train and validate their models. Using sophisticated methodologies, they employed FC-DenseNet103 for semantic lung and heart segmentation and ResNet-18 architecture for classifying various lung conditions, achieving commendable accuracy in differentiating normal, bacterial pneumonia, TB, viral pneumonia, and COVID-19 cases.

For those of us who don’t know what lung segmentation is (or any organ segmentation), like me when I started reading all this research; this is for you: Lung segmentation is the process of accurately identifying regions and boundaries of the lung field (or any other organ) from surrounding thoracic tissue. It is an essential first step in the pulmonary image analysis of many clinical decision support systems.

Yujin Oh’s approach involved leveraging patch-based deep neural networks and investigating potential biomarkers in CXR images. They developed a novel probabilistic Grad-CAM saliency map designed for the patch-based approach, helping in the differentiation of COVID-19 from other conditions. The study addressed the challenges of limited training data during the pandemic, proposing solutions such as a triage workflow and exclusion of certain conditions at the early stage of diagnosis.

At the same time, Subhankar Roy's research, “Deep Learning for Classification and Localization of COVID-19 Markers in Point-of-Care Lung Ultrasound”, explored Point-of-Care Lung Ultrasound (LUS) images for COVID-19 marker analysis. Their research introduced innovative Deep Learning architectures mixed with Spatial Transformer Networks (STN) to predict pathological artefacts and evaluate disease severity scores in LUS frames. The proposed method outperforms several baseline models, revealing the effectiveness of the approach for frame-based pathology detection in LUS images.

They selected the Italian COVID-19 Lung Ultrasound Database (ICLUS-DB), consisting of a large number of LUS videos with annotations. This allowed them to have a comprehensive analysis. Their approach showed the effectiveness of Deep Learning models in precisely locating COVID-19 imaging biomarkers, enabling automated diagnosis from LUS images.

The third one is Deng-Ping Fan's research, called “Inf-Net: Automatic COVID-19 Lung Infection Segmentation from CT Images” which focuses on CT imaging for COVID-19 diagnosis. Their proposed Inf-Net architecture combined parallel partial decoders and attention mechanisms to tackle challenges in segmenting infected regions in chest CT slices. They also addressed the shortage of labelled data by implementing a semi-supervised segmentation framework. Their work showed an effective solution for automatic COVID-19 lung infection segmentation, significantly enhancing the diagnosis and treatment of COVID-19 and the model’s performance compared to existing segmentation models was outstanding.

Even though they were different in many ways, for example, their data type: X-ray, Ultrasound images, and CT scans and some of the challenges they faced; there were a lot of similarities between these three papers: Each aimed to tackle the pressing need for accurate and efficient COVID-19 diagnosis, treatment, and prediction tasks by using AI and DL. They faced difficulties of the same nature, related to limited labelled data, noise, disease differentiation, and the urgent nature of COVID-19. Additionally, they all showed the progression of automated diagnostics can be beneficial in different clinical settings.

So, even when we have the data, it doesn’t mean it’s without any problems, and it’s correctly labeled. There are still so many challenges to face before sitting back with a cup of coffee and enjoying while looking at your AI while it’s training on a database. It wouldn’t be wise to think that only a random database and no preparation of the said data will lead you to an accurate outcome. Now, would it? Unless you get it from a friend who had prepared it beforehand and had a history with the data. That would be another story. But let’s move on now because we’re going to get back to databases at the end.

But COVID-19 and drama over what kind of scanning device to use was not the only cool thing in 2020 papers. “Identification of HIV-1 Vif Protein Attributes Associated with CD4 T Cell Numbers and Viral Loads Using Artificial Intelligence Algorithms” by Jose S. Altamirano-Flores introduced a new AI-based approach, capable of breaking down complex interactions inside HIV sequences. This study focused on decoding the intricate genetic interactions of the HIV-1 viral infectivity factor (Vif) protein and its impact on CD4+ T cell counts and viral loads using innovative Artificial Intelligence algorithms and traditional statistical methods. This method discovered new connections that could change how we understand HIV/AIDS development.

The study group includes DNA sequences from 50 HIV-1-infected Mexican mestizo patients, providing a unique genetic context for analysis. Employing AI algorithms like Apriori, Multifactor Dimensionality Reductor, C4.5, Artificial Neural Networks, and ID3, the research aimed to identify relations between specific attributes of the Vif protein and clinical outcomes, including CD4+ T lymphocyte numbers and viral loads.

The results were significant, unveiling specific Vif sequence traits linked to critical clinical endpoints in AIDS progression. Mutations in BC Boxes, APOBEC motifs, Cullin5 binding motifs, and Nuclear Localization Inhibition Signals were associated with distinct clinical outcomes, revealing previously unexplored aspects of HIV pathogenesis.

However, the study acknowledged the limitation of a small sample size, which might have impacted the robustness of the findings. The authors emphasized the need for further research involving larger and more diverse study groups to confirm and expand upon these findings. Still, they believed using AI-based approaches in hospitals could be a game-changer and change how we treat HIV. It potentially could lead to groundbreaking advancements in HIV/AIDS management and more personalized care for people with HIV/AIDS.

It’s amazing that with AI, we can zoom in more on things like HIV and work our way into more personalized medication which helps with side effects and efficiency of medicine, which leads to a better outcome and easier life.

But when we reach 2021, things get more exciting. Remember that I said that we only liked to think about using Artificial Intelligence in medicine, but it was hard to actually see it in the hospital environment, and COVID made us use it more and look at it more seriously? In late 2020 and after, we can see the results of the push that was named coronavirus.

In 2021, Diu Khue Luu's paper, “Artificial Intelligence Enables Real-Time and Intuitive Control of Prostheses via Nerve Interface” changed neuro-prosthetics by developing a system that uses AI to interpret an amputee's intended movements through a peripheral nerve interface. The system achieved exceptionally high accuracy. This cutting-edge neuro-prosthetic system, shown in a long-term study over 16 months of implant duration, displayed a strong predictive performance.

This research aimed to create a neuro-prosthetic system using AI to decode movement intentions from nerve data in real time. The AI agent, which was based on a recurrent neural network (RNN), accurately decoded six degrees of freedom (DOF) from multichannel nerve data. It allowed actual control of prosthetic hands with up to 97-98% accuracy for individual finger and wrist movements.

The research involved three human amputees with microelectrode implants for periods of 6 to 16 months, collecting nerve data through Neuronix neural interface chips. Results showed the AI agent's impressive real-time performance, with a median reaction time of 0.81 seconds and an information throughput of 6.09 bits per second at 99% accuracy. The study also highlighted the agent's strength over the 16-month implant duration, displaying its stability and continued accuracy in decoding intended movements.

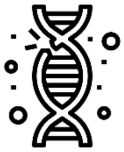
Still, the study addressed concerns and challenges on the rising population of upper-limb amputees, the existing prosthetic control schemes, limitations of myoelectric-based control systems, invasiveness and risks associated with brain implants, and the challenge of translating high-dimensional neural signals into real-time prosthetic movements.

The groundbreaking results presented the potential for intuitive control of prosthetic hands through direct neural interfaces. This emphasizes the importance of AI-enabled nerve technology in advancing prosthetic control to improve the quality of life for amputees. Even though the outcome was promising, they discussed the possible requirement for occasional fine-tuning and possible latency issues when running the decoder on devices with different processing power.

Let’s move to another branch of using AI in healthcare systems. Cancer has always been a complex problem for humans because of its nature. But what if Artificial intelligence can help us in the process and make the path easier?

In 2022, Yujin Oh's paper, "Multi-Scale Hybrid Vision Transformer for Learning Gastric Histology: AI-Based Decision Support System for Gastric Cancer Treatment," introduced an AI-based decision support system for gastric cancer diagnosis. The innovative system uses a 2-stage multi-scale hybrid vision transformer network to differentiate between five subclassifications of gastric cancer pathology. They trained and tested the model on a dataset comprising 1,000 gastric cancer histology slides from 10 hospitals in China. So, it can provide explainable probability maps and slide-level predictions to aid pathologists in making diagnoses.

An observer study examined the AI-assisted pathologist's performance in daily gastric endoscopic screening, to evaluate the system's effectiveness. The results displayed a class-average sensitivity above 0.85 on multicentric cohort sets. It means pathologists assisted by the AI system had significantly improved diagnostic performance compared to human pathologists for all classes. This advancement has a significant impact on guiding appropriate treatment for early-stage gastric cancer patients. However, the researchers acknowledge the limitations of the system, including the necessity for further validation on larger datasets and the potential risk of overfitting. The system's sensitivity to performance fluctuations is based on input slide quality and the pathologist's expertise when using the system.



Now we got to the recent year. We've covered many fields that Artificial Intelligence could be useful in. Now, we dive into something that AI can be helpful with, but we haven't talked about yet: genomic mutation.

In 2023, Matteo Bastico's paper titled "DrOGA: An Artificial Intelligence Solution for Driver-Status Prediction of Genomics Mutations in Precision Cancer Medicine" presented a comprehensive approach to analyzing genomic mutations in cancer. The research aimed to predict driver-status mutations, presenting models that had outperformed existing methods across various metrics like F1-score, Recall, Precision, and Accuracy. They openly shared both their dataset and code, encouraging other researchers to further research and collaboration in the genomics analysis field. Their concerns included the dependency on annotations' availability and accuracy, the imbalanced nature of certain attributes, and potential challenges arising from incomplete datasets.

The dataset used for analysis consisted of non-synonymous mutations in both driver and neutral somatic types collected from multiple public repositories. It resulted in a dataset with 16,360 driver samples and 46,444 neutral/passenger mutations. The study's methodology involved an extensive feature engineering pipeline to preprocess ANNOVAR annotations. The final dataset was a dataset of 32,574 training samples, and 8,102 test samples, which were created using min-max normalization and one-hot encoding.

The proposed models mixed traditional machine learning (ML) and deep learning (DL) architectures like Logistic Regression (LR), Support Vector Machine, Decision Tree Classifier, Random Forest (RF), XGBoost (XGB), Deep Multi-Layer Perceptron (Deep MLP), and Convolutional Neural Network (CNN). They optimized hyperparameters using Random Search and Bayesian optimization. To handle class imbalance, they explored various loss functions, including weighted Binary Cross-Entropy Loss and Focal Loss. They analyzed the model's interpretability using SHapley Additive exPlanations (SHAP) to understand feature relevance and interactions.

The results showed that the DrOGA models exceeded state-of-the-art algorithms and achieved high performance in metrics such as F1-score, Recall, Precision, and Accuracy for predicting driver-status mutations. They identified critical predictors in the classification process and highlighted the efficacy of the feature engineering pipeline. The open-sourced dataset and code encourage collaboration in the genomics analysis field, potentially advancing precision cancer medicine.

The paper also addressed concerns about the model's dependencies on annotation availability, the challenges of incorporating imbalanced annotations, and incomplete datasets and at the same time emphasized the importance of comprehensive, complete, and accurate data sources.

In the same year, 2023, Sherzod Turaev published a paper named “Review and Analysis of Patients’ Body Language from an Artificial Intelligence Perspective”. The paper explored and analysed patients' body language across various health conditions through the lens of artificial intelligence (AI).

They reviewed studies focusing on abnormal movements and behaviors connected to conditions such as Parkinson's disease, neurological disorders, and musculoskeletal disorders. These studies studied a wide range of activities such as walking, falling, various postures, and specific gestures related to specific health issues. The data for these analyses were collected through sensors, depth cameras, and wearable devices, and they had diverse data types, including videos, images, audio, motion, EMG, and sEMG signals.

The researchers utilized a variety of machine learning algorithms such as SVM, KNN, and deep learning models like CNNs. The findings of these studies highlighted high accuracy rates in detecting activities, such as falls, tremors, and unusual movements connected to different diseases. However, they also faced challenges, like the handling of noisy clinical environments, imbalanced datasets, and addressing variability in patient movements.

They stressed the need for collaboration between AI and healthcare professionals to improve the accuracy and reliability of AI models in reading and monitoring patients' health conditions through their body language.

Conclusion

Is it worth it?

Like I said at first, in the early days the thought of AI in medicine was like science fiction. The researchers thought adding AI to medicine could have a positive effect but didn’t know that coronavirus would affect everything and push every person to use the resources delicately. It made us look for ways to be able to use limited resources, treat contagious diseases fast and accurately and save as many lives as possible. This resulted in the use of Artificial intelligence algorithms in more ways than we imagined we would before and made us braver when interacting with them.

In summary, the growth of AI in medicine has been a journey, transforming from theoretical ideas to practical applications, and increasing its speed by facing the challenges made by the COVID-19 pandemic. What started with cautious exploration by computer scientists before the pandemic has transformed into a collaborative effort between medical professionals and AI scientists. Hopefully, this will lead to more advanced and usable tools for medical staff to use every day in their workspace.

The use of Artificial Intelligence in combating COVID-19 shows the potential of large datasets and complex algorithms in advancing diagnostics and personalized treatments. The importance of advancing in diagnostics comes from the fact that early disease detection has been proven to be more cost-effective, and significantly improves patients' quality of life. Early diagnostics also help in improving the management of the disease and care, shortening the path to a patient’s well-being, and ultimately benefiting people. Personalized treatments are important because they reduce the side effects of treatments and medications. personalized treatments will only target the affected areas. This will safeguard healthy tissues, reduce collateral damage, and enhance the effectiveness of therapies.

Beyond the pandemic response, AI has made major contributions in many medical fields, from HIV/AIDS research to cancer diagnostics. But this progress comes with challenges like data imbalances and interpretability issues which should be worked on in the future.

Ethics

Artificial Intelligence requires extensive datasets and when it comes to the healthcare system, we need to be able to trust the models’ output. That means we should be able to have a reliable database, with balanced and non-biased data. When using patient information for any Artificial Intelligence algorithms, ethical considerations are vital. It's crucial to maintain strict ethical considerations to make sure the privacy of patients, their confidentiality, and overall well-being are protected.

It is necessary to anonymize or de-identify data to avoid personal identification. Security measures should be implemented to protect the data from unauthorized access, misuse of this information, or breaches and exposures, to make sure that the data will remain safe and secure.

Getting clear and informed consent from patients about their data usage for AI analysis or research is also vital. Patients should understand how their information will be used, who will have access to it, and the potential risks and benefits involved. Transparency in data usage, who has access to it, and the purposes and accountability are very important. It is only possible through clear guidelines and responsible management. Patients should be able to withdraw their consent at any time and have a say in how and where their data is being used.

Attempts to lower the biases, maintain fairness, and maintain beneficence and non-maleficence in AI processes using patient data are crucial. Making sure that AI algorithms are trained on diverse and representative datasets will reduce biases in decision-making processes and lead to more reliable outcomes. Compliance with relevant laws (such as HIPAA and GDPR), continuing to monitor and evaluate ethical implications, and addressing any developing ethical concerns or risks will ensure responsible and ethical usage of patient data. This will ensure both patient trust and data to be used for Artificial intelligence algorithms to be used to implement innovation.

By keeping these ethical considerations, healthcare organizations, researchers, and Artificial Intelligence developers can use the power of patient data for AI while respecting patient rights and ensuring responsible and ethical use.

Shortcomings

One of the things that would catch the eye when reading through all of this research and more, is the fact that nobody has ever asked the patients how they would if they knew an Artificial Intelligence was assisting their doctor in diagnosing or choosing the treatment. Would they feel safer, or would they want to change their doctor to one without an AI assistant? If something went wrong, would they blame the AI assistant or medical staff? Or just their bad luck?

There are also questions about the relationship between nurses and patients. There are AI models that are attempting to assist in gathering data and adding them to a patient's medical journal, to help nurses with tasks that are recurrent. This will enable nurses to manage time efficiently and enable them to have more important tasks. But how will this affect their relationship with patients? We know that nurses are the backbone of the healthcare system. How will using AI assistants affect their work experience and patient care? How will it affect the patient’s experience?

Aside from the relationship between medical personnel and patients, one other thing that would be affected by using Artificial Intelligence in the healthcare system is the relationship between medical personnel. We can only hope that an A system could help reduce the bias each individual has, but what would happen if the person and AI assistant both have biases the same way? How to fix the situation if something like this happens? There should be many surveys to evaluate the relationship between people and how they will change when and if they use AI like they use their phones these days. But there aren’t many and as we have seen in the papers we went through.

One other important aspect of this topic is “Who would take the blame if things went south?” Who is responsible for the decision an AI would make? The doctor? The hospital? The developer? There is so much to say about this part that it could make a whole essay on its own. Some say the developers’ team is responsible for an AI’s actions and decisions because they’re the ones that ‘gave life’ to the algorithm and trained it. But on the opposite side, some say the organizations who use AI are the ones responsible for the decisions because they’re the people, in this case, doctors, who are giving input to the machine and interacting with the system. Some even go further and blame the government too, because they should establish guidelines, laws, and regulations to oversee AI development and deployment to make sure it is being used fairly and ethically. In our case, we’re imagining that we’re in a position where it has been used ethically, but in the end, the AI made a big error that cost a lot, something as precise as human life. Who is to blame here? The reality is that probably everyone is involved in the process. But we don’t know for sure and there hasn’t been any investigation to know what should be done in a situation like this.

In conclusion, I believe there should be more surveys and experiments should be done around people’s behaviour and the changes in their feelings and experiences when it comes to Artificial Intelligence.

Cool facts

Experimental Research is a study done with a scientific approach using two sets of variables. The first set will act as a constant, which one will use to measure the differences of the second set. In a nutshell, it is used to test cause-and-effect relationships. Quantitative and Diagnostic Research is a type of research design that involves data collection, analysis, hypothesis testing, and setting objectives to define the best possible solution. In a nutshell, it is a study conducted to observe datasets and analyze numbers.

Almost all the papers we completed together and the ones that we didn't, were either experimental research or quantitative research. It raises a recurring concern, as mentioned before. It is a deficiency in research that studies user behaviour through observational methods and investigation in hospital systems. If we look at this other way, these researches were restricted to the controlled environment of a laboratory setting. To effectively use the tool that was developed inside the lab, it is necessary to observe and investigate its function and effect in and around the real world, outside of the lab boundaries.

In addition, one thing that was amusing to me was that the most repeated name of the country was China, the USA, and Korea. It shows how this topic is hot and people in different areas are encouraged to experiment with Artificial Intelligence and medicine.

I believe what we've discovered and done with Artificial Intelligence until now is only a pretty shell in front of a vast ocean and we have a long way to go, as Isaac Newton once said,

"I do not know what I may appear to the world, but to myself, I seem to have been only like a boy playing on the seashore and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

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