www.ijecs.in
International Journal Of Engineering And Computer Science
Volume 11 Issue 8 August 2022, Page No. 25601-25617
ISSN: 2319-7242 DOI: 10.18535/ijecs/v11i08.4697

AI-Enhanced Information Security: Safeguarding Government and Healthcare PHI

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Abstract
Ransomware attacks on government agencies and the tendency of gangs are contributing to an unprecedented crisis in the U.S. These strikes not only lock organizations, including large healthcare providers and government networks, data for large amounts of ransom but also, in some cases, suspend patient care and critical social services provided by vital government employees. In addition to these recent destructive attacks, the annual Verizon Data Breach Investigation Report (DBIR) always shows that government and healthcare organizations have numerous security incidents and data crimes. These incidents cost millions of dollars in response tendencies and remediation measures, damage or extinction of data, and harm the reputation of affected organizations. Furthermore, the potential for causing physical harm to a patient has raised concerns about the current summary of the implications of cybercrime.This demonstrates that healthcare data collection and protection are of increasing importance to the public and the government. However, protecting healthcare-protected health information (PHI) is very difficult. Hospital information systems are complex, fragmented, and heterogeneous, involving a large number of medical devices, sensors, and software applications from multiple manufacturers. Protecting sensitive data in this environment is not easy, especially when the purpose of providing medical care is to improve the patient's condition through treatment by collecting, accessing, and sharing data. Most security measures are not compatible with this mission, so cybersecurity is still important. A recent report by the International Health Research Institute found that 82 American hospitals have been targets of last year's ransomware attacks, and it is very likely that these attacks and their negative impact will continue to grow. A recent report from the Obama Administration's President's Information Technology Advisory Committee (PITAC) described this particular situation in detail. The report further states that healthcare organizations must be prepared for future large-scale cyber attacks and that it is likely that highly motivated attackers have the potential to shut down large parts of critical network infrastructure.

Keywords:AI-Enhanced Information Security, Industry 4.0, Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML), Smart Manufacturing (SM),Computer Science, Data Science,Vehicle, Vehicle Reliability

1. Introduction

The introduction of healthcare and patient data into health information technology and the dissemination of patient health information throughout the health data management chain have dramatically improved the speed and quality of patient care. However, these improvements have come with corresponding threats to patient privacy and adversarial interference with healthcare delivery, management, and planning. These threats place both individual patients and the larger healthcare industry at risk. Protecting the personal health information (PHI) of individuals by appropriate safeguards has been an essential requirement of all national governments and

international health authorities.Many potential security procedures can control unauthorized access to PHI. The problem is that if an unauthorized person can gain access to any PHI system using a particular security procedure, then that security procedure has failed. Consequently, all security procedures for PHI must be a priori guaranteed to provide secure protection always. One AI approach to developing secure procedures is to model the goal of reason-based security as a security parameter in the end-to-end training of structured reasoning cognitive programs. If that can be achieved, then,

At least in theory, properly designed AI-enhanced programs will, by design, have in their knowledge sufficient to provide proof or disproof that a given implementation mechanism provides or does not provide secure protection for PHI.AI-enhanced programs are envisioned to revolutionize the security landscape of PHI by integrating structured reasoning into their frameworks. This approach not only aims to anticipate vulnerabilities but also to proactively address them through continuous learning and adaptation. By embedding security parameters into the end-to-end training of these cognitive programs, the goal is to establish robust mechanisms that can autonomously validate the efficacy of security procedures. This proactive stance is crucial in healthcare, where the stakes are high due to the sensitivity of patient data and the regulatory requirements surrounding its protection. Furthermore, AI-driven solutions promise to enhance the agility of healthcare organizations in responding to evolving threats, thereby safeguarding patient privacy and maintaining the integrity of health data management chains.These AI-enhanced programs leverage advanced algorithms to not only detect potential security gaps but also to simulate attack scenarios and evaluate the effectiveness of security measures preemptively. By integrating structured reasoning, these programs can analyze complex interactions within PHI systems, identify vulnerabilities in real-time, and recommend adaptive security protocols. Moreover, the continuous learning capabilities of AI enable these systems to evolve alongside emerging threats, ensuring that defenses remain robust and resilient.In practical terms, AI-driven security solutions in healthcare can encompass anomaly detection in access patterns to PHI, real-time monitoring of data transmissions for unauthorized disclosures, and predictive analytics to forecast potential security breaches. These capabilities enable healthcare providers to implement proactive measures to mitigate risks before they materialize, thereby enhancing overall patient data protection. Additionally, AI's ability to process vast amounts of data quickly and accurately enhances the efficiency of compliance audits and regulatory reporting, ensuring adherence to stringent privacy laws and standards.As AI technologies continue to evolve, they hold the promise of transforming healthcare cybersecurity from reactive to proactive, thereby bolstering patient trust, reducing the likelihood of data breaches, and advancing the overall quality and safety of healthcare delivery. Integrating AI into PHI security strategies represents a pivotal step towards achieving comprehensive and resilient protection against adversarial threats in the healthcare sector.

Fig 1:Electronic Health Record

1.1. Background and Significance

Although traditional techniques may still be partially effective for large-scale, high-traffic, high-visibility systems, mitigation of cyberattacks is an increasingly complex problem, and a considered, multi-disciplinary systems approach is essential. This is particularly the case when the stakes are high, such as protecting the nation's highly interdependent critical infrastructure and the functioning of cyber governments. As an example, in 2021, the University of Vermont Medical Center paid approximately $1.5 million in ransomware to

computer criminals. The University of Vermont Medical Center is a medium-sized non-profit hospital in Burlington, Vermont; therefore, large private hospitals such as Columbia University Irving Medical Center in New York City would likely be willing to pay substantially more. Given large targets and large dollar amounts, it is not too surprising that some attackers are the equivalent of cyber cartels. In the United States, some cyber cartels have been traced to countries with histories of poor working conditions and weak human rights records.At the same time, at least some attackers are both surprisingly close and surprisingly far. Without too much difficulty, those with advanced degrees in systems engineering can find and download information developed by senior members of large, nation-state organized crime groups that simultaneously control dollars, bots, tools, and specifications. However, it is unlikely that actual attackers, or especially the coders are senior members of those groups. The coders seem more likely to be script kiddies looking for cash that can be tips to our servers. While they may think of themselves as bank robbers of the past, actually they appear to be more like delivery boys smuggled in the undercarriage of a money train, bribing the conductor before the real killers arrive on board. Large, civil infrastructure-protecting companies need to carefully position themselves to stop the real killers, not just those tipped with a few dollars for cybercap work. Are we prepared to do that? In response to the escalating threat landscape, organizations must adopt a multifaceted approach that integrates advanced cybersecurity measures with comprehensive risk management strategies. Protecting critical infrastructure and essential services from cyber threats requires not only robust technical defenses but also stringent governance frameworks and proactive threat intelligence. The incident at the University of Vermont Medical Center underscores the high stakes involved when healthcare institutions become targets, highlighting the need for enhanced cybersecurity investments across the sector.As cybercriminals become more organized and sophisticated, capable of orchestrating attacks akin to cyber cartels, the scale and impact of breaches continue to escalate. Large institutions, such as major hospitals in metropolitan areas, are particularly vulnerable due to their reliance on complex IT systems and the sensitivity of patient data. The ransomware incident at the University of Vermont Medical Center serves as a wake-up call for healthcare providers and other critical infrastructure operators to bolster their defenses against evolving cyber threats.Moreover, the global nature of cybercrime means that attackers can operate from jurisdictions with lax regulations and enforcement, complicating efforts to apprehend and prosecute cybercriminals effectively. This underscores the importance of international cooperation and unified efforts in combating cyber threats across borders. Organizations must invest in cybersecurity education, training, and technology to empower their teams to detect, respond to, and mitigate cyber incidents effectively.Ultimately, ensuring the security and resilience of critical infrastructure requires a proactive stance, continuous adaptation to emerging threats, and collaboration between public and private sectors. By prioritizing cybersecurity as a strategic imperative and integrating advanced technologies and practices, organizations can mitigate risks and protect against potential disruptions to essential services and national security.

Fig 2: 5 Data sources for pharmacoepidemiological research

1.2. Research Objectives

This research is focused on the leveraging of advances in AI to address the growing threat of security breaches in two of the most targeted sectors: government and healthcare. All organizations have the responsibility to maintain the security and confidentiality of the personal or corporate information with which they have been entrusted. Generally, organizations wish to avoid the negative impacts that have recently been experienced by some who have not done so. Individuals could potentially suffer a diminution of rights or a loss of property if data on social media

and financial systems are hacked. A loss of life is one of the outcomes that the security breach of health system data has the potential to produce. The question at hand is why these security breaches are possible at all. An area that has been addressed by an area with considerable resources is still left with an enormous problem.The increasing volume and sophistication of today's cyber threats, especially those targeting both federal and state resources, require organizations to remain agile and adaptable to effectively counter state and non-state attackers. These threats continue to rise in both frequency and scale and government agencies need to ensure cybersecurity professionals are ready to defend against and respond to these attacks. The ability of the healthcare industry to access an unlimited health record has the benefit of being important in identifying and treating medical conditions. However, transactions performed by healthcare providers satisfy an essential need and carry a charge in the form of protected health information (PHI) that, if breached, could potentially harm more than the primarily concerned party. With the proliferation of digital patient data, there are legitimate concerns about protecting PHI from increasing security threats. It is important to recognize that the presently viable safeguards that are in place, such as encryption, tokenization, and de-identification, in combination with the applicable laws and ethical norms, are responsible for most healthcare information staying private and out of the wrong hands.As organizations grapple with the pervasive threat of security breaches, particularly in sectors like government and healthcare, the imperative to safeguard sensitive information has never been more critical. The repercussions of data breaches can extend beyond financial losses to include profound impacts on individual rights and even life itself, especially when health system data is compromised. Despite substantial investments in cybersecurity, the persistence and evolution of cyber threats pose ongoing challenges that require continual vigilance and innovation in defense strategies.Government agencies and healthcare providers alike face mounting pressures to fortify their defenses against both state-sponsored and independent cyber adversaries. The increasing digitalization of patient records underscores the importance of robust security measures such as encryption, tokenization, and strict adherence to privacy laws. These safeguards are pivotal in preserving the confidentiality of protected health information (PHI) and mitigating the risks posed by cyber threats.Moving forward, organizations must not only invest in advanced AI-driven technologies to detect and respond to threats proactively but also foster a culture of cybersecurity awareness and readiness across all levels. By prioritizing cybersecurity as a strategic imperative and integrating cutting-edge solutions, governments and healthcare providers can uphold their commitment to protecting sensitive data and maintaining public trust in an increasingly interconnected digital landscape.

1.3. Scope and Limitations

The covered entities under HIPAA have been extended to include business associates and their subcontractors that create, receive, transmit, or maintain PHI. However, these entities do not regularly require their employees to obtain HIPAA training and may not prioritize information security. The HHS provides guidance and may assess penalties to the covered entities yet do not have explicit jurisdiction over the business associates. The state and regional HIEs may impose additional information security and privacy requirements but may not have express jurisdiction over all of the covered entities and business associates that they interact with. In the process of meeting their meaningful use criteria, the incentive programs also accentuate the integration of information security for the new EHR incentive programs. However, these complex incentivized changes may stress the existing information security models and processes, and Kennedy et al. argue that since security is often an afterthought, it is desirable to have security by design. Cebula et al. argue that if one applies a higher-order purpose (HOP) architecture, then various encounters with health information will incur different information security requirements.These various legislative protections include The Federal Information Security Management Act of 2002 (FISMA), which instructed NIST to establish standards and guidance for Federal information systems. States have also acted by establishing their own state jurisdiction privacy and security protections for state PHIs. States also have established criminal sanctions for unauthorized access to PHI. California, in its Civil

Code 56.36, requires organizations to implement "reasonably appropriate security measures to protect the privacy of Californians' PHI". The CA Medical Information Act (CMIA) in CA Civil Code 56.10-56.16 similarly requires administrative, technical, and physical safeguards to protect PHI.

2. The Role of AI in Information Security

Healthcare organizations increasingly employ AI to address challenges in managing PHI and to more effectively address privacy and potential policy violations. AI provides opportunities to monitor and manage PHI through integration with real-time alerts and dashboards, predictive forensics, and prompt notifications. In government, risk-aware decisions about security are possible without threatening information sharing or citizen and organization services that require the exchange and management of data. AI's first successes in identifying and mitigating access risks are seen in cost allocation improvements. Some high-volume and skilled labor shepherding of data systems is augmented, not replaced. Software developers who presently build AI solutions under a security-aware design regime will expand to include secure processes and include AI training to secure the whole system, not just layer AI inside a secure system.The role of AI in the security layer is two-tiered: use AI to tailor security policy and add AI features to strengthen security under current policies. In the former, AI can accomplish risk measurement by pre-market testing, like forensics for tracking and guarding PHI; insight prioritizes alert backlog for actual risk cases; and persuades through data representation since teams can reach early consensus. For stronger security building, AI team training must move from employing secure software developers to seeking and training secure AI algorithm implementers, and risk estimation, with an upgrade of security features required by a new AI. Fortunately, this process-aiding use is current and growing.

Fig 3:Process flow of DDoS attack confirmation using machine learning

2.1. Overview of AI Technologies

Multiple AI techniques are valuable today in adding power to conventional information security hardware and software. As a group, AI technologies make it possible to invest the same time and money in creating security as the criminals and other bad actors invest in carrying out the crime. Several researchers have outlined the advantages of AI-enhanced PHI for routine administrative tasks. The performance gains available with the introduction of AI into the environment outweigh the cost of operation. Phishing is at an all-time high. More than 304 billion emails are exchanged each day, much of which are seen by employees in a work environment. Often, the polished and dangerous phishing email gets through this first line of defense and the email is opened by someone in the organization. That first click is an essential step towards financial fraud, theft of PHI, and actions that can harm the operations and even the credibility of the healthcare organization. Specifically, AI's contributions to the security of information by preventing, detecting, monitoring, and responding to cybersecurity attacks are described in this report segment.Multiple AI techniques are valuable today in adding power to conventional information security hardware and software. As a group, AI technologies make it possible to invest the same time and money in creating security as the criminals and other bad actors invest in carrying out the crime. Several researchers have outlined the

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2.2. Applications of AI in Information Security

When it comes to information security, there are several applications of AI to help achieve the desired objectives. These are typically associated with specific aspects or elements of the enterprise threat defense model that we have discussed in the preceding section. Now it would be useful to examine these applications in some little detail. The use of AI in information security is a rapidly developing field and potentially falls under many different applications. However, a limiting focus in the way in which it is done in this book is essential and the approach being adopted is to address the subject in the context of enterprise security as proposed in the generic model of enterprise security that we covered at the beginning of this section. This is, primarily, sourced in the work of Pajcevska and Pachovska and is too little known or applied according to existing literature.The applications to be covered are therefore limited to those that are potentially applicable and relevant to achieve enterprise security objectives. This focus helps to put the topic in a more specific context and, at the same time, provides a unifying thread that links the different chapters in the book. The remainder of this section is therefore composed of several subsections. In each subsection, a particular application of AI in information security is covered, again primarily in terms of what it is and why it is employed. However, an emphasis is also placed on how the organization can deploy AI successfully to leverage its capabilities according to the focus of the entire set of chapters. Help is provided to readers about the facilitators and constraints that exist in different applications to set out a complete picture of each of the relevant applications of AI technologies.When it comes to information security, there are several applications of AI to help achieve the desired objectives. These are typically associated with specific aspects or elements of the enterprise threat defense model that we have discussed in the preceding section. Now it would be useful to examine these applications in some little detail. The use of AI in information security is a

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3. Challenges and Risks in Protecting Government and Healthcare PHI

Phi faces numerous challenges and risks, beyond the usual network-based and application-area threat to personally identifiable information (PII). Safeguarding PHI also typically involves a higher degree of compliance with industry and government oversight and regulation directions, including the Privacy Act, HIPAA (Health Care Portability and Accountability Act of 1996), and HITECH (Health Information Technology for Economic and Clinical Health Act). In an unusual government-specified cybersecurity situation, guidelines on how best to safeguard PHI and PII could be centrally developed, with a neutral third party facilitating consensus development of best practices. A detailed road map could, and one might argue, be developed, enabling an orderly and well-structured transition from current practice to a more robust and automated PII/PHI security environment featuring an AI as the principal technology designed to thwart and protect such data.Designed system state and programmed reactions will only take appropriate action when everything is neatly defined, precisely on point, and in the correct order, from the AI-asserted system context (which can then dictate conditions for policy execution) or alerting situations, leading to preemptive data safeguards. If no current defenses are apparent to the AI in its situation awareness, adaptive response AI could require more than new incoming data or a threat reflex policy to be dynamically activated post-system-assertion/infection/damaging event. Uncertain reactogenic events may drive adaptive responses. These events may translate into potential danger, disruptive regulatory notifications, or compliance integrity results where a healthcare system evolves, based on learned data from the consequence paths derived. Necessary AI reactions (e.g., zero-day events or assumed learning data provided to the AI environment) should come from neutral organizations or trusted actors where the learned reaction data is provided. Defining AI compliance (and burning in the data set) will enable the AI language of intelligent and proactive security AI features drawn from the database of past, present, and future evolving states in compliance context arenas.

3.1. Regulatory Compliance and Legal Implications

Artificial intelligence (AI) plus traditional systems and security organizations can provide stronger, more diverse technical search capabilities, automated incident analysis, and some degree of response automation. Over the short term, AI can free up a limited number of human security experts for higher-value assessment, to create a more effective security system. Over the long term, systemic AI may fundamentally change the world of threats and risks.Healthcare security must comply with various federal regulations. First, the Health Insurance Portability and Accountability Act (HIPAA) mandates that covered entities and their business associates implement necessary administrative, physical, and technical safeguards to ensure the integrity, confidentiality, and availability

of their protected health information (PHI). Second, healthcare security practitioners must comply with the Health Information Technology for Economic and Clinical Health (HITECH) Act, which provides financial incentives for the adoption of certified electronic health record (EHR) systems and strengthens many of the HIPAA privacy and security rules.In the United States, federal and state laws are continuously being presented, changed, or passed to protect the privacy of individuals. However, government regulation often lags far behind technically advanced criminals and technology. In addition, the legal system has no jurisdiction over foreign cyber criminals in certain foreign countries which legislates natural boundaries.Some elected officials publicly oppose a powerful, expensive intelligence community to resolve both the United States national security concerns and the free market to prevent companies from making too much money. Meanwhile, in recent years, corporate failure has come mainly from ignoring existing laws and regulations, not from writing insufficient regulations. Security companies are subjected to SEC fines when they don't reveal fairly to the investing population the cost of multiple data breaches and resource shortfalls that lead to them. Therefore, they should have easily recognizable, fair demands of any company or vertical market they are in for the level of information security measures that were taken. Demonstrating compliance shortly follows.Small businesses, especially minorities and women, during the COVID-19 pandemic are especially affected by the recent internal security legislation.Small businesses, especially minorities and women, have faced heightened challenges during the COVID-19 pandemic, exacerbated by the increasing complexities of internal security legislation. The need for accessible resources and clear regulatory guidance is crucial for these vulnerable sectors to navigate and implement effective cybersecurity measures.

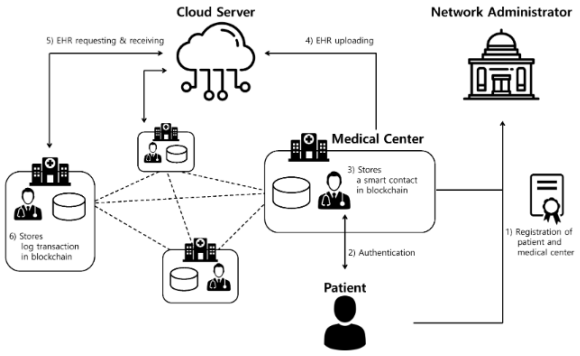

Fig 5:Patient Record Management Systems E Diagram

3.2. Cybersecurity Threat Landscape

Cyber adversaries have progressively demonstrated the ability to operate undetected within enterprise environments, leverage an organization's information assets against it, destroy entire networks, deceive and manipulate on a massive scale, and steal critical information. Targeted actions against high-profile organizations, as well as those aimed at energy infrastructure, elections, financial, healthcare, transportation, and water systems, have been troubling and newsworthy. The point is not just to disrupt, but to undermine trust in the systems upon which critical infrastructure depends.In this environment, enhanced but increasingly singularly dependent AI and machine learning-based cyber defenses are considered to be among the most promising. However such systems have their unique issues and challenges. AI research, development, and deployment imperatives, ethical norms, national security considerations, and ethical barriers are examined and considered.Significant research, development, and deployment efforts are investigating and applying machine learning to information security (cybersecurity). The field is both challenging and dynamic. A foreshadowing of related considerations is presented in Exhibit A-4. Rapid advances in machine learning, increased data available for establishing good signals, the emergence of a commodity surveillance data ecosystem, and ease of creation of new information features, and the development of new algorithms indicate that a move favoring the defense appears feasible.There is a growing recognition among both defenders and attackers as they vie for superiority in adaptability, control, counter-measurement, and deception. In response, AI can potentially give defenders more

leverage, capacity, and control over their operational plays. A balance can be achieved, and adversary-initiated deceptions can be reduced.Cyber adversaries have progressively demonstrated the ability to operate undetected within enterprise environments, leverage an organization's information assets against it, destroy entire networks, deceive and manipulate on a massive scale, and steal critical information.

4. AI Solutions for Enhancing Information Security

To address the evolving challenges of information security, including the proliferation of PII and PHI data, stricter regulations, non-deterministic threats, and user behavior, various AI techniques including machine learning, deep learning, and natural language processing can be used to produce AI-enhanced information security solutions. AI-enhanced information security solutions aim to harness AI techniques' unique capability to learn, adapt, and perform, to enhance existing automated, rule-based security systems by improving security processes and reducing human intervention. This includes properly identifying PII and PHI, enforcing rules and guidelines for data sharing with trusted parties, creating a learning model that understands data, identifying and controlling access to PII and PHI, enforcing data protection, understanding normal user behaviors in accessing data, detecting theft, and identifying compromised network devices and endpoints. Additionally, AI-enhanced security solutions can integrate with other security appliances such as data leak prevention, email security, and web security.AI-enhanced security solutions can generate good accuracy by simultaneously processing and analyzing multi-dimensional, high-speed datasets, including network traffic and network security. After examining the AI applications at different layers in Fig. 1, most of these AI applications focus on three general tasks: Network Security, User Access Control and Monitoring, and Data Security & Protection. Network-based detection and classification systems have been developed for identifying and isolating both internal and external threat patterns in data traffic. The monitoring and analysis of user behavior, through email analysis, log analysis, and other techniques, can detect and prevent potential information thefts. Although these techniques are successful for numerous information security applications, they could also be used to securely share PII and PHI data.

4.1. AI-Driven Threat Detection and Prevention

AI-driven, cloud-delivered Zero Trust Exchange service not only leverages AI as the main line of defense to block cyber threats before delivery into government and private healthcare networks, but also identifies and responds to employee behavioral threats and IT adversaries, such as credential theft through multi-factor authentication attacks. As mentioned in the previous section, AI can deduce a combination of behavioral parameters, ranging from identity risk scores to device, location, real-time network traffic, and mobile app access patterns to determine whether or not an employee should be provided access to protected data. This AI evaluation of trusted security mechanisms balances employee FCCP with sensitive PII and PHI protection, and its cloud delivery also fends off security service outage risks due to natural disasters and unstaffed facilities.In addition to leveraging AI as the primary defense mechanism against cyber threats, the AI-driven, cloud-delivered Zero Trust Exchange service provides robust capabilities to manage and mitigate employee behavioral threats and IT adversaries within government and private healthcare networks. By analyzing a diverse array of behavioral parameters such as identity risk scores, device characteristics, location data, real-time network traffic patterns, and mobile application access behavior, the AI system can dynamically assess the trustworthiness of access requests to protected data.This proactive AI evaluation ensures a balanced approach between facilitating efficient employee access (FCCP - Fast, Convenient, Compliant, Productive) and safeguarding sensitive Personally Identifiable Information (PII) and Protected Health Information (PHI). By continuously monitoring and analyzing these parameters, the Zero Trust Exchange service can swiftly identify and respond to anomalies that may indicate potential threats, such as credential theft through multi-factor authentication attacks.Moreover, the cloud-based delivery model of the Zero Trust Exchange service offers additional resilience against security service disruptions caused by natural disasters or unstaffed facilities. By centralizing security measures in the cloud,

organizations benefit from enhanced scalability, reliability, and accessibility, ensuring continuous protection of critical data assets in dynamic and evolving healthcare environments.

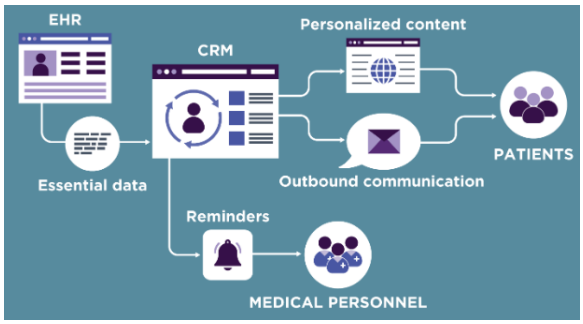

Fig 6:Healthcare CRM system: benefits, features,development guides

4.2. AI-Powered Data Encryption and Access Control

The idea to apply machine learning to safeguard existing information security tools and projects is anticipated in the proposals to utilize artificial neural networks for intrusion detection. Exploit the self-learning capabilities of artificial intelligence for decision-making in key management, certificate revocation, certificate expiration, and certification path validation, as well as the learning noise of AI-controlled ciphers in steganography. In line with this line of research and the recent advances achieved in the explainability of the black box predictive models, this study proposes to apply artificial intelligence to the encryption management process and associated access control implementation.ML-enhanced encryption provides an opportunity to improve security as well as confidentiality and integrity of sensitive information protected with encryption. The application allows the protection of personal information, regardless of its location or movement. For example, on a laptop, smartphone, PC, NAS, or within a corporate IT network. The user's information is protected with encryption, which cannot be cracked or decrypted maliciously. As a model, artificial intelligence enables detecting potential future threats or breaches and taking further defensive actions, including data access blocking, before a single bit of data gets lost.Implementing machine learning (ML) in information security tools and projects represents a significant advancement in safeguarding sensitive data against evolving threats. By leveraging artificial neural networks for intrusion detection, AI can autonomously learn and adapt to emerging attack patterns, enhancing the detection accuracy and speed compared to traditional methods. This proactive approach not only improves the efficiency of key management processes but also strengthens certificate handling by automating tasks such as revocation checks, expiration monitoring, and validation of certification paths.Furthermore, integrating AI into encryption management offers substantial benefits in enhancing data security. ML-enhanced encryption systems can provide robust protection for personal information stored across diverse devices and networks, including laptops, smartphones, PCs, NAS devices, and corporate IT infrastructures. This ensures that sensitive data remains confidential and integral, even in dynamic and mobile computing environments.Moreover, AI's predictive capabilities enable preemptive threat detection and proactive defense measures. By continuously analyzing data access patterns and anomalies, AI-powered encryption solutions can anticipate potential threats and preemptively block unauthorized data access attempts. This proactive stance helps mitigate risks before data breaches occur, safeguarding organizations against financial losses, reputational damage, and regulatory non-compliance.In summary, the application of artificial intelligence in encryption management not only enhances security measures but also streamlines operational efficiencies by automating complex tasks and improving overall threat detection and response capabilities.

5. Case Studies and Best Practices

AI techniques are rapidly being deployed in a variety of different problem spaces. The following sections present a few examples from healthcare, government, and finance, each of the five AI techniques: ML, leveraging mostly new, consumer-based, and big data sources; computer vision; natural language processing and text analytics; expert system/rule-based support; and Bots. In most cases, an institution can derive best practice guidelines from these early AI movers. Furthermore, the utilization of AI in information security and infosec/privacy governance is often conducted by more risk-aware institutions that have a better understanding of what information is of

high value on the dark web (e.g., combing it constantly for interesting IP over time). Small to medium-sized organizations should learn from the best while performing a comprehensive census of data that matters across many different sources and platforms, and managing and governing it effectively. In essence, it is not just traditional structured enterprise data that counts. Unstructured data from a variety of sources like computer logs, printed or referenced content from libraries, previously unchecked consumer IoT services, social media accounts, and more are increasingly subject to infosec/privacy violations. As we describe in the following case studies, safeguards also need to increase around transactions from data lakes, data warehouses, real-time exchanges, APIs, and data tools requiring infosec containing richer structured and unstructured data. Start with data that matters and retire data that doesn't, with AI systems constantly testing and learning to discover how to keep information safe, while supporting ethical data governance and flexible innovation. In all these cases, the introduction of AI in infosec requires training by senior managers and the incorporation of synthetic up-to-date AI-generated threat models in business continuity plans. More importantly, the policies necessary to govern the role of synthesized AI-generated citizen and consumer PII disclosure agents—especially sustaining consistent policy frameworks for citizens, not the complete reliance on specialist governance and specialized AI tools and bots over time.

5.1. Successful Implementations in Government Agencies

This collaboration had one objective: use AI technologies and threat event-causal patterns to discover alterations in student activity to discern negative modifications. This partnership between the Federal Department of Education and the IBM-CM University Team used educational accuracy evaluation (designed by the Federal Office of Education) to focus on the negative patterning of in-use computer hardware and software in a school environment. Actions taken by the school were prepared as knowledge and then embedded in the autonomous learning agent's heuristic process. Within a six-month time frame of collecting school information and then using AI for predictive analysis, thirty-six hidden K-select indicators emerged. These negative alteration indicators were indicative of server file resets and router admins and use that were slightly higher than normal. It took an additional seventeen secondary events (removal/install computer-cs50 servers/tree and Stanley firewall) alterations to signal school staff to respond.The task of the sub-agent AI systems was to help a group of people manage a large number of options in a task decision environment. The goal of the sub-agents was to simplify the decision path by reducing the number of options the people could see, so the people could move faster to an end state. In this project, the Composite Small Units Department had to decide which chip components to replace in four faulty army battlefield wheat killer machinery systems. Each battlefield wheat killer machinery system had two channels. Each channel had weapon cartridge sensors (five pairs on the carrot kill belt) in which chips could fail. Careless handling or age may have produced the chip failure. Each wheat killer had to perform its task within a twenty-minute design window of error-free activity. Discovery of the faulty chips occurred slowly. CompletableFuture AI was used to simplify the viewing of the failures by agent choreography and rule protocoling traffic among people. Twenty sensor pairs could cause a 20-channel interrupt if there was an errant symbol raised. Explanation of the results and solution heuristic coding was on Aristotle-like knowledge. These were embedded in learning agents for any field scanned and found errors.

5.2. Lessons Learned from Healthcare Organizations

Healthcare companies are held to strict standards to ensure patient data remains secure. If that confidential information is disclosed or if the system is breached and patient information is tampered with, the Patient Safety and Quality Improvement Act (PSQIA) of 2005 is designed to protect healthcare organizations from penalties - provided the organization is collecting and analyzing their data. According to a study conducted by the Ponemon Institute, healthcare organizations are investing in solutions to simplify compliance with relevant Health Insurance Portability and Accountability Act (HIPAA) regulations and to provide XP or better security features and other hardening features that help

businesses address patient safety or data action plans mandated under the PSQIA and its associated Common Rule.The attack vectors and primary motivations for attackers to target healthcare organizations have dramatically changed and evolved over the past few years. It is likewise important for healthcare organizations to keep pace with a newer approach to securing data and assets. However, studying and understanding the impact AI technology can have on data security, and the complexities surrounding the full incorporation, design, and protection of that data when it is shared through AI is a first step to understanding what can work and what can go wrong. Security policy updates are areas that healthcare organizations are willing to invest in - according to the Ponemon report, increases in training and other updates are available but are currently underused and could be accomplished at a low cost per individual.Healthcare organizations face continuous challenges in safeguarding patient data due to evolving cyber threats and regulatory requirements like HIPAA and the PSQIA. These regulations mandate strict compliance to ensure patient information remains confidential and secure, with severe penalties for breaches or mishandling of data. The Ponemon Institute's study highlights that healthcare entities are actively investing in solutions that streamline compliance efforts and enhance security measures, such as implementing XP or better security features and conducting regular security hardening procedures.As cyber attackers' tactics become more sophisticated, healthcare organizations must adopt advanced security measures to protect sensitive data effectively. This includes leveraging AI technology to bolster their defenses against emerging threats. However, integrating AI into healthcare data security frameworks requires careful consideration of design complexities and potential vulnerabilities that AI implementations may introduce. Effective security policies and ongoing staff training are crucial components in maintaining robust cybersecurity posture and ensuring compliance with evolving regulatory standards.Moving forward, healthcare organizations need to continue investing in technology and training to mitigate cybersecurity risks effectively and safeguard patient data against an increasingly hostile threat landscape. By staying proactive and adaptive, healthcare providers can uphold patient trust and regulatory compliance while leveraging the benefits of AI-driven advancements in data security.

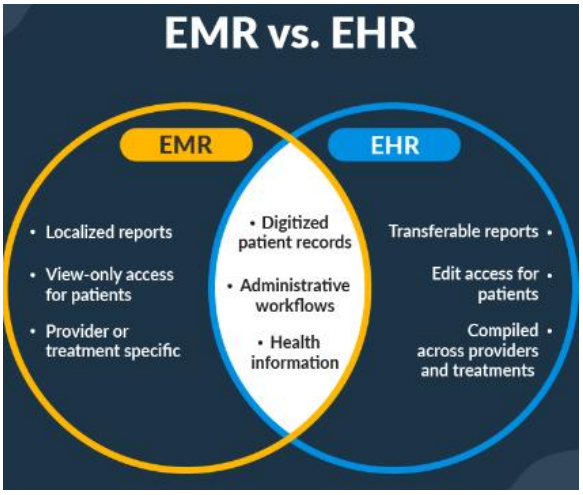

Fig 7:Types of Electronic Health Record (EHR) Systems in 2024

6. Conclusion

Artificial intelligence (AI) converges on the policy front with issues of cybersecurity and privacy, particularly as digital privacy concerns have gained prominence in the public consciousness and are increasingly expressed in law and public policy. This is also the case, particularly in the specific era of the COVID-19 global pandemic. In the world of the privacy professional, public health scenarios can be seen in the protection of personal health information (PHI). In this context, the maxim of "no harm" finds an echo in the duty to protect that information, expressed in federal and state laws and agency regulations.In our healthcare providers who contract with the Centers for Medicare & Medicaid Services (CMS), breaches of PHI can be particularly costly as large, affected numbers of individuals must be quickly notified, and individual credit protection services acquired, as required by the Health Insurance Portability and Accountability Act (HIPAA) Breach Notification Rule. To improve CMS privacy controls to avoid such breaches, this study merges concepts from the fields of both big data analytics and privacy to create an innovative privacy-protecting framework and use it to develop privacy-enhanced training data. This AI-enhanced data was then used to train large and deep learning models designed to automatically verify a user's access request. The results of these AI verification

solutions were then evaluated using standard predictive performance metrics on patterns of actual CMS employee access requests to determine their efficacy in supporting scalable privacy controls. Based primarily on these empirical toolkit validation assessments, our study, in closing, yields normative policy conclusions. The reasons for these assessments also offer normative recommendations, as they supply subtle policy insight as to the efficacy of our AI-enhanced safeguards, as well as the reduction in the likelihood of all-too-human guardian misuse.Artificial intelligence (AI) plays a pivotal role at the intersection of cybersecurity, privacy, and public policy, especially amid heightened concerns about digital privacy, which have become increasingly regulated in law and policy frameworks worldwide. This trend is particularly evident in the context of the COVID-19 pandemic, where the protection of personal health information (PHI) has become paramount in public health scenarios.

For healthcare providers, especially those contracting with entities like the Centers for Medicare & Medicaid Services (CMS), breaches of PHI can lead to substantial costs and regulatory obligations under laws such as the Health Insurance Portability and Accountability Act (HIPAA) Breach Notification Rule. Rapid notification and mitigation measures, including offering credit protection services to affected individuals, are mandatory in such cases.

To bolster privacy controls within CMS and mitigate the risks of PHI breaches, this study integrates concepts from big data analytics and privacy protection to develop an innovative framework. This framework utilizes AI-enhanced training data to train sophisticated deep learning models aimed at automating the verification of user access requests. The effectiveness of these AI-driven solutions is assessed using standard predictive metrics applied to actual patterns of employee access requests within CMS.Ultimately, the study provides empirical validation of the AI-enhanced privacy safeguards, offering insights into their efficacy and potential to reduce the risks associated with human error or misuse of access controls. These findings contribute normative policy recommendations aimed at enhancing privacy protections and maintaining compliance with evolving regulatory requirements in healthcare data management.

6.1 Future Directions

Despite the increasing awareness and concern on safeguarding government and healthcare PHI, the methods will become significantly more sophisticated, outpacing the state of the art in AI-enhanced security in several ways. The threats from ever-so-sophisticated adversaries are dynamic and grow and vary across time, and the security protocols and systems have to be adaptive and capable of taking quick actions. This is only possible through the ability of AI-enhanced security systems to process a massive amount of data quickly and be able to learn almost in real-time to predict and respond to risks. The AI cybersecurity response has to be capable of providing full spectrum cyber defense including forward defense, public-private partnership, international collaboration, resilience, modeling, and simulation to simulate and predict threats. AI enhancement in cybersecurity will bring many new attack constructs and attack vectors as well. Additionally, adversarial machine learning can influence the decision-making process of the security system, such as misclassifying malware as benign. The adversarial machine learning threat can be even more severe in training datasets for testing purposes. Therefore, robustness is key in securing AI-enhanced security protocols as per the broader recommendation by the National Security Commission on Artificial Intelligence.The security of machine learning models engaged in transforming and processing information is crucial. Data poisoning attacks on adversarial machine learning can result in defensive security architectures exposing critical security features, or semi-commercial privacy leakage. Therefore, the mechanisms to secure the machine learning model have to be capable of detecting data poisoning. Most importantly, adversaries also build and engineer knowledge of AI-enabled security systems, to design and execute attacks in a manner that renders the defense network plans ineffective. The question of how humans, humans AI, and AI alone prevent adversaries from capitalizing on the security mechanisms must be explored in depth. Any system that is designed to deeply radiate particular knowledge of the AI cannot protect the confidentiality and security of the data well. While

the humans, humans AI, and AI-only machine capability support needs to be secured, the potential vulnerabilities from knowledge radiated on security due to lack of training domain on AI needs to be well understood and factored. The users and the developers need to be cautious about the AI systems in a manner that they do not inadvertently radiate their PI behind any jet machine learning intentions of adversaries.

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