IMPROVING THE ANALYTICAL APPROACH TO RELIABILITY AND RISKS IN ENGINEERING SYSTEM USING INTELLIGENT BASED SUPER CAPACITOR

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Abstract

Reliability and risk management are critical aspects of engineering systems, where failures can result in significant economic losses, safety hazards, and environmental impacts. Traditional analytical approaches often fall short in addressing the complexities and uncertainties inherent in modern engineering applications. This study explores the potential of intelligent-based supercapacitors as a transformative solution to enhance the reliability and risk analysis of engineering systems. By integrating the advanced energy storage capabilities of super capacitors with artificial intelligence techniques, this approach enables real-time monitoring, predictive maintenance, and adaptive risk mitigation. The research highlights the limitations of conventional methods and demonstrates how intelligent-based super capacitors can overcome these challenges by providing improved accuracy, efficiency, and scalability. Key focus areas include the application of machine learning algorithms for failure prediction, optimization of energy usage, and enhanced system resilience under varying operational conditions. The findings underscore the importance of adopting innovative technologies to meet the growing demands for reliable and safe engineering systems. This study contributes to the development of a robust framework for reliability and risk assessment, offering significant implications for critical sectors such as power systems, transportation, and industrial automation. The proposed approach lays the foundation for future advancements in intelligent engineering solutions, ensuring sustainable and resilient infrastructure. The conventional Cyber security Vulnerabilities causes of failure in the analytical approach to reliability and risks in engineering system was 10%. However, when an Intelligent based super capacitor was imbibed in the system, it drastically reduced it to8.7%. finally, the percentage improvement in the analytical approach to reliability and risks in engineering system was1.3%

Keywords; Improving, analytical, approach, reliability, risks, engineering, system, intelligent, based, super capacitor

1.0 INTRODUCTION

Engineering systems are critical to the functioning of modern societies, providing essential services in areas such as energy, transportation, healthcare, and manufacturing. The reliability of these systems is pivotal, as failures can lead to significant economic losses, environmental hazards, and threats to human safety (Rao, 2019). Traditional approaches to reliability assessment and risk management often rely on deterministic methods, which, while effective to some extent, struggle to capture the complexities and uncertainties inherent in engineering systems (Zio, 2016). In recent years, intelligent-based systems have emerged as transformative tools in enhancing the reliability and risk analysis of engineering systems. These systems integrate advanced computational methods, including artificial intelligence, machine learning, and optimization algorithms, to provide more accurate and adaptive solutions (Wang et al., 2020). Among these, the use of supercapacitors has garnered significant attention due to their high energy density, rapid charging capabilities, and long operational lifespan (Burke, 2018). Supercapacitors, when coupled with intelligent-based systems, offer a unique advantage in dynamically assessing and managing reliability and risks in engineering applications. The intelligent-based supercapacitor approach seeks to optimize system performance by predicting potential failure points, mitigating risks, and ensuring continuous functionality under varying conditions. This capability is particularly crucial in critical infrastructure such as power grids, aerospace systems, and industrial automation, where reliability is non-negotiable (Zhang et al., 2021). Despite these advancements, there remains a gap in fully integrating intelligent-based supercapacitor solutions into mainstream engineering reliability frameworks. Existing research highlights the need for more robust analytical models that effectively leverage the unique properties of supercapacitors in conjunction with intelligent algorithms (Li & Chen, 2022). Addressing this gap is essential for advancing the reliability and safety of engineering systems in a rapidly evolving technological landscape. This study aims to explore the potential of intelligent-based supercapacitors in enhancing the analytical approach to reliability and risks in engineering systems. By doing so, it contributes to developing more resilient and adaptive engineering solutions capable of meeting the demands of modern industries.

2.0 Method

To characterize and establish the causes of failure in the analytical approach to reliability and risks in engineering system

Table 1 characterized and established causes of failure in the analytical approach to reliability and risks in engineering system

Cause of Failure	Description	Estimated Contribution (%)
Inadequate Modeling Techniques	Reliance on oversimplified or deterministic models that fail to capture system complexities and uncertainties.	25%
Data Insufficiency	Insufficient or poor-quality data for reliability and risk assessments, leading to inaccurate predictions.	20%
Component Wear and Degradation	Failure due to physical wear and aging of system components, which are not adequately predicted by the models.	15%
Human Errors	Errors in design, operation, or maintenance of systems that impact reliability and safety.	10%
Environmental Factors	Unpredictable external factors such as temperature, humidity, and vibrations that influence system performance.	10%
Cybersecurity Vulnerabilities	Risks from cyberattacks and data breaches affecting system reliability, particularly in digitally controlled systems.	10%
Lack of Integration of Intelligent Systems	Limited adoption of AI, machine learning, and advanced technologies to improve risk analysis and mitigation.	10%

The percentages are approximate and may vary depending on the specific engineering field or system under consideration. The table illustrates the need for holistic approaches that address both technological and human factors in improving reliability and risk management.

To design a conventional SIMULINK model of analytical approach to reliability and risks in engineering system

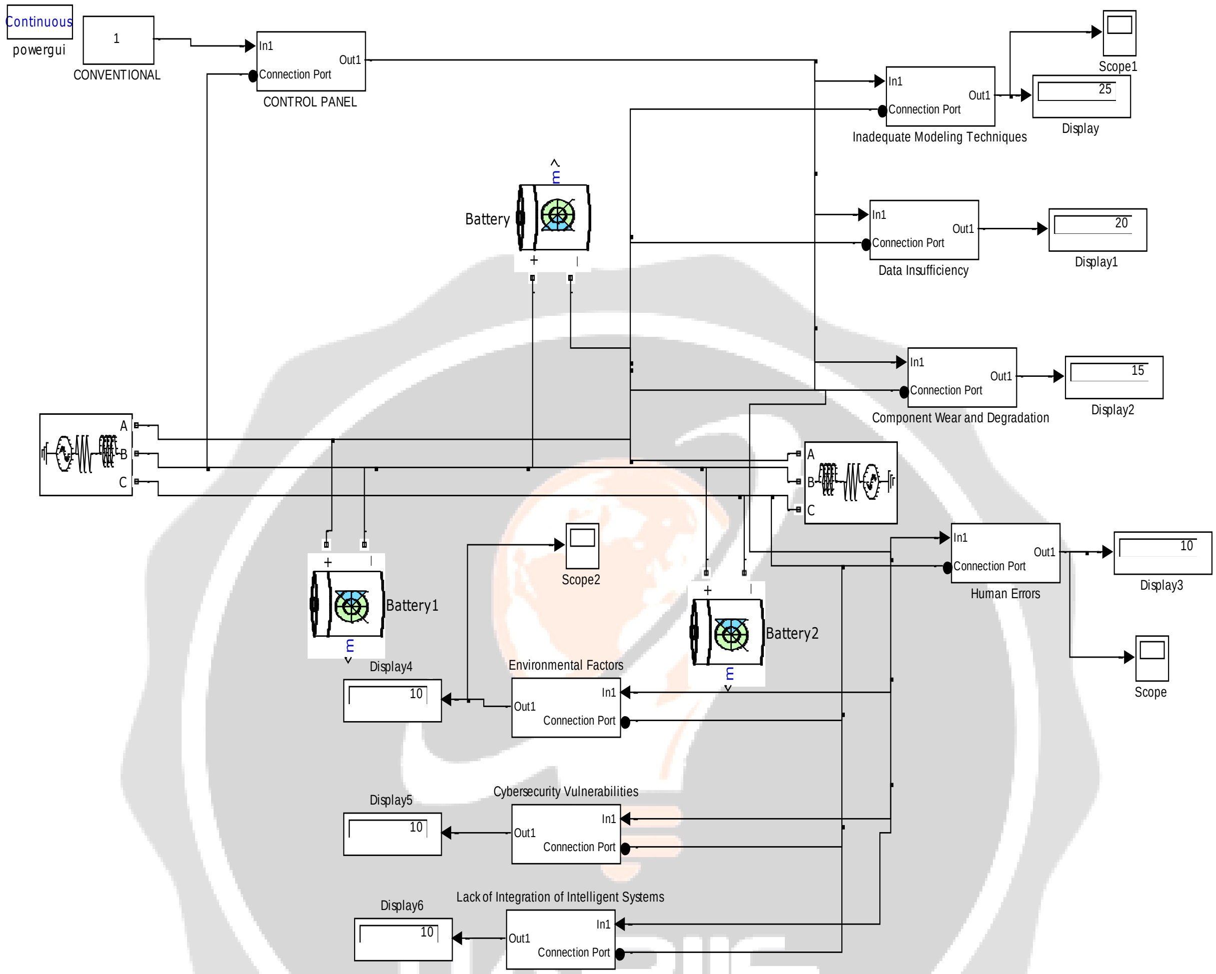

Fig 2 designed conventional SIMULINK model of analytical approach to reliability and risks in engineering system

The results obtained were as shown in figures 7 and 8

To develop super capacitor rule base that will minimize the causes of failure in the analytical approach to reliability and risks in engineering system

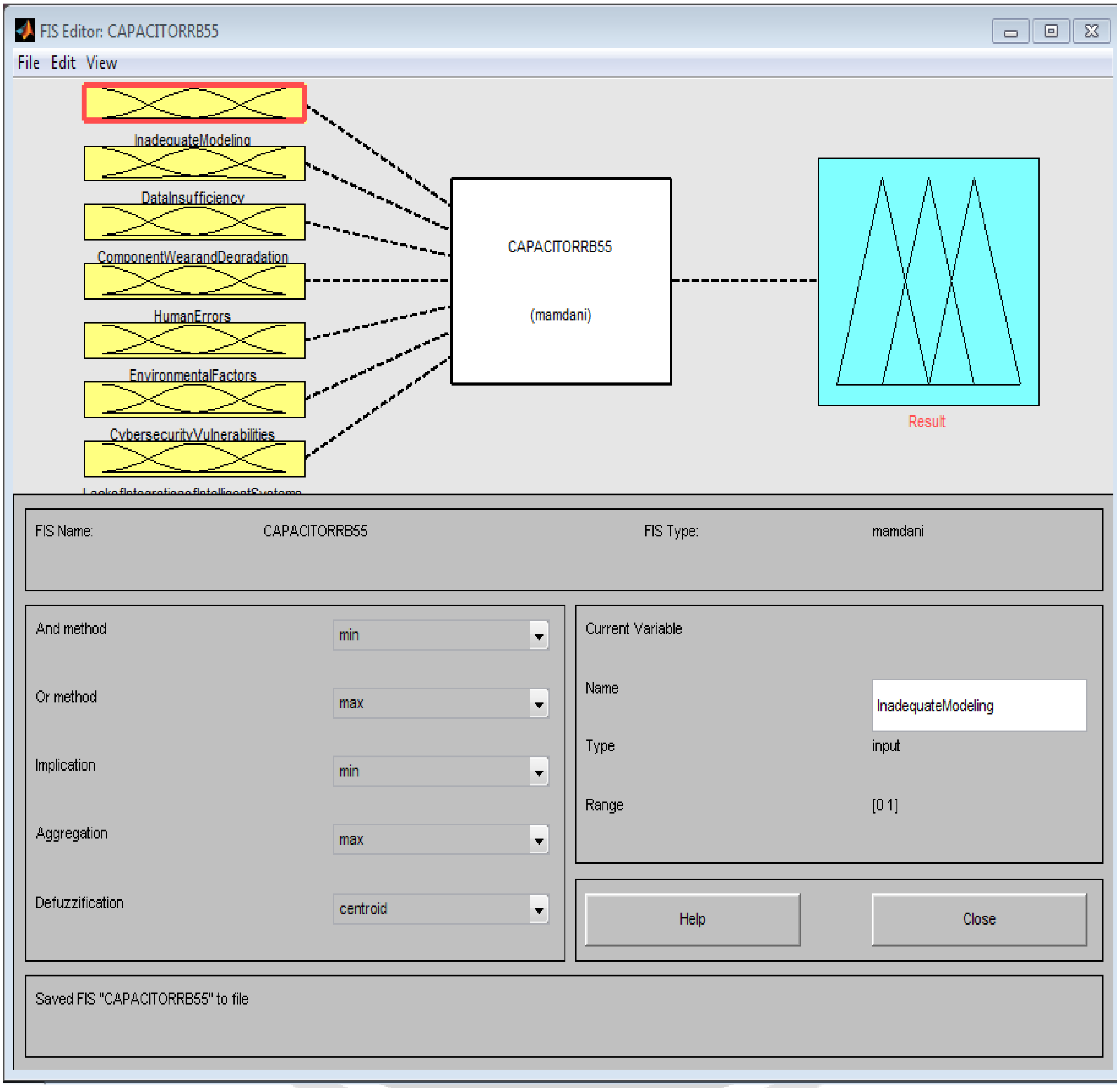

Fig 2 develop super capacitor fuzzy inference system that minimize the causes of failure in the analytical approach to reliability and risks in engineering system

It had seven inputs of inadequate modeling technique, data insufficiency, component wear and degradation, human errors, environmental factors is, cyber security vulnerabilities and lack of integration of intelligent systems. It also had an output of result

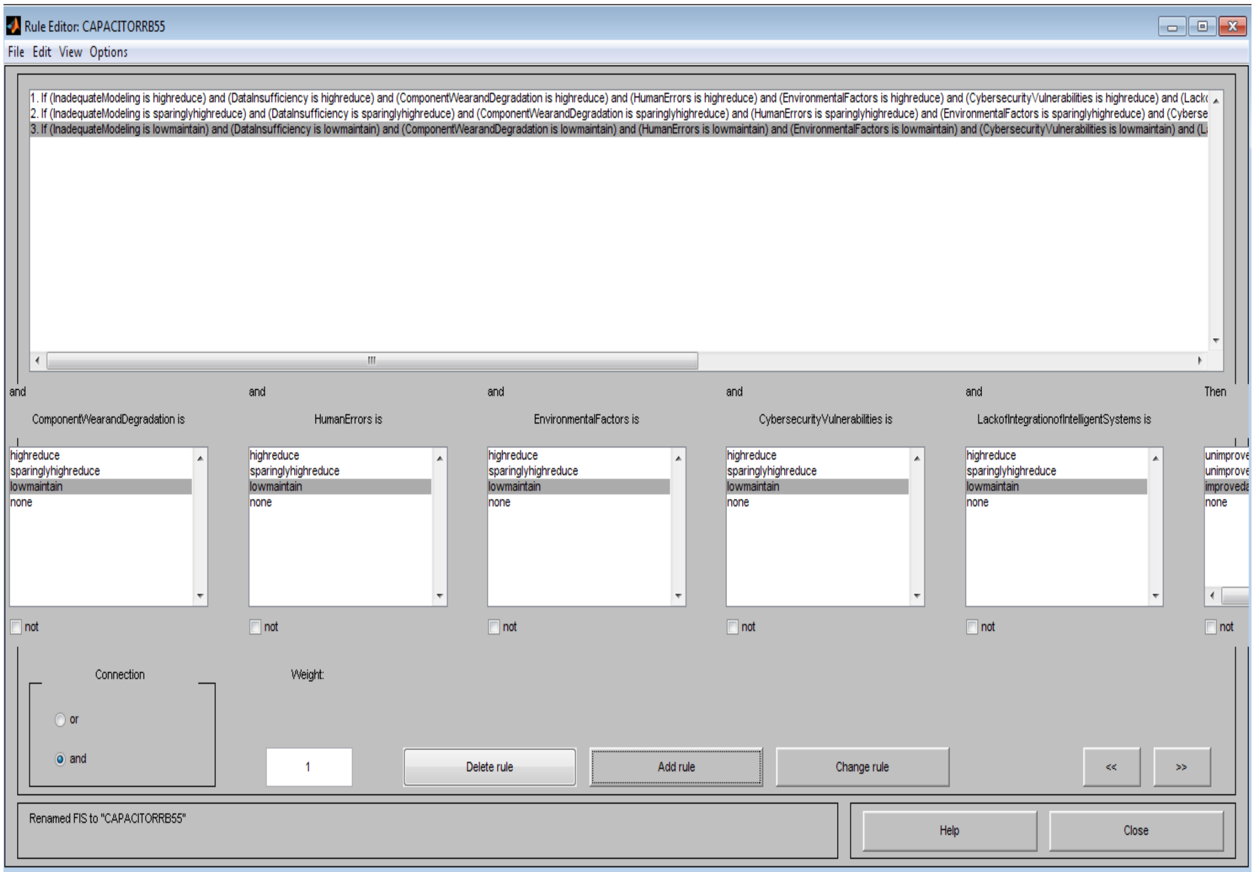

Fig 3 developed super capacitor rule base that will minimize the causes of failure in the analytical approach to reliability and risks in engineering system

It was detailed comprehensively in table 2

Table 2comprehensive developed super capacitor rule base that will minimize the causes of failure in the analytical approach to reliability and risks in engineering system

1	if inadequate modeling techniques is high reduce	and data insufficiency is high reduce	and component wear and degradation is high reduce	and human errors is high reduce	and environmental factors is high reduce	and cyber security vulnerabilities is high reduce	and lack of integration of intelligent systems is high reduce	then result is un improved the analytical approach to reliability and risks in engineering system
2	if inadequate modeling techniques is	and data insufficiency is sparingly	and component wear and degradatio	and human errors is sparingly	and environmental factors issparingly high reduce	and cyber security vulnerabilities is sparingly	and lack of integration of intelligent systems is	then result is un improved the analytical

	sparinglyhigh reduce	high reduce	n is sparingly high reduce	high reduce		high reduce	sparinglyhigh reduce	approach to reliability and risks in engineering system
3	if inadequate modeling techniques is low maintain	and data insufficiency is low maintain	and component wear and degradation is low maintain	and human errors is low maintan	and environmental factors is low maintain	and cyber security vulnerabilities is low maintain	and lack of integration of intelligent systems is low maintain	then result is improved the analytical approach to reliability and risks in engineering system

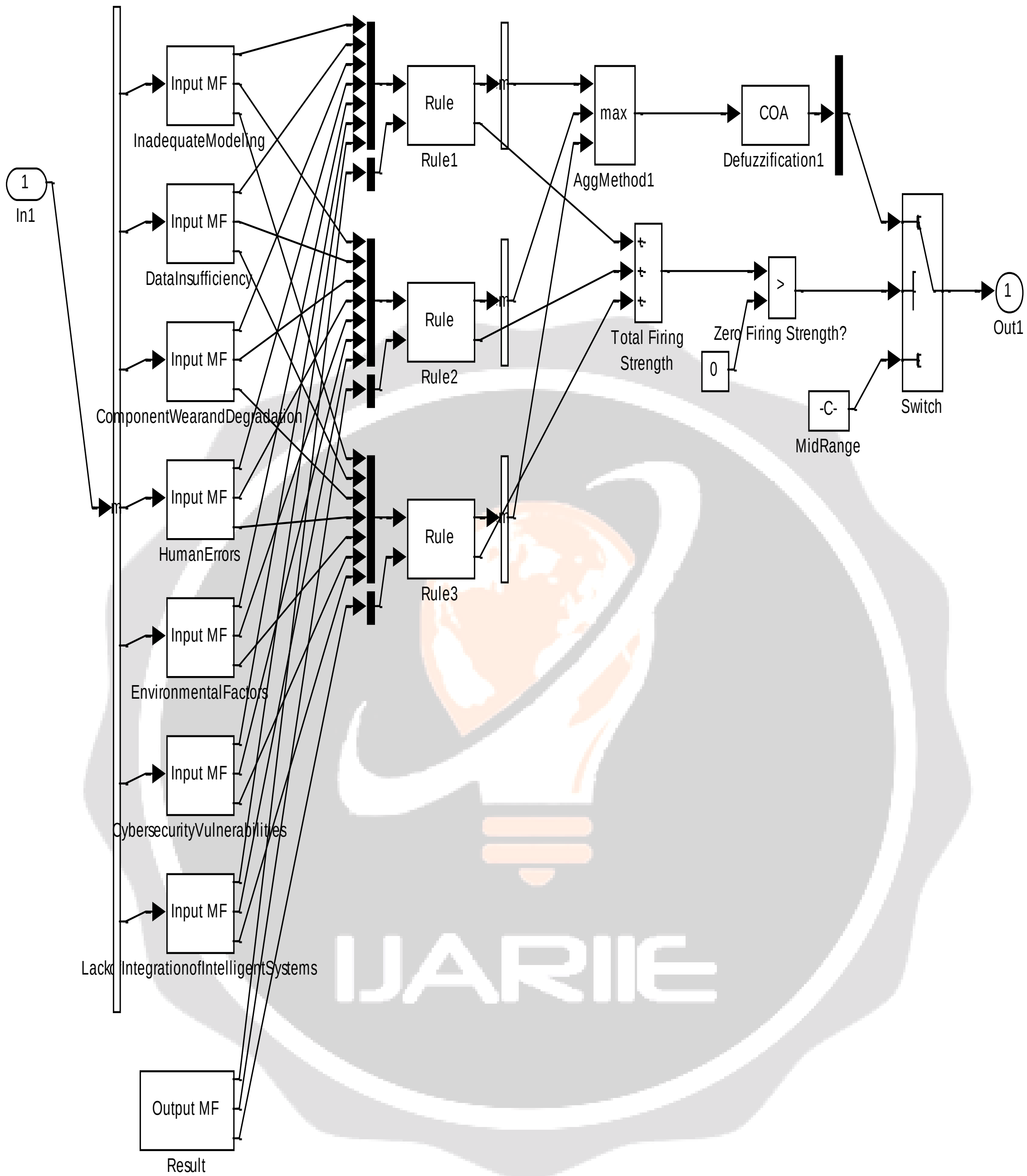

Fig4 the operational mechanism of the rules

To design a SIMULINK model for super capacitor

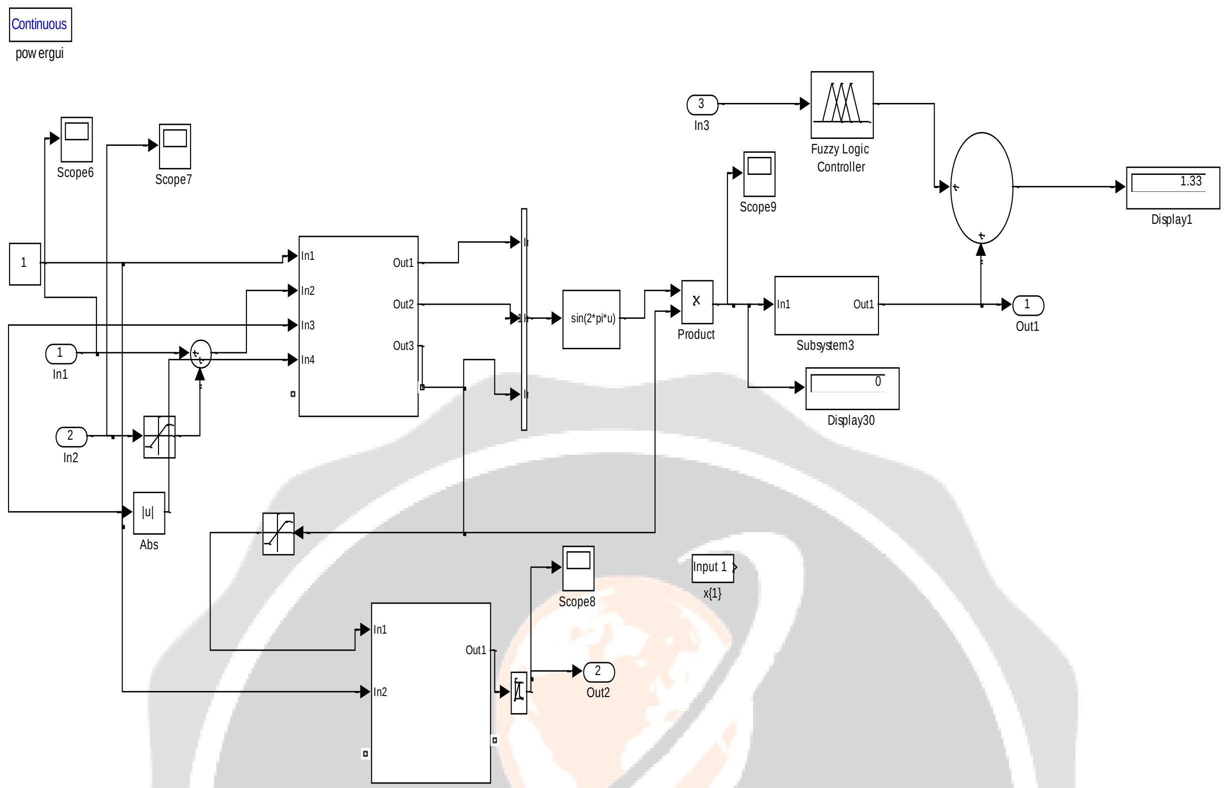

Fig 5 designed SIMULINK model for super capacitor

To develop an algorithm that will implement the process

1. Characterize and establish the causes of failure in the analytical approach to reliability and risks in engineering system
2. Identify Inadequate Modeling Techniques
3. Identify Data Insufficiency
4. Identify Component Wear and Degradation
5. Identify Human Errors
6. Identify Environmental Factors
7. Identify Cyber security Vulnerabilities
8. Identify Lack of Integration of Intelligent Systems
9. design a conventional SIMULINK model of analytical approach to reliability and risks in engineering system and integrate 2 through 8
10. develop super capacitor rule base that will minimize the causes of failure in the analytical approach to reliability and risks in engineering system
11. design a SIMULINK model for super capacitor
12. Integrate 10 and 11
13. Integrate 12 into 9
14. Did the failure in the analytical approach to reliability and risks in engineering system reduce when 12 was integrated in 9?
15. IF NO go to 13
16. IF YES go to 17
17. Improved analytical approach to reliability and risks in engineering system
18. Stop
19. End

To design a SIMULINK model for improving the analytical approach to reliability and risks in engineering system using intelligent based super capacitor

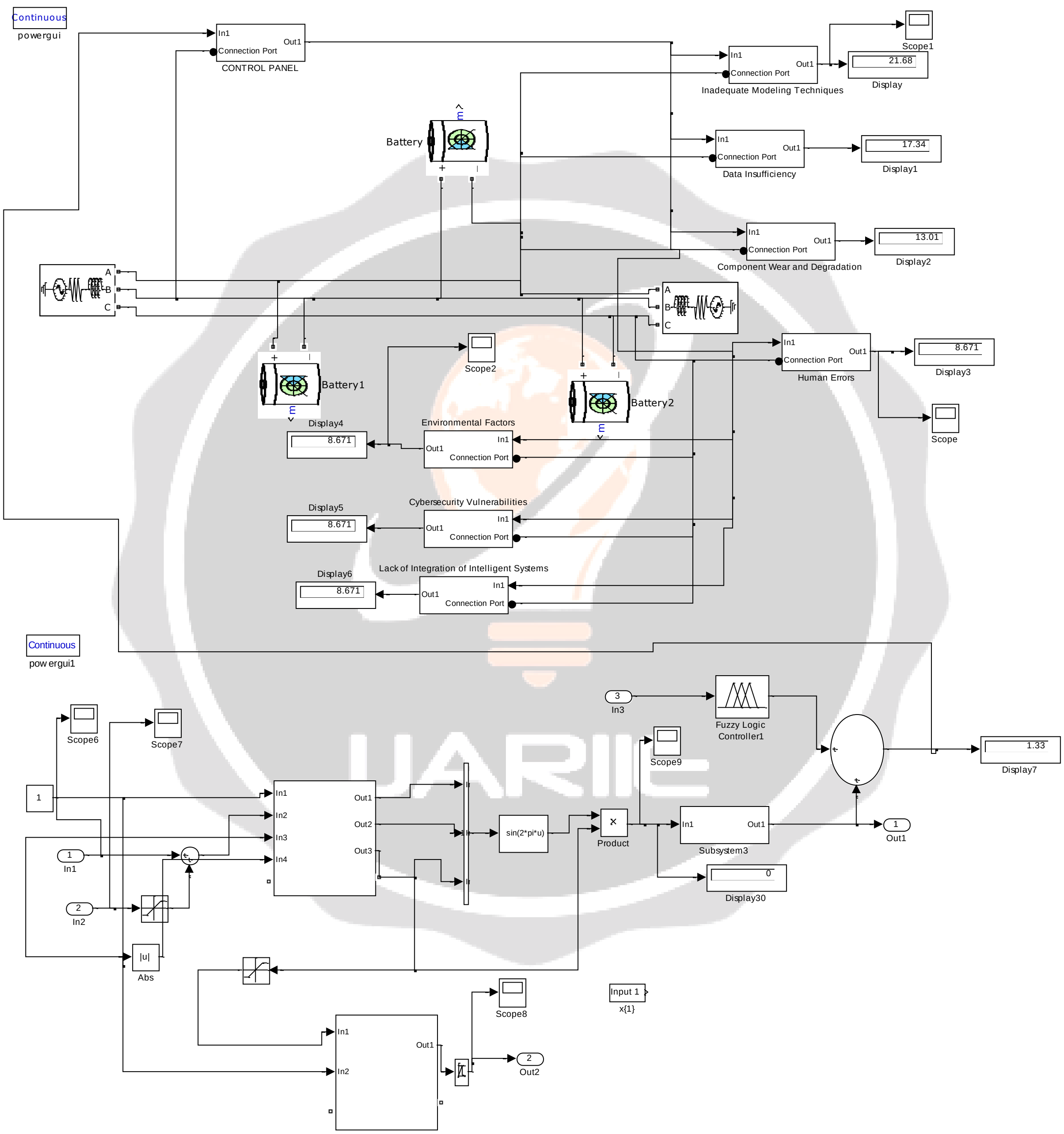

Fig 6 design a SIMULINK model for improving the analytical approach to reliability and risks in engineering system using intelligent based super capacitor

The results obtained were as shown in figures 7 and 8

To validate and justify the percentage improvement in the reduction of causes of failure in the analytical approach to reliability and risks in engineering system with and without intelligent based super capacitor

To find percentage improvement in the reduction of Inadequate Modeling Techniques causes of failure in the analytical approach to reliability and risks in engineering system with intelligent based super capacitor

Conventional Inadequate Modeling Techniques =25%

Intelligent based super capacitor Inadequate Modeling Techniques=21.6%

%improvement in the reduction of Inadequate Modeling Techniques causes of failure in the analytical approach to reliability and risks in engineering system with intelligent based super capacitor=

Conventional Inadequate Modeling Techniques - Intelligent based super capacitor Inadequate Modeling Techniques

%improvement in the reduction of Inadequate Modeling Techniques causes of failure in the analytical approach to reliability and risks in engineering system with intelligent based super capacitor=25% - 21.6%

%improvement in the reduction of Inadequate Modeling Techniques causes of failure in the analytical approach to reliability and risks in engineering system with intelligent based super capacitor=3.4%

To find percentage improvement in the reduction of Cyber security Vulnerabilities causes of failure in the analytical approach to reliability and risks in engineering system with intelligent based super capacitor

Conventional Cyber security Vulnerabilities =10%

Intelligent based super capacitor Cyber security Vulnerabilities s=8.7%

%improvement in the reduction of Cyber security Vulnerabilities causes of failure in the analytical approach to reliability and risks in engineering system with intelligent based super capacitor=

Conventional Cyber security Vulnerabilities - Intelligent based super capacitor Cyber security Vulnerabilities

%improvement in the reduction of Cyber security Vulnerabilities causes of failure in the analytical approach to reliability and risks in engineering system with intelligent based super capacitor=10% - 8.7%

%improvement in the reduction of Cyber security Vulnerabilities causes of failure in the analytical approach to reliability and risks in engineering system with intelligent based super capacitor=1.3%

3.0Results and Discussion

Table 3 comparison of conventional and Intelligent based super capacitor Inadequate Modeling Techniques causes of failure in the analytical approach to reliability and risks in engineering system

Time(s)	Conventional Inadequate Modeling Techniques causes of failure in the analytical approach to reliability and risks in engineering system(%)	Intelligent based super capacitor Inadequate Modeling Techniques causes of failure in the analytical approach to reliability and risks in engineering system(%)
1	25	21.6
2	25	21.6
3	25	21.6
4	25	21.6
10	25	21.6

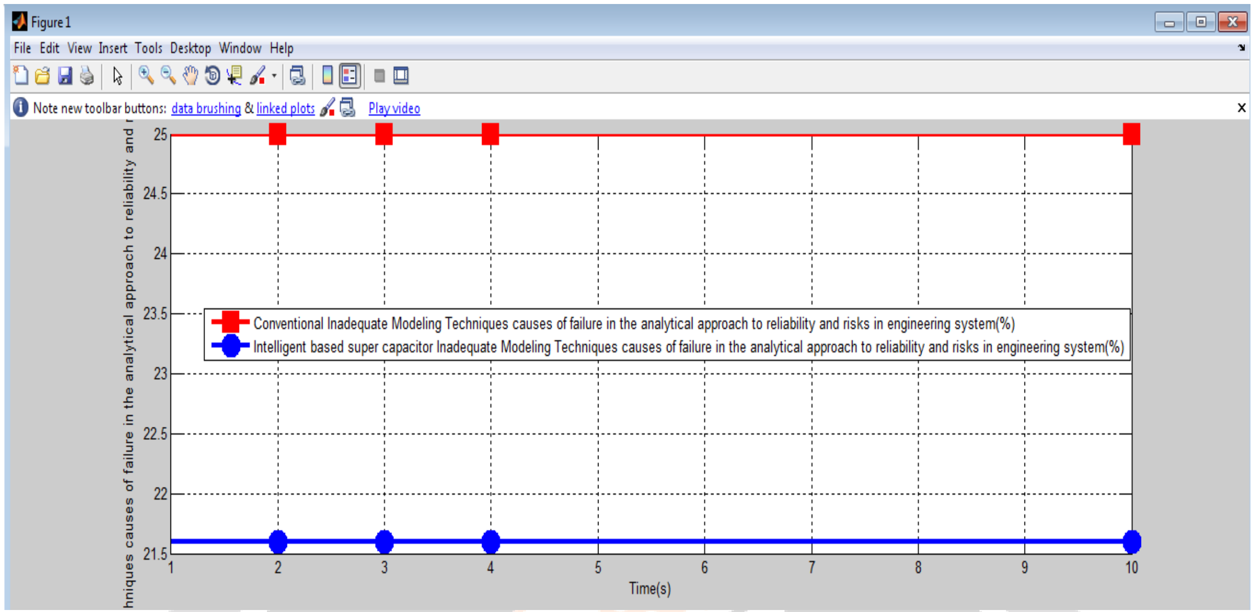

Fig 7 comparison of conventional and Intelligent based super capacitor Inadequate Modeling Techniques causes of failure in the analytical approach to reliability and risks in engineering system

The conventional Inadequate Modeling Techniques causes of failure in the analytical approach to reliability and risks in engineering system were 25%. On the other hand, when an Intelligent based super capacitor was integrated into it , it decisively reduced it to21.6%.

Table 4 comparison of conventional and Intelligent based super capacitor Cyber security Vulnerabilities causes of failure in the analytical approach to reliability and risks in engineering system

Time(s)	Conventional Cyber security Vulnerabilities causes of failure in the analytical approach to reliability and risks in engineering system(%)	Intelligent based super capacitor Cyber security Vulnerabilities causes of failure in the analytical approach to reliability and risks in engineering system(%)
1	10	8.7
2	10	8.7
3	10	8.7
4	10	8.7
10	10	8.7

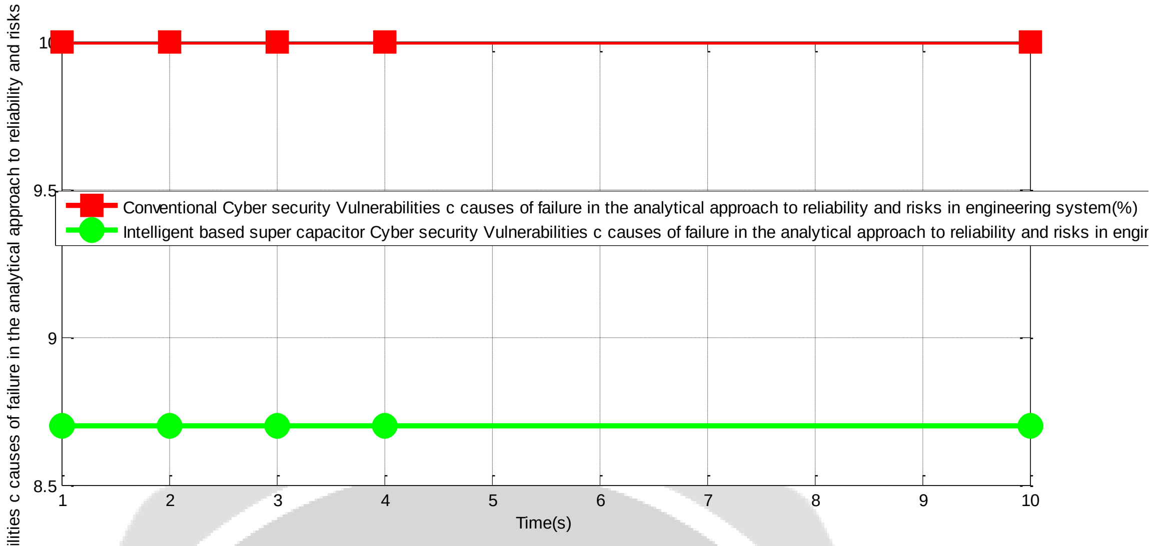

Fig8 comparison of conventional and Intelligent based super capacitor Cyber security Vulnerabilities causes of failure in the analytical approach to reliability and risks in engineering system

The conventional Cyber security Vulnerabilities causes of failure in the analytical approach to reliability and risks in engineering system was 10%. However, when an Intelligent based super capacitor was imbibed in the system, it drastically reduced it to8.7%. finally, the percentage improvement in the analytical approach to reliability and risks in engineering system was1.3%

4.0 Conclusion

Improving the analytical approach to reliability and risks in engineering systems is critical to ensuring the safety, efficiency, and resilience of these systems in modern applications. The integration of intelligent-based super capacitors presents a transformative solution that combines the advanced capabilities of artificial intelligence with the superior energy storage properties of super capacitors. This approach offers real-time adaptability, enhanced predictive analysis, and improved risk mitigation strategies, addressing the limitations of traditional reliability frameworks. By leveraging intelligent-based super capacitors, engineering systems can achieve greater reliability under diverse operational conditions, reduced failure rates, and optimized performance. This study underscores the importance of adopting innovative technologies to bridge existing gaps in reliability analysis and risk management, particularly in critical sectors such as power systems, transportation, and manufacturing. Future research should focus on developing more robust models that integrate intelligent-based super capacitors with other advanced technologies, ensuring scalability and adaptability across different engineering applications. Through continued innovation and implementation, this approach has the potential to redefine the standards of reliability and risk analysis in engineering systems, contributing significantly to sustainable development and technological advancement. The conventional Cyber security Vulnerabilities causes of failure in the analytical approach to reliability and risks in engineering system was 10%. However, when an Intelligent based super capacitor was imbibed in the system, it drastically reduced it to8.7%. finally, the percentage improvement in the analytical approach to reliability and risks in engineering system was1.3%

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