Chapter 7
Explainable AI Driven Applications for Patient Care and Treatment

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Abstract The continuous development of technology has saved countless lives and improved the quality of living. Artificial Intelligence is reshaping the healthcare industry from hospital care to clinical research, drug development, to insurance, and has been able to reduce costs and improve patient outcomes. Most AI system works as a black box with little or no explanation which results in a lack of trust and accountability among patients and doctors. This chapter is written with the intent to share with the audience how exquisitely the health care sector has integrated with the technology. The chapter initiates with a brief description of the use of Artificial intelligence and technology in the health domain, and how computers are helping not only doctors, but patients, health care departments, and Insurance companies. This chapter later focuses on various AI-driven Applications which are used for patient care and treatment. This chapter shed light on the purpose and benefits of XAI along with a few real examples.

Keywords Electronic health record · Artificial intelligence · Machine learning · Deep learning · Explainable artificial intelligence · Clinical decision support system

7.1 General

Society is getting enormous benefits from the advancement and innovation in technology. Technology has become an indispensable aspect of our lives. The continuous

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development in technology has saved countless lives and also have improved the quality of living. Technology is proving to be very relevant in the Health care sector, starting with EHR where the records of the patient are maintained electronically, a system to compile patient's medical history, which includes patients' past and present details. These days the data is collected through various devices like smartwatches, bands, patient's email, apps, etc. to provide a better monitoring system that will help in analyzing the health information.

Any IT gadgets or programming designed to enhance emergency clinic and authoritative efficiency, provide new bits of understanding about medications and therapies or improve the general nature of treatment is referred to as medical services innovation. Artificial Intelligence is being used extensively in various domains, like the reviews about the most-watched movie or series on Netflix, the most purchased product on Amazon, traffic congestion on road can be predicted by Google Maps, etc. are a few instances of the use of the AI.

AI technologies are reshaping the healthcare industry from hospital care to clinical research, drug development, to insurance, and have been able to reduce costs and improve patient outcomes. With the use of Artificial Intelligence in the subsequent years, it has been observed that there is a paradigm shift from what technology can do, to how technology should be used responsibly to improve health care services and patients' health. As most the AI system works as a black box; with very little or no explanation it results in a lack of trust and accountability amongst patients and doctors. The results generated by the AI tools could not be cross verified, and in case if they are generating a wrong decision; could lead to disaster specifically when it comes to the health care sector, which involves human life and one wrong decision can ruin a life. Therefore, it is essential and very crucial to use XAI, as it provides an explanation in natural language for a better understanding and rational decision making.

The present medical care industry is a $2 trillion behemoth (https://builtin.com/healthcare-technology). The apps and other health care devices with the use of AI have improved and helped in diagnosis, as it is more comfortable scanning and observing the pattern related to health like heart rate, blood pressure, footsteps took, calories burn/taken, to even monitor the sleep quality, etc. Artificial Intelligence is supporting emergency clinics by taking the decisions for better diagnosis based on analyzing and predicting the data.

With the enhancement in Artificial Intelligence, the medical domain has created robotic surgeries, where actually the physician is not even in the operation theater with the patient. The patient might be at the clinic or hospital in his home town eliminating any stress and hassle of traveling. Robotic surgeries also allow a minimally-invasive procedure that reduces the scars, and pain; which helps the patient cure fast (Bouronikous 2013). AI systems, such as deep learning or machine learning as the name suggests the machine is being trained by taking inputs and later producing outputs with no decipherable explanation or context.

Erik Birkeneder, a medical device, and digital health expert, in an interview with Forbes, "We can't be sure an AI system will discover those outliers or otherwise appropriately diagnose patients if it isn't properly trained with the relevant

data and we don't understand how it makes its decisions" (https://www.capestart.com/resources/blog/how-explainable-ai-for-health-care-helps-build-user-trust/#:~:text=When%20and%20in%20what%20context,undetectable%20by%20the%20human%20eye).

Many of the AI algorithms are really insightful an algorithm to estimate the brain age is based on more than 5000 brain scans using a deep learning algorithm and is good in predicting the age and identifying if someone is getting cognitive decline or dementia and also has the capability to trace back the neural network and the changes in the brain due to the age or any other reason. Similarly, the genetic algorithm works very fine, so the algorithms refer to the image visualization and take the decisions based on the visuals, the results are often correct.

Explainable AI is the need of the hour, though XAI has been in the existence for approximately 40 years. It is gaining good popularity now as people are using Artificial intelligence extensively in almost all domains; especially in medicine where we are dealing with human lives we need to be assured, need to trust the solution/output given by AI system. The human need to understand why this decision has been taken or why this diagnosis has been proposed by the AI system. Designers and developers need the ability to explain to improve system robustness and allow diagnostics to avoid prejudice, injustice, and discrimination, as well as to raise user trust in why and how decisions are made. It is essential to give people a feeling that they can trust the software, the output should be interpretive (predicted or inferred), especially in cases where the images are synthesized. In short, XAI is required where the user needs an explanation to make a decision.

7.2 Benefits of Technology and AI in Healthcare Sector

From the invention of X-ray equipment to advances in surgical techniques, technology has improved our health and prolonged our lives (Hosny et al. 2018), Scherman (2019). Continued developments, and research in innovations that cure illnesses especially using Artificial Intelligence, training the devices to not only collect the data through sensors, and actuators but also to analyze the data using numerous algorithms which can predict with accuracy and precision (Mojsilovic 2019). Technology is helping us start by maintaining and keeping the patient's records handy through EHR (Electronic Health Record) instead of conventional paper-based manual methods. Also, the technology has made it possible to connect through Telemedicine, use remote monitoring health, and also share our health information through wearable and sensors technology with our doctors (Gulavani and Kulkarni 2010). Sequencing the human genome has been one of the greatest advancements in medical technology (McDonough 2021).

The innovation is certainly helping and permitting us to analyze a huge amount of data. The way Amazon has imagined Alexa, which is a virtual assistant based on an AI framework. Alexa helps in responding/answering conversational questions immediately, even in a noisy environment. Another AI application can help examine

the information identified with individuals' wellbeing, permitting us to analyze the patterns they could turn into the key to well-being screening, early analysis, and treatment plan for a patient. The data accumulated by technology and sensors can have various advantages (Bouronikous 2013; Laal 2012; Luci 2015), for example:

- **Reduced healthcare cost and enhanced speed**—With the assistance of innovation, the data provided by the sensors can help in observing the well-being of the patients living at remote places. Real-time cautions can likewise assist a patient with counselling a specialist before health deteriorates. This remote monitoring of heath also eliminates hospital room expenses and staff costs. Splendid advancement can streamline claims planning, and cut costs by a colossal edge (Patel 2022).
- **Reducing healthcare waste**—According to the World Health Organization, healthcare waste accounts for about a quarter of all waste produced. An approximate 16 billion injections are issued per year around the world, however, the disposal of all needles and syringes is not done properly. Measures to guarantee the effective and ecologically sustainable disposal of medical wastes might assist to minimize harmful health and environmental implications. Providers and health insurers should follow these three ways to maximize healthcare costs during a period when 25% of spending is deemed unsustainable, (Thimbleby 2013), WHO/Unicef (2018).
- **Virtual Reality is helping in fighting Depression and Mental Health**—Approximately more than 800,000 peoples commit suicide every year; generally, because of emotional well-being issues. Psychological maladjustment can't be recognized by taking blood tests or breaking down information in an electronic clinical record. The data can suggest subtle traces of problems provided that they are well analyzed. Clinical psychologists and doctors identify the behavior and perform a cognitive test on the patients to know the situation. Especially the patients who have been born with any kind of prior traumas, doctors gradually trained the patient's brains to talk and build up tolerance through exposure treatment, until such memories no longer negatively affect them (Builtin).
- **New medicine and therapies are being developed**—According to a recent report, it takes at least 10 years for a drug to make the journey from discovery to the marketplace, at an estimated cost of $2.6 billion. The probability of a drug entering clinical trials being approved is currently estimated to be less than 12%. Incorporating AI into the drug-discovery process can have a significant impact on the development of safer and more successful drugs (Laal 2012).
- **AI-based Apps as a Scheduler**—To keep a human healthy, two important things need to be done, eat healthily and on time and follow a fitness regime. AI helps in analyzing the medical record and scheduling the fitness routine (Ksolves.com 2021).
- **AI for visually impaired or disabled people—**Many of the researches are going on to help people with any disability. AI-based devices are available in the market from gloves, shoes, etc. which will help and guide the disabled person (Ksolves.com 2021; Patel 2022).

- **AI for old people**—In research conducted in Japan observed that many clinics and old age homes have AI pets to keep the old people engrossed and stay connected with the devices. They have tried to use technology by designing AI robots in form of pets to give emotional support to the patients.

7.3 Most Common AI-Based Healthcare Applications

In recent times, AI has been benefiting the patients, doctors, and admin staff; without human intervention can complete task at a faster pace and are the talk of almost every conversation, especially in the medical domain. It has been observed that AI is often discussed by the modern medical industry to identify and diagnose the disease. There are numerous benefits of using artificial intelligence in today's contemporary medicine, but at the same time there are several issues that are bothering people; one such concern is a miss of the "human touch" in this people-oriented profession where people need to be supported emotionally as well and the trust; the patients have on the doctors mentally strengthen the patient and positive attitude heal the patient faster.

Artificial intelligence (AI) in modern medicine is used to describe the usage of AI software and pre-programmed processes to detect and treat patients that require medical treatment. Besides analysis and cure, there are a number of other processes that must be completed to appropriately take care of a patient designated, which may appear to be trivial tasks, including:

i. Gathering data from patient talks and examinations
ii. Dealing with and analyzing the results
iii. Obtaining precise identification by utilizing a multitude of data sources.
iv. Selecting an acceptable treatment method
v. Organizing and monitoring the treatment plan
vi. Observation by the patient
vii. Rehabilitation and continuing plans.

Healthcare has a wide range of applications, from identifying genetic code connections to powering surgical robots. Predictive, comprehending, reading, and acting machines are being reinvented. Artificial intelligence has been a benefit to the healthcare business in general.

Automation is delivering enormous benefits as creativity continues to flourish. Some applications that help to improve health care accuracy in addition to having a specialist solution that saves time and money in the treatment process (Datta et al. 2019; Nicholson 2019; Pawar et al. 2020).

- **Diagnostic Imaging Interpretation**—Deep learning programs and technology classification is used to provide AI-based imaging systems with algorithms that can read photos swiftly. Buoy Health, one of the most popular AI-based diagnostic checkers, uses an algorithm to help with sickness treatment (Your Team in India 2020). For instance, in the case of Lung cancer screening and to help

detect pulmonary nodules, in many cases, early discovery can save a patient's life. Artificial intelligence (AI) can assist in recognizing and categorizing these nodules as benign or cancerous. Similarly, in the case of abdominal, mammography, brain tumor, and many more cases; artificial intelligence can interpret and evaluate whether they are benign or malignant. In the case of skin cancer, deep learning algorithms are handling and help detect suspicious areas (Hosny et al. 2018).

- **Accuracy**—According to the research diagnosis done by doctors are 71.40% accurate and diagnosis based on AI and ML is 72.52% accurate (Leibowitz 2020). Doctors are adopting a more contemporary strategy that emphasizes prevention and data collecting. This involves genetic data collection, wearable gadgets, and electronic healthcare system developments. Apple watches, Fitbits, Garmin watches, and other fitness trackers monitor your heart rate and activity levels (Luci 2015; Medttech; Your Team in India 2020).
- **Interactive Assistant for Fitness**—AI businesses have created digital health aides that focus on augmented reality, cognitive computing, speech, and body motions. A virtual health assistant is a one-of-a-kind method for reducing the number of trips to the hospital (Rauv 2017; Your Team in India 2020).
- **Bots that provide customer service—**Natural language processing (NLP) and sentiment analysis were used to construct collaborative Chatbots. Patients can ask inquiries regarding bill payment, appointments, and medication refills 24*7 all through the year (Rauv 2017; Xu et. al. 2019; Your Team in India 2020).
- **The Process of Robot-Assisted Surgery**—When acquiring insights, doctors might use pre-op medical data to acquire information. Specific movement, robotic arms, and magnetic imaging are all characteristics of the robotic surgical system (Ksolves.com 2021; Your Team in India 2020).
- **Digital Consultation**—There are numerous health care apps available, which will respond to and would handle the patients' queries in case the concerns raised by the patient need real doctors' intervention, and the call is transferred to the real practitioner (The Medical Futurist 2021). It uses emotional artificial intelligence to provide personalized medical consultations. These days the bots are the first line of primary care (Xu et. al. 2019).
- **Health Observation**—Artificial intelligence (AI) and relevant technologies such as ML and DL are used to monitor the patient's health. When modifications are made, the applications send notifications to the user.
- **Drug Creation**—The search for novel drugs is predicted to become faster, cheaper, and more effective as a result of machine learning and other technologies. When it comes to generating new drugs, clinical trials take a lot of time and money (Ksolves.com 2021; Xu et. al. 2019).
- **Machines that are linked together**—The unique artificial intelligence makes the operation both simpler and more intuitive (Xu et. al. 2019).
- **Electronic Health Records (EHR) Standard**—Traditionally, physicians would manually record or type findings and patient data, and no two were alike. Interactions with patients, clinical diagnoses, and future therapies can all be augmented and reported more reliably (Xu et al. 2019).

7.4 Issues/Concerns of Using AI in Health Care

According to a survey conducted by Accenture, "The AI healthcare market will expand at a compound annual growth rate of 40% by 2021 (Bresnick 2017). However, adoption in healthcare is still in its early stages." Here are some of the AI-related problems and concerns in healthcare.

- **Data Accessibility**: the training of AI systems necessitates a large quantity of data from many sources, including electronic health records. Data is frequently spread across several systems. Handle such a huge data and too fragmented data enhances the chances of inaccuracy, minimizes the database completeness, and also expands the cost of acquiring the data (Patel 2022).
- **Wounds and Fault**: One major concern is that if at any point in time, AI systems diagnoses or handle the patient incorrectly; it will be leading to a disaster or patient injury. If an AI system prescribes the wrong medicine, fails to discover a tumor, or assigns a hospital bed to the wrong patient, then the patient may suffer harm (Patel 2022).
- **Questions about privacy**: Developers are enticed to collect data from a high number of patients while working with enormous datasets. Some patients may be concerned that their privacy would be violated as a result of this data collection. As a result of data sharing between huge health systems and AI companies, lawsuits have been brought (Patel 2022).
- **Bias and inequality**: There is a risk of prejudice and inequity in healthcare AI. The AI system may be biased. As the machines learn from the data they're given and may incorporate biases based on that data (Patel 2022; Dilmegani 2017).
- **Safety and Transparency**: IBM Watson for Oncology has come under fire for allegedly making "unsafe and incorrect" cancer care guidelines. Instead of using actual patient data, the program was only trained with a few "synthetic" cancer cases (Price II 2019; Patel 2022).
- **Technical Debt**: In the last five to seven years, the new AI techniques based on deep neural networks have achieved incredible results. Few individuals possess the technical skills required to solve the full spectrum of difficulties relating to data and software engineering Limited data and changeable data quality will be a common problem for AI solutions (Price II 2019; Patel 2022).
- **Unexplainable AI Models**: In order to produce better performance, most AI models become more complicated. Both healthcare companies and patients are concerned about the lack of logic. To function appropriately.
- **Strict monitoring protocols to avoid diagnostic errors**: Diagnostic mistakes account for 60% of all medical errors, causing 40,000–80,000 fatalities per year (Kelly et. al. 2019; Price II 2019; Patel 2022).

7.5 Why Explainable AI?

Symbolic AI was the first form of AI, in which logic rules represented knowledge. There was no ability to learn and a weak ability to deal with ambiguity. Then there's Statistical AI, which uses huge data to train statistical algorithms for specific areas. There is no contextual capacity and only a bare minimum of explainability. As depicted in the figure below the results of AI creates confusion (Pawar et al. 2020; Turek 2016; Thimbleby 2013) (Fig. 7.1).

Later systems were constructed using Explanatory models (Ahmad 2020). Systems learn and reason with new tasks and situations. As shown in Fig. 7.2, how AI is different from XAI? In AI it just computes and gives end result; why this result has been given no explanation is provided. XAI will give explain the result, which will give better clarity and understanding of the decision. Explainable AI is a field where techniques are developed to clarify AI system predictions. In this chapter, XAI is explored as a strategy for using AI-based systems to analyze and diagnose health data. In the field of healthcare, accountability, outcome tracing, and model improvement are all essential. XAI can be used to achieve transparency in the healthcare industry. It is required to make it easier to share data about a patient's medical history with doctors and practitioners.

In recent years, AI researchers have worked to bring neural networks out of the shadows and make them more apparent. The initial AI Models built were based on a black box in which when the result is produced it is difficult to trace the detailed information about why this result has come. Let us understand with an example—if a company has implemented the AI for fraud detection so the machine will give a scoring or a rank but will not give a detailed explanation for the same. Whereas as depicted in Fig. 7.3, XAI explains the predictions made by the machine, which will help the organization understand with logic and clarity the predictions made by the machine. Similarly, if a customer's loan has been rejected, he can see the details and work on improving his score (Bizarro 2020). Similarly, if a person has a family

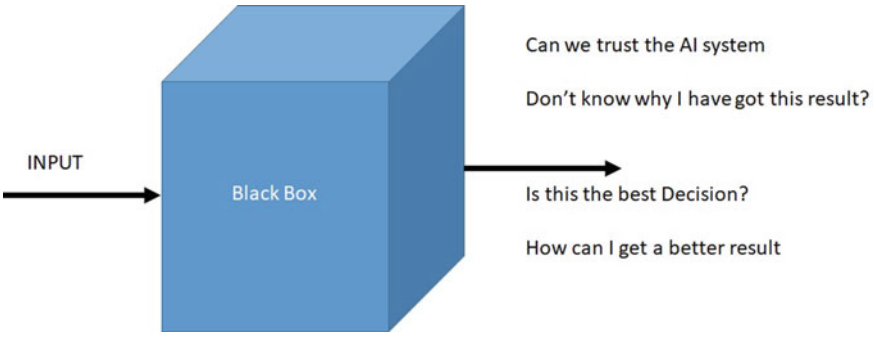

Fig. 7.1 AI may create confusion as a decision is given without any explanation

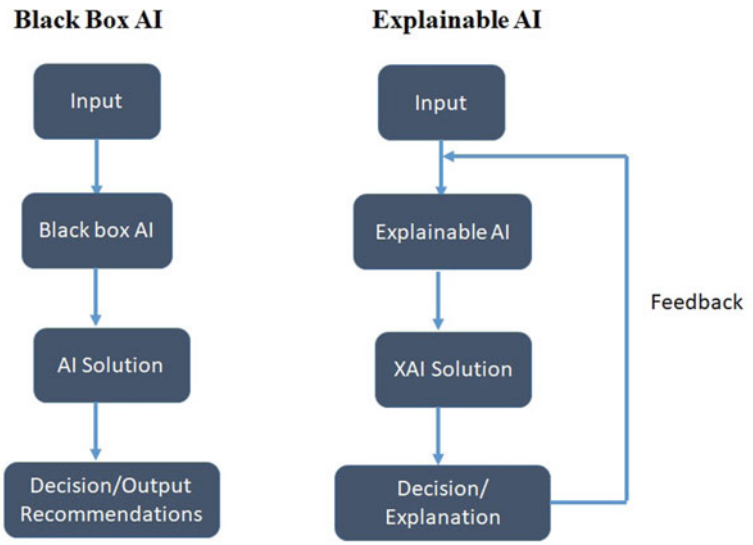

Fig. 7.2 Need for XAI

history of any disease such as Diabetes or Cancer, can get the tests done and based on the analysis, and the results doctors can suggest a lifestyle, diet for prevention.

IBM has announced AI Explainability 360, describing it as "a robust open-source toolset of cutting-edge methods that aid machine learning model interpretability and explanation" (Mojsilovic 2019). AI must be viewed as black boxes, having internal inference procedures that are impenetrable to humans and undetectable to

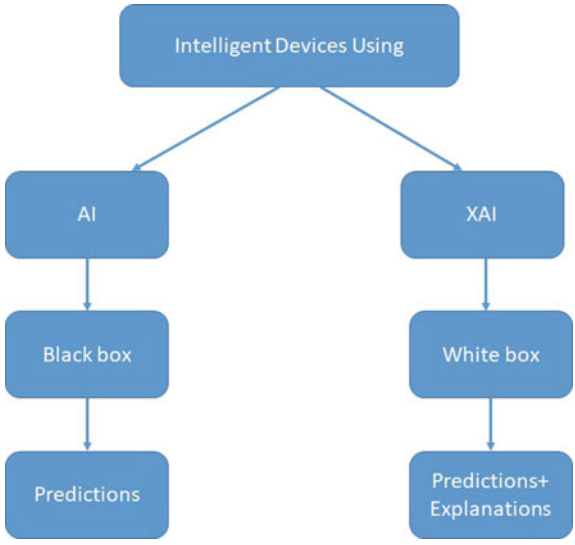

Fig. 7.3 XAI works as a white box that explains the results produced

the observer. The two most important aspects of XAI are transparency and post-hoc interpretation. In the eyes of developers, the transparency architecture shows how a model works, which includes feature relevance and evaluating & comparing the model.

Relevant features (specific data) for the study are provided like transaction amount, location, payment method, etc., and so on over a period of time can be used to detect fraud and prevent the same. The average money withdrawn from an account per month is an example of a feature. XAI assigns a value to each feature. Take a look at the features listed below:

- average monthly credit card charges in dollars.
- This card is likely to be used in this merchant category in this zip code.
- in the last week, the number of unique clients who utilized this IP address;

The model ranked the characteristic 'the average amount of credit card charges per month' in this case. Organizations can monitor and also can alter the priorities to improve the overall fraud detection and prevention. Later organizations can use model evaluation to assess the model's performance before releasing it. XAI model evaluation and comparison, is a critical component as organizations gain from testing the performance of a machine learning model since they can assess how accurate the model is and what the false positive rate is before relying on it for fraud detection and prevention. If the false positive rates do not satisfy the organization's objectives, the team tweaks the model until it performs optimally. Model comparison, as the name suggests, provides a side-by-side comparison of how different models perform when compared. Organizations can choose the best fraud detection models to deploy into production.

Let us shed a light on the components of Explainable AI, to attain transparency and post-hoc interpretation. Post-hoc extracts relationships between feature values and predictions, the behavior of a model. Model-agnostic methods can be used on any type of model, but model-specific methods can only be used on one type of model. They reject ante-hoc approaches, which build explainability into the model's structure, making it explainable even before the training phase is completed.

It attempts to (a) comprehend the model structure, such as decision tree construction; (b) understand single elements, such as a logistic regression limitation and (c) know the strategy for training, such as finding the solution in convex optimization. The post-doc interpretation explains why a result is presumed in the eyes of the customers. It tries to (d) provide analytic assertions, such as why a product is recommended on a shopping website; (e) provide visualizations, such as a saliency map for displaying pixel value in an object classification result; and (f) many transparent, interpretable algorithms such as K-nearest-neighbors, Convolutional Neural Networks, etc. are used to support the results (Dilmegani 2021; Xu et. al. 2019) (Fig. 7.4).

The Explainable AI (XAI) program aims to develop a set of machine learning techniques that will:

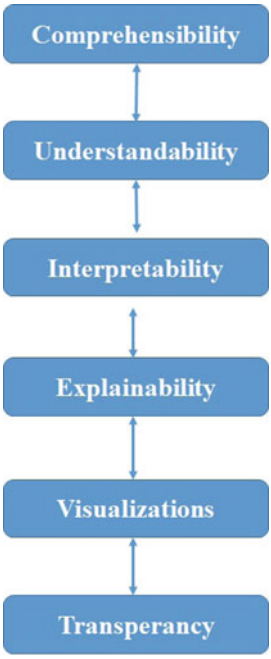

Fig. 7.4 Components of explainable AI

- Enable users to comprehend, effectively manage and adequately trust, the emerging generation of artificially intelligent partners.
- Producing more explainable models while preserving high learning performance (prediction accuracy).

Various XAI solutions have been proposed in the recent past, and have also been applied to the healthcare sector. Some XAI models are self-explanatory, based on the decision sets, which have influenced largely the prediction of several diseases like diabetes, asthma, lung cancer, etc. by seeing the patient's health record. The patient's records are self-explanatory as they are developed by mapping an instance of data to an outcome using IF-THEN rules. For example, decision sets will learn to forecast lung cancer given the following circumstances.

Predict lung cancer: If the individual smokes and has a history of respiratory disease. Self-explainable AI models have the drawback of limiting the amount of AI models that can be used to increase accuracy. There has been a surging interest in XAI techniques that can explain any AI model to address explainability in a larger number of AI models.

Model-agnostic XAI procedures are those that are unaffected by the AI model that needs to be explained. One of the most extensively used model-agnostic approaches, ***Local Interpretable Model-Agnostic Explanation*** (LIME), was presented by researchers as a framework for explaining predictions by quantifying the contribution of all the components involved in calculating prediction.

Researchers utilized LIME to describe how Recurrent Neural Networks (RNNs) forecast heart failure, and their explanations helped them identify the most frequent health problems that raise the risk of heart failure in people, such as renal failure, anemia, and diabetes. In the healthcare arena, various model-independent XAI approaches like Anchors and Shapley values have been developed and are actively used. An outline/ framework was specified for using human reasoning expertise in the development of XAI approaches, to improve details by incorporating the user's cognitive skills. The methodology developed could be used for any specific fields, such as to improve healthcare, and to provide user-friendly comprehension of how AI-based systems that apply XAI techniques at various phases enhances the clinical decision-making work.

There are certain challenges in putting XAI techniques into practice. XAI has created explanations to benefit the end-users, who might be physicians with medical domain knowledge or ordinary people. It is possible to create proper user interfaces for successfully displaying explanations.

7.6 History of XAI

Before talking about the XAI history, let us have a quick glimpse of AI. AI is where the machines depict and mimic human intelligence. Like—Self-driving cars, games using AI like chess, Amazon echo, Alexa, Siri, Google Alpha Go, IBM Watson, chatbots on websites working as virtual assistants (Kalinin 2020), etc. One can see many sci-fi movies like The Terminator, Star Trek, ex Machina, etc. AI is also used by E-Commerce organizations to suggest products based on previous purchasing patterns. Pepper recognizes human faces with a few emotions, Da Vinci Surgical System can perform minimally invasive surgeries, and Google Duplex can make reservations over the phone.

AI has moved from making intelligent machines to Machine learning, which has the ability to learn without being explicitly programmed. ML consists of 3 techniques Supervised learning (An input is mapped with an output, data sets are mapped—help to predict the next value), Unsupervised (Data-driven approach and clusters are formed), and Reinforced learning (learn from Mistakes—like these days gaming apps are based on this). It uses data to detect patterns and adjust accordingly, developing programs that can teach themselves to change and grow when needed and enables computers to find hidden insights using algorithms. In short, ML automates analytical model building. Numerous ML Techniques are available like Classification, Categorization, Clustering, Trend Analysis, Anomaly Detection, Visualization, and Decision Making. ML is used in Image processing, health care, robotics, text analysis, video games, and data mining. ML is used in various applications like—spam filtering, information extracting, and sentiment analysis. ML is a subset of AI and superset of DL. ML models need human intervention to reach the optimal outcome.

Deep Learning makes predictions independent of human intervention. DL makes the computation of multi-layer neural networks, based on the human brain. A few examples of DL, ImageNet a database of 14 million labeled images used to train neural nets, 2012, Google Brain team trained the neural networks by watching unlabeled images of cats from frames of YouTube Videos. In the year 2014, Facebook's Deep face was released identifying the face with 97.35% accuracy with a training set of 4 million images. Alpha Go developed by Google Deep mind defeated the 18-time world champion Lee Sedol in the year 2015. Deep learning is reshaping healthcare through image analytics and diagnosis and drug discovery and precision medicine.

Explainability in XAI derives from a combination of strategies that improve machine learning models' contextual flexibility and interpretability. There is no formal definition, however, it can be defined as the ability to draw conclusions based on conceptions (as a person) rather than probability alone. It can be seen as "contextual reasoning". An explainable Artificial Intelligence generates information or justifications to make its operation understandable or simple to comprehend. The next generation of artificially intelligent partners, with the help of XAI, will develop a set of machine learning algorithms to assist people in comprehending, trusting, and managing the diagnosis.

Explainable AI isn't a new notion. In the first work on explainable AI, which was published in the literature forty years ago, certain expert systems used rules to explain their conclusions. Since the dawn of AI, experts have advocated that intelligent systems should be used to explain AI findings, particularly when it comes to judgments. If a rule-based expert system refuses to accept a credit card charge, it must provide an explanation. The principles and knowledge of expert systems are simple to comprehend and infer since they are explained and established by human experts. A logically structured decision tree is a common strategy as shown in the following figure to demonstrate that why a loan application gets rejected on what parameters using decision tree (Fig. 7.5).

Similarly, XAI, helps in health care, let us see with the following figure, which helps the patient knows about the lump detected is benign or cancerous (Fig. 7.6).

7.7 Explainable AI's Benefits in Healthcare

Health care workers utilize AI to speed up and improve a variety of functions, including forecasting, risk management, decision-making, and even diagnosis, by scanning medical pictures for anomalies and patterns that are undetected to the naked eye. Many health care practitioners now use AI as a critical tool, but it is often difficult to understand, causing dissatisfaction among clinicians and patients, especially when making high-stakes decisions.

Machine learning's lack of explainability limits its use in healthcare applications where decision-makers need to understand the underlying reasoning. If artificial intelligence (AI) is unable to justify itself in the field of business, it will not be implemented on a big scale. If anyone is in charge of healthcare, the risk of taking

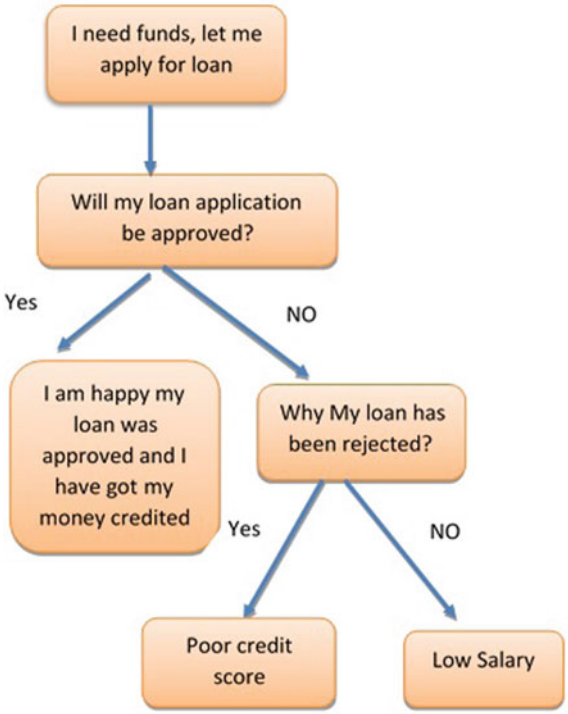

Fig. 7.5 Illustrates an example of a decision tree, which is constructed by working down from the top, level by level, according to the reasoning stated

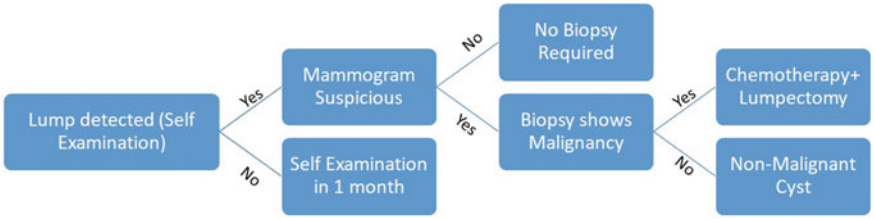

Fig. 7.6 Decision tree for detecting breast cancer

a poor/wrong decision may outweigh the benefits of precision, pace, and decision-making efficiency. This will, harm the environment. As a result, its reach and utility will be severely limited. As a result, it's important to take a close look at these issues. Until a model can be implemented in the healthcare domain, standard tools must be developed. Explainability is one such method (Gulavani and Kulkarni 2010).

XAI increases medical practitioners' and AI researchers' confidence in AI systems, resulting in the more widespread use of AI in healthcare. The heart disease

dataset as an example of how explainability approaches can be used to build trustworthiness when using deep learning systems in healthcare. The adoption of XAI comes with a slew of advantages. No matter what industry you work in, these advantages will help you and your company succeed. These are only a few of the main benefits of using XAI, according to Philip Pilger Storfer, a Quantum Black Data Scientist and XAI specialist:

- Developing user trust,
- Complying with legal obligations,
- Providing ethical reasoning, and
- Obtaining actionable and strong insights (Gill 2001).

Many companies are implementing XAI methodologies and techniques to achieve greater effectiveness, as shown by the findings described above. Explainable AI alleviates AI's problems and offers the following advantages (Gill 2001):

- **Trust and confidence**: Due to the uncertain existence of AI systems, gaining trust and confidence in doctors and patients is difficult. Users ask for answers from computers. In the pursuit of better efficiency, modern machine learning architectures are becoming more complex, often relying on black box-style architectures that provide computational benefits at the cost of model intelligence.
- **Detect and Remove Prejudice**: Since the system lacks clarity, users are unable to identify the system's flaws and biases. As a consequence, identifying and removing bias, as well as offering bias defense, becomes difficult.
- **Model Performance**: Model users are unable to monitor the model's actions due to a lack of knowledge.
- **Regulatory Standards**: Consumers are unable to assess whether or not the device complies with regulatory standards. Otherwise, the device could be affected.
- **Risk and Vulnerability**: It's important to be able to explain how systems deal with threats. Especially in circumstances where the user is unsure of the surroundings. Explainable AI assists in identifying it in a timely manner and taking effective action. But what if the device doesn't tell the consumer how to stop these dangers?

Explainable AI has accelerated the use of AI systems in healthcare. It is difficult for a person to make decisions because AI systems understand trends and make decisions based on Big Data. Explainable AI provides the following features (Gill 2001):

1. **Transparency**: The most important principle of Explainable AI is transparency. It is the algorithm, model, and features that the user can comprehend. Different users can need different levels of transparency. It is including appropriate explanations for appropriate users.
2. **Reliability**: The device offers reliable details. It should be in line with the model's production.
3. **Domain meaning**: The framework offers a user-friendly description that makes sense in the context of the domain. It is elucidating in the proper sense.

4. **Consistency**: For all forecasts, the interpretation should be consistent because different explanations will confuse the consumer.
5. **Generalizability**: The device should be able to explain things in a broad sense. However, it should not be too broad.
6. **Simplicity**: The system's description should be clear. It needs to be as transparent as possible.
7. **Reasonable**: It achieves the objective of each AI system's result.
8. **Traceable**: Explainable AI can track data and logic. The contribution of data in the production is revealed to the users. The user can track and solve logic and data problems.

7.8 XAI Has Proposed Applications for Patient Treatment and Care

Algorithms "that are inherently explainable" are the simplest method to develop functioning XAI in health care. Simpler solutions like decision trees, regression models, bayesian classifiers, and other transparent algorithms can be employed instead of sophisticated deep learning or ensemble approaches like random forests "without sacrificing too much performance or accuracy." XAI has been benefiting the medical practitioners and experts

1. **Assisted or automated diagnosis and prescription**: Chatbots can assist patients in self-diagnosis as well as doctors in diagnosis. Based on the symptoms identified by the patient, many healthcare organizations provide useful health and triage information. They do, however, note that no diagnosis has been made. This is to reduce their legal liability, but if the accuracy of chat bots increases, we may see chatbots delivering diagnoses in the future (https://medicalfuturist.com/top-12-health-chatbots/) Kalinin 2020; Kaushal et al. 2019).
2. **Prescription auditing**: Prescription auditing systems that use artificial intelligence (AI) can assist decrease prescription mistakes.
3. **Pregnancy Management**: Keep an eye on both the mother and the fetus to assuage the mother's fears and enable an early diagnosis.
4. **Real-time case prioritization and triage**: Prescriptive analytics on patient data enables real-time case prioritization and triage.
    - Jvion: The Cognitive Clinical Success Machine accurately predicts danger and comprehensively, providing prescribed actions that enhance outcomes.
    - Well frame: It flips the script by offering interactive care services to patients via their mobile devices. The Care Team's portfolio of clinical modules, which are based on evidence-based care, allows it to give a tailored experience.
    - Enlitic: Patient triaging solutions search incoming cases for various clinical findings, priorities them, and route them to the network's most suitable doctor.
5. **Personalized medications and care**: Assess the most appropriate treatment options based on patient data, decreasing costs and increasing care efficacy.

- GNS Healthcare: The business uses machine learning to match patients with the most effective treatments.
- Oncora Medicals: Software that helps health systems structure, interpret, and learn from their data in order to provide personalized care.

6. **Patient Data Analytics**: Analyze data from patients and/or third parties to uncover information and make recommendations. The organization (hospital, etc.) may use AI to analyze clinical data and derive deep insights into the health of patients. It allows for lower healthcare costs, more effective resource usage, and easier population health management (Daley 2018).

    - Zakipoint Health: The organization uses a dashboard to show all related healthcare data at the member level, allowing users to better understand risk and cost, as well as have personalized services and increase patient engagement.

7. **Surgical robots**: AI and collaborative robots are combined in robot-assisted surgeries. These robots are suitable for procedures that involve the same, repetitive movements because they can operate without being fatigued. AI can detect trends in surgical procedures, helping surgeons to improve their best practices and surgical robot control accuracy to sub-millimetre precision.
8. **Early diagnosis**: Analyze lab results and other diagnostic data to achieve an early diagnosis of chronic diseases.

    - Ezra: Ezra uses artificial intelligence to interpret full-body MRI scans and assist clinicians in cancer detection.

9. **Medical imaging insights**: Advanced medical imaging may be utilized to analyze and manipulate pictures, as well as to simulate future situations.

    - SkinVision: By taking pictures of your skin with your phone and going to a doctor at the right time, you can spot skin cancer early.
    - Medical imaging powered by artificial intelligence is also frequently used to diagnose COVID-19 cases and classify patients that need ventilator support. For example, Huiying Medical, a Chinese company, has developed a 96 percent accurate AI-powered medical imaging solution.

7.9 Future Prospects of XAI in Medical Care

The real healthcare advantage in the future would most likely come from the synergies gained by integrating the power of XAI-related technologies across the entire patient journey. Like, currently wearable devices could monitor heart rates, calories taken, sleep patterns, exercise levels, over time, blood glucose levels, and many more. In the future, this data could be synced to a central monitoring system that uses machine learning to detect irregular or undesirable behavior. The monitoring system will automatically alert the patient's physician and advise the patient to make an appointment (Fig. 7.7).

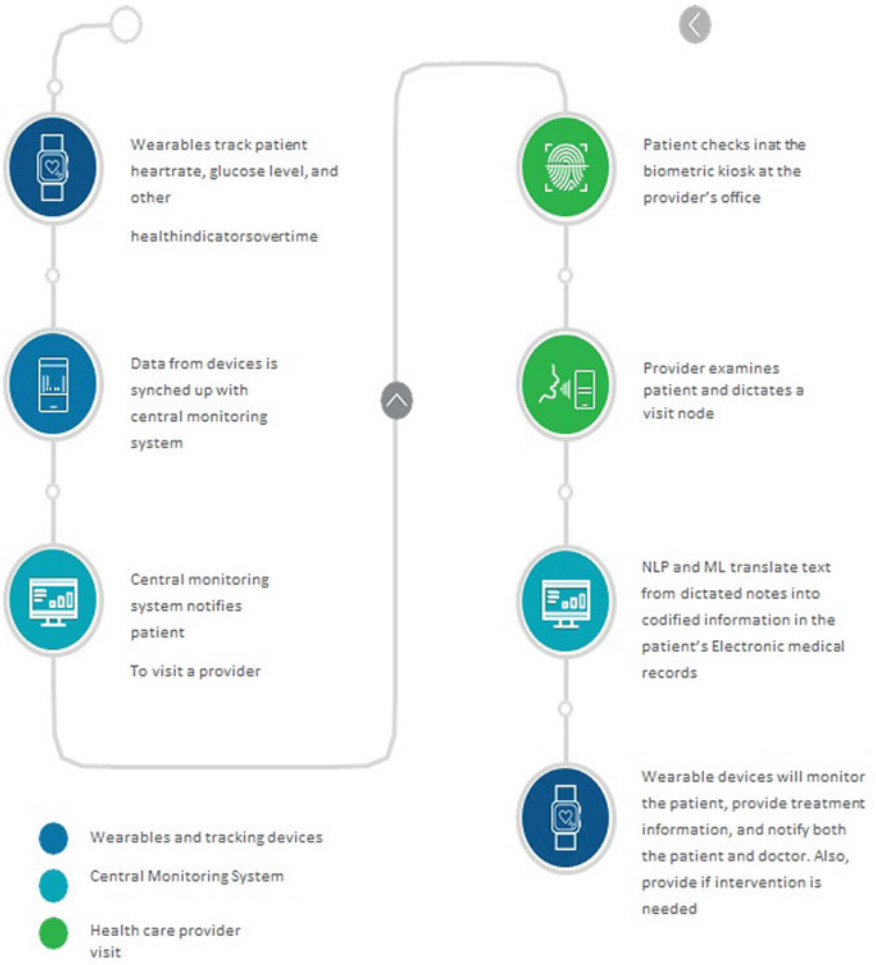

Fig. 7.7 XAI in health care sector

7.10 Case Study on Explainable AI

Explainable AI can help give local or global explanations for single predictions. There are techniques like model agnostic, and model specific. Various algorithms produce non-explainable predictions like the random forest, SVM, NN, etc. There are methods like Intrinsic/Ante-hoc and Post hoc methods. The ante-hoc methods are transparent, can be said that they are based on a white-box approach. The algorithms like Decision Trees, KNN, Fuzzy, Bayesian, etc. are used for transparent and fair predictions. Post-hoc is based on algorithms like PCA, CAM, LIME (**L**ocal **I**nterpretable **M**odel-Agnostic **E**xplanations), or SHAP (**Sh**apley **A**dditive ex**p**lanations) (Daley 2018).

Diabetes is a very common disease in modern days due to lifestyle and eating habits. Diabetes is a condition in which the patient's blood glucose, often known as sugar, is usually either very high or too low. Glucose is the main source of energy that one gets from the food one eats. Although diabetes has no permanent cure, one can try to control/manage the sugar levels. It is necessary to keep track of the body. Explainable AI explains the data used for the prediction, their correlation, and EDA (Exploratory Data Analysis) to understand the hidden data patterns.

7.11 Framework for Explainable AI

XAI aims to make the model work transparently. It aims to select the right data and preprocess it for the model. It is required to have an accuracy of the model to predict the correct result, we need to be doubly sure when we are dealing with the health care domain as that is impacting the life and health of any individual. A single wrong result can have a threat to human life.

- Which feature influences more diabetes?
- What amount of Glucose do I need to maintain?
- Why did the system say that I can have diabetes in the future*?*

The explainable nature of AI can help doctors

The Glucose value of a person influences the result more while predicting whether a person can have diabetes or not. Doctors and health practitioners can answer what Glucose value an individual need to maintain to have diabetes. The explainable nature of AI can help us look at the change of having diabetes in the future. LIME and SHAP, two of the most common feature-based techniques, are very similar in intent but take very diverse methods.

Unlike LIME, which can only provide local explanations, SHAP can provide both global and local explanations. The dataset is used to generate many plots that illustrate the dataset globally and provide details about the relationships between the features and their significance.

Explainability is a key to producing a transparent, proficient, and accurate AI system. It makes it easy for the enduser to understand the AI systems' complex work. (Fig. 7.8).

Case Study's Conclusion

Explainable AI's contribution to the Diabetes Prediction framework simplifies the intricate workings of AI systems for the end-user. It offers the user a human-centered GUI. Explainability is essential for creating a transparent, competent, and reliable AI system that can assist healthcare practitioners, patients, and researchers in comprehending and using the system.

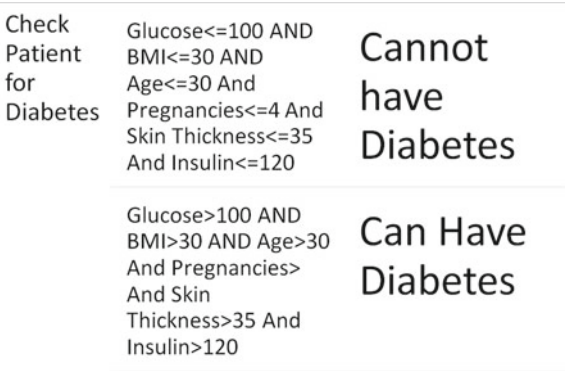

Fig. 7.8 XAI in detecting diabetes

7.12 Conclusion

The disruptive impact of technology on the healthcare business is undeniable. Even though it is a sector that necessitates highly skilled employees with several years of education, it also necessitates a significant amount of infrastructure and instruments. The rise in global life expectancy and the ageing of societies have fueled a surge in healthcare innovation and technology. With the environment changing every year, it looks like field innovation is highly powerful.

The majority of AI systems are not accountable for their outcomes, which can often damage society or users by producing incorrect results. Explainable AI and its values improve the way a system operates by describing the algorithm, model, and features it employs. The domain of XAI must be defined and deployed in AI-based health systems continuously. Most AI system is not answerable for their result, which can sometimes harm society or the user. Explainable AI and its principle bring a change in the system's traditional functioning.

The value of improving explainable AI capabilities has begun to be recognized by the markets. Many companies like Microsoft Azure and Google Cloud Platform have influenced many AI adoption patterns.

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