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Sugeno Fuzzy Based WBAN Management for Bio-Signal Monitoring System

Rejin Rose.V.H
Sivaji College of Engineering and Technology

Abstract: **Biomedical applications have made extensive use of wearable body area networks. These systems affix many sensors to the human body to continually track the bio signals of the patient. Numerous WBAN varieties have been studied for ongoing medical applications. In this case, a number of bio signals are captured from bodily sensors, and then data is gathered, managed, and stored in a controller. For wearable healthcare applications, the WBAN controller with Branched Bus topology and Continuous Data Transmission protocol is suggested. It has low power consumption and self-reconfigurability. A WBAN controller based on the Sugeno fuzzy model is suggested, in addition to the CDT protocol and BB topology. It has the capacity to produce an entirely distinct input-output mapping by adding only one more degree of flexibility to the fuzzy system design parameters. The suggested method can be used for decision-making processes, fuzzy controller design, and fuzzy model discovery. It makes two contributions: first, compared to the corresponding ones, the current result is less conservative, and second, the matrix dimensions are significantly less. According to simulation studies, the suggested WBAN controller allows for more dependable performance in applications involving continuous bio-signal monitoring, including sleep monitoring.**

Keywords: **Wearable Body Area Network (WBAN), Biomedical applications, Bio signal monitoring, Branched Bus (BB) topology, Continuous Data Transmission (CDT) protocol, Low power consumption, Self-reconfigurability, Sugeno fuzzy model, Fuzzy controller design**

I.INTRODUCTION

Wireless sensor network technologies, with their various applications in healthcare, entertainment, travel, retail, industry, dependent care, and emergency management, among many other industries, have the potential to revolutionize our way of life. One method to accomplish this goal is to use wearable and implanted body sensor network systems. These systems are widely used in these fields to integrate consumer electronics with sensing technologies, enabling people to be watched while they go about their daily lives. Healthcare services including medical monitoring, memory improvement, appliance control, medical data access, and emergency communication can all be facilitated by body sensor network systems.

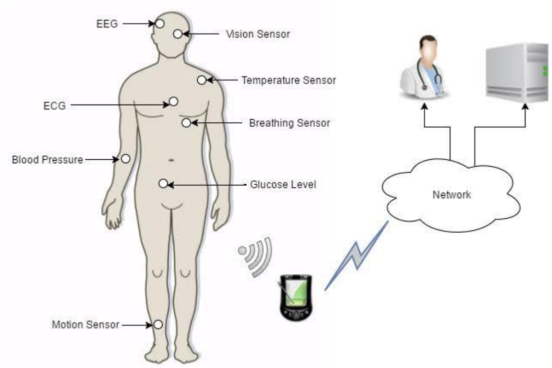

Fig:1. wireless body area sensor networks.

Wearable body area networks have become increasingly popular in biomedical applications recently. In these systems, a number of sensors are affixed to the human body in order to continuously monitor the bio signals of the patient. These bio signals include electrocardiography, electroencephalography, electromyography, and electrooculography. The data is then collected, managed, and stored in a controller. Since every device is portable, the most crucial factor in the application of WBAN is low power consumption. BAN nodes have numerous benefits because they are wireless, including mobility, interoperability, and connection [7]. Furthermore, stable contact between all electrodes is crucial for WBAN applications in the biomedical field since unstable electrode contact might result in undesired noise signals in addition to wire disconnection. Given that the human body is inherently flexible and prone to movement, which is more likely to cause electrode deformation than wire breakage, WBAN fault tolerance should also account for the appropriate reaction to an unstable electrode contact. Although a number of WBAN types have been studied up to this point for continuous healthcare applications, none of them take into account the reliable contact issue, which may be the primary cause of system failure. In addition to offering a wide range of healthcare services for persons with varying degrees of cognitive and physical disabilities, continuous monitoring using wearable and implantable body sensor networks will boost early detection of emergency illnesses and diseases in at-risk patients. These platforms will help families with working parents offer their infants and children with high-quality care services, in addition to the elderly and those with chronic illnesses.

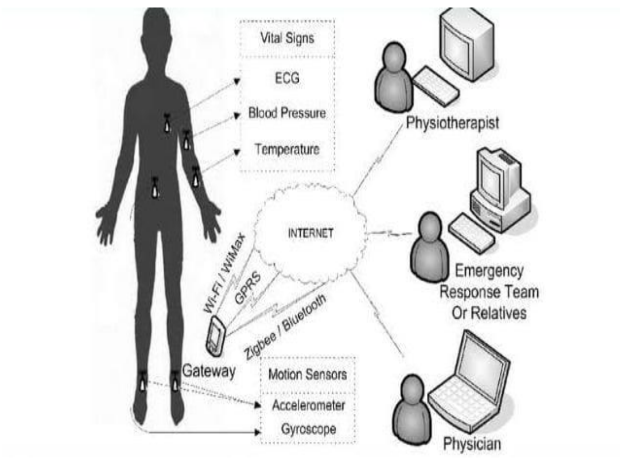

Fig:2. wireless body area sensor networks in health care applications

II. REMOTE SENSOR NETWORK

The number of different wearable health monitoring technologies has significantly increased during the past few years. These devices range from inexpensive implanted sensors [8] to basic activity monitors and pulse monitors [11]. Reliability, precision, adaptability, affordability, and ease of deployment are the core goals of sensor networks. The following is a summary of the salient features and advantages of wireless sensor networks:

Accuracy of sensing: When a greater number and diversity of sensor nodes are used, the information gathered may be more accurate than when information is obtained from a single sensor.

Coverage area: This suggests that a quick and effective sensor network could cover a larger area without having a negative effect on the total cost of the network.

Fault tolerance: To guarantee a certain degree of fault tolerance in each individual sensor, device redundancy and subsequently information redundancy might be used.

Connectivity: Sink nodes allow the current wired networks (like the Internet) to be connected to several sensor networks. Network clustering allows individual networks to concentrate on particular topics or occasions and exchange only pertinent data.

Minimal human interaction: Reducing human interaction increases the likelihood of fewer system disruptions.

Operational robustness in harsh environments: Sensor nodes with high degrees of fault tolerance and robust sensor design can be placed in difficult situations to increase the efficacy of sensor networks.

• Dynamic sensor scheduling: The ability of a sensor network to determine the priority of data transmission is implied by a scheduling scheme.

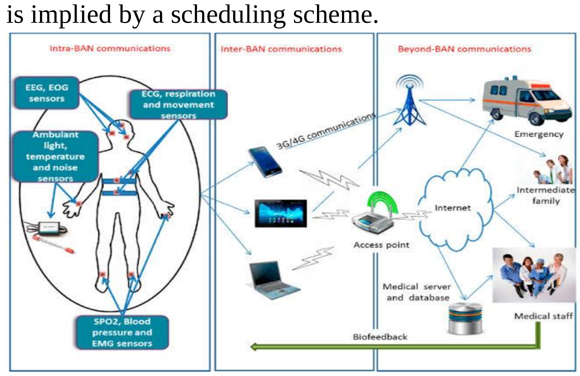

Fig:3 The general architecture of Wireless Body Area networks.

A.SENSOR TYPES

BANs are transformed into practical systems with clear objectives via sensors. The goal of utilizing sensors within or outside the body is to gather signals related to the user's physiological state or physical activity. Additionally, evaluations of the efficacy of a medicine and/or medication therapy can be made using the data they supply. The MCU of the sensor node receives data from sensors as analog or digital signals that can be processed right away. A new generation of wireless sensor networks appropriate for numerous applications has been made possible by recent technological advancements in wireless networking, micro-fabrication, embedded microcontrollers, and the integration and shrinking of physical sensors on a single chip. They can be utilized, for instance, in transportation infrastructure monitoring, machine health monitoring and guidance, and habitat monitoring [4]. Nevertheless, BAN requires two different kinds of hardware devices: plant monitoring in agriculture [6], pattern monitoring and navigation. Wearable technology is utilized on the outside of the body, whereas medical implants are placed inside the body.

III.WEARABLE WIRELESS BODY AREA NETWORK

Through continuous monitoring in an ambulatory setting, early detection of abnormal conditions, supervised rehabilitation, and potential knowledge discovery through data mining of all gathered information, WSN technology has the potential to offer a wide range of benefits to patients, medical staff, and society. Many low-cost, lightweight, and small sensor platforms with one or more physiological sensors, such as motion sensors, ECGs, EMGs, and EEGs, make up a typical wireless body area network. The tracking of a user's movements while walking is a typical example of this kind of application [15]. Wearable health monitoring systems give users the ability to closely monitor changes in their key functions and offer input on how to maintain optimal health. When life-threatening changes arise, these systems can notify medical staff if they are incorporated into the telemedicine system. Furthermore, patients might gain from ongoing, long-term monitoring as a component of a diagnostic process. We can monitor patients during the period of recuperation. A WBAN is created by carefully positioning several small wireless sensors within or on top of a patient's body [12].

IV. EXISTING SYSTEM

The current approach entails: Topology of buses and stars: Topology of buses: Every node in a bus architecture is connected to a single wire. A single bus cable connects every server or PC. When a signal from the source reaches its intended recipients, it flows in both directions to all machines linked to the bus wire. The machine ignores the data if the machine address does not match the intended address for the data. Alternatively, the data is accepted if it matches the machine address. Compared to other topologies, the bus topology is relatively cheap to implement because it only requires one wire. But the high cost of network management more than makes up for the low cost of technology implementation.

Furthermore, because there is only one wire used, it may be the single point of failure. The network will not function at all if the network cable is not terminated on both ends, data transfer stops, and the cable breaks. Star network topology: In a star topology network, every network host has a point-to-point link to a central hub. Every node in a star topologya computer workstation or any other peripheral is connected to a hub or switch, which is the center node. Peripherals are clients, while the switch is the server. To be called a star network, a network does not have to look like a star; instead, it only needs to have every node connected to a single central device. The central hub is where all network traffic travels through. The hub serves as a repeater for signals. The ease of adding more nodes is one benefit of the star topology. The hub's role as a single point of failure is the main drawback of the star architecture.

V.TDMA protocol

The full band width capacity of the TDMA protocol is shared in real time by M stations as a single channel. Even if a node is the only one with frames to send, it must always wait for its turn until its slot time arrives. In wireless sensor networks, time division multiple access is a popular MAC paradigm. TDMA-based solutions created a schedule in which a network-wide common frame is divided into one or more slots for each node. Each node is given a set time slot by TDMA protocols to send one message every frame.Nodes send during their designated slots and awaken to receive in their neighbor's slots. However, because a lengthy frame length is required to provide collision-free transmissions, TDMA-based protocols suffer from low channel utilization and significant message delay, which is especially problematic in dense wireless sensor networks.

Large power consumption, energy inefficiency, and the inability of either the bus or star topology to enable the shortest routing are the drawbacks of the current systems.

VI.PROPOSED SYSTEM

For wearable healthcare applications, a low power sugeno fuzzy model based WBAN controller with Branched Bus topology and Continuous Data Transmission protocol is suggested. The suggested method might be useful for creating fuzzy controllers and decision-making procedures. Additionally, the suggested WBAN controller permits more dependable operation in applications involving continuous bio-signal monitoring, including sleep monitoring.

The suggested system's advantage is its lower power consumption. By managing the sensors, it may also reduce the redundant power dissipation and make the network self-reconfigurable.

VII.FUZZY BASED SYSTEM

A static or dynamic system which makes use of fuzzy sets or fuzzy logic and of the corresponding mathematical framework is called a fuzzy system.

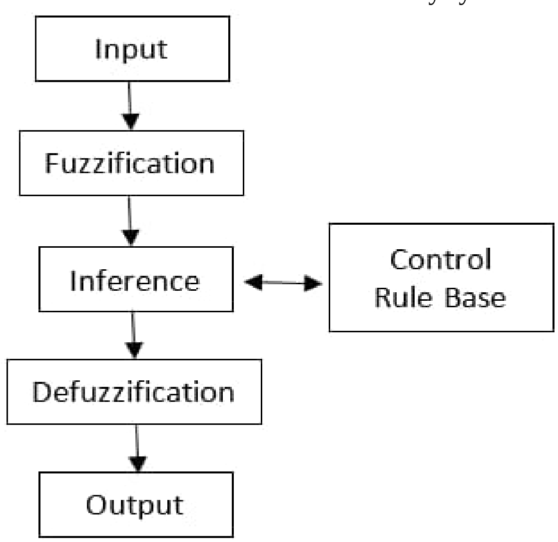

Fig:4: A generic fuzzy system with fuzzification and defuzzification units.

A probabilistic arrangement would first establish a scalar variable for the glass's fullness and then conditional distributions that would indicate the likelihood that a given fullness level would prompt someone to declare the glass full. But without acknowledging the possibility of certain events, like the glass getting halfway empty in a few minutes, this model makes no sense. It should be noted that either a distribution over deterministic observers, a singular observer who chooses the glass's label at random, or both can accomplish the conditioning. As a result, chance and fuzziness are two entirely unrelated notions that only appear similar on the surface due to their use of the same real number interval [0, 1].

Still, since theorems such as De Morgan's have dual applicability and properties of random variables are analogous to properties of binary logic states, one can see where the confusion might arise.

A. Applying truth values

A simple application could describe a continuous variable's subranges. An anti-lock brake temperature measurement, for example, may have multiple distinct membership functions specifying different temperatures.

B. Fuzzy logic:

Extending traditional (Boolean) logic to accommodate the notion of partial truthtruth values that fall between "completely true" and "completely false" is known as fuzzy logic. As the name implies, it is the approximate rather than exact logic that underlies styles of thinking.The majority of human reasoning, and particularly common sense reasoning, is approximate in nature, which makes fuzzy logic crucial. The following are the key elements of fuzzy logic as established by Zader Lotfi.

Exact reasoning is considered a limited instance of approximate reasoning in fuzzy logic.

- Everything in fuzzy logic is a matter of degree.
- Fuzzifying a logical system is possible.

The interpretation of knowledge in fuzzy logic is as a set of fuzzy or elastic constraints on a set of variables. It is believed that inference is the propagation of elastic constraints.

C. Fuzzification

Fuzzification is the process of changing a real scalar value into a fuzzy value. Basically, this operation translates accurate crisp input values into linguistic variables. In a number of engineering applications, it is necessary to defuzzify the result or rather "fuzzy result" so that it must be converted to crisp result. Fuzzification is done by recognizing various assumed crisp quantities as the non-deterministic and completely uncertain in nature. This uncertainty may be emerged because of imprecision and uncertain that lead variables to be presented by a membership function because they can be fuzzy in nature. Fuzzification translates the crisp input data into linguistic variables which are represented by fuzzy sets. After that, it applies the membership functions to measure and determine the degree of membership.

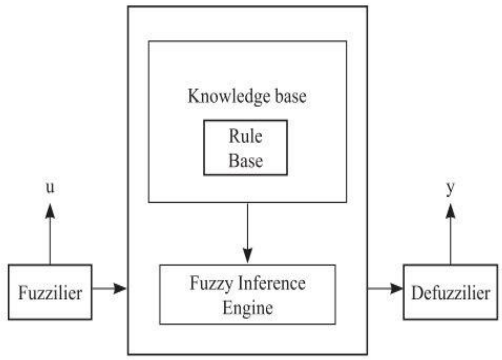

Fig:5 Fuzzy logic controller.

D. Fuzzy Sets

In 1965, Lofti Zadeh, a professor at the University of California, formalized fuzzy set theory. The proposal put forth by Zadeh represents a significant paradigm shift that was initially accepted in the Far East and has since been successfully implemented globally. A paradigm is a system of guidelines that establishes bounds and provides instructions on how to successfully solve issues inside them. A paradigm shift might be the creation of fuzzy set theory from traditional bivalent set theory, for instance, or the usage of transistors in place of vacuum tubes.

E. Fuzzy Rules

The decision and the means of choosing that decision are replaced by fuzzy sets and the rules are replaced by fuzzy rules. Fuzzy rules also operate using a series of if-then statements. For instance, if X then A, if y then b, where A and B are all sets of X and Y. Fuzzy rules define fuzzy patches, which is the key idea in fuzzy logic. A machine is made smarter using a concept designed by Bart Kosko called the Fuzzy Approximation Theorem. The FAT theorem generally states a finite number of patches can cover a curve as seen in the figure below. If the patches are large, then the rules are sloppy. If the patches are small then the rules are fine.

F. Defuzzification

Defuzzification may be defined as the process of reducing a fuzzy set into a crisp set or to convert a fuzzy member into a crisp member. Mathematically, the process of Defuzzification is also called "rounding it off". Defuzzification basically transforms an imprecise data into precise data. However, it is a relatively complex to implement defuzzification as compared to fuzzification. Defuzzification is basically the reverse process of fuzzification because it converts the fuzzy data into crisp data. In some practical implementations, the defuzzification process is required for crisp control actions to operate the control.

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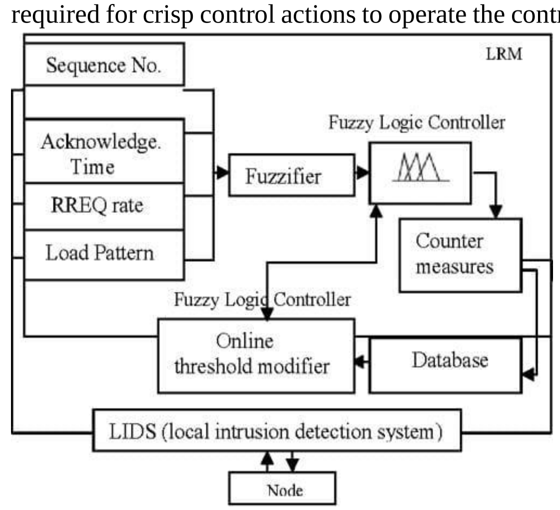

Fig: 6 Proposed fuzzy controller.

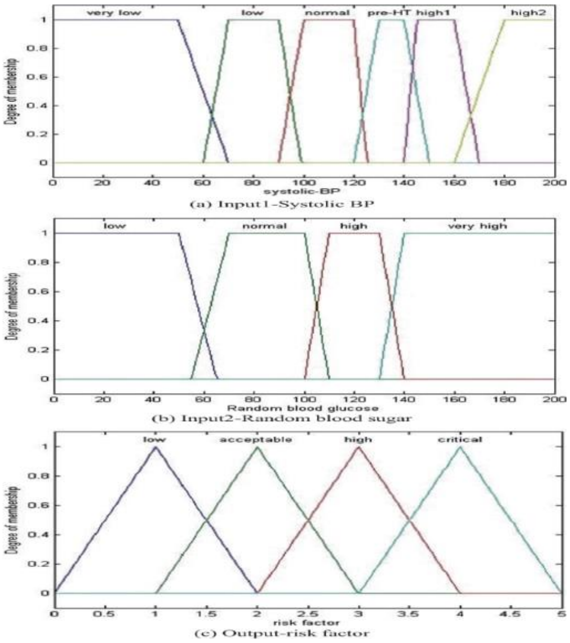

Fig:7 Fuzzification and Defuzzification in proposed fuzzy control method.

VIII.CONCLUSION

The most significant difference that you should note here is that fuzzification converts a precise data into imprecise data, while defuzzification converts an imprecise data into precise data. In this project, low power Sugeno fuzzy model based WBAN controller is proposed. In this work in addition to the leave detector and join detector fuzzy logic is added to the network controller. The proposed approach may help to designing fuzzy controller and decision-making process. It carries the ability of yielding a completely different input-output mapping by only introducing a new degree of freedom in parameters of fuzzy system design. The main controller is designed by Verilog HDL synthesis, and the leave and join detector is designed by full-custom process. When network leave is detected in the leave detector, the main network controller modifies the network configuration.

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