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# Postgraduate Colloquium 2024

Innovating for a Sustainable Future: Interdisciplinary Approaches  
in the Digital Era

Editors  
Zahidah Zulkifli  
Ahsiah Ismail

KICT Publishing

**POSTGRADUATE COLLOQUIM 2024  
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THE DIGITAL ERA**

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# Preface

The Postgraduate Colloquium 2024, held as a special event in conjunction with the 3rd International Interdisciplinary Conference on Research & Opportunities (IICRO 2024), took place on 7th August 2024 at the Kulliyah of Information and Communication Technology (KICT), International Islamic University Malaysia (IIUM). This event was proudly hosted by Universitas Raharja, Indonesia, the Indonesian Lecturer Association, and the International Islamic University Malaysia, under the theme "Innovating for a Sustainable Future: Interdisciplinary Approaches in the Digital Era."

The colloquium provided a unique platform for postgraduate students across diverse fields—such as computer science, information systems, software engineering, data science, cybersecurity, and creative multimedia—to share their research. It emphasized the importance of exploring not only research findings but also their broader implications for academic and professional communities. Participants were encouraged to present challenges encountered in their work, fostering dialogue and collaboration among peers and experts.

This hybrid-mode event welcomed students at all stages of their research journey. Early-stage researchers gained valuable insights into postgraduate research, while those in the middle or final stages received constructive critique to refine their projects. Out of 14 submissions, 8 papers were selected for publication, reflecting the innovation and academic rigor of the participants.

Aligned with the overarching theme of IICRO 2024, this colloquium underscored the importance of interdisciplinary collaboration and highlighted the pivotal role of postgraduate research in addressing the challenges of a sustainable future in the digital era.

We extend our deepest gratitude to all participants, reviewers, and judges, as well as to the hosting institutions for their unwavering support. We hope this collection of selected works inspires future research and collaboration across disciplines.

## **Editors**

Zahidah Zulkifli

Ahsiah Ismail

Postgraduate Colloquium 2024

Kulliyah of Information and Communication Technology

International Islamic University Malaysia (IIUM)

# TABLE OF CONTENTS

No.	Content	Page No.
1	<a href="#">An Enhanced Mental Health Intervention Using EEG-Based Emotion Detection</a> <i>Marini Othman, Muna Azuddin, Ain Shaheada Abdul Rahim Dapit</i>	1
2	<a href="#">Event-Based Cybersecurity Risk Assessment</a> <i>Wan Azlena Wan Mohamad, Nurul Nuha Abdul Molok, Noor Hayani Abd Rahim</i>	5
3	<a href="#">Formulation of Muscle Spasticity Characteristics Model for Quantifying the Clinical Assessment of Neurological Disorder Patients</a> <i>Muhamad Aliff Imran Daud, Asmarani Ahmad Puzi, Shahrul Na'im Sidek, Salmah Anim Abu Hassan, Ismail Mohd Khairuddin and Mohd Azri Abd Mutalib</i>	9
4	<a href="#">Cloud-Based Security Solutions for Cryptocurrency Wallets</a> <i>Sohel Rana, Rizal Mohd Nor</i>	14
5	<a href="#">Design Affordances for Sensemaking of Online Risks by Muslim Parents: A Conceptual Model</a> <i>Fadzlin Binti Ahmadon, Murni Binti Mahmud, and Muna Binti Azuddin</i>	18
6	<a href="#">A Framework for The Development of an Optimized Artificial Intelligence Model for Diabetes Mellitus Prediction and Treatment Recommendation</a> <i>Md Ziarul Islam, Mohd Khairul Azmi Bin Hassan, Amir 'Aatieff Bin Amir Hussin</i>	22
7	<a href="#">From Chalk to Clicks: The Benefit of Youtube in Special Education: A Pilot Study</a> <i>Nur Aswani, Mohd Azhar, Nur Leyni Nilam Putri Junurham, Muna Azuddin, Aishah Abd Karim, Roosfa Hashim</i>	38
8	<a href="#">Third-Party Engagement in E-Banking System Development: A Literature Review</a> <i>Gobinath Karuppiah</i>	44

# AN ENHANCED MENTAL HEALTH INTERVENTION USING EEG-BASED EMOTION DETECTION

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**Abstract:** This research addresses the challenge of identifying and quantifying emotions related to mental health using Electroencephalography (EEG) signals. Mental health issues are on the rise, impacting individuals' well-being and creating a need for effective emotion detection methods, especially in human-computer interface applications. While EEG signals offer insights into emotional states important for decision-making and perception, accurately interpreting these states, particularly in mental health contexts, remains a significant challenge. This is worsened by the unreliability of self-reporting methods and the complexity introduced by cultural and contextual factors. Innovative approaches that combine EEG-based emotion detection with traditional analysis techniques are proposed. The research aims to develop an application that utilizes EEG signals to identify and display emotions, exploring individual interactions with the technology and its effectiveness in recognizing and visualizing emotions for various applications. The objectives include studying individuals' emotional responses to stimuli, creating a framework for quantifying emotions through EEG signals, and evaluating the developed system's effectiveness through experimental validation. The significance of this research lies in its potential to address pressing mental health issues such as anxiety and depression by providing insights into emotional expressions and their impact on well-being. Methodologically, the research approach involves collecting EEG data, designing and developing the application, and conducting experimental validation with diverse participants. Overall, this research contributes to the advancement of mental health interventions by utilizing emerging technologies like EEG-based emotion detection and AI models, combined with manual analysis techniques, to enhance our understanding and treatment of mental health conditions.

**Keywords:** EEG, mental health, emotions.

## 1. INTRODUCTION

With a notable increase in mental health issues impacting individuals' ability to achieve optimal well-being, there is a growing demand for effective methods of automatic emotion detection, particularly in applications utilizing human-computer interfaces. Accurately interpreting and responding to emotional states in mental health interventions remains a significant challenge despite technological advancements. Traditional methods relying on subjective self-reporting may not always provide reliable data, and cultural and contextual factors can further complicate understanding emotional experiences (Siddiqui et al., 2021). This lack of precise measurement obstructs the development of tailored interventions for individuals' specific emotional needs. While machine learning algorithms offer promise in automating emotion recognition, combining these approaches with manual analysis is necessary to ensure accuracy and reliability (Mirheidari, 2024).

## 2. METHODOLOGY

The research employs a mixed-methods approach, integrating quantitative EEG data collection and analysis with qualitative user feedback and validation through user testing. It uses an experimental design to classify EEG patterns related to emotional states using machine learning algorithms, validated by statistical tests. Sampling focuses on participants without diagnosed mental health conditions, providing a baseline for understanding emotional

responses in a general population. According to Bosch-Bayard et al. (2020), participants must be in a healthy mental condition, with neurophysiologists eliminating abnormal EEG recordings. Key instruments include EEG machines, MATLAB software for data processing and application development, and user interface design and machine learning tools. EEG data collection involves using an electrode cap, with participants performing tasks and watching videos to stimulate emotions. Application development starts with gathering user requirements, creating prototype designs, and incorporating feedback. MATLAB facilitates rapid prototyping, efficient coding, and AI model integration for emotion recognition. Experimental validation involves recruiting normal participants to generate emotional responses, with EEG data and self-reported emotions recorded. Statistical tests compare self-reported emotions with detected ones to evaluate the system's effectiveness.

### 3. PRELIMINARY RESULTS

#### 3.1 Dataset

Preliminary EEG data collected at Neurocoach Digital Lab (NDL) includes participants with mental health issues. The initial dataset consists of 7 adults with formal diagnoses or reported symptoms of mental disorders and 4 adults from a control group. Tables 1 and 2 describe the demographics of the adults with mental disorders and the control group.

**Table 1. Demographics of Adults with Mental Disorders**

Participant	Gender	Age (Years Old)	Mental Disorder
P1	Female	39	ADHD and OCD
P2	Male	24	Anxiety
P3	Female	38	ADHD
P4	Female	50	Anxiety
P5	Male	18	PTSD
P6	Male	22	Bipolar
P7	Male	23	Bipolar

**Table 2. Demographics of the Control Group**

Participant	Gender	Age (Years Old)	Mental Disorder
C1	Male	35	None
C2	Female	42	None
C3	Female	31	None
C4	Male	50	None

### 3.2 Interface Design

The interface design for the application focuses on user-friendly navigation. Key functionalities include modules for participant information management. The application will provide a comprehensive view of each participant's information, ensuring confidentiality and ease of access. Additionally, participant results will be displayed through infographics, offering clear and visually appealing representations of data to facilitate understanding and engagement. Figure 1 and Figure 2 show the design interface and the layout of these key features:

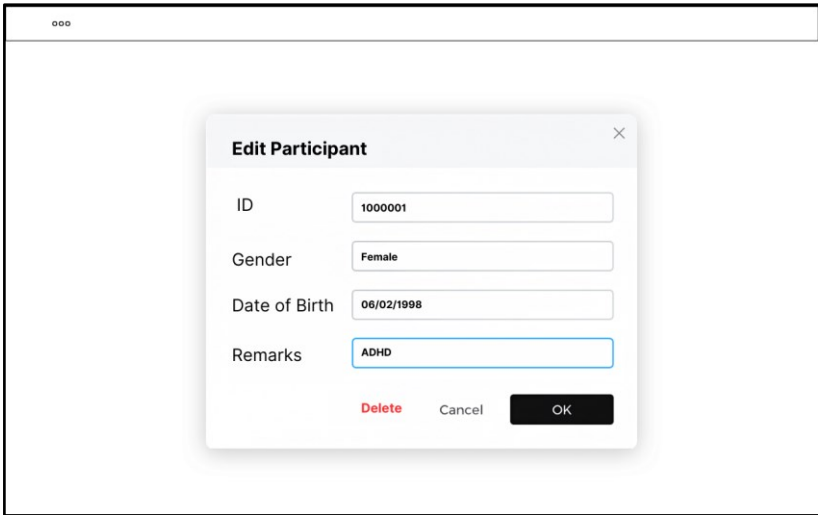


Figure 1. Interface Design for Participant Information

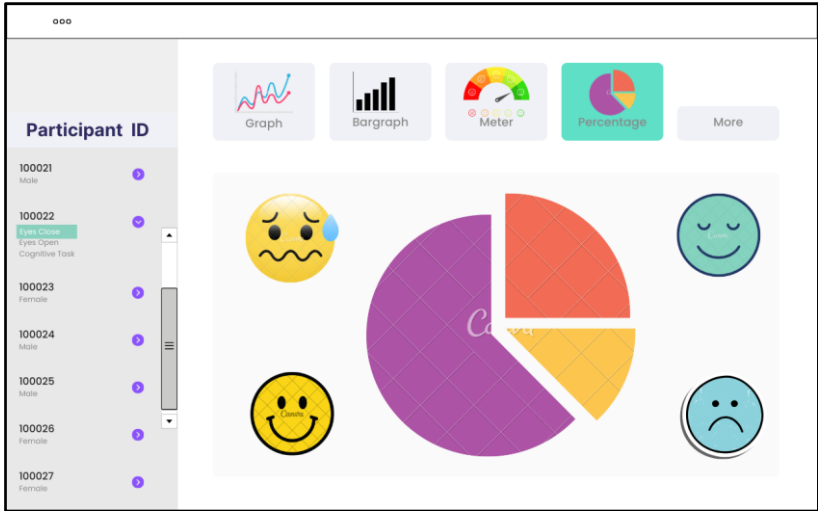


Figure 2. Interface Design for Participant Result

### 4. CONCLUSION

This research has demonstrated the feasibility of using EEG signals to identify and quantify emotions related to mental health. Preliminary findings show distinct EEG patterns associated with various emotional states, validated through machine learning algorithms and statistical tests. The study highlights the potential of combining EEG-based emotion detection with traditional analysis methods to enhance accuracy and reliability. The initial application prototype, designed for user-friendly navigation and effective data visualization, shows promise for practical implementation. Continued research is encouraged to expand the dataset, refine



the algorithms, and further validate the system's effectiveness across diverse populations. Future studies should also explore integrating this technology into real-world mental health interventions, potentially offering new avenues for personalized and precise mental health care.

## 5. ACKNOWLEDGMENT

We extend our gratitude to our instructors and professors for their commitment, which has enabled us to make progress in the areas of EEG-based emotion detection and mental health studies.

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# EVENT-BASED CYBERSECURITY RISK ASSESSMENT

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**Abstract:** In today's digital age, organisations' dependence on technology for operational efficiency, improved service delivery, and client interaction has grown considerably. This increasing reliance has, however, also amplified vulnerability to cyber risks, underscoring the urgent need for effective cybersecurity risk management within organisations. Cybersecurity risk management involves the identification, assessment, and mitigation of threats to safeguard individuals, organizations, and nations from cyber risks. At the heart of this process is the cybersecurity risk assessment, a crucial activity focused on understanding and mitigating potential cyber threats. Two main approaches are commonly employed in risk assessment: the event-based approach and the asset-based approach. Here, an "event" denotes any occurrence or shift in circumstances that might affect security. This study investigates the event-based risk assessment by assessing potential cyber-attacks or events that could compromise the confidentiality, integrity, and availability of digital data, thereby posing significant cybersecurity risks to organizations. Academic research has often focused on asset-based methods, potentially weakening strategies against new and emerging cyber threats. Many academic findings are tailored to specific application systems or sectors, which might not adequately address the unique risks and necessary controls pertinent to different sectors. Moreover, there is a noticeable disconnect between academic approaches and established cybersecurity guidelines that align with international standards, such as those from the National Institute of Standards and Technology (NIST) and the International Organization for Standardization (ISO). To bridge these gaps, this study examines an event-based cybersecurity risk assessment for organisations. Utilizing a qualitative research approach, interviews will be conducted with risk assessment officers who have served in the organisations for over 10 years and have experience in cybersecurity risk assessment within them. Through thematic analysis of the qualitative data, this study aims to examine an event-based cybersecurity risk assessment, contributing to the strengthening of the cybersecurity framework within organisations.

**Keywords:** Cybersecurity, Risk Assessment, Risk Management, Event-based

## 1. INTRODUCTION

In today's digital environment, the organisation's dependence on technology for improving operational efficiency, service delivery, and citizen engagement has grown considerably. This increased reliance has also elevated the exposure to cyber risks, highlighting the urgent need for strong cybersecurity risk management within organisations (National Cybersecurity Agency, 2020). Cybersecurity risk management involves identifying, evaluating, and mitigating threats to safeguard individuals, organisations, and nations from cyber risks (J. Chen et al., 2021; Lau et al., 2021; Sukumar et al., 2023). At the core of this process is cybersecurity risk assessment, a crucial activity focused on understanding and mitigating potential cyber threats (NIST SP 800-30, 2012). There are two primary approaches to risk assessment: event-based approach and asset-based approach (ISO/IEC 27005, 2022). In this context, an "event" refers to any occurrence or change in circumstances that might impact security (ISO/IEC 27005, 2022). This study examines event-based cybersecurity risk assessment by investigating potential cyber-attacks or events that could threaten the confidentiality, integrity, and availability of digital data, thereby presenting significant cybersecurity risks to organizations.

Despite technological advancements and the increasing complexity of cyber threats (Ukwandu et al., 2020; Zhang et al., 2022), organisations' predominant reliance on an asset-

based approach to cybersecurity risk assessment may not sufficiently address the evolving nature of cyber risks (Bagheri et al., 2023). Scholarly focus has similarly leaned towards asset-based methods, possibly weakening strategies against emerging cyber threats (Jung et al., 2023). Scholars often examine cybersecurity risk assessment components specialized for certain application systems or specific sectors, which might not encompass the distinctive risks and necessary controls relevant to different sectors. Furthermore, there is a lack of harmonization between scholarly and established cybersecurity guidelines based on international standards, such as those by the National Institute of Standards and Technology (NIST) and the International Organization for Standardization (ISO) (Melaku, 2023). To address these gaps, this study examines an event-based cybersecurity risk assessment for organisations based on ISO and NIST.

**2. METHODOLOGY**

This study employs a qualitative research approach to examine an event-based cybersecurity risk assessment for organisations. The theoretical phase involves a comprehensive literature review, synthesizing insights from published and unpublished documents, including reference books, journal articles, conference proceedings, research theses, international standards, and governmental policies. Various online databases such as ACM Digital Library, Scopus, Science Direct, Web of Science, Proquest, and Google Scholar are utilized. Documents that meet the criteria are downloaded and analysed. The synthesis of academic literature involves a thorough review to identify key components of the event-based cybersecurity risk assessment, forming the basis for the conceptual framework as presented in Figure 1.

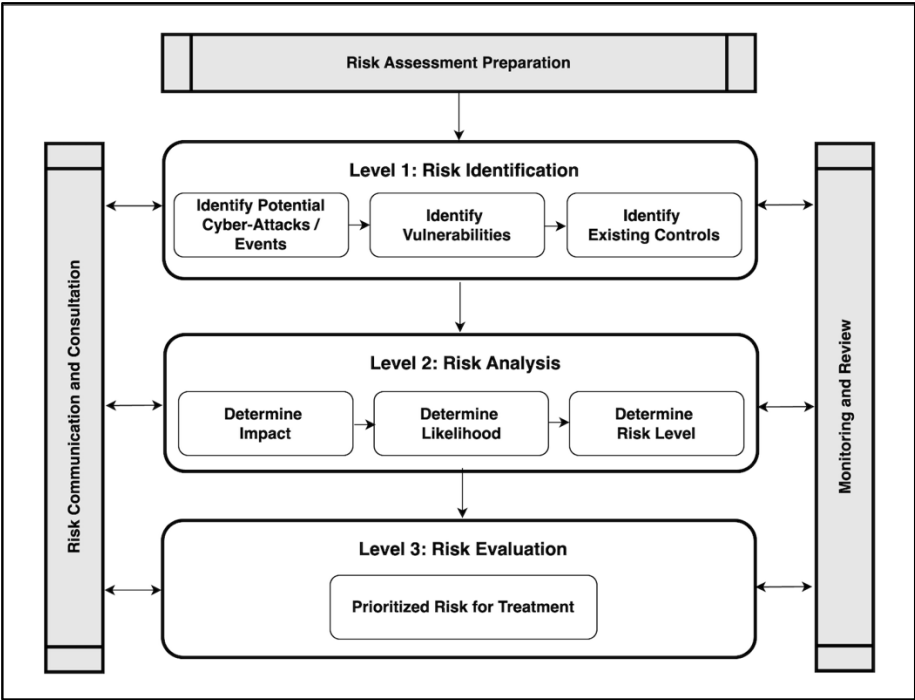


Figure 1. Conceptual framework

Expert interviews are a commonly employed qualitative method, often utilized to gather insights or explore a particular area of expertise (Döringer, 2021). In this study, the selected participants for the interview are experts who have served in the organisations for more than 10

years and have been or are currently involved in cybersecurity risk assessment in their organizations. Ten (10) experts were identified as presented in Table 1.

**Table 1. Identified participants.**

<b>PARTICIPANTS</b>	<b>ORGANISATIONS</b>	<b>POSITIONS</b>
PARTICIPANT A	Prime Minister’s Department (JPM)	Risk Assessment Officer
PARTICIPANT B	National Cybersecurity Agency (NACSA)	Risk Assessment Officer
PARTICIPANT C	National Digital Department (JDN)	Risk Assessment Officer
PARTICIPANT D	Ministry of Finance (MOF)	Risk Assessment Officer
PARTICIPANT E	National Cybersecurity Agency (NACSA)	Risk Assessment Officer
PARTICIPANT F	Prime Minister Office (PMO)	Risk Assessment Officer
PARTICIPANT G	Public Service Department (JPA)	Risk Assessment Officer
PARTICIPANT H	Ministry of Works (KKR)	Risk Assessment Officer
PARTICIPANT I	Ministry of Education (KPM)	Risk Assessment Officer
PARTICIPANT J	National Institute of Public Administration (INTAN JPA)	Risk Assessment Officer

Thematic analysis is used to analyse the qualitative data from these interviews, contributing to the examination of the event-based risk assessment key components.

**3. RESULTS AND DISCUSSION**

The main finding of this study is the key components of event-based cyber security risk assessment that identify potential cyber-attacks or events in organisations. The key components are formulated based on the findings of the empirical study. The findings align with international standards such as NIST and ISO. It also integrates insights from academic literature and practical experiences of risk assessment officers, ensuring its relevance and applicability.

**4. CONCLUSION**

This study addresses the critical need for an examination of event-based cybersecurity risk assessment in organisations. By expanding the focus from assets to events, the findings offer a dynamic and responsive approach to managing cyber risks. The theoretical and empirical phases of the research provide a robust foundation for the key components, ensuring it is grounded in both academic knowledge and practical insights.

The study's findings contribute to the academic field by highlighting the key components of an event-based risk assessment. It offers practical implications for policymakers, IT managers, and cybersecurity professionals in organisations, providing a guideline to enhance their cybersecurity posture. Future research can build on this study by validating the key components in different contexts and sectors, further refining its effectiveness.

In conclusion, the key components of the event-based cybersecurity risk assessment represent a significant advancement in the field, offering a tailored solution to the evolving cyber threats faced by organisations.

**5. ACKNOWLEDGEMENT**

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<https://doi.org/10.1109/ACCESS.2022.3204051>

# FORMULATION OF MUSCLE SPASTICITY CHARACTERISTICS MODEL FOR QUANTIFYING THE CLINICAL ASSESSMENT OF NEUROLOGICAL DISORDER PATIENTS

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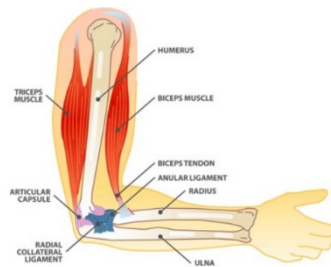
**Abstract:** Patients with neurological disorders usually experience conditions where their muscles are stiff, tight and prone to resist stretching, which in essence defines muscle spasticity. The current method of muscle spasticity assessment is based on subjective assessment by therapists who rely on their inner intuition, experience and skills that comply with the Modified Ashworth Scale tool. This leads to inconsistency in assessment and could affect the efficacy of the rehabilitation process. Although current trends to quantify the clinical assessment offer some positive results, they have been shown to pose challenges in identifying significant spasticity characteristics to produce a proficient model of muscle spasticity characteristics of neurological disorder patients by ignoring the composition of the measured signals. Thus, the research's main objective is to formulate the spasticity muscle characteristics model based on the Modified Ashworth Scale (MAS) scores from forearm musculature by using Mechanomyography (MMG) signals. To achieve the objective, a systematic study on forearm musculature and MMG signals generated during flexion/extension will be carried out. This is due to finding a suitable setup arrangement in acquiring the most significant signals that represent the muscle spasticity characteristics. The cues from the MMG signals pattern will be used to select the sampling features for the development of the classifications algorithm model. A customized non-invasive MMG device will be used to collect the signal characterizations from patients with different scores of MAS clinical assessment. It is envisaged that the main output of the research will be a novel spasticity muscle characteristics model including significant muscle composition. The impact from this research can serve significantly as the standardized and objective assessment tool for measuring the muscle spasticity level of the affected limb. Hence warranting a more effective rehabilitation process and reduction in overall expenditures pertaining to saving cost, time and energy.

**Keywords:** Mechanomyography, Muscle spasticity, Quantitative assessment, and Neurological disorders.

## 1. INTRODUCTION

Initially, Lance was the first person who explained that spasticity is a motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes (muscle tone) with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex, as one component of the upper motor neuron syndrome (Lance, 1980; Starosta et al., 2024). Another means to look at spasticity is as a disorder where abnormally high muscle tone or stiffness is present which can cause pain, difficulty speaking, and even difficulties with movement

(Whitten et al., 2024). Patients with neurological disorders due to stroke, cerebral palsy (CP) and traumatic brain injury (TBI) are most likely to suffer from muscle spasticity. The significant muscles contracted in flexion and extension movement are the biceps and triceps muscle respectively which is shown in Figure 1. The Modified Ashworth Scale (MAS) and the Australian Spasticity Assessment Scale (ASAS) have been widely accepted and considered the most reliable methods to assess spasticity in clinical settings (Wang et al., 2022). The MAS scale assesses the level of resistance and spasticity in a joint when it is moved passively, with the resistance being assigned a value ranging from 0 to 5 (De Santis & Perez, 2024).



**Figure 1. Muscles of Forearm**

Previous research has indicated that spasticity scales fail to provide adequate information regarding the specific muscles involved in spastic movements, and their reliability and validity have been critically questioned by numerous researchers (Marek et al., 2023). Thus, introducing quantitative measurement based on the MAS may help to overcome the inadequacy of the current method. The Mechanomyography (MMG) signal is a mechanical signal generated from the non-invasive surface of a muscle when the muscle is contracted. Sensors like microphones or accelerometers are used to assess muscle vibrations (mechanical activity) as an alternative to EMG which has been utilized in previous research to assess spasticity levels (Meagher et al., 2020; Santos et al., 2021). However, the approach used is not leveraged on spasticity muscle characteristics or features in developing the spasticity muscle model. In this study, the correlation of the MMG signal to the muscle spasticity characteristics of the forearm was investigated based on the MAS tool. This enabled the formulation of a muscle spasticity characteristics model, incorporating the quantitative evaluation of the spasticity level. The recording of the MMG signal was done using an MMG electrode patch sensor to allow detailed profiling of muscle contraction activity on the skin surface.

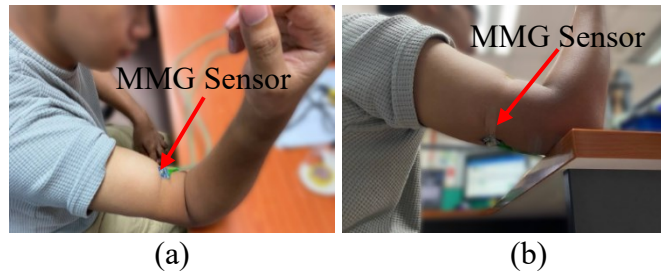
## **2. METHODOLOGY**

The study involved patients with neurological disorders, such as stroke, traumatic brain injury, and down syndrome, who underwent assessment and rehabilitation with experienced therapists. The selection of patients was based on the MAS level evaluated by the expert therapist. The patients, aged between 18 and 70 years, were recruited from Sultan Ahmad Shah Medical Centre (SASMEC) and National Stroke Association of Malaysia (NASAM). Most patients suffer from stroke, apart from one patient who had a spinal cord injury which shown in Table 1.

**Table 1. Demographic data of the patients (divided into four groups).**

MAS level	NUMBERS	GENDERS (M/F)	AGE (YEAR)
0	13	11/2	35 ±17
1	15	7/8	60 ±10
1+	7	6/1	66 ±10
2	5	5/0	62 ±9
3	2	1/1	70 ±2

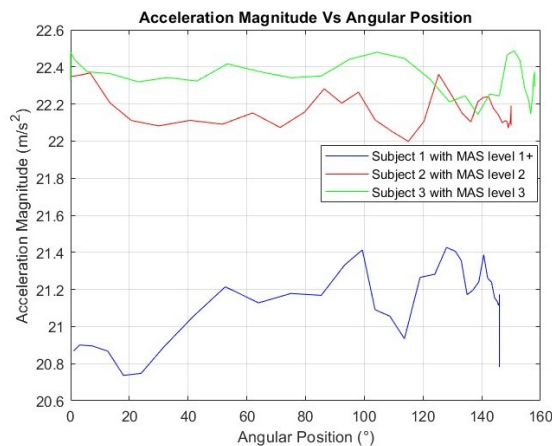
Consent from the patient or guardian was obtained before the experiment. The first expert therapist assessed the patient's forearm spasticity level, and the MAS level was recorded in the supine position. Raw data signal collection was performed using customized MMG sensors and a potentiometer attached to the patient's forearm. The patient's forearm was flexed and extended by the expert therapist, and data was captured using a data acquisition system connected to a laptop. The experiment was repeated three times, and the research variables were the MAS level and the position of the forearm in degrees with respect to the horizontal. Figure 2 shows how the MMG sensor is placed on the mid belly of the biceps and triceps during assessment.



**Figure 2. MMG Sensor Placement: (a) on the Biceps and (b) on the Triceps**

### 3. RESULTS AND DISCUSSION

Figure 3 presents a raw data signal of the Mechanomyographic (MMG) data obtained during the evaluation of the biceps muscle group using the Modified Ashworth Scale (MAS). Within this figure, the data is arranged to exhibit the variations observed in the magnitude of acceleration for upper limb movements at different MAS levels. Essentially, it provides a graphical illustration of how the intensity of muscle spasticity, as indicated by MAS scores, relates to the corresponding measurements of upper limb movement acceleration. This graphical representation serves as a valuable tool for visually discerning and analyzing the correlation between MAS levels and the associated biomechanical data acquired during the assessment of the biceps muscle group.



**Figure 3. Raw data signal of MMG Sensor based on MAS level**



The performance of the machine learning algorithms, as shown in Table 2, is significantly influenced by the training and testing split. Notably, the Support Vector Machine (SVM) and K-Nearest Neighbor (KNN) algorithms achieve 82% accuracy with a 90-10 split, demonstrating their effectiveness in learning from a small testing set. Conversely, the Random Forest and Gradient Boosting Classifier algorithms show lower accuracy, suggesting the need for further investigation and optimization in feature selection and parameter tuning.

**Table 2. Accuracy of Various Algorithms in Quantitative Spasticity Assessment Models**

Algorithm	TRAINING AND TESTING SPLIT	
	PERCENTAGE	
	80-20	90-10
SVM	75	82
K-NEAREST NEIGHBOR	70	82
RANDOM FOREST	60	64
GRADIENT BOOSTING CLASSIFIER	55	54

#### 4. CONCLUSION

In summary, this study aims to address the subjectivity and inconsistency in muscle spasticity assessment among patients with neurological disorders by developing a new model based on Modified Ashworth Scale (MAS) scores and Mechanomyography (MMG) signals. This model promises to standardize assessments, enhance rehabilitation processes, reduce costs and time, and improve patient care quality. The machine learning algorithms' performance varies with different training/testing splits, with K-Nearest Neighbor and Support Vector Machine algorithms demonstrating the highest robustness and accuracy.

#### 5. ACKNOWLEDGMENT

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# CLOUD-BASED SECURITY SOLUTIONS FOR CRYPTOCURRENCY WALLETS

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**Abstract:** The increasing prevalence of cryptocurrency adoption has brought about a pressing need for robust security solutions to safeguard digital assets stored in cryptocurrency wallets. Traditional security methods are often inadequate in dealing with the constantly evolving threats present in the digital realm. Cloud-based security solutions have emerged as a promising avenue to enhance the protection of cryptocurrency wallets by leveraging the scalability, flexibility, and advanced security features offered by cloud computing technologies. This research investigates the various challenges faced by cryptocurrency wallet security and investigates the potential of cloud-based solutions to mitigate these challenges. It discusses the key features and benefits of cloud-based security solutions tailored for cryptocurrency wallets, such as multi-factor authentication, real-time monitoring, encryption mechanisms, and secure backup and recovery processes. Furthermore, the paper examines the implications of integrating cloud-based security solutions into cryptocurrency ecosystems, including regulatory considerations and privacy concerns. Through an analysis of current trends and case studies, this paper aims to provide insights into the effectiveness and feasibility of employing cloud-based security solutions and cost mitigation to enhance the protection of cryptocurrency assets in digital wallets. This research explores a cost-effective approach to enhancing the security of cryptocurrency wallets. It provides cloud-based scalability, advanced security technologies, regulatory compliance, and optimized total cost of ownership.

**Keywords :** Cryptocurrency wallets, Cloud-based security, Blockchain Technology, Cost mitigation

## 1. INTRODUCTION

Cryptocurrency is rapidly gaining popularity, increasing the use of wallet applications for personal transactions. These wallets serve as the primary means for managing cryptocurrency and, thus, are attracting a lot of attention from attackers. However, selecting a safe and suitable wallet has become increasingly difficult due to the various types and specifications available. (Houy et al., 2023).

HSMs securely maintain key confidentiality by storing them in a physically secure area that is resistant to tampering. However, regarding the misuse or intentional harm caused by the key, HSMs provide few restrictions. HSMs often lack means for detecting key abuse and do not have established quorum permission systems for key usage (Tova Dvorin,2024).

The primary objective of this research is to conduct a comprehensive analysis of decentralized cloud-based security solutions for cryptocurrency wallets, aiming to identify and implement effective measures to enhance the overall cost-effective and security posture.

## 2. METHODOLOGY

A systematic literature review (SLR) is a methodological approach employed to systematically gather and evaluate extant literature on a specific subject matter. This process encompasses the formulation of research inquiries, the identification of pertinent studies, the appraisal of their methodological rigor, and the synthesis of the findings. Various academic domains such as healthcare, social sciences, and computer science commonly undertake SLRs

to elucidate the existing evidence surrounding a particular issue. This study delves into the use of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. Moher et al. promulgated the original PRISMA statement in 2009. Assessing the prevalence of executed systematic reviews and meta-analyses is a significant criterion within PRISMA. The PRISMA framework has three main parts: finding relevant studies, choosing eligible articles, and extracting relevant data from those publications; and the last part, which is putting together all the information from the reviewed literature (Hossain, Mahadi, & Haron, 2023)

The literature review aims to formulate hypotheses or theoretical frameworks underpinning research endeavors. There exist at least four fundamental attributes that scholars must consider when conducting a literature review. According to Zed, the investigator first engages with textual or quantitative data rather than firsthand field information. Secondly, the information from the library is readily accessible. The researcher primarily focuses on data sources housed within the library, eliminating the need for direct field visits. Thirdly, library data is frequently classified as a secondary source, wherein the researcher acquires knowledge or data that is derivative rather than original, emanating from the initial field data. Lastly, the status of library data is susceptible to variations beyond mere temporal and spatial factors (Hossain, Mahadi, Haron, et al., 2023)

There are numerous variations of eligibility and exclusion criteria. To begin with, the literature we selected exclusively encompassed articles that were based on empirical data. Moreover, we limited the search parameters to only journal articles published in English to avoid potential complications or misinterpretations due to translation issues, thus eliminating non-English publications. Furthermore, the selection process included only those papers disseminated between 2015 and 2022.

### **3. RESULTS AND DISCUSSION**

A considerable discrepancy persists between the potential countermeasures and their actual implementation. Consequently, we advocate for further investigation to bridge this divide. Scalability could pose a challenge. The HSM device's constrained confines accommodate a finite number of keys within each "slot." AWS Cloud HSM can maintain a maximum of 3,300 keys. Establishing a master key using the HSM module might mitigate this limitation. The master key is responsible for encrypting the seed phrase of an Ethereum wallet. Numerous prominent corporations employ cryptographic technologies within their secure networks to protect sensitive information. Historically, cryptography has played a critical role in facilitating secure communication among parties. In today's world, cryptographic systems and applications protect organizational networks from cyber threats. The proposed cybersecurity framework minimizes false positives while providing optimal transaction security. Ultimately, users must comprehend the risks associated with exchanges and websites. Additionally, each exchange should inform them about its inherent security features. Visual secret sharing is secure, and the wallet does not require initial trust configurations. It is both straightforward and secure. Our comprehensive analysis evaluated Bitcoin wallets from multiple perspectives. We initiated our inquiry by developing a taxonomy of cryptocurrency wallets to delineate their unique attributes. We discovered a vulnerability in mempool wait times, which could potentially allow a malicious actor to compromise a single miner. To counteract this, we partition the network data into two segments, with two seasoned miners transmitting half of the block data to a novice miner and the other half to an experienced miner. Blockchain technology, which facilitates the decentralized and secure storage and transfer of digital assets, has revolutionized financial transactions. Cryptocurrency wallets, which safeguard digital currencies, represent a prevalent application of blockchain technology. This

work introduced two concurrent methodologies based on shared and heterogeneous memory to streamline Lagrange interpolation computation. We proposed homomorphic encryption (HE) and blockchain to ensure data privacy and confidentiality. Byzantine Fault Tolerance (BFT) consensus mechanisms prevent data alterations that could jeopardize data integrity. Cloud Service Providers (CSPs) will not communicate directly within this proposed verification framework. One should consider web-based and hardware wallets. When selecting optimal Bitcoin wallets, given the frequency of wallet malfunctions, users often underestimate significant fault risks. There needs to be more user studies that quantify essential fault probabilities for theoretical research and user guidance. Additionally, the model could incorporate correlation. We illustrate how to amalgamate wallet protocols to create novel iterations. We examined how cloud-based blockchain technology could thwart attacks. However, we must acknowledge the limitations of blockchain technology. Ethereum offers superior internet speeds and reduced costs for consumers compared to Bitcoin. We also elucidate the practical implementation of this approach, its developmental requirements, and data security considerations. Key management systems excel in secret management rather than secret security. The ability to quickly cycle or maintain secrets presents security benefits while consolidating them within the same backend service introduces drawbacks; however, it remains a prudent strategy. When blockchain is combined with machine learning algorithms in HSMs or FPGA architectures, it will become impenetrable. This will reassure customers and businesses that care about security that their data will be safe across all applications. We propose a comprehensive discussion regarding SEC and CSA enforcement actions and regulations to deter unethical conduct.

#### 4. CONCLUSION

Current scholarly investigations have revealed a significant divergence between effective security protocols and their actual deployment in practice. This manuscript offers a pathway for forthcoming inquiries to reconcile this discrepancy, although it may face scaling-related challenges. For example, given the limited storage capacity of the Hardware Security Module (HSM) for key management, which accommodates a maximum of 3,300 keys in AWS CloudHSM, one feasible strategy could be to develop a master key using the HSM. This master key could subsequently encrypt the seed phrase associated with an Ethereum wallet. Numerous leading institutions presently employ cryptographic solutions to protect sensitive information within their classified infrastructures. These days, modern cryptographic frameworks and applications are needed to protect company networks from cyber threats. As a result, the suggested cybersecurity model might cut down on false positives while making digital transactions safer.

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# DESIGN AFFORDANCES FOR SENSEMAKING OF ONLINE RISKS BY MUSLIM PARENTS: A CONCEPTUAL MODEL

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**Abstract:** In this digital age Muslim parents are increasingly concerned about the ways their children’s online activities may impact their Islamic values. This research addresses the need for a framework that assists Muslim parents in sensemaking of online risks through a religiously informed way by proposing a conceptual model for integrating Islamic values in sensemaking. The conceptual model is derived from literature review that identifies four key constructs—sensemaking, online risks, Islamic values, and design affordances—that form the building blocks of the proposed model. This model integrates Islamic values into the process of online risk management, with design affordances that facilitate intuitive user interactions. The conceptual model aims to inform future works that may empower Muslim parents to guide their children safely in digital spaces, ensuring that online activities are harmonious with Islamic values.

**Keywords:** Sensemaking, Online Risks, Islamic Values, Design Affordances, Digital Parenting

## 1. INTRODUCTION

In the era of digital connectedness, Muslim parents face unique challenges in safeguarding their children's online experiences. Some of the challenges include making sure their experience online is aligned with Islamic values. This research addresses the crucial need for a supportive framework that aids Muslim parents in making sense of online risks through a culturally and religiously informed lens. The primary aim is to develop a sensemaking model of online risks that integrates Islamic values, with considerations on the ways design affordances can inform the design of this model.

## 2. METHODOLOGY

The methodology for developing the conceptual framework is rooted in an extensive literature review, focusing on integrating findings from multiple areas, and concept synthesis. The review was done to answer two research questions: 1) What are the key concepts that are the foundational building blocks of this model, and 2) How are these key concepts connected in a conceptual model. Figure 1 below shows the methodology diagram of this paper.

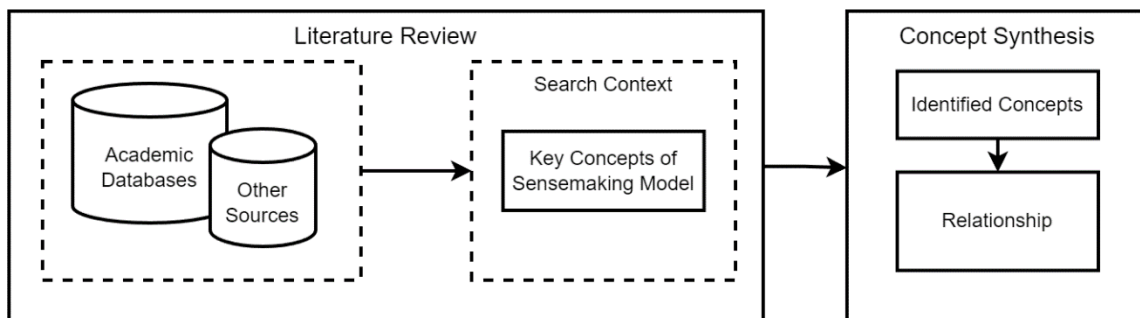


Figure 1. Research Methodology

### 3. RESULTS AND DISCUSSION

#### 3.1 Key Concepts

Key concepts were chosen based on their relevance and potential to contribute to an effective sensemaking model. These concepts and its descriptions are discussed below.

##### 1.1.1 Sensemaking

Sensemaking is defined as the process through which individuals give meanings to situations (Nardon & Hari, 2022). Various theories have been established across multiple domains, including organizational communication, knowledge management, cognitive systems engineering, and human-computer interaction (HCI) (Turner et al., 2023). In designing sensemaking models in digital interface, the sensemaking theory posited by Pirolli and Card (Pirolli, 2009) hold the most potential.

##### 1.1.2 Online Risks

Risk is defined as uncertainty about and severity of the consequences of an activity with respect to something that humans value (Aven, 2016). In the context of online risks for children, a leading framework categorized these risks as the 4Cs which are *content* (what is found on the web), *contact* (someone else making contact), *conduct* (child contacts someone), and *contract* (child is party to and/or exploited by harmful contract) (Livingstone & Stoilova, 2021). In the management of online risks for children, several strategies have been discussed in literature including active mediation, restrictive mediation, co-using (Ren & Zhu, 2022), and monitoring (Page Jeffery, 2021). Of these approaches, active mediation is said to be the strategy that can best support resilience within children in the face of risks and the harms it may bring online (Chen et al., 2023). This strategy relies on parents communicating with children about the nature of the risks, and in this context, sensemaking of online risk is very crucial. Another risk management framework proposed for addressing children's risky online behaviours is the 'three M' countermeasures, urging teachers and carers to mentor, mitigate, and monitor children's online experience (Renaud & Prior, 2021).

##### 1.1.3 Islamic Values

In Islam, parents play the most important role in shaping their children's upbringing. Children are born pure and free of sin, in a state of *fitrah*, and it is the parents' responsibilities in raising them as Muslims or as adherent in other beliefs (Sudrajat et al., 2020). From Islamic traditions, there are schemas that can be used to make sense of situations such as in the classification of actions – *fard* (obligatory), *sunnah* (recommended), *haram* (prohibited), *makrooh* (discouraged), or *mubah* (permissible) (Barzak et al., 2019), or the *Maqasid al-Shariah*, higher purposes of Islamic law where the preservation are of five categories, namely faith, life, intellect, lineage, and wealth (Kamali, 2008).

##### 1.1.4 Design Affordances

Affordances in design are the relationships between an object's properties and a user's ability to determine how the object can be used (Norman, 2013). Affordances are considered as clues on how an object can be operated, with the cues provided by context or the object itself (Shin, 2022). In sensemaking study, several affordances have been proposed to better support targeted users. For example, on supporting users of digital news services, affordances that are deemed important include hypertextuality, retrievability, importance, immediacy, convenience, adaptability, genre, and interactivity (Kiesow et al., 2023).

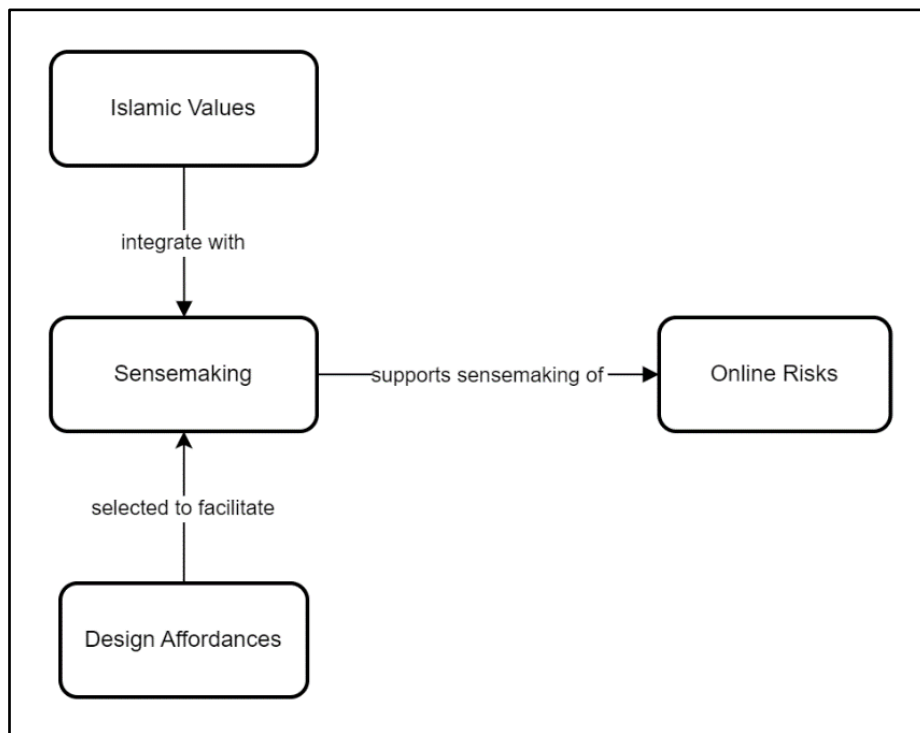


## Concept Synthesis

Upon synthesis, the relationships between these concepts are identified. Here, these four concepts are connected in framework with the following relationships.

- i. *Islamic values* are integrated with sensemaking the purpose is for the values from Islamic sources to inform the sensemaking.
- ii. *Design affordances* are integrated in the design of sensemaking to facilitate intuitive sensemaking.
- iii. *Sensemaking*, integrated with Islamic values and supported by design affordances, may be done intuitively for the process of making sense of *online risks*.
- iv. *Design Affordances* refer to the relationship between an object's properties and the user's ability to perceive how it can be used, providing cues for interaction through the object or its context.

Figure 2 below shows the conceptual model with all four key concepts and the relationships between them.



**Figure 2. Conceptual Model of Design Affordances for Sensemaking of Online Risks by Muslim Parents**

This model addresses both the practical and ethical dimensions of the sensemaking of online risk.

## 4. CONCLUSION

This conceptual model serves as a pioneering approach to integrate Islamic values into digital parenting practices, especially in the scope of making sense of online risks. By enhancing the understanding of online risks, this model aims to empower Muslim parents in making sure that their children are shaped within the framework of Islamic values, even in online interactions. This conceptual model is intentionally abstract, where the specific sensemaking theory, types of design affordances, and Islamic schema for sensemaking are not discussed, showing the next steps that could be undertaken in the research of this area.

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# A FRAMEWORK FOR THE DEVELOPMENT OF AN OPTIMIZED ARTIFICIAL INTELLIGENCE MODEL FOR DIABETES MELLITUS PREDICTION AND TREATMENT RECOMMENDATION

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## ABSTRACT

Diabetes mellitus presents a significant public health challenge, especially in Malaysia, with its rapidly increasing prevalence. By 2024, an estimated 20.1% of the Malaysian population will be affected by diabetes, potentially rising to 5 million by 2030. This study presents a framework that leverages the Indian Pima Diabetes dataset to develop and evaluate an optimized artificial intelligence (AI) model for diabetes prediction and treatment guidance. Combining machine learning, deep learning algorithms, and ensemble techniques like model stacking, the framework aims to achieve high prediction accuracy, balancing sensitivity and specificity, to support clinical decision-making. The study also highlights the importance of addressing ethical considerations, data privacy, and algorithmic biases to harness AI's full potential in transforming diabetes care.

**KEYWORDS:** Diabetes Prediction, Artificial Intelligence, Model Stacking, Pima Diabetes Dataset, Ensemble Learning

## 1. INTRODUCTION

Diabetes mellitus in Malaysia is gradually increasing to become a noticeable public health concern of great magnitude on the international level. According to the International Diabetes Federation (IDF) Among the 38 nations and territories that make up the IDF Western Pacific region is Malaysia. 206 million people in the Western Pacific Region and 537 million people worldwide are estimated to have diabetes by 2045. In Malaysia, there are 4,431,500 adult cases of diabetes and 22,130,900 total adult population as of 2021 (International Diabetes Federation, 2021). The NHMS 2023 is a cross-sectional survey with a 15.6% overall prevalence of diabetes and a 9.7% known diabetes among adults. It was conducted using complex weighted sample analysis and a two-stage stratified random sampling methodology. 5.9% of those without known diabetes had elevated blood sugar (<https://iku.gov.my/Nhms-2023>, n.d.). The prevalence of diabetes in adults is 20%. The Malaysian demographic, consisting of around 15 million individuals, with a 5% incidence rate, translates to nearly 3.9 million diagnosed with diabetes, expected to rise to about 5,024,900 by the year 2030 (IDF, 2023). According to the findings by (Hussein et al., 2016), diabetes is a major public health concern in Malaysia, and the prevalence of type 2 diabetes (T2D) has escalated to 20.8% in adults above the age of 30, affecting 2.8 million individuals. The burden of managing diabetes falls on primary and tertiary healthcare providers operating in various settings. Despite these efforts, Malaysia's healthcare system faces challenges such as limited resources, high patient-to-doctor ratios, and manual processes for diabetes prediction and treatment (Muhammad Shoib Farooq et al., 2023). Experts suggest that the high prevalence of diabetes and prediabetes necessitates comprehensive national diabetes control programs (Akhtar et al., 2022). The incorporation of artificial intelligence (AI) and machine learning (ML) offers promising solutions for improving diabetes management, including enhanced diagnostics, predictive modeling, and personalized care (Mohamad Zulfikrie Abas et al., 2024; Guan et al., 2023). The incorporation of artificial intelligence (AI) and machine learning (ML) in the healthcare sector presents a promising solution to the

numerous challenges it faces. The potential exhibited by AI and ML technologies in transforming diagnostics, enhancing patient outcomes, optimizing healthcare systems, and improving decision-making processes is substantial (Dankwa-Mullan et al., 2019; Ellahham, 2020). Furthermore, AI and ML can streamline administrative duties, optimize hospital operations, improve resource allocation, and enhance patient engagement through the utilization of virtual assistants and chatbots (Prabhod, 2024; Al Kuwaiti et al., 2023; Tariq Osman Andersen et al., 2023). Nonetheless, realizing the full advantages of AI and ML in healthcare necessitates addressing issues such as data privacy, algorithmic biases, and ethical considerations. Therefore, we are developing utilized India Pima diabetes dataset a unique framework for Malaysia's healthcare system. The expected effects include improved Malaysian population health, decreased future healthcare expenditures in the population, and a sustainable healthcare system in the country of Malaysia. This paper's research contributions are as follows:

- **Model Comparison:** Evaluation of multiple machine learning and deep learning algorithms on the Pima Diabetes Dataset based on key performance metrics.

- **Hybrid Model Optimization:** Application of soft voting between stacked ML and DL models to create a balanced, robust prediction model for healthcare datasets

- **GANs Algorithm:** The combination of several models to capture different patterns in the data proved to be effective in stacking. Due to their ability to handle intricate, non-linear relationships within datasets, GANs individually achieved 84.51% accuracy.

The rest of the paper is organized as follows. Section 2 discusses the Indian Pima dataset employed and its contents, cites prior works, outlines the study's methodology, and describes Various Machine Learning and deep learning techniques with stacked model development in this study. Section 3 Soft voting technique used and founding hybrid model. Section 4 discusses the results and justifies their reliability. Finally, Section 5 provides concluding remarks on the paper, an overview of the entire article, and some scopes for further research.

## 2. METHODOLOGY

### 2.1 Data Collection and Preprocessing

One of the most well-known datasets in machine learning, particularly for binary classification used to predict diabetes, is the Pima Indians Diabetes dataset. The National Institute of Diabetes and Digestive and Kidney Diseases provided the study's data, which included 768 records of female Pima Indian individuals who were 21 years of age or older (Kumar et al., 2021). Eight characteristics make up the dataset: age, diabetes pedigree function (the ancestry of diabetes), triceps skin fold thickness, two-hour plasma insulin, pregnancy, diastolic blood pressure, and BMI. Because the dependent variable is dichotomous, an answer of "1" indicates that the person has been diagnosed with diabetes, while a response of "0" suggests otherwise. This dataset is especially helpful for evaluating and contrasting the precision with which various machine learning algorithms predict the onset of diabetes (Muhammad & Suriani, 2024). As a result, it can be used as a tool to create models that support early disease identification. , were preprocessed to handle missing values and outliers through techniques like imputation and normalization (G R, Ashisha et al., 2023). The dataset was split into training and testing sets to assess model robustness and accuracy. The Indian Pima Diabetes Dataset Used for Various Machine Learning and Deep Learning Algorithms is displayed in Tables 1.1 and 1.2 below.

**Table 1. Indian Pima Diabetes Dataset Used for Various Machine Learning Algorithms**

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Indian Pima Diabetes Dataset used

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<b>Algorithms</b>	<b>Accuracy</b>	<b>Recall /Sensitivity</b>	<b>Precision</b>	<b>F1 score</b>	<b>ROC-AOC</b>	<b>Cohen's Kappa</b>
<b>Random Forest Classifier</b>	76.95%	60.09%	69.89%	64.38%	82.71%	47.54%
<b>Gradient Boosting (GBM)</b>	76.55%	60.81%	68.94%	64.26%	83.39%	46.98%
<b>XGBoost</b>	74.46%	59.97%	64.27%	61.91%	79.76%	42.77%
<b>Artificial Neural Networks (ANN)</b>	70.31%	70.31%	70.31%	70.31%	70.31%	70.31%
<b>Support Vector Machines (SVM)</b>	75.91%	48.53%	74.29%	57.98%	82.10%	42.33%
<b>Logistic Regression</b>	77.60%	58.23%	73.59%	64.38%	83.17%	48.44%
<b>Decision Trees</b>	70.29%	57.45%	57.80%	57.32%	67.33%	34.65%
<b>K-Nearest Neighbors (KNN)</b>	71.09%	51.85%	59.94%	55.37%	73.58%	34.24%
<b>Naive Bayes</b>	75.52%	60.83%	67.19%	63.35%	81.39%	45.12%
<b>LightGBM</b>	73.03%	57.75%	62.09%	59.72%	80.28%	39.52%

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**Table 2. Indian Pima Diabetes Dataset Used for Various Deep Learning Algorithms**

Algorithm	Accuracy (%)	Sensitivity (%)	Precision (%)	Recall (%)	F1 Score (%)	ROC-AUC (%)	Cohen's Kappa (%)
Artificial Neural Network (ANN)	65.89	42.11	54.26	42.11	45.55	68.27	21.88
1D Convolutional Neural Network (1D CNN)	58.47	51.75	45.01	51.75	39.62	64.61	12.38
Recurrent Neural Network (RNN)	69.01	44.03	58.11	44.03	49.24	70.52	27.84
Long Short-Term Memory (LSTM)	70.44	42.87	61.71	42.87	49.78	72.31	30.01
Autoencoders	64.94	45.00	49.32	45.00	47.06	69.18	20.93
Generative Adversarial Networks (GANs)	84.51	55.84	63.24	55.84	59.31	90.14	49.79
Multilayer Perceptron (MLP)	72.73	42.50	66.67	42.50	51.91	72.38	34.15
Gated Recurrent Unit (GRU)	73.59	46.25	67.27	46.25	54.81	76.27	37.05
Stacked Denoising Autoencoder (SDAE)	67.10	53.75	52.44	53.75	53.09	72.23	27.76
Extreme Learning Machine (ELM)	64.50	55.00	48.89	55.00	51.76	68.29	23.84

Ultimately, it demonstrated accuracy, precision, F1 score, ROC-AUC, and Cohen's Kappas using conventional machine learning and deep learning based on a Pima Indian dataset and a 10-fold cross-validation technique. However, utilizing clinical, lifestyle, and demographic data, Malaysia's healthcare sector will create and evaluate an enhanced AI model for diabetes mellitus prediction with higher accuracy.

## 2.2 Model Stacking Application

An ensemble learning method called "model stacking" combines several models to increase prediction accuracy overall. Predictions are made using many base models, which are then fed into a meta-model (also known as a meta-learner) to produce the final forecast. Combining several models might help you make use of each one's advantages while mitigating its shortcomings because different models may identify distinct patterns in the data (Md Shamim Reza et al., 2024)

## 2.3 Model Stacking Application in Pima Database

### 2.3.1 Machine Learning Model Stacking

Model stacking, often called stacked generalization, is an ensemble learning approach that combines many models to enhance prediction performance in machine learning. This method uses the same dataset to train multiple models (base learners), whose predictions are then fed into a final model (meta-learner) to get the final prediction. By combining the outputs of several models, the goal is to take advantage of their advantages and lessen their disadvantages (Yadav et al., 2023; Mienye & Sun, 2022). Usually, there are two primary processes in the stacking process:

### 2.3.2 Machine Learning Meta Level

Train a meta-model with the predictions from the base models as features, and it will learn how to integrate the predictions from the base models in the most effective way to get a final prediction (Tripathi et al., 2023).

In this analysis, five base models were used on the Indian Pima Dataset.

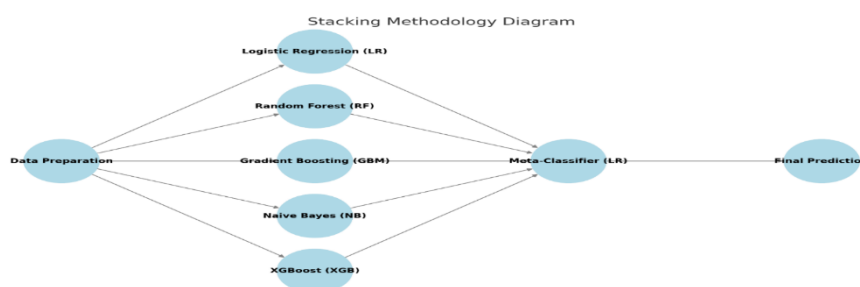
- Logistic Regression: A simple and interpretable linear model.
- Random Forest: An ensemble of decision trees that captures complex interactions and is robust to overfitting.
- Gradient Boosting: A sequential ensemble model that optimizes the errors made by previous models, often resulting in high performance.
- Naive Bayes: A probabilistic model based on Bayes' theorem, assuming feature independence.
- XGBoost: An advanced implementation of gradient boosting that is highly efficient and often provides state-of-the-art results in machine learning competitions.

### 2.3.3 Machine Learning Meta-Classifier

Logistic Regression was used as the meta-classifier. This model took the predictions made by the base models as inputs and learned how to best combine these predictions to make the final decision. The meta-classifier essentially learns how to weigh the contributions of each base model to optimize the final prediction (Zhao & Wang, 2023).

### 2.4 Machine Learning Model Stacking Methodology Diagram

Machine Learning Model Stacking, or simply "stacking," is an ensemble learning technique that combines the predictions of multiple models (often called "base models" or "level 0 models") to produce a more accurate and robust final prediction (Zohair et al., 2023). The key idea is to leverage the strengths of various models to minimize their weaknesses, leading to improved overall performance. The methodology used in this analysis can be represented in a flowchart that includes the following steps.



**Figure 1. Machine Learning Model Stacking Methodology Diagram**

#### 1. Data Preparation

- The dataset is split into features (X) and the target variable (y).

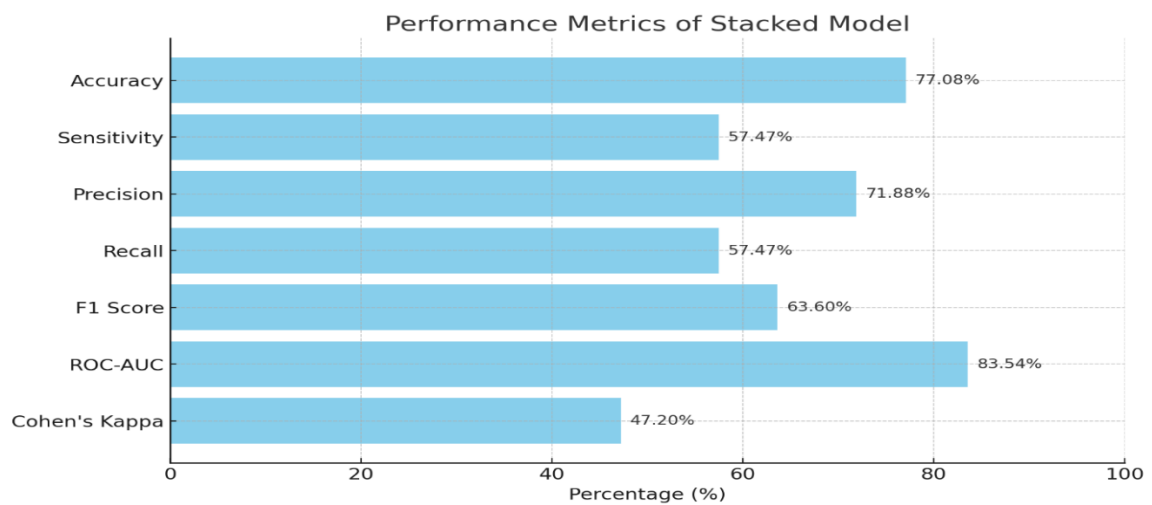
#### 2. Machine Learning Base Models

- Logistic Regression: Linear model.
- Random Forest: Ensemble of decision trees.

- Gradient Boosting: Sequential ensemble model.
  - Naive Bayes: Probabilistic model.
  - XGBoost: Advanced gradient boosting model.
3. Training the Machine Learning Base Models
    - Each base model is trained on training data.
  4. Meta-Model (Meta-Classifer)
    - The predictions from the base models are combined and passed to a Logistic Regression model as the meta-classifier.
    - The meta-classifier learns how to best combine the predictions from the base models.
  5. Evaluation
    - The final model's performance is evaluated using metrics such as accuracy, sensitivity, precision, F1 score, ROC-AUC, and Cohen's Kappa.

## 2.5 Initial Performance Metric of Machine Learning Model Stacking

Initial performance metrics on the Indian Pima dataset demonstrate that Machine Learning Model Stacking can significantly improve prediction accuracy for diabetes diagnosis compared to individual models alone (C.S. Manikandababu et al., 2022). By combining various base models, stacking effectively reduces prediction errors and enhances robustness (Abdollahi & Nouri-Moghaddam, 2022). After running the stack model on the Pima database, these are the initial findings.



**Figure 2. Pima Dataset Performance Metrics of Stack Model**

- Accuracy (77.08%): The stacked model correctly predicted the outcome (diabetes vs. no diabetes) 77.08% of the time, indicating strong overall correctness.
- Sensitivity (Recall) (57.47%): Sensitivity measures the model's ability to correctly identify positive cases (i.e., individuals with diabetes). A sensitivity of 57.47% means that the model correctly identified 57.47% of all true positive cases. This suggests that while the model is reasonably accurate overall, there is still room for improvement in correctly identifying all cases of diabetes.
- Precision (71.88%): Precision indicates the proportion of positive identifications that were correct. With a precision of 71.88%, the model made accurate predictions when it identified a case as diabetic 71.88% of the time.
- F1 Score (63.60%): The F1 Score, which is the harmonic mean of precision and recall, is 63.60%. This score provides a balance between precision and recall, indicating that



the model performs reasonably well in both identifying and correctly predicting positive cases.

- ROC-AUC (83.54%): The ROC-AUC score of 83.54% measures the model's ability to distinguish between positive and negative cases. A higher ROC-AUC score suggests that the model is very capable of distinguishing between diabetic and non-diabetic individuals.
- Cohen's Kappa (47.20%): Cohen's Kappa accounts for the possibility of agreement occurring by chance. A Kappa of 47.20% suggests moderate agreement beyond chance.

## 2.6 Significance of Machine Learning Model Stacking in the Pima Database

Machine Learning Model Stacking, applied to the Pima Indian Diabetes dataset, enhances predictive performance by combining diverse models like Logistic Regression, Random Forest, Gradient Boosting, Naive Bayes, and XGBoost. This approach leverages the strengths of each model to capture a wide range of data patterns and improve generalization (Khondokar Oliullah et al., 2023)

- Enhanced Performance: Stacking is used to combine the strengths of different models, potentially leading to better generalization and predictive performance than any single model could achieve on its own.
- Diversity of Models: The base models used in this stacking approach are diverse in their methodologies. Logistic Regression handles linear relationships well, Random Forest and Gradient Boosting capture complex, non-linear interactions, Naive Bayes deals well with probabilistic aspects, and XGBoost is a powerful gradient boosting method known for its accuracy and efficiency. This diversity allows the stacking model to capture a broader range of patterns in the data.
- Handling Different Data Characteristics: The inclusion of models like XGBoost adds another layer of sophistication, as XGBoost is known for handling large datasets with a variety of features effectively. The combination of models ensures that different aspects of the data are considered, leading to potentially better generalization.

## 2.7 Perceived Improvement of The Stacked Machine Learning Model

Comparison Stacked Model vs. Singular Models: By combining multiple models, the stacked model is generally expected to provide a more robust and accurate prediction compared to any individual model (Ekemini et al., 2023). The inclusion of XGBoost 77.08% likely contributed to a stronger overall performance due to its advanced boosting techniques.

- Improvements: The outcome of XGBoost, which is recorded at 77.8%, demonstrates a harmonious enhancement in both precision and recall, which are frequently in conflict with individual models. While specific individual models may demonstrate superior performance in a singular aspect (high precision but low recall), the composite model more adeptly harmonizes these conflicting priorities.

## 2.8 Deep Learning Model Stacking

Deep Learning Model Stacking refers to an ensemble learning method in which various deep learning models are trained independently on a dataset and their outputs are combined to create a final predictive model (Kalagotla et al., 2021). The process involves:

1. **Deep Learning Base Learners:** Training several deep learning models (such as CNNs, RNNs, or transformers) on the same dataset.
2. **1. Deep Learning Meta-Model:** Using the predictions from these base learners as features to train another model, which synthesizes their outputs to make the final prediction.

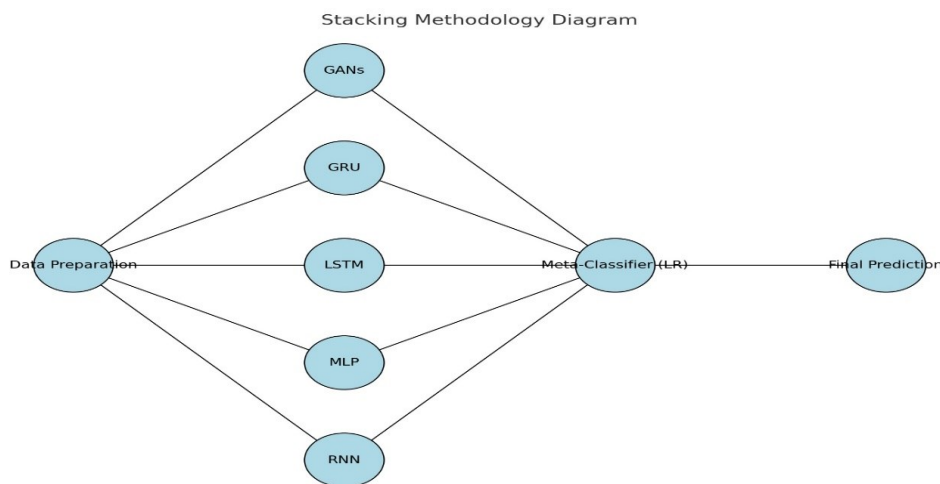
This analysis explores the application of a stacked ensemble model on the Pima Indians Diabetes dataset. We selected the five best-performing models based on their accuracy, ROC-AUC, and F1 score metrics (Li et al., 2023). The models chosen for stacking were:

- **Generative Adversarial Networks (GANs)**
- **Gated Recurrent Unit (GRU)**
- **Long Short-Term Memory (LSTM)**
- **Multilayer Perceptron (MLP)**
- **Recurrent Neural Network (RNN)**

The goal was to improve the overall performance by combining these models through a meta-learning approach, where a logistic regression model was used as the meta-learner.

### 2.9 Deep Learning Model Stacking Methodology Diagram

Stacking is an ensemble learning technique where multiple models (referred to as base learners) are trained, and their predictions are combined using a meta-learner (Singh & Singh, 2020). The meta-learner's role is to learn from the outputs of the base learners and make the final prediction.



**Figure 3. Deep Learning Model Stacking Methodology Diagram**

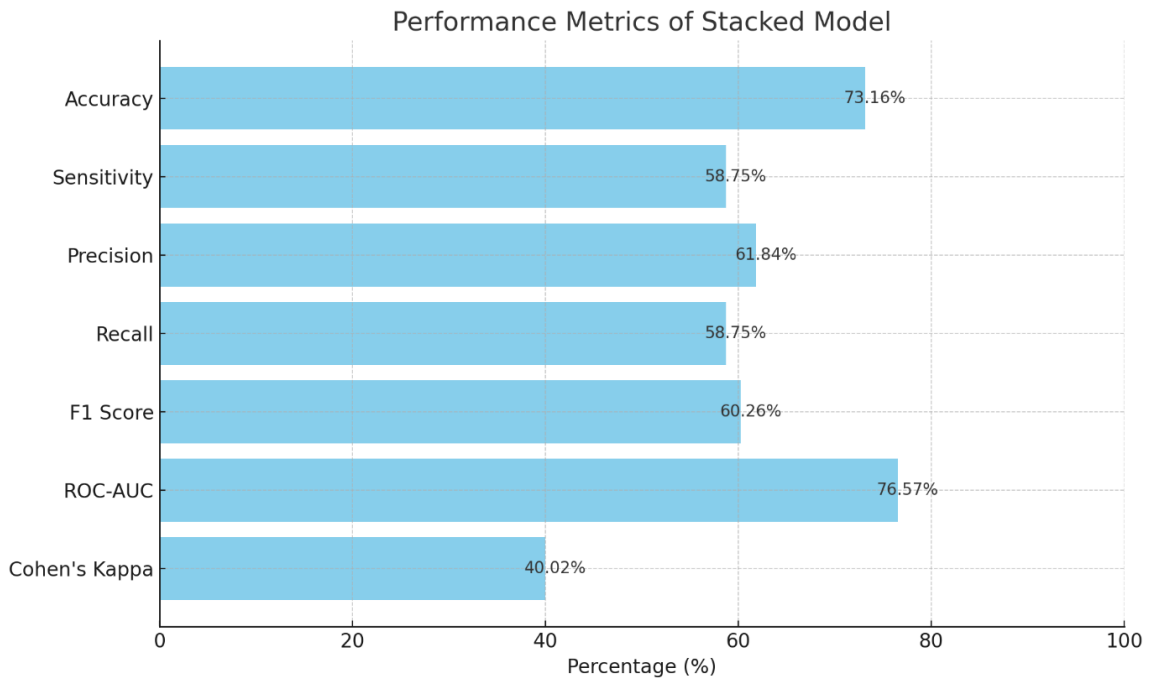
The Deep Learning Model Stacking Methodology Diagram below shows the process involved.

1. **Training Each Base Model:** The selected models were trained separately on the training data. Each model learned to make predictions independently.
2. **Generating Predictions:** The trained models were used to generate predictions on the training and test data.
3. **Stacking Predictions:** The predictions from all the base models were combined to form new features (one feature for each model's prediction).
4. **Meta-Learning:** A logistic regression model was trained on these stacked predictions. This meta-learner's task was to learn the best way to combine the predictions from the base models to make a final prediction.
5. **Evaluation:** The stacked model was evaluated on the test set using standard metrics such as accuracy, sensitivity, precision, recall, F1 score, ROC-AUC, and Cohen's Kappa.

#### 2.10 Initial Performance Metric of Deep Learning Model Stacking

The deep learning stacked model on the Pima Indian Diabetes dataset achieved a 73.16% accuracy, demonstrating competitive performance. Sensitivity and precision were well-balanced, resulting in an F1 score of 60.26%. The model's ROC-AUC of 76.57% indicates strong discriminative power, and a Cohen's Kappa score of 40.02% reflects moderate agreement with actual classifications.

- **Accuracy:** The stacked model achieved an accuracy of 73.16%, which is competitive with the individual models.
- **Sensitivity and Precision:** The sensitivity (recall) and precision of the stacked model are fairly balanced, indicating that the model has a good trade-off between capturing positive cases and minimizing false positives.
- **F1 Score:** The F1 score of 60.26% reflects the model's balance between precision and recall, making it a reliable metric for assessing overall performance.
- **ROC-AUC:** With a ROC-AUC of 76.57%, the model demonstrates good discrimination ability, meaning it is effective at distinguishing between positive and negative classes.
- **Cohen's Kappa:** The Cohen's Kappa score of 40.02% suggests moderate agreement between the predicted and actual classifications, accounting for chance agreement.



**Figure 4. Initial Performance Metric of Deep Learning Model Stacking**

### 2.11 Significance of Deep Learning Model Stacking in the Pima Database

The improvement in these metrics highlights the advantage of model stacking. By leveraging the diverse strengths of multiple models, the stacked model offers a more robust and reliable prediction, reducing the weaknesses inherent in any single model. The stacked model's results show an improvement over most of the individual models.

- The accuracy (73.16%) is higher than the accuracy of individual models like ANN (65.89%), RNN (69.01%), and MLP (72.73%).
- The F1 score of 60.26% surpasses that of most individual models, indicating a better balance between precision and recall.
- The ROC-AUC is competitive, demonstrating that the stacked model effectively combines the strengths of the individual models.

### 2.12 Perceived Improvement of The Stacked Deep Learning Model

The stacked model built from the top five performing models has demonstrated superior performance compared to individual models across key metrics. The use of a logistic regression meta-learner to combine the predictions of GANs, GRU, LSTM, MLP, and RNN resulted in a model that is better equipped to generalize to new data, providing more accurate and balanced predictions. This analysis underscores the value of ensemble learning techniques, particularly stacking, in enhancing predictive performance in complex datasets like the Pima Indians Diabetes dataset. The results suggest that the stacked model is a more effective approach than relying on a singular model, offering a promising method for future predictive modeling tasks.

### 3. DETAILED DISCUSSION ON PIMA DATASET ANALYSIS

In this comprehensive study, we explored various machine learning (ML) and deep learning (DL) models to predict diabetes outcomes using the Pima Indian Diabetes dataset. Our goal was to maximize predictive accuracy by employing different strategies, including individual models, stacking ensembles, and soft voting techniques.

#### 3.1 Stacking Model Approach

The stacking model for diabetes prediction uses Logistic Regression, Random Forest, XGBoost, and SVM as base models to capture diverse data patterns. A neural network serves as the meta-model, combining these predictions to improve accuracy (Khilwani et al., 2021). This approach enhances prediction accuracy and balances sensitivity and precision effectively (Gollapalli et al., 2022). Given the strong performance of individual models, we explored stacking—aiming to combine their strengths in a single ensemble. We created two primary stacking models.

#### 3.2 Machine Learning Stacking

We combined Logistic Regression, Random Forest, Gradient Boosting, Naive Bayes, and XGBoost to get this result.

**Table 3. Machine Learning Stacking Results**

Metric	Value (%)
Accuracy	77.08
Recall	57.47
Precision	71.88
F1 Score	63.60
ROC-AUC	83.54
Cohen's Kappa	47.20

#### 3.3 Deep Learning Stacking

This model stacked GANs, GRU, LSTM, MLP, and RNN, with Logistic Regression again serving as the meta-learner. We achieved the following result.

**Table 4. Deep Learning Stacking Results**

Metric	Value (%)
Accuracy	73.16
Precision	61.84
Recall	58.75
F1 Score	60.26
ROC-AUC	76.57
Cohen's Kappa	40.02

#### 3.4 Soft Voting Approaches

Soft voting is an ensemble learning technique used in machine learning to combine the predictions from multiple models to make a final prediction (Nahid Hossain Taz et al., 2021). Unlike hard voting, where the majority class prediction is chosen, soft voting aggregates the probabilistic outputs of each model and makes the final prediction based on the averaged probabilities. Suppose you have three base models predicting whether a patient has diabetes. Each model outputs probabilities for each class (e.g., 0 and 1). Soft voting calculates the average

probability for each class and selects the class with the highest average probability as the final prediction. Following the stacking attempts, we explored soft voting, where the predicted probabilities from multiple models are averaged to make the final prediction. Soft Voting between 5 Stacked Machine Learning Models (Logistic Regression, Random Forest, Gradient Boosting, Naive Bayes, XGBoost) and 5 Stacked Deep Learning Models (Generative Adversarial Networks (GANs), Gated Recurrent Unit (GRU), Long Short-Term Memory (LSTM), Multilayer Perceptron (MLP), Recurrent Neural Network (RNN)). Here, we tried soft voting between the two major stacked models—one composed of ML algorithms and the other of DL algorithms.

**Table 5. Soft Voting Approaches results**

Metric	Value (%)
Accuracy	75.76
Precision	66.67
Recall	60.00
F1 Score	63.16
ROC-AUC	81.93
Cohen's Kappa	45.17

*3.5 Different Methods Tested ML and DL Increased Accuracy*

- The output results of stacking the top four algorithms, likely machine learning Random Forest, logistic regression, and deep learning GANs and GRU it shown using the Indian Pima.

**Table 6. Top 4 algorithm Tested ML and DL Increased Accuracy Results**

Metric	Value (%)
Accuracy	74.03
Precision	62.20
Recall	63.75
F1 Score	62.96
ROC-AUC	80.06
Cohen's Kappa	42.97

- The Indian Pima diabetes dataset is used to display the results of stacking traditional Machine Learning and Deep Learning top 10 algorithms, including Generative Adversarial Networks (GANs), Logistic Regression, Random Forest Classifier, Gradient Boosting (GBM), Naive Bayes, Support Vector Machines (SVM), XGBoost, Gated Recurrent Unit (GRU), LightGBM, and K-Nearest Neighbors (KNN).

**Table 7. Top 10 algorithm Tested ML and DL Increased Accuracy Results**

Metric	Value (%)
Accuracy	73.59
Recall	66.25
Precision	60.92
F1 Score	63.47
ROC-AUC	78.35
Cohen's Kappa	42.85

- Predictions are made by stacked machine learning models (Random Forest, Logistic Regression, XGBoost, and Gradient Boosting) and stacked deep learning models (GANs and GRU), which display outcomes on the Indian Pima dataset.

**Table 8. Top 4 Algorithms ML and DL 2 algorithms Increased Accuracy Results**

Metric	Value (%)
Accuracy	68.40
Recall	52.50
Precision	54.55
F1 Score	53.50
ROC-AUC	71.08
Cohen's Kappa	29.58

- The following five deep learning models are stacked on the Indian Pima dataset: recurrent neural networks (RNNs), long short-term memory (LSTM), multilayer perceptrons (MLP), gated recurrent units (GRUs), and generative adversarial networks (GANs). All of the ensemble techniques, including stacking and soft voting, tried their hardest, but none of them could match the accuracy of the independent GAN model.

**Table 9. Top 5 Deep Learning Algorithm Increased Accuracy Results**

Metric	Value (%)
Accuracy	73.16
Recall	58.75
Precision	61.84
Recall	58.75
F1 Score	60.26
ROC-AUC	76.57
Cohen's Kappa	40.02

#### 4. RESULTS AND DISCUSSION

The Indian Pima Diabetes Dataset is a dataset used for predicting diabetes. It contains 768 instances with 8 features like glucose levels, BMI, and age, plus a binary outcome indicating diabetes presence. Collected from Pima Indians, it's widely used in machine learning for binary classification. Some features may have missing values. It's popular for testing algorithms in healthcare analytics. The extensive exploration revealed that the deep learning GAN algorithm model consistently provided the highest accuracy 84.51 % in predicting diabetes outcomes to various machine learning and deep learning algorithms models on the Pima Indian Diabetes dataset. While stacking and soft voting are powerful ensemble techniques, they did not offer the anticipated improvements over the highly optimized GAN model in this specific case. The study highlights the robustness and effectiveness of GANs in handling complex prediction tasks, even when compared to sophisticated ensemble approaches.

#### 5. CONCLUSION AND FUTURE RESEARCH

The AI framework proposed in this study successfully optimized diabetes prediction by combining machine learning and deep learning approaches, utilizing ensemble learning for improved accuracy. The study's findings suggest that ensemble methods, especially model stacking and hybrid soft voting, can create a robust framework for diabetes prediction, enhancing model reliability and precision in clinical applications. Future research will apply this framework to larger datasets with broader demographic characteristics, aiming to create an optimized AI model tailored for diverse populations, such as those in the Malaysian healthcare sector.

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# FROM CHALK TO CLICKS: THE BENEFIT OF YouTube IN SPECIAL EDUCATION: A PILOT STUDY

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**Abstract:** In Malaysia, the special education field traditionally does not seem to be the most first popular career choice by Malaysia graduates as facing with student with disabilities, especially those that are blind and deaf, requires lots of skill and patient in ensuring each of this student understand and receive each information and knowledge been delivered in classroom. Basically, special education teachers are individuals that have been trained in teaching special needs students. Therefore, as in line with global trends towards inclusive education, the Malaysia government itself has established three programs for special needs student that is *segregation, integration, and inclusion*. But however, this article only focuses on segregation which explain specific schools for the blind and hearing impairment. As the proverb goes, “*tell me and I forget. Teach me and I remember. Involve me and I learn*”. This timeless wisdom encapsulates the importance of effective education and engagement to be applied in the classroom especially when involving special needs students. In the realm of special education field in Malaysia today, there are a huge number of responsibilities that need to be held by special education teachers apart from teaching and learning. Presently, there are also many students with deaf blindness that have multiple disabilities such as autism, learning disabilities and others, which require teachers to have specialized knowledge and skills for teaching and learning in the classroom since in findings also reveal most of this students has the low level of IQ which require teachers to not rely on textbooks only. As this issue goes by, many special education teachers find various methods to help their students learning experience in the classroom to be more creative. YouTube is one of the most popular sites visited by special education teachers in Malaysia due to its features being easily understood and interactive, but there is less study that has been done on how effective and useful YouTube for special education teachers can be despite a wealth of research on YouTube today, research on the benefit and use of YouTube among special education teachers is scare. which leaves a question mark on how the use of YouTube can give advantages to teachers and students and what information is needed by teachers. **Therefore, this study aims to accomplish a primary objective, which the first one is to identify the information preferred by special education teachers for their professional practice and the second being to explore the benefit of for special education teachers.** This research employs qualitative methods, specifically using semi structured interviews to gain in-depth insight into participant experience and perspectives. Thus, this study could significantly impact the Malaysia Ministry of Education by highlighting more digital courses to enhance teachers’ digital skills and improve their overall effectiveness. In conclusion, mastering digital literacy particularly on you tube is necessary for special education teachers to create engaging and fun leaning environment with students.

**Keywords:** YouTube, Special Education, Malaysia, Teachers, Students

## 1. INTRODUCTION

According to United Nations of Convention on the Rights of Person with Disabilities (CRPD) (2007), it explains that special needs people are people who have faced long term physical, mental, intellectual or sensory impairments that lead to difficulties to participate in society. Basically, The Malaysia special education field has developed steadily since its

establishment with a number of several of academic institutions offer various level of degree related to special needs. Seriyuna (2021) highlights that the Anglican Church founded by St. Nicholas in Malacca in 1926, marking the start of special education in Malaysia for children with visual impairments, including blindness, and Princess Elizabeth Primary School in Johor Bahru was established in 1948 as the second blind school. Meanwhile, the first school for children with hearing issues was established in 1954 in Tanjung Bunga, Penang. Today, there are a total of 34 special needs school in every state in Malaysia for deaf and blind students with the total number of teachers being 1313. A special education teacher is a qualified teacher with experience working with special education pupils, particularly in teaching and learning methods (T&L) (Chandramogan et al.,2015). According to Rosilawati (2015), special education teachers carry a variety of roles and tasks which differ from teachers in general schools, such as educator, counsellor, mentor, coach, babysitter and as therapist. Apart from that, it also involves administrative duties and managing and implementing various programs and curriculum. Therefore, with the workload faced by special education teachers, additional information and resources are required to ensure each of roles and task can be done according to the needs of student. According to Rohani, et al. (2017), developing proficient students with special needs in the twenty-first century is possible if teachers use cooperative learning approaches, democratic classrooms, and proper inspirational motivational. During the learning and teaching process (PdP), students will be interested and focused on receiving knowledge with an interesting style and method of delivery from an educator or teacher (Omar, 2016) For that reason, special education teachers are required to be creative and innovation in class.

The era of black board and chalk which used to control the education system has moved to smart learning techniques with the presence of advanced technology. Nowadays, everyone including the education system has moved to use YouTube which provides benefits for teachers and students, especially in special needs area. YouTube is one of the most popular social media nowadays, not only for young people but by individuals of all ages. Since its inception in 2005, YouTube has almost 1.9 million monthly users (You tube, 2019), due to its ability of offering a vast array of content including music videos, educational videos, vlogs, tutorials, movie, comedy and many more. Teaching special needs students required teachers to be more visual-oriented, as most special needs students have low IQ levels, according to Sharma and Shurti (2021), YouTube as a creative approach to visual learning has made learning easier and fun, such as those who are deaf and blind. It is essential for teachers to make sure that the student is engaged in the classroom towards the information delivered, since reading may not the best method of teaching this type of students. Videos are communication tools which can attract students' attention to learning, address both eyes and ears and have high levels of effectiveness in learning (Chen and Wu 2015). Apart from that, using video as instructional material can provide cognitive benefits in terms of learning, memorizing, motivation and visualization of knowledge (Gaudin and Chalies 2015; Whitton and Maclure 2017).

## **2. METHODOLOGY**

Qualitative methodology has been used in this study to gain deeper understanding of teachers' experience on information needed by special education teachers for their professional practice. Qualitative method is known as the non-numerical method and direct observation which able to help gain deep understanding of users. Through participant experience,

qualitative research helps to gain specific meaning and behavior in certain social phenomena. Qualitative method is about finding ideas and experiences to explore comprehensive understanding on phenomena and the participant itself (Ugwu, Chinyere, and Eze 2023). As this study focused in identifying the information preferred by special education teachers for their professional practice and exploring the benefit of YouTube for special education teachers, an interview has been conducted involving two teachers in a special needs school in Shah Alam using semi structured question provided by researchers. The participants were identified according to criteria set up by researchers which is based on previous research, that was: *a) 5 to 10 years' experience, b) academic background related to special needs, c) Teaching blind and deaf students, d) teaching more than one subject and hold additional positions in school.* Meanwhile, the interview questions were based on Wilson information seeking behavior model, as this model explains the individual seeking of information and resources for a variety of purposes such as for fulfilling needs on work roles. Before conducting interview, researchers have applied for permission from the Malaysia Ministry of Education before proceeding to the school principal to set up the interview date and time. All participants were given a short briefing on the aim of the study and the interview questions. All participants were coded as follows: T1 and T2. The interview was conducted in Malay language, video recorded, transcribed, coded, and analyzed based on participant response towards each question been asked. Interview was conducted on 19 October 2023.

**Table 1. Participant’s demographic information**

<i>No</i>	<i>Participant code</i>	<i>Type of student been taught</i>	<i>position</i>	<i>Working experience</i>	<i>Academic qualification</i>	<i>Subject been taught</i>	<i>Gender</i>
1	T1	Blind and deaf	Senior Teacher	18 years	Bachelor	Islamic study  Sains Social	Female
2	T2	Deaf	Senior Teacher	17 years	Bachelor	Math’s	Male

**3. RESULTS AND DISCUSSION**

*ROI: To identify information needed by special education teachers for their professional practice*

Previous literature has mentioned many special education teachers need to carry out a variety of roles beyond their primary responsibilities to help their students reach their full potential. Teaching special needs students required teachers to be more specialized in a variety of skills as special needs students have different kinds of abilities and IQ level. With the tasks and responsibilities, they need to carry out, teachers must ensure they are well-equipped with diverse information, so that every activity in the classroom with special education students

facilitates interaction and helps them comprehend every detail of the knowledge. From the interview session, teachers need information most on teaching material as the mentioned information in the schoolbook text is limited.

*“Teaching material like for example I’m teaching science we need to see more detail like example today teaching about animal, at schoolbook text is incomplete so I need to find more information such what animal eat grass, I need to find more information. And like Islamic studies I need to find latest information like mufti fatwa”.*

Meanwhile another respondent mentioned:

*“The content on module provided is enough but in terms of additional exercises, worksheet, activity in classroom, some of us use YouTube as platform as reference to apply in classroom.*

*RO 2: To explore the benefit of YouTube for special education teachers.*

YouTube is one of the most powerful resources that has been used rapidly by everyone as it allows user to share, upload and view videos on a variety of topics that might be very useful. This is no exception in the education field, where teachers have opportunities to engage with experts in the education sector, especially on special education to get a variety of information on teaching aids, activities, various review exercises / worksheet and many more. As interviews have been conducted with both teachers, they reveal the same answer in using YouTube to get a variety of information like pictures or worksheets.

*“During pdpr (teaching and learning at home) YouTube is important because it has lot of worksheets, but in classroom I only use book text, because YouTube requires internet and in classroom there is no internet.”*

From the findings above, most of the teachers feel YouTube helps in providing plenty of teaching aids that might attract students but due to internet connection, it has become a limitation unlike during the Covid -19 hit, when classes were run online which gave them the opportunity to display YouTube videos to students.

*“YouTube is more practical rather than books more to theory. For students with special needs, sometimes we need give more examples and activities then only they reach the level of understanding because if [we give] only reading for students who faced dyslexia, they faced difficulties in reading; they are more towards visualizing , doing activities and being hands on, they are multi-sensory..*

Therefore, to get engaged with students in classroom teachers need to be more creative to meet the limitation of students as most special needs students faced low IQ required teachers to more visualize for their better understanding.

**Table 2. Findngs and Discussion**

<b>Research Objective</b>	<b>Findings</b>	<b>Discussion</b>
To identify Information needed by special education teachers for their professional practice	Both teachers agree they more need information on teaching aid / method as in book text information are limited	Students with special needs required detailed understanding on one particular things as most of them faced low IQ which made teacher cannot fully depend on schoolbook text. Teacher also needs to creative in delivering the information.
To explore the benefit of YouTube for special education teachers	YouTube is very benefit for the teachers to describe each information and knowledge that wants to be delivered to special needs students.	Teaching special needs students needs to be more visualized and hand on, You tube help students to gain understanding but internet in the main barrier.

#### **4. CONCLUSION**

Students with special needs require a more strategic approach as well as specific assistance, support, and instructional strategies that are suited to their needs and abilities. Special education teachers play a major role in helping these students see their abilities rather than their disabilities and to discover their potential. Therefore, YouTube should be implemented as the main reference of sources for special needs teachers as it provides plenty of benefit for teachers and student as well. In future research, studies should be conducted on the level of digital literacy of special education teachers, as there are a limited number of studies done on digital literacy among special education teachers in Malaysia. This is to ensure teachers master the use of various forms of technology. This includes YouTube as well to ensure teachers are on the right track in seeking local and global information. Apart from that, internet connection for the students and teachers in schools should be taken seriously by relevant authorities as we are living in the 21st century whereby technology is transforming the world. We've moved from using chalk to simply clicking to access information and deliver knowledge.

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# Third-Party Engagement in E-Banking System Development: A Literature Review

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**Abstract:** Third-party software development practices play a crucial role in preventing customer data leaks in global e-banking systems. Despite adherence to central bank of Malaysia guidelines and the PDPA, significant breaches occurred at a Malaysian payment gateway company, highlighting the impact of individual behaviors, organizational culture, and system issues. Emphasizing PDPA compliance, insights from reputable auditing firms reveal challenges within the third-party e-banking landscape, underscored by potential breaches at major international banks. Integrating the Delphi Technique, Socio-Technical Approach, and thematic analysis, this research aims to understand breach risks and assess the Socio-Technical framework's effectiveness. Interview findings emphasize the need to address regulatory hurdles and foster collaboration in third-party software development, navigating the socio-technical sphere and emphasizing regulatory compliance and industry best practices to mitigate risks and improve cybersecurity. Enhanced vendor management with precise selection criteria and adherence to Information Security and regulatory standards, alongside a tailored cybersecurity checklist, aims to bolster security in third-party e-banking development.

**Keywords:** third-party, data privacy breaches, e-banking, data privacy, socio-technical

## 1. INTRODUCTION

In the digital age, electronic banking (e-banking) is preferred by customers for convenient financial transactions, offering services through websites or mobile apps. Integrated with core banking systems, e-banking reduces reliance on physical branches, leading to cost savings. The following research holds significant relevance for third-party software system development, particularly within Malaysia's digital e-banking domain. It aims to deepen our understanding of the intricate relationships between the banking sector and third-party developers, offering insights into information systems, cybersecurity, and banking practices. By addressing a gap in existing theory, the research focuses on the intersection between third-party e-banking software development and data privacy in the Malaysian banking sector, aiming to develop a framework applicable across different contexts. Furthermore, it contributes to discussions on the vulnerabilities of involving third parties in critical sectors like e-banking, enhancing our understanding of e-banking software development processes and cybersecurity. The investigation also explores regulatory frameworks such as Bank Negara's Risk Management in Technology and Cybersecurity Malaysia's Guidelines for Secure Software Development Life Cycle, integrating regulatory perspectives with a theoretical framework to understand data privacy in e-banking. Moreover, the study aims to understand customer viewpoints on data privacy breaches and identify gaps in e-banking software development models utilized by third-party developers. This research aligns with Malaysia's goals for sustainable economic growth, digital transformation, and the development of a secure banking ecosystem, supporting efforts to enhance e-banking system security. However, significant breaches persist, often attributed to individual behaviors, organizational culture, and system deficiencies. The heightened risk of cybercrime, especially within the banking sector, is exacerbated by third-party involvement, as highlighted by the Malaysian Computer Emergency Response Team.

## **2. METHODOLOGY**

The research employs a multifaceted approach integrating the Delphi Technique and Thematic Analysis to address challenges in e-banking procedures, focusing on mitigating data breaches in third-party e-banking systems. By leveraging expert opinions from e-banking developers and bank IT security professionals, it aims to achieve consensus on social and technical issues. The research employs rigorous interview sampling and combines qualitative and quantitative methodologies to gain insights into current practices and assess breach risks, emphasizing adherence to regulatory requirements. Through this approach, the study seeks to inform policy formulation and enhance understanding of e-banking operations, facilitating informed decision-making in the dynamic banking environment. The actionable recommendations based on research findings are provided, focusing on collaborative technology practices in the Malaysian banking sector. Recommendations are structured around Strengthening Regulatory Compliance, Fostering Collaboration and Communication, Balancing Innovation with Security, Enhancing Vendor Management, and Cultivating a Culture of Continuous Improvement. Insights from Information Security software development best practices and frameworks like ISMS, NIST, CIS, and others are utilized to support these recommendations.

## **3. RESULTS AND DISCUSSION**

In summary, the results from interviews with industry professionals underscore the critical importance of addressing regulatory challenges and enhancing collaboration in third-party software development engagements within the banking sector. By adeptly navigating the social-technical landscape and prioritizing effective regulatory compliance, alongside adopting industry best practices in development processes and communication, organizations can effectively mitigate risks and bolster their cybersecurity posture while enhancing customer data leakage prevention. Despite the hurdles involved in adopting regulatory frameworks, taking proactive measures such as leveraging collaborative technology tools, incorporating user feedback, and fostering a culture of innovation and collaboration are vital for effectively safeguarding against the threat of customer data leakage in the ever-evolving landscape of e-banking system development.

## **4. CONCLUSION**

In conclusion, the research consolidates its final recommendations into a proposed cybersecurity checklist, which integrates industry best practices and Malaysia's cybersecurity laws together with central bank guidelines (RMiT). This checklist serves as a comprehensive evaluation tool for third-party e-banking vendors, ensuring adherence to regulatory requirements and security standards. It is imperative that this checklist is strictly adhered to and integrated into Governance, Risk, and Compliance (GRC) tools for automated verification. By doing so, compliance throughout the e-banking development process is ensured, safeguarding customer data and bolstering overall cybersecurity measures.

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