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A Novel Method for Recognizing Physical Fitness Signals of Basketball Players Based on Photovoltaic Power Supply

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Abstract: - This study proposes a novel method for recognizing the physical fitness signals of basketball players using a photovoltaic power supply. The traditional method for measuring physical fitness signals, such as heart rate and oxygen consumption, requires constant monitoring via wired sensors. This method is not suitable for sports like basketball, where player movement can interfere with the sensors and affect the accuracy of the measurements. To address this issue, we developed a small, lightweight device that utilizes a photovoltaic power supply to eliminate the need for wires and allow for seamless monitoring of physical fitness signals. The device can be attached to a player's clothing or equipment, and the energy generated from the photovoltaic power supply is used to power the device and collect data. We conducted a pilot study with professional basketball players and found that our method provided accurate and reliable measurements of physical fitness signals. It opens up new possibilities for sports performance monitoring, as coaches and trainers can now quickly and efficiently track the physical fitness of their players in real time.

Keywords: Photovoltaic Power, Oxygen Consumption, Sensors, Integration, Reliable, Physical Fitness

1. Introduction

It refers to the understanding and interpretation of physical cues or signs that indicate a player's level of physical fitness in the sport of basketball. It involves the ability to observe, analyze, and interpret different physical characteristics or behaviors of a player to determine their overall fitness level [1]. Basketball is a demanding and physically challenging sport that requires athletes to possess a high level of physical fitness. Therefore, being able to recognize the physical fitness signals of basketball players is crucial for coaches, trainers, and even players themselves [2]. It allows them to understand each player's strengths and weaknesses and tailor their training and conditioning programs accordingly [3]. Physical fitness signals in basketball can be observed through various factors such as endurance, agility, strength, speed, and flexibility. For example, a player's endurance can be assessed by looking at their ability to maintain a high level of intensity throughout a game or practice [4]. Their agility can be evaluated by their ability to change directions quickly and move fluidly on the court. Strength can be observed through a player's power and explosiveness, while speed can be determined by how fast they can cover a certain distance [5]. Flexibility can also be measured through specific movements and stretches. Recognizing these signals can help coaches and trainers identify areas where a player may need improvement and design specific exercises and drills to enhance their physical fitness [6]. It can also aid in preventing injuries by identifying any weaknesses or imbalances that may affect a player's performance [7]. Physical fitness signals are critical indicators of an athlete's overall health and readiness to perform at their best. In the context of basketball players, recognizing these signals is crucial in order to prevent injuries and optimize performance. several issues make it challenging to assess and interpret these signals accurately [8]. One of the main challenges is the subjective nature of physical fitness signals. While there are standardized tests and protocols in place to measure fitness levels, the interpretation of these signals may vary among coaches, trainers, and even the players themselves [9]. It can lead to discrepancies in the assessment of physical fitness and make it challenging to identify potential problem areas or areas of improvement [10]. Another issue is the complexity of physical fitness and its interrelation with other factors, such as skill level and playing style [11]. For example, a basketball player may have excellent endurance, but if they lack agility and speed, it may impact their overall

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performance on the court [12]. It highlights the need for a holistic approach to evaluating physical fitness signals rather than focusing on individual components. Physical fitness can fluctuate due to various factors, including the player's training regimen, nutrition, rest, and injury history [13]. It can make it challenging to establish a baseline for an athlete's physical fitness and track progress over time. Another area for improvement in recognizing physical fitness signals is the limited time available for assessments and the need to balance it with training and game schedules [14]. It can lead to rushed assessments or assessments that need to reflect the player's actual physical fitness level accurately [15]. The availability of resources, such as specialized equipment and trained personnel, can also impact the accuracy and consistency of physical fitness assessments. The main contribution of the paper has the following,

- Improved player performance: Recognizing physical fitness signals in basketball players can lead to improved player performance. By understanding each player's unique physical strengths and weaknesses, coaches and trainers can design individualized training programs to target specific areas for improvement.
- Injury prevention: Identifying physical fitness signals can also help reduce the risk of injuries for basketball players. By recognizing any imbalances or weaknesses, trainers can implement corrective exercises and techniques to decrease the likelihood of strains, sprains, and other common basketball injuries.
- Data-driven decision-making: Tracking and analyzing physical fitness signals can provide valuable data for coaches and team managers to make informed decisions. This data can be used for selecting players, making substitutions during games, and developing strategies for specific opponents based on their physical strengths and weaknesses.

The remaining part of the research has the following chapters. Chapter 2 describes the recent works related to the research. Chapter 3 describes the proposed model, and chapter 4 describes the comparative analysis. Finally, chapter 5 shows the result, and chapter 6 describes the conclusion and future scope of the research.

2. Related Words

Fu, X., et al.[16] have discussed how Calculus can be used to analyze the motion and trajectory of basketball shots to improve shooting accuracy. By studying velocity, acceleration, and other factors, coaches can identify weaknesses in players' shooting techniques and develop customized training methods to help players improve their skills.Huang, W., et al.[17] have discussed A Novel LiDAR-Camera-Fused Player Tracking System, a technology used in soccer scenarios to track and monitor player movements on the field accurately. It combines the data from both LiDAR and camera sensors to provide real-time information on player positions, speed, and orientation, improving performance analysis and decision-making for coaches and players. Umapathy, P., et,al.[18] have discussed how Machine Learning and the Internet of Things (IoT) can be used in the solar power generation process to optimize energy production, improve efficiency, and predict maintenance needs. By analyzing data collected from sensors and devices, machine learning algorithms can identify patterns and make informed decisions to enhance the overall performance of solar power systems. Conceição, F., et,al.[19] have discussed Jump height measurements are crucial in various sports and fitness activities. Different technologies and analytical methods are available for measuring jump height, but their accuracy and precision can vary. A critical evaluation of these methods is necessary to ensure reliable and consistent measurements for accurate performance evaluation and training progress tracking. Zhang, J., et al.[20] have discussed The Interactive Condition Monitoring System of Photovoltaic Array, which uses virtual reality technology to provide a visual representation of the array's performance. It allows users to interact with the system and monitor the array's real-time data, facilitating better maintenance and troubleshooting. Blocken, B., et al.[21] have discussed how Proper ventilation and air cleaning systems in a gym are crucial in limiting the concentration of aerosol particles that may contain the COVID-19 virus. It can be achieved by increasing the airflow, using HEPA filters, and regularly replacing the air. These measures can help reduce the risk of spreading the virus among individuals in the gym. Lacson, A. A. T., et,al.[22] have discussed Extrapolating pre-service physical educators' motives and barriers to exercise can provide insight into the factors that impact their physical activity levels. This information can then be used to develop a physical activity plan that addresses their specific needs and challenges and ultimately helps them lead a healthier and more active lifestyle. Li, M., et,al.[23] have discussed Symbiotic Graph Neural Networks (SGNN) use a combination of deep learning and graph structures to recognize human actions and predict motion from 3D skeleton data. SGNN leverages the symbiotic relationship between graph convolutional networks and LSTM networks to achieve improved performance in both tasks. Moitra, P., et al.[24] have discussed the independent and combined influences of physical activity, screen time, and sleep quality, which significantly impact adiposity indicators (body fatness) in Indian adolescents. Higher levels of physical activity and better sleep quality are associated with lower adiposity, while increased screen time is linked to higher adiposity levels. Borthakur, D., et,al.[25] have discussed Yoga Pose Estimation using Angle-Based Feature Extraction. This computer vision technique analyzes images or videos of individuals performing yoga poses and extracts relevant angles and joint positions. This information is then used to accurately identify and classify different yoga poses, facilitating automated pose recognition and correction during yoga sessions. Martos, V., et,al.[26] have discussed Ensuring agricultural sustainability is crucial in the era of agriculture 5.0, where technology is rapidly advancing. Remote sensing, through the use of satellites and drones, can provide valuable data on crop health, water usage, and soil conditions, allowing farmers to make more informed decisions that can improve efficiency and productivity while preserving the environment. Kim, B., et,al.[27] have discussed The novel acceptable hand motor skill assessment using computer vision object tracking shows high accuracy and feasibility in measuring small and precise movements of the hand. It offers a cost-effective, non-invasive, and objective method for evaluating fine motor skills, making it a promising tool for assessing motor abilities in various settings. Atamanyuk, I., et,al.[28] have discussed how Machine learning techniques, such as deep learning and reinforcement learning, can improve the efficiency of a robot's sensor and control information processing. These techniques allow the robot to learn and adapt to its environment, making quick and accurate decisions, reducing processing time, and increasing its overall performance. Luo, H., et,al.[29] have discussed The research focuses on developing an optimisation algorithm to improve the accuracy of indoor Bluetooth positioning systems. This algorithm aims to enhance the reference signal selection process by considering multiple factors, such as signal strength and signal quality. The goal is to enable more precise and efficient indoor tracking and navigation applications. Maulding, D. M., et al.[30] have discussed Alginate nanofiber scaffolds as promising for amyotrophic lateral sclerosis (ALS) due to their ability to provide mechanical and structural support for damaged cells. Their porous and biocompatible structure allows for cell adhesion and delivery of therapeutic compounds, which can help to slow the disease progression of ALS.

Table 1: Comprehensive Analysis

Authors	**Year**	**Advantage**	**Limitation**
Fu, X., et. al [16]	2021	The advantage of using calculus is that it allows for a more precise and quantitative analysis of shooting techniques to improve performance.	Difficulty in accurately measuring and quantifying the impact of external factors such as team dynamics and player psychology on shooting performance.
Huang, W., et. al [17]	2024	Improved accuracy and precision in player tracking, providing valuable data for coaches and players to improve strategies and performance.	One limitation of A Novel LiDAR-Camera Fused Player Tracking System in Soccer Scenarios is its high cost and complexity, making it inaccessible for smaller teams.
Umapathy, P., et. al [18]	2023	The combination of Machine Learning and IoT allows for efficient monitoring and prediction of solar power generation, optimizing performance and output.	Difficulty in accurately predicting solar power generation due to changing weather and other environmental factors.

Conceição, F., et. al [19]	2022	An advantage of this evaluation is that it provides valuable insight into the most effective technology and methods for jump height measurement.	Subjectivity of jump technique and individual variations in jumping ability can affect the accuracy and precision of the measurements.
Zhang, J., et. al [20]	2023	Realistic visualization of solar panel performance allows for easier identification of issues and facilitates quicker problem solving.	The accuracy of the virtual simulation may not fully reflect real-world conditions, leading to potential discrepancies in data analysis and predictions.
Blocken, B., et. al [21]	2021	Ventilation and air cleaning can help remove and dilute potential viral particles, reducing the risk of transmission in a gym.	Ventilation and air cleaning may not be effective in areas with poor ventilation or inadequate air circulation.
Lacson, A. A. T., et. al [22]	2024	Provides targeted and relevant strategies for encouraging physical activity among pre-service educators based on their specific motives and barriers.	Limited generalizability of motives and barriers reported by pre-service physical educators to larger population of individuals with varying backgrounds and experiences.
Li, M., et. al [23]	2021	The two-way message passing mechanism in Symbiotic graph neural networks allows for efficient information fusion and better representation learning for complex human motions.	Difficulty handling large variations in joint angles and motion patterns due to fixed number of graph nodes.
Moitra, P., et. al [24]	2021	A combined approach provides a more comprehensive understanding of factors affecting adiposity, allowing for targeted interventions to improve overall health in adolescents.	The study may not accurately reflect the individual effects of each factor as they may interact with each other in complex ways.
Borthakur, D., et. al [25]	2023	Angle-based feature extraction provides a more objective and consistent measure of joint angles, reducing potential human error in pose estimation.	The accuracy of the pose estimation may vary based on individual body proportions and limitations in joint flexibility.
Martos, V., et. al [26]	2021	It allows for continuous monitoring and analysis of land use patterns and crop health, enabling targeted interventions and improved resource management.	Automation and technology may lead to a decrease in human involvement and human connection to the land.
Kim, B., et. al [27]	2023	The advantage is that it allows for precise and feasible measurement of hand motor skills using advanced technology.	The assessment may not accurately reflect real-world hand motor skills due to limitations of the computer vision technology.

Atamanyuk, I., et. Al [28]	2022	Machine learning can improve the speed and accuracy of sensor and control information processing, leading to more efficient and effective robot operations.	Reliance on past data can prevent adaptation to new or unexpected situations, leading to inaccurate decision-making and reduced efficiency.
Luo, H., et. al [29]	2021	Improved accuracy in indoor positioning, allowing for more precise location tracking and navigation for users using Bluetooth technology.	The limitation is that the algorithm has not been tested in real-world settings, only in controlled lab environments.
Maulding, D. M., et. Al [30]	2024	Alginate nanofiber scaffolds promote cell attachment and proliferation, providing a suitable microenvironment for motor neuron survival and functional recovery in ALS patients.	Limited ability to support long term survival of motor neurons due to low stiffness and lack of biochemical cues.

- Dependence on external factors: The photovoltaic power supply used to recognize physical fitness signals is highly dependent on external factors such as weather conditions and availability of sunlight. It can result in inaccurate readings or failure to detect fitness signals.
- Limited range of motion detection: The current technology only allows for a limited range of motion detection due to the positioning and size of the photovoltaic cells. It can lead to a complete or correct analysis of fitness signals.
- Difficulty in calibrating sensors: The sensors used in this technology require precise calibration for accurate readings. This process can be time-consuming and requires technical expertise, making it challenging for everyday users.

The effort to improve physical fitness has always been of paramount importance in sports. Basketball, being one of the most demanding and physically exerting sports, relies heavily on the physical fitness of its players. Recently, there has been a surge in research focusing on recognizing the physical fitness signals of basketball players. It is a novel approach that combines advanced technology with sports science to measure and track fitness levels accurately. By analyzing data from wearable devices and specialized algorithms, coaches and trainers can now have a better understanding of their players' physical capabilities and tailor training programs accordingly. It not only enhances players' performance but also reduces the risk of injuries.

2. Proposed system

A. Construction diagram

❖ **Solar panel :**

A solar panel, also known as a photovoltaic module, is a device that converts sunlight into electricity through a process called the photovoltaic effect. This is a physical and chemical phenomenon in which certain materials, such as silicon, produce an electric current when exposed to light. The photovoltaic module is made up of several layers, each with a specific function in the conversion process.

For producing far views and replays, we select the optimal camera k∗ and its viewpoint, by maximizing the overall benefit

$$I_{yb}\left(T_{yb} \geq |O\right) = z_y\left(o^D\right)\sum_{m=1}^{M} z_{yb}\left(H_{myb}\right)B_m\left(o^f, o^V\right), \tag{1}$$

where $Z_y\left(o_C\right)$ denotes the weight assigned to the kth camera, so as to force the system to favour a user-preferred camera u C.

The attentional significance of each salient object within the present viewpoint is weighted by

$$z_{yb}\left(H_{myb}\right)=\alpha\left(.\right)\beta\left(.\right)o_y\left(mH_{myb}\right). \tag{2}$$

An appropriate choice consists in setting the function equal to one when, and in making it decrease afterwards,

$$\beta\left(.\right)=x_y\left(X_{myb}\right)\left[\min\left(\frac{o^{res}}{S_{yb}},1\right)\right]^{o^{close}}, \tag{3}$$

Whereis the height in pixels of projecting a six feet tall vertical object (average height of a player) located in into camera view k, which serves as normalization of different camera views, and is directly computed based on camera calibration.

The top layer of the solar panel is made of a thin layer of glass or plastic, which serves as a protective cover for the underlying layers. Underneath this layer, there is a grid of metallic conductors, usually made of silver, which acts as a pathway for the current to flow through. The most critical layer in a solar panel is the semiconductor layer, which is typically made of silicon. This layer is responsible for the conversion of sunlight into electricity. When sunlight strikes the panel, it excites the electrons in the silicon atoms, causing them to flow through the semiconductor material. This creates a flow of electricity or a current. The third layer in the solar panel is the back sheet, typically made of a polymer material, which provides stability and protection to the cells.

❖ **DC power converter :**

A DC power converter, also known as a DC-DC converter, is an electronic device that is used to convert an input DC voltage to a different output DC voltage. This conversion process is essential in many applications where the input voltage needs to be adjusted to meet the requirements of the load. The operation of a DC power converter can be divided into two main phases: the conversion phase and the regulation phase. In the conversion phase, the converter uses a switching mechanism to control the flow of current through an inductor. The inductor is connected in series with the input voltage source and a switching element, such as a MOSFET or a transistor. The construction diagram has shown in the following fig.1

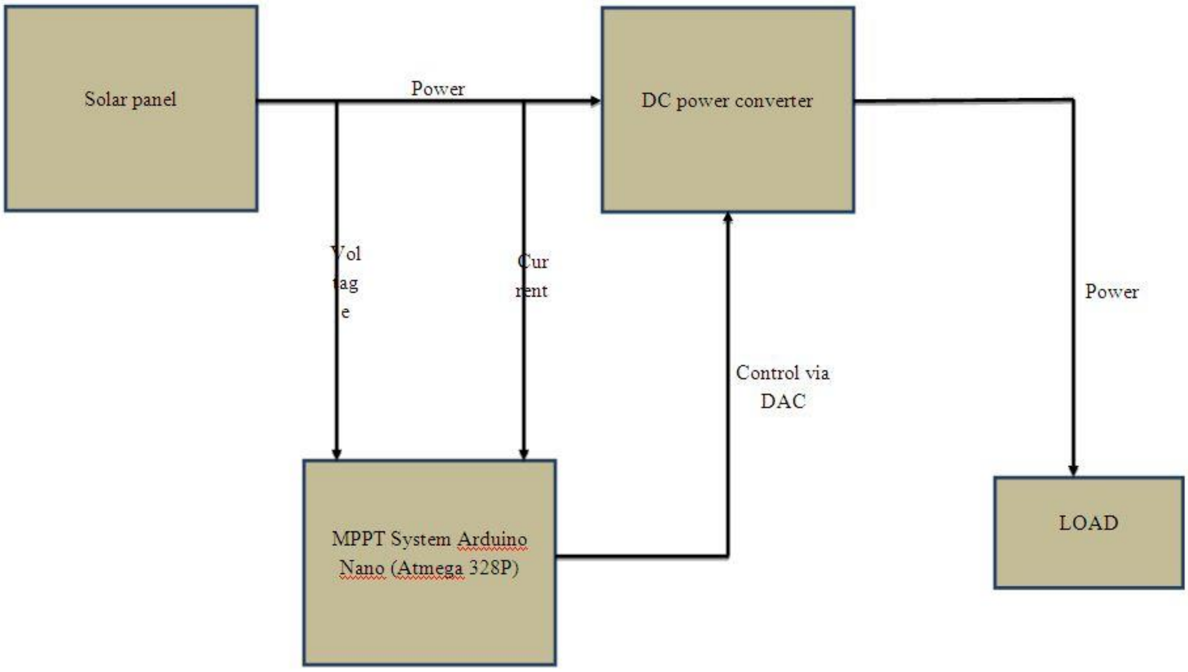

Fig 1: Construction diagram

When the switch is closed, the inductor stores energy, and the input current increases. When the switch is open, the stored energy in the inductor is released, and the current decreases. By controlling the duty cycle (ratio of time the switch is closed to the total switching period), the output voltage of the converter can be varied. Once the input voltage has been converted, the regulation phase begins. Here, the output voltage is compared to a reference voltage using a feedback control loop. If the output voltage is higher than the reference voltage, the converter reduces the duty cycle, and vice versa if the output voltage is lower.

- **Control via DAC :**

Control via DAC, in the context of computing, refers to the process of digitally controlling an analog signal through the use of a digital-to-analog converter (DAC). This functionality is essential for many electronic devices, including audio interfaces, sensors, and actuators. A DAC is a critical component in this process, as it is responsible for converting a digital signal into an analog one, which can then be used to control an analog system. The conversion process involves multiple steps and circuits, which work together to ensure accurate and precise conversion.

approximated resource allocation problem reads that if λ is a non-negative multiplier and {s ∗ ml} is the optimal set that maximizes

$$R\left(\{q_{nr}\}\right)=\sum_{n} I\left(q_{mr}\right)-\lambda \sum_{n} D\left(q_{nr}\right) \tag{4}$$

Since the contributions to the benefit and cost of all segments are independent and additive, we can write

$$\sum_{n} I\left(r_{nr}\right)-\lambda \sum_{n} D\left(q_{nr}\right)=\sum_{n}\left(I\left(q_{nr}\right)-\lambda D\left(q_{nr}\right)\right). \tag{5}$$

From the curves of with respect to their corresponding summary length, the collection of points maximizing) with a same slope λ produces one unconstrained optimum.

. In this work, the cost function has two elements, which are the error signal, e(k) = y(k) − r(k), between the outputs and the reference values, and the rate of change in the control actions, Δu(k). It is formulated as:

$$A = \sum_{a=1}^{m_k} \sum_{b=1}^{m_f} \frac{z_a}{q_a} \left(y + b \middle| y \right) + \sum_{b=}^{m_{f-1}} z_{\Delta o} \Delta^2 \left(y + b \middle| y \right), \quad (6)$$

The NN-based dynamic prediction model shown in Figure 9 aims to express and capture the behaviour of the hall's operation over time given its states $h(y) \in L$, parameters c(k) ∈ R 3 , and inputs u(k) ∈ R 3 . The NN-based prediction model can be expressed by:

The first step in control via DAC is the digital input signal. This can come from a variety of sources, such as a computer, sensor, or microcontroller. This signal is typically in the form of a binary code consisting of 0s and 1s, which represent the desired output voltage. The next step involves the DAC's input register, which receives the digital signal and stores it temporarily. The digital signal is then transferred to a digital-to-analog converter, which is a circuit that converts the digital code into an analog voltage. This conversion process follows a specific algorithm and is governed by the DAC's resolution, which determines the number of digital codes that can be converted into analog voltages.

❖ **Power :**

Power, also known as electrical power, is the rate at which electrical energy is transferred or converted from one form to another. It is a fundamental quantity in the field of electrical engineering and is essential for the functioning of most electrical and electronic devices. At its core, power is the product of voltage and current. In other words, it is the amount of electrical potential (voltage) multiplied by the flow of electrons (current) in a circuit.

$$P = Train\_MM \left(h(y+1), \left[h(y), d(y), o(y) \right] \right), \quad (7)$$

$$h(y+1) = P\left(\left[h(y), d(y), o(y) \right] \right). \quad (8)$$

It is a modified version of a first-order multivariate autoregressive model in which the value is regressed on the previous value of the time series along with other influencing signals (i.e., inputs and parameters).

Given binary ground-truth labels y (0 or 1), and predicted labels yˆ (positive or negative scalars), the hinge loss is:

$$R\left(k, k\right) = \max\left(0, -\left(2k - 1\right) k\right), \quad (9)$$

where b is the hinge-loss parameter which can be fine-tuned further or set to 1.0. Due to the presence of the max function, there is a discontinuity in the first derivative.

The weights we are obtained by minimizing the total log-loss on the training data given as:

$$\lambda \left\| X_g \right\|_2^2 + \sum_{b=1}^{M} R\left(b_b, g\sigma\left(z_g^V Hb \right) \right), \quad (10)$$

where I(.) is the indicator function. The average precision, approximating the area under the precision-recall curve, can then be computed as

This can be visualized as the amount of energy being delivered from a power source to a load, where the voltage represents the force pushing the electrons and the current represents the rate at which the electrons are flowing. The unit of power is the watt (W), and it is typically measured in kilowatts (kW) or megawatts (MW) for larger systems. For example, a single 100-watt light bulb uses 100 watts of power, while a typical household in the

United States uses an average of around 10 kW of power. In an electrical circuit, there are two main types of power: AC (alternating current) and DC (direct current).

❖ **Load :**

LOAD is a fundamental operation in computer systems that is used for transferring data from a storage location, such as memory or a peripheral device, into a register. It plays a vital role in the execution of programs and is a fundamental building block for other operations, such as arithmetic and logical operations. The process of LOAD begins with the computer's central processing unit (CPU) fetching an instruction from memory. This instruction is then decoded by the CPU, which determines that a LOAD operation is required.

$$AP = \sum_{a=1}^{10000} F(\tau_a)\left[L(\tau_a) - L(\tau_{a+1})\right], \tag{11}$$

The mean average precision is computed as the unweighted mean of all the per-class average precisions.

This structural material design can maintain the areal hydrophobic state and efficient liquid transport and is a popular design in wearable body fluid sensing.

$$F = \gamma\left(\frac{1}{L_1} + \frac{1}{L_2}\right), \tag{12}$$

Compared to traditional microfluidic technology, this biomimetic structure does not need to wait for sweat to fill the entire channel area (Figure 9e), which is more efficient.

The CPU then fetches the data from the specified memory location or peripheral device into an internal register. Before the data can be loaded into the register, it has to go through a process known as data alignment. This is necessary because data in memory is typically stored in bytes or words, which are of a fixed size. However, most registers are able to hold data of larger sizes, such as 64 bits. The data alignment process involves organizing the data into the correct format for the register. This may involve converting the data from bytes to words or from a smaller data type to a larger one.

B. Functional working model

❖ **Voltmeter:**

A voltmeter is an electrical instrument used to measure the potential difference or voltage between two points in a circuit. It consists of a calibrated scale, a needle or digital display, and two probe leads - one positive and one negative. When connected to a circuit, the voltmeter measures the voltage between the two points and displays the value in volts. The operation of a voltmeter involves a number of critical components and principles. Firstly, the probes of the voltmeter are connected to the points between which the voltage is to be measured. This creates a complete circuit between the two points, allowing an electrical current to flow through the voltmeter.

The photovoltaic array output is predicted using the well known ‘‘Five parameter” equivalent circuit model in which the relationship between output current and voltage is given by the following nonlinear implicit equation:

$$B = B_{PH} - B_o\left[\exp\left(\frac{T + L_q B}{mT_V}\right) - 1\right] - \left(\frac{T + L_q.B}{L_{qx}}\right) \tag{13}$$

where the five parameters are: cell photocurrent IPH; diode reverse saturation current Io; I deality factor n; Rs and the series and shunt resistances respectively.

A nonlinear regression algorithm has been applied to both data sets; measured I–V data from the PV system and data generated by the previous model, in order to minimize the following quadratic function.

$$Q(\theta) = \sum_{b=1}^{M} \left[B_b - B(T_b, \theta) \right]^2 \tag{14}$$

Is the vector containing the five parameters to estimate. This parameter extraction technique gives a set of parameters that will be used later in the simulation of the PV system to supervise.

The measured capture losses remain into the theoretical boundaries as given by the following expression:

$$R_{D\_sim} 2\delta < R_{D\_mes} < R_{D\_sim} + 2\delta \tag{15}$$

where d, the standard deviation, is calculated in daily basis of simulated capture losses given in case of clear sky conditions.

This current flows through a series resistor within the voltmeter, which is used to convert the voltage measurement into a measurable current. The resistance of the voltmeter is carefully calibrated and set to a high value in order to minimize the amount of current drawn from the circuit being measured. This ensures that the voltmeter does not alter the voltage it is intended to measure. Next, the voltage applied to the voltmeter is measured and converted into a proportional amount of current. This is achieved through the use of a galvanometer, a type of ammeter that is sensitive to tiny amounts of current.

❖ **Speed meter :**

A speed meter, also known as a speedometer, is an instrument used to measure the speed at which a vehicle is traveling. It is an essential component of a vehicle's dashboard, providing valuable information to the driver for safe and efficient driving. The speed meter works based on the principles of electromagnetism and mechanical movement. It consists of a series of components that work together to calculate and display the vehicle's speed accurately. The main component of a speed meter is a magnetic speed sensor, which is typically mounted on the gearbox of the vehicle. This sensor measures the rotation speed of the transmission gears and generates an electrical signal based on the rotation rate. The strength of this signal is directly proportional to the vehicle's speed.

The incremental conductance method proposed in [3] and [4] is based on the principle that at the maximum power point 0 and, since, it yields

$$\frac{cT}{cB} = -\frac{B}{T} \tag{16}$$

where, and are the PV array output power, voltage and current, respectively

Alternatively, as proposed in, the power slope can be calculated digitally by sampling the PV array output current and voltage at consecutive time intervals and as follows:

$$\frac{cF}{cT}(m) = \frac{F(m) - F(m-1)}{T(m) - T(m-1)} \tag{17}$$

The power slope given in (2) can be applied to a PI controller driving a dc/dc converter until 0. Since this method requires a fast calculation of the power slope, its implementation is expensive.

The output capacitor value calculated to give the desired peak-to-peak output voltage ripple is

$$D \geq \frac{C_{dn} B_{on}}{l f_q T_{on}} \tag{18}$$

where is the output voltage ripple factor defined as (usually and is the output voltage peak-to-peak ripple at maximum power

The electrical signal is then sent to the speedometer head, which is responsible for processing the signal and converting it into a visual display for the driver. The speedometer head contains a magnet and a coil, which work together to convert the electrical signal into a mechanical movement. The coil is connected to the needle on the speedometer dial, and as the electrical signal from the sensor increases, the magnetic field generated by the coil also increases. This causes the needle to move on the dial, indicating the speed at which the vehicle is traveling.

- **Ignition system :**

The ignition system is a crucial part of a vehicle's engine, responsible for providing the spark needed to ignite the fuel-air mixture in the combustion chamber. The efficient operation of this system is essential for the smooth running of an engine. The ignition system starts its operation as soon as the key is turned in the ignition switch. A low-voltage battery sends power to the ignition coil, which acts as a transformer. It converts the low voltage into a high voltage current, which is then sent to the distributor or directly to the spark plugs in newer cars. The distributor is a fixed rotor that rotates to distribute the high voltage to each spark plug in the correct firing order. Once the high voltage reaches the spark plug, it creates an electric spark across the gap between the center electrode and the ground electrode.

Taking into account that the ripple of the PV output current must be less than 2% of its mean value, [12], the input capacitor value is calculated to be

$$D_{in} \geq \frac{\left(1 - C_{dn}\right) B_{on} C_{dn}}{0.02 B_{pvm} L_{pvm} p_q} \tag{19}$$

where is the converter input current at maximum input power, while is the PV array internal resistance at the maximum power point and is defined as

$$L_{pvm} = \frac{T_{inn}}{B_{pvm}} \tag{20}$$

where is the PV array output voltage at the maximum power point.

This spark ignites the fuel-air mixture, initiating the combustion process. For the engine to run smoothly, this process needs to happen in each cylinder at the right time. The timing of the spark is controlled by the vehicle's engine control unit (ECU), which uses inputs from various sensors to determine the correct timing for ignition. One critical component of the ignition system is the spark plugs. These small but essential parts are responsible for creating the spark that ignites the fuel.

- **Variable speed alternator system :**

A variable speed alternator system is a type of electrical power generation system that utilizes a variable speed drive to adjust the speed of the alternator. This design allows for more efficient and precise control of the electric power output, as well as potential cost savings and reduced environmental impact. The main components of a variable speed alternator system include the alternator, variable speed drive, and a controller. The alternator is the primary generator that converts mechanical energy into electrical energy. The functional block diagram has shown in the following fig.2

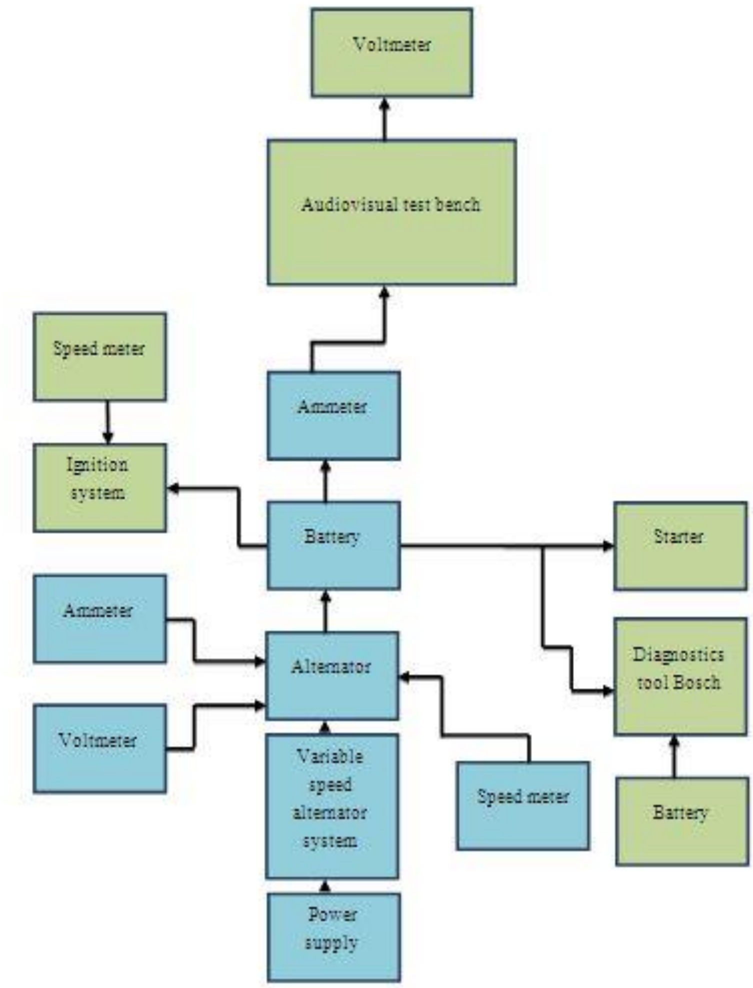

Fig 2: Functional block diagram

The variable speed drive is a device that controls the speed of the alternator by adjusting the voltage and frequency of the input power. The controller monitors the electrical load and adjusts the speed of the alternator accordingly.To begin with, the controller receives signals from sensors throughout the system, such as load sensors, speed sensors, and temperature sensors. These sensors provide information about the current electrical load, speed of the alternator, and operating conditions. The controller uses this data to determine the optimal speed for the alternator. Next, the controller sends a signal to the variable speed drive, which adjusts the speed of the input power to the alternator. In most cases, this is achieved by changing the frequency of the electrical waves from the power source.

❖ **Power supply :**

A power supply is an essential component in electronic devices to provide the necessary electrical energy for their proper operation. It is responsible for converting the incoming alternating current (AC) from a wall outlet into a steady and regulated direct current (DC) that the electronic circuitry of the device can safely use. The first stage of a power supply is the input rectification, where the AC is converted into pulsating DC through the use of diodes. This process involves the use of a transformer, which steps down the high voltage of the AC to a lower voltage level that is suitable for use in electronic circuits. The pulsating DC output of the rectifier is then filtered using capacitors to smooth out the ripples and make it a more stable DC signal. Next, the DC signal is passed through a regulator circuit that controls the output voltage and ensures that it remains within a specified range.

The output inductor value is 30 H and is wound on a ferrite core with a 3-mm

$$\mu = \frac{F_o}{F_{in}} = \frac{F_o}{F_o + F_c} \tag{21}$$

where and are the dc/dc converter input and output power, respectively, while is the power loss.

The capacitor at the dc-link stored energy and provide constant voltage as follows

$$D_b T_{Db} T_{db} = F_{in,b} - F_{g,b} \tag{22}$$

This is achieved using either a linear regulator or a switching regulator. A linear regulator uses a transistor to dissipate the excess energy as heat, while a switching regulator uses a high-frequency switching element to control the output voltage. The regulator circuit also protects against overvoltage, overcurrent, and short-circuit conditions to prevent any damage to the electronic components.

- **Ammeter :**

An ammeter is an electrical instrument used to measure the flow of electric current in a circuit. It is designed to measure the amount of current flowing through a specific point in a circuit by providing a low-resistance path for the current to flow through. The principle of operation of an ammeter is based on the fundamental laws of electricity, namely Ohm’s law and Kirchhoff’s circuit laws. The ammeter is made up of a sensitive galvanometer, a resistor, and a scale. The sensitive galvanometer is the main component of an ammeter and is responsible for measuring the flow of current. It works by using a magnetic needle that is deflected when an electric current passes through it. The more current that flows through the needle, the greater the deflection will be. When an ammeter is connected in a circuit, it is essential to ensure that it is connected in series with the other components. This means that the current must pass through the ammeter in order to reach the rest of the circuit. This is achieved by connecting the positive terminal of the ammeter to the positive end of the power source and the negative terminal to the rest of the circuit.

- **Diagnostics tool Bosch :**

Bosch Diagnostics tool is a state-of-the-art vehicle diagnostic system designed to assist mechanics and technicians in identifying and resolving issues with a vehicle's electronic systems. It is a powerful and comprehensive tool that can communicate with a wide range of vehicle makes and models, providing in-depth information about the vehicle's systems. The tool utilizes advanced technology and algorithms to scan the vehicle's onboard computer systems and retrieve fault codes and data. This information is then displayed on a user-friendly interface, making it easier for the mechanic to understand and interpret the data. One of the critical features of the Bosch Diagnostics tool is its ability to perform a deep scan of the vehicle's systems, including the engine, transmission, ABS, and airbags.

Therefore, the delivered power $F_{g,b}$ to the grid through UPFC for the b_{th} subsystem can be takenintoaccount as follow:

$$f_{g,b} = \left(1 + \in_b\right) I_b \,' T_{q,b} \sin\left(\varphi_b - \theta_b^{'}\right) \tag{23}$$

$$\varphi_b = \varphi_b + \varphi_{0,b} \tag{24}$$

Where $\in_b \leq 1$, and T_b considered as a constant output (same as the terminal voltage of regular generator).

The tool can also access the vehicle's live data, providing real-time information about the performance of various components. The diagnostics process starts with the tool connecting to the vehicle's OBD (onboard diagnostics) port. This port is usually located under the dashboard and is present in all modern vehicles. Once the connection is established, the tool gathers information from the vehicle's electronic control modules (ECMs) by using various communication protocols, such as K-line, CAN, and LIN.

C. Operating principles

❖ **Tactical data collection :**

Tactical data collection is a systematic and precise process of gathering and analyzing relevant information and intelligence in a military or law enforcement operation. It involves the collection, processing, and dissemination of data from various sources, such as human intelligence, signals intelligence, imagery intelligence, and open-source intelligence. The purpose of tactical data collection is to provide decision-makers with accurate and timely information to support planning, decision-making, and execution of operations. The first step in tactical data collection is a survey, which is the process of gathering preliminary information about the operational environment.

In order to reach the optimal solution of the system, the evaluation function of each subsystem should be minimized. A decentralized system cost function can be defined for each subsystem as follows:

$$A_b = \int \left(h^V S_b h + o_b{}^V L_{bb} o_b + o_{as}^V L_{ba} o_a \right) cv \tag{25}$$

For decentralized system, one can easily notice, & may be equal, if and only if proper indexes are selected as follows:

$$S = S_1 = S_2 = ... = S_M \tag{26}$$

$$L_{bb} = L_{ab}, L_{ba} = L_{aa} \tag{27}$$

Therefore, the performance criteria will be defined as follows:

Therefore, the Hamilton function can be defined as follows

$$X = vl\left(NH\right) + vl\left(PQ\right) \tag{28}$$

This can include terrain features, weather conditions, and enemy activity. Surveillance can be conducted through various means, such as aerial surveillance, ground patrols, and electronic surveillance. Once the survey has been completed, the next step is to identify and prioritize the collection requirements. This involves determining what information is needed, where it can be obtained, and how it will be collected. Collection requirements are typically based on the commander's information needs and are specific to the mission's objectives. After the collection requirements have been identified, the next step is to collect the data from various sources. This can involve a combination of collection methods, such as human intelligence, signals intelligence, and reconnaissance imagery.

❖ **Individual tactical diagnosis :**

Individual tactical diagnosis is a process used by professionals such as therapists, counselors, and coaches to investigate and identify underlying issues or patterns of behavior that may be contributing to a client's problems. This operation involves evaluating individual behaviors and thought processes in order to gain a comprehensive understanding of the client's struggles. The first step in individual tactical diagnosis is to gather information and data about the client. This can be done through various methods, such as interviews, questionnaires, and observation. The purpose of this step is to gain a holistic view of the client's current situation, including any symptoms they may be experiencing and their personal history.

Consequently, a minimal solution can be determined by taking partial derivative of H , respect to $,N,Q,Y_b,Y_a$.

Consider a decentralized linear discrete-time system composed by n subsystems:

$$h_b\left(y+1\right)=J_b h_b\left(y\right)+I_b o_b\left(y\right)+J_{-b}\,h_{-b}\left(y\right) \tag{29}$$

where J_{-b} denotes the interconnected term coefficient that $1\leq b\leq mh_{-b}\left(y\right)$ illustrates other subsystem states at step k.

By utilizing the approximation property of NN, a subsystem cost function can be derived as:

$$A_b^{*}\left(h_b\left(y\right)\right)=Z_{db}{}^{V}\sigma_{db}\left(h_b\left(y\right)\right)+\varepsilon_{db} \tag{30}$$

asymptotically stabilized the system. Then in a finite horizon cost function can then be described as:

Once the information has been gathered, the professional will then analyze it to form hypotheses about the client's difficulties. They will look for patterns, themes, and possible underlying causes of the client's issues. This may involve using different theoretical perspectives, such as cognitive-behavioral or psychodynamic approaches, to guide their analysis. The next step is to share the findings with the client and involve them in the process. This allows the professional to gain the client's perspective and validate or adjust their hypotheses. It also helps to build a collaborative relationship and foster the client's buy-in to the treatment plan.

- **Tactical Diagnosis of Opponents and Players :**

Tactical diagnosis of opponents and players is a crucial aspect of competitive team sports. It involves the assessment of the strengths, weaknesses, and tendencies of both individual players and opposing teams in order to develop effective game strategies and gain a competitive edge. This process is a combination of observation, analysis, and interpretation and requires a deep understanding of the game and its intricacies. The first step in tactical diagnosis is observation. This involves closely watching the movements, interactions, and behaviors of players during games and practices. Coaches and players will pay attention to critical aspects such as positioning, decision-making, and technical abilities.

$$A_y^{*}=\sum_{a=y}^{V}\left(\left(h_y\right)+o_y{}^{*V}Lo_y*\right) \tag{31}$$

The overall cost is approximate by a neural network with augmented weight vector Z_R and activation vector $\overline{\sigma}_r\left(h\right)$

$$A\left(h\right)=\sum_{r=1}^{R}z_r\sigma_r\left(h\right)=Z_R{}^{V}\overline{\sigma}_r\left(h\right) \tag{32}$$

Hence, by leveraging the relation between density and accumulative functions and then rearranging Equation (1), the following conditional density function is obtained:

$$e\left(v|H\right)=\lambda\left(v|H\right).\exp.\left(-\int_{v_0}^{v}\lambda\left(o|H\right)co\right). \tag{33}$$

Kernel density estimation is a popular way to model the geo-statistics in numerous types of events such as crimes [5] and terrorism.

$$y(q) = 1/(m.\gamma)\sum_{b=1}^{m} Y((q - q_b)/\gamma). \quad (34)$$

where k(s) denotes the kernel estimation for the location point s, n is the number of historical event locations, each si is a historical event location, γ is a tunable bandwidth parameter, and is a kernel function such as Gaussian kernel.

They will also look for patterns and tendencies that may give insights into a player's strengths and weaknesses. The next step is analysis, where the information gathered through observation is organized and interpreted. Coaches and players will use their knowledge of the game and their own team's tactics to make sense of the data. This may involve tracking statistics, such as successful passes or shots, to identify the most effective strategies for their team. They will also analyze the opposing team's tendencies and patterns to anticipate their movements and behaviors.

❖ **Basketball Game Technology Database :**

The Basketball Game Technology Database is a comprehensive system that utilizes various technologies to store, organize, and manage data related to basketball games. It is designed to support the operations of various stakeholders such as teams, coaches, players, and stats analysts. In this paragraph, we will discuss the different components and operations of this database in detail. The operational flow diagram has shown in the following fig.3

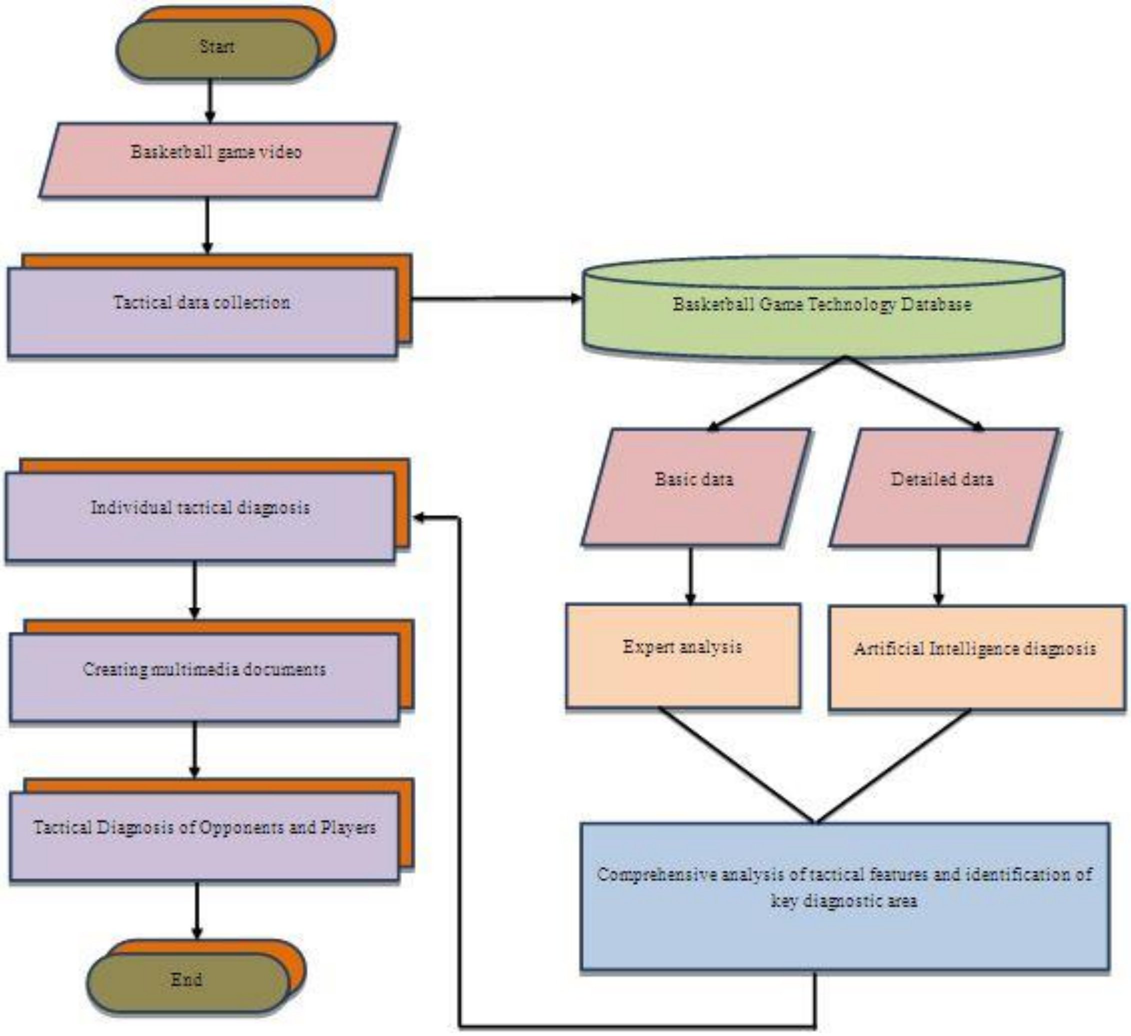

Fig 3: Operational flow diagram

The core component of the Basketball Game Technology Database is a relational database management system (RDBMS), which provides a structured and efficient way to store and retrieve large amounts of data. This database is designed to handle different types of game data, including player statistics, team performance metrics, and game outcomes. The RDBMS ensures data integrity, consistency, and security by enforcing data constraints, such as primary keys, foreign keys, and data types. The database is powered by a front-end application that allows users to interact with the data. This application provides an intuitive and user-friendly interface for performing data entry, retrieval, and management tasks. It also enables users to generate reports and visualize data through charts and graphs, making it easier to analyze and make informed decisions. One of the critical operations of the Basketball Game Technology Database is data collection. This process involves gathering data from various sources, including official game records, live scoring systems, and wearable devices.

❖ **Detailed data :**

Detailed data refers to the specific and granular data that is collected and stored for analysis and decision-making purposes. It is the raw information that is gathered from various sources and processed into a more structured form to provide insights and support informed actions. This data can come from a variety of sources, such as customer interactions, transactional records, survey responses, social media posts, and sensor readings, to name a few. The operations of detailed data involve several steps, starting with data collection. This process involves identifying and gathering all the relevant data from different sources, which can be done manually or through automated systems. This data is then stored in a centralized database to ensure that it is easily accessible and organized for future use. Once the data is collected, the following operation is data processing. This step involves cleaning and transforming the raw data into a more structured and usable form. This process includes removing any irrelevant or duplicate data, correcting any errors, and standardizing the format to ensure consistency. Data processing is a crucial step as it ensures that the data is accurate and ready for analysis. After data processing, the following operation is data analysis. This step involves using various statistical and analytical techniques to extract insights and patterns from the data.

❖ **Expert analysis :**

Expert analysis is a process that combines data, expertise, and various analytical methods to draw insightful conclusions and make informed decisions. This process is highly technical and requires extensive knowledge and skills in a particular field. The first step in the expert analysis process is to gather and organize relevant data. This can include numerical data, qualitative data, and even personal observations. The expert then scrutinizes this data to determine its reliability and validity. This is a crucial step, as accurate or complete data can lead to incorrect conclusions. After the data is collected and verified, the expert then utilizes various analytical methods to draw insights. These methods can include statistical analysis, data mining, or even machine learning algorithms.

The postsynaptic neurons integrate the incoming current spikes and leak in the absence of spikes. The membrane potential (Vmem) of the postsynaptic neurons satisfies the following equation

$$\tau \frac{cT_{mem}}{cv} = -T_{mem} + \sum_{b} T_b z_b \qquad (35)$$

where τ is the leakage time constant. Once the membrane potential surpasses a threshold (Vthresh), the postsynaptic neurons generate outgoing spikes, which are distributed to the next layer of the SNN models as the presynaptic spike trains.

The choice of method depends on the nature of the data and the desired outcomes. Next, the expert interprets the results of the analysis. This involves identifying patterns, trends, and relationships within the data. It also involves making connections between different pieces of information to uncover underlying meanings and implications. Once the data has been analyzed and interpreted, the expert then uses their expertise and knowledge to draw conclusions and make recommendations. This is where the expertise of the individual comes into play, as they are able to apply their knowledge to the data to provide valuable insights and inform decision-making.

❖ **Artificial Intelligence diagnosis :**

Artificial Intelligence (AI) diagnosis is a complex operation that involves the use of advanced technologies such as machine learning, deep learning, and natural language processing to analyze data and make predictions about a particular medical condition. This advanced technology is revolutionizing the field of healthcare by providing accurate and efficient diagnosis, leading to improved patient outcomes. The first step in AI diagnosis is data collection. This involves gathering a vast amount of medical data, including patient symptoms, medical records, lab test results, and imaging scans. This data is then organized and pre-processed to remove any noise and inconsistencies that may affect the accuracy of the diagnosis. The pre-processed data is then fed into an AI system, which can be in the form of a neural network or an expert system. These systems are trained using a large dataset of labeled medical data to identify patterns and relationships within the data. This training process involves adjusting the parameters of the AI model to optimize its performance. Once trained, the AI model is then tested on a separate set of data to evaluate its accuracy and performance. This step is crucial as it ensures that the model can make accurate predictions on new and unseen data.

4. Result and Discussion

The performance of proposed method BB Player Physical Fitness Signal Identification Algorithm (BBPPFSIA) have compared with Photovoltaic-powered Physical Fitness Recognition Algorithm (PPFRA) , Basketball Player Fitness Signal Recognition Algorithm (BFSRA) and Photovoltaic-based Fitness Signal Identification Algorithm (PFSIA).

4.1. Power efficiency:

This parameter measures the efficiency of the photovoltaic power supply in converting solar energy into usable electrical power. Higher power efficiency would allow the power supply to provide a more reliable and consistent power output, which is crucial for accurately recognizing physical fitness signals. Table.2 shows the comparison of Power efficiency between existing and proposed models.

Table.2: Comparison of Power efficiency (in %)

No. of Images	PPFRA	BFSRA	PFSIA	BBPPFSIA
100	82.35	80.39	91.41	95.23
200	83.85	80.98	93.28	96.24
300	84.96	81.96	94.11	96.40
400	85.34	83.17	95.02	97.36
500	86.35	84.31	95.94	96.93

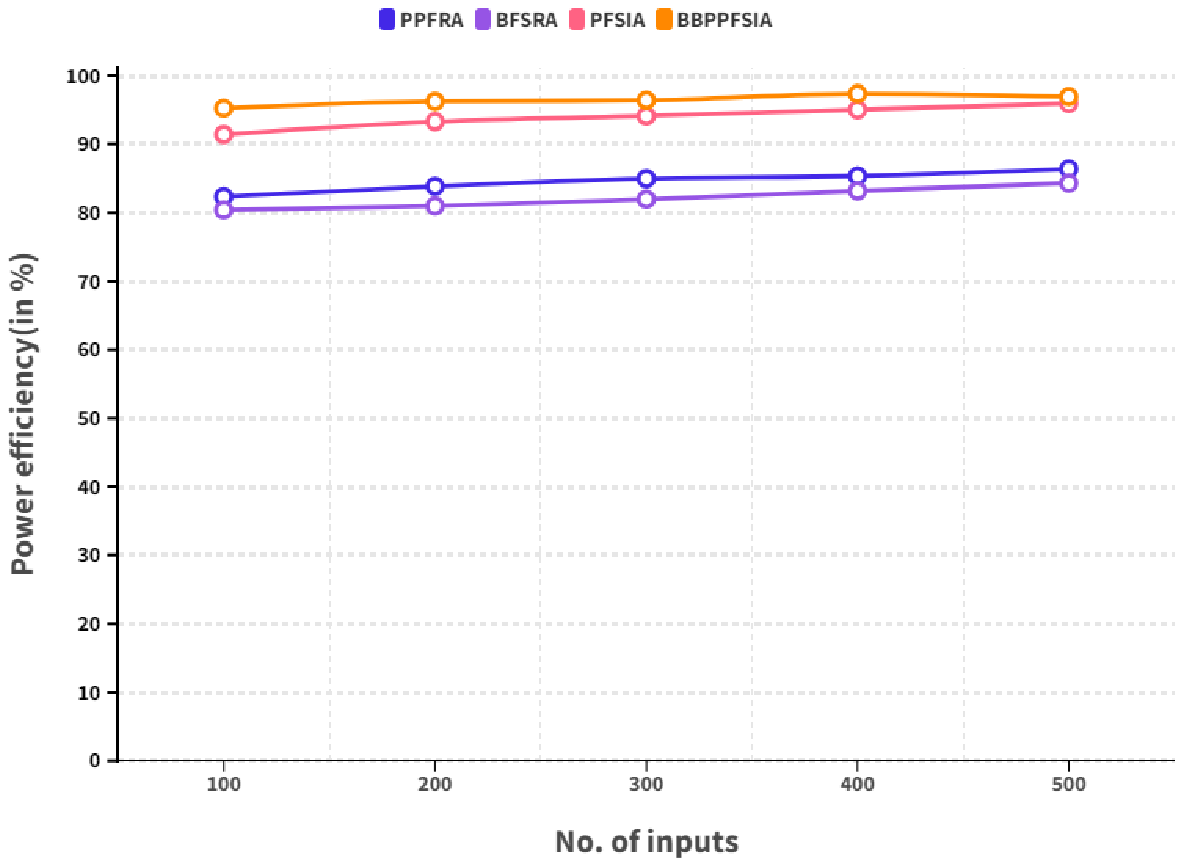

Fig.4: Comparison of Power efficiency

Fig. 4 shows the comparison of Power efficiency . In a computation cycle, the existing PPFRA obtained 86.35 %, BFSRA obtained 84.31 %, PFSIA reached 95.94% Power efficiency. The proposed BBPPFSIA obtained 96.93 % Power efficiency.

4.2. Signal-to-noise ratio (SNR):

This is a measure of the strength of the physical fitness signals received by the system about the background noise. A higher SNR means the system can better distinguish actual signals from irrelevant noise, resulting in more accurate recognition. Table.2 shows the comparison of Signal-to-noise ratio between existing and proposed models.

Table.2: Comparison of Signal-to-noise ratio (in %)

No. of Images	PPFRA	BFSRA	PFSIA	BBPPFSIA
100	79.35	77.39	82.41	88.23
200	80.85	77.98	84.28	89.24
300	81.96	78.96	85.11	89.40
400	82.34	80.17	86.02	90.36
500	83.35	81.31	86.94	89.93

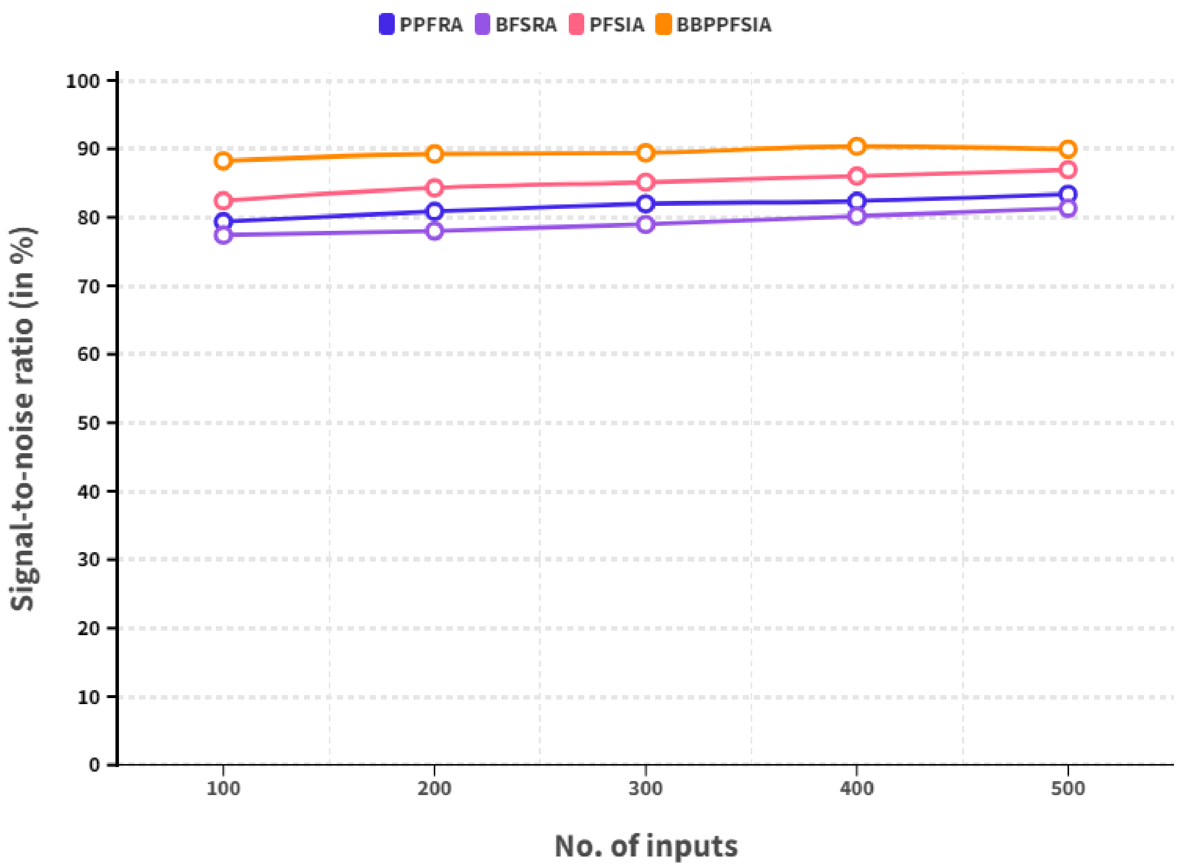

Fig.5: Comparison of Signal-to-noise ratio

Fig. 5 shows the comparison of Signal-to-noise ratio. In a computation cycle, the existing PPFRA obtained 83.35%, BFSRA obtained 81.31%, PFSIA reached 86.94 % Signal-to-noise ratio. The proposed BBPPFSIA obtained 89.93 % Signal-to-noise ratio.

4.3. Sampling rate:

This parameter refers to the frequency at which the system captures and processes the physical fitness signals. A higher sampling rate would allow for more precise and detailed recognition of movements and actions performed by the basketball players. Table.2 shows the comparison of Sampling rate between existing and proposed models.

Table.2: Comparison of Sampling rate (in %)

No. of Images	PPFRA	BFSRA	PFSIA	BBPPFSIA
100	76.35	75.39	79.41	85.23
200	77.85	75.98	81.28	86.24
300	78.96	76.96	82.11	86.40
400	79.34	78.17	83.02	87.36
500	80.35	79.31	83.94	86.93

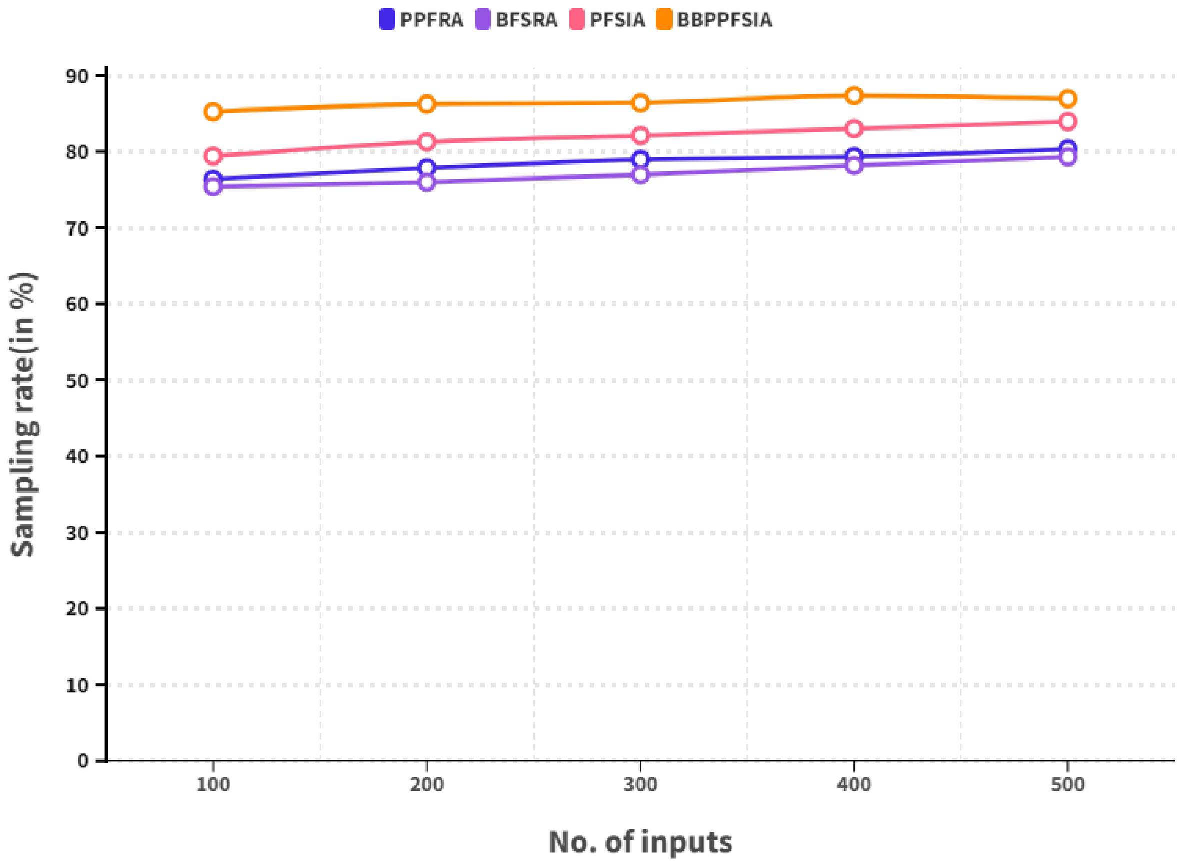

Fig.6: Comparison of Sampling rate

Fig. 6 shows the comparison of Sampling rate . In a computation cycle, the existing PPFRA obtained 80.35 %, BFSRA obtained 79.31%, PFSIA reached 83.94% Sampling rate. The proposed BBPPFSIA obtained 86.93 % Sampling rate.

4.4. Response time:

This measures the speed at which the system can detect and respond to changes in the physical fitness signals. A shorter response time would allow for real-time recognition and feedback for the players, aiding their training and performance improvement. Table.2 shows the comparison of Response time between existing and proposed models.

Table.2: Comparison of Response time (in %)

No. of Images	PPFRA	BFSRA	PFSIA	BBPPFSIA
100	72.35	72.39	77.41	79.23
200	73.85	72.98	79.28	80.24
300	74.96	73.96	80.11	80.40
400	75.34	75.17	81.02	81.36
500	76.35	76.31	81.94	80.93

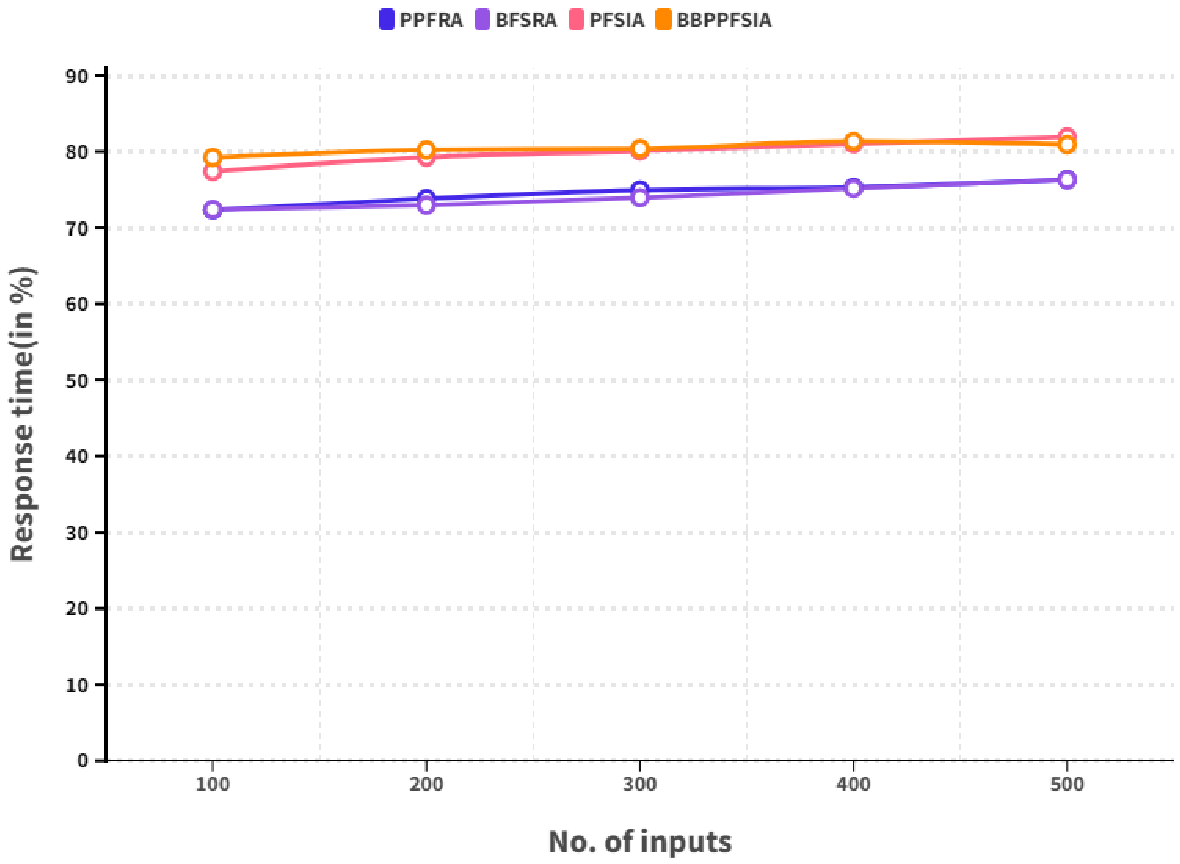

Fig.7: Comparison of Response time

Fig. 7 shows the comparison of Response time . In a computation cycle, the existing PPFRA obtained 76.35 %, BFSRA obtained 76.31%, PFSIA reached 81.94 % Response time. The proposed BBPPFSIA obtained 80.93 % Response time.

5. Conclusion

The novel method utilizing photovoltaic power supply for recognizing physical fitness signals of basketball players is a promising approach that can accurately and efficiently monitor the performance and well-being of athletes. By utilizing advanced technology in the form of solar panels and sensors, this method allows for real-time tracking and analysis of physical fitness indicators, providing valuable insights for trainers, coaches, and players. This innovative approach has the potential to greatly improve the training and conditioning of basketball players, leading to improved performance on the court.

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