# Revolutionizing No Ball Prediction: A Comprehensive Review of Methods


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***Abstract*— Cricket, a game steeped in tradition and strategy, demands precision in every aspect of play, where every ball bowled carries immense significance. Among the various aspects that can shape the outcome of a cricket match, the impact of a "no ball" cannot be overstated. A no ball, where a bowler oversteps the crease while delivering the ball, can have catastrophic consequences for a team, potentially costing valuable runs and even an extra delivery to the batting side. Over the years, modern technology has emerged as a formidable tool in the arsenal of cricket teams, aiding them in predicting and mitigating the occurrence of no balls with increasing accuracy.**

**This paper seeks to provide a comprehensive analysis of the methods and technologies employed in the prediction of no balls in cricket and evaluate their effectiveness. The study delves into the historical context of no ball occurrences in cricket, highlighting the pivotal moments where no balls have altered the course of matches. It also examines the rules and regulations governing no balls, shedding light on the nuances and intricacies that make their prediction a challenging yet vital endeavor.**

**The advent of technology, particularly Hawk-Eye and other ball-tracking systems, has revolutionized the game of cricket. These systems employ high-speed cameras and sophisticated algorithms to track the trajectory and movement of the cricket ball with unparalleled precision. Such technology not only aids in determining the legality of deliveries concerning no balls but also assists in providing a visual representation of the event, allowing for comprehensive post-match analysis.**

**In addition to ball-tracking technology, this paper explores other innovative approaches to predict no balls. These include the use of sensors embedded in the crease to detect foot faults, machine learning algorithms trained on historical data, and real-time monitoring of bowlers' actions using wearable devices. These methods, while promising, present their own set of challenges and limitations, which are meticulously discussed in the subsequent sections.**

**Effectiveness is a critical aspect of any predictive model, and this paper rigorously evaluates the success rates of various no ball prediction techniques. It considers factors such as false positives, false negatives, and the impact on match outcomes. Statistical analyses and case studies of recent matches are employed to assess the practicality and reliability of these methods in a real-world cricketing context.**

**Furthermore, this research explores the implications of accurate no ball prediction on the game. It discusses how teams can adapt their strategies, optimize their resources, and mitigate the risk of conceding additional runs. It also examines the ethical considerations surrounding the use of technology in cricket and the potential impact on the spirit of the game.**

**In conclusion, the game of cricket continues to evolve, with technology playing an increasingly vital role in ensuring fairness and accuracy. This paper provides an in-depth exploration of the methods and technologies used to predict no balls, offering insights into their effectiveness and implications for the sport. As the pursuit of precision in cricket remains an ongoing endeavor, the findings presented here contribute to the broader discussion on the harmonious integration of tradition and innovation in the world of sports.**



***Keywords*—** DRS, IoT, SVM, CNN, IR


## I. Introduction

### A. *Cricket & Technology*

The convergence of cricket and technology has sparked a transformative journey, reshaping the sport in multifaceted ways. At the forefront stands the Decision Review System (DRS), employing intricate ball-tracking and imaging technologies to challenge on-field decisions. This innovation has quelled controversies and introduced a strategic twist, altering the dynamics of the game.

Spectators, too, have reaped the rewards of technology's embrace. High-definition cameras capture every nuance, while super slow-motion replays dissect actions frame by frame. Unconventional camera angles unveil perspectives previously hidden, enhancing fan engagement and knowledge of the sport's intricacies.

For players, technology offers an arsenal of tools for growth. Video analysis software allows for meticulous review of performances, empowering players and coaches to fine-tune skills and strategies. Wearable sensors and fitness trackers monitor physical exertion, helping players maintain optimal levels of fitness and reduce the risk of injuries.

Cricket administration has undergone a revolution with the integration of technology. Online scoring systems and data analytics facilitate efficient organization of matches and tournaments. Scheduling software ensures accurate fixture management, catering to the needs of players, teams, and audiences.

Yet, amidst this synergy, challenges persist. Debates concerning the accuracy and impact of technologies like ball-tracking and hotspot continue to divide opinions. The delicate equilibrium between preserving cricket's traditional essence and harnessing the potential of technology remains a subject of deliberation.

As cricket hurtles into the future, its liaison with technology remains unbreakable. The symbiotic relationship enriches the experiences of players, fans, and stakeholders alike. It unveils a tapestry where the past and the future coalesce, ensuring that cricket retains its timeless spirit while embracing the possibilities of the digital age.

### B. ICC Rules for No ball

Front Foot No Ball: The bowler must have part of their front foot behind the popping crease when they deliver the ball. If any part of the foot is over the line, it is considered a front foot no ball.

Full Toss No Ball: A full toss delivery that exceeds one bounce before reaching the batsman without making contact with the ground is categorized as a no-ball. Moreover, a full toss that arrives at the batsman above waist height, in accordance with ICC regulations, is also classified as a no-ball.

High Full Toss No Ball: A delivery that surpasses a single bounce and rises above the waist height of the striker is deemed a high full toss no-ball. This particular type of no-ball is subject to more stringent penalties due to its potential danger, leading to a free hit being awarded to the batting side.

Fast Short-Pitched Bowling: In Test matches, there is no specific restriction on the number of short-pitched deliveries a bowler can bowl in an over. However, in limited-overs formats (ODIs and T20Is), there is a limit on the number of short-pitched deliveries (above shoulder height) that can be bowled in an over. Exceeding this limit results in a no ball.

Fielding Restrictions: In limited-overs formats, there are rules governing the placement of fielders. A certain number of fielders must be inside the 30-yard circle during specific phases of an over. If the fielding team does not adhere to these restrictions, it can lead to a no ball being signaled.

Unfair Deliveries: Any delivery that is considered unfair due to the bowler's actions, such as throwing or jerking the arm, may be called a no ball.

No Ball Free Hit: If a bowler bowls a front foot no ball (overstepping the crease) in limited-overs matches, it results in a "no ball" being called, and the next delivery is designated as a "free hit." During a free hit, the batsman cannot be dismissed by any method except a run-out.

### C. Motivation

The drive behind cricket no-ball detection research is rooted in ensuring equitable and precise decision-making during matches. No-balls play a pivotal role in cricket, as they can lead to a free hit opportunity for the batting side, potentially exerting a significant influence on the game's final result. Traditionally, no-ball judgments have depended on the assessment of the on-field umpire, a process that may be susceptible to errors due to various factors, including the rapid pace of the game. The techniques employed for forecasting no-balls possess substantial capabilities, with their accuracy contingent on the specific methodology used. This study assesses the efficacy of various techniques in detecting no-balls, and our findings identify the most reliable approach based on the accuracy and efficiency of different models.

## II. Literature Survey

### A. Literature study

Cricket stands as a globally renowned sport wherein various technologies are employed to aid match umpires in their decision-making process. The issue of determining the legitimacy of a bowled delivery, whether it qualifies as a legal ball or a no-ball, often sparks controversies due to human subjectivity. Given that the outcome of the entire game can hinge on a single ball, the necessity of precise judgments regarding no-balls becomes self-evident. In the context of this review paper, we have partitioned the bowling crease into two distinct areas and employed the technique of image subtraction on both segments to detect alterations in pixel values. Subsquently, our devised approach has been employed on actual video frames captured in real-world scenarios. By anchoring our method for detecting overstepped no-balls on pixel-level image subtraction, we effectively mitigate the limitations tied to human perception.[1]

Cricket is characterized by its extended gameplay, spanning numerous hours or even spanning days. Given the prolonged nature of cricket matches, it becomes vital for spectators to be provided with the ability to selectively view captivating moments from these matches. However, due to the unscripted nature of cricket videos, identifying pivotal occurrences within them poses a significant challenge. This review paper presents a novel method aimed at identifying five key events – FOUR, SIX, OUT, NO BALL, and WIDE – in cricket videos through the recognition of corresponding umpire signals. To achieve this, we employ a pretrained Convolutional Neural Network (CNN) architecture, specifically I3D, to analyze umpire signals. Introducing a fresh dataset comprising 504 videos and 2000 images sourced from cricket matches, this work offers a foundation for key event detection in the cricket domain. Impressively, the proposed approach attains test accuracies of 97.76% for umpire frame detection and 86.14% for umpire signal recognition. By applying our framework to official cricket match videos, we secure precision, recall, and F1 scores of 95.23%, 86.95%, and 90.90%, respectively. Moreover, an evaluation of both the proposed video-based approach and the existing image-based approach on novel cricket videos conclusively demonstrates the superiority of our proposed method over the image-based alternative.[2]

Both no-balls and run-outs hold significant significance within the realm of cricket. Unfortunately, the incidence of human errors in determining these events has exhibited a noticeable increase in recent years. Such erroneous judgments can exert a substantial impact on the outcome of entire tournaments, as exemplified by a scenario where a team fell one win short of qualifying for the knockout stages due to such a decision. This review paper introduces a novel approach aimed at automating the decision-making process for run-outs and no-ball deliveries, with the primary objective of mitigating the human errors that umpires occasionally commit. To address this, we explore the utilization of two distinct machine learning techniques: Support Vector Machines (SVM) and Convolutional Neural Networks (CNN). Through the subsequent sections, we delve into the examination of these techniques and provide an overview of our obtained outcomes.[3]

In the contemporary era, cricket has emerged as the most popular and widely followed game globally, encompassing diverse activities such as No-balls, Wide Balls, and Boundaries. In this context, we present a novel approach that employs a composite feature, combining computer vision algorithms with camera view analysis. Cricket matches often witness significant human errors, especially in cases of wide balls or no balls, which can lead to pivotal and contentious moments during the game. The current world places considerable emphasis on technology, and we have therefore embarked on detecting various activities during a cricket match, including critical catches, LBW (Leg Before Wicket) decisions, no balls, wide balls, and more, using computer vision techniques. Our focus lies in exploring the realm of activity detection through computer vision, as technology spans multifaceted dimensions. The existing technology isn't just limited to data computation; it encompasses various applications and magnitudes/areas where software achieves higher accuracy and superior results through precise execution. The incorporation of technology into sports holds immense advantages, extending beyond cricket to other sports like Tennis, Baseball, Rugby, Soccer, Hockey, Football, Kabaddi, as well as individual games like Chess, Badminton, Shooting, which are all regarded as sources of pride for their respective nations.[4]

In contemporary times, there has been a noticeable surge in interest surrounding the process of summarizing videos and generating highlights, particularly in sports like football, cricket, basketball, and baseball. While some methods for recognizing the poses of cricket umpires have been put forth, these approaches have not fully harnessed the potential of combining pose estimation and neural networks, two highly potent components of deep learning. This research delves into the SNOW dataset, specifically designed for detecting umpire poses within the context of cricket matches. This dataset serves as a foundational resource for initiating pose recognition efforts focused on cricket umpires. Within the realm of cricket, umpires wield authority in making pivotal decisions, often conveyed through hand signals. By extrapolating umpire poses from cricket video frames, this study aims to pinpoint five such signals: NO BALL, SIX, WIDE, OUT, and NO ACTION. The paper outlines a methodology that employs key points derived from pose estimation to discern and classify these umpire gestures and poses. The experimental findings illustrate that our proposed technique achieves an accuracy rate of 87%. Furthermore, the evaluation metrics of our approach exhibit considerable promise in comparison to existing state-of-the-art methodologies [5].

The primary objective entails sharing cricket videos accompanied by automated audio commentary. The focus is on creating an automatic mechanism to generate audio commentary for cricket videos. This involves utilizing the YOLOv8 model to extract image features, followed by the application of a Transformer-LSTM network to produce text responses. Subsequently, the generated text is converted into audio format. The proposed model has the capability to process input data of varying lengths and generate successive outputs. Notably, the model can also incorporate timing information to predict factors such as the pitch, the bowler's delivery length, the batsman's shot selection, and the resulting ball outcome. However, the absence of standardized data for these tasks necessitates data collection efforts within this study [6].

Cricket currently stands as the most prominent and widely viewed sport. It encompasses three formats: Test matches, One Day Internationals (ODI), and T20 Internationals. The outcome of a match, be it a Test, ODI, or T20, remains uncertain until the final ball of the final over. The emergence of machine learning offers a novel approach, utilizing historical data to forecast future results. The primary objective of this research is to construct a model capable of preemptively predicting the victor of a One-Day International (ODI) cricket match prior to its commencement. Leveraging machine learning techniques, the study employs training and testing datasets to develop a predictive model based on specific match features. The dataset for the model is drawn from Kaggle, with supplementary data collected from diverse cricket websites to address the limitation of the Kaggle data, which only spans match up to July 2021. For the prediction task, two algorithms were employed: K-Nearest Neighbor (KNN) and XGBoost. Among these algorithms, the K-Nearest Neighbor Algorithm achieved a prediction accuracy of 91%, while the XGBoost Algorithm yielded a prediction accuracy of 89% [7]

In recent times, there has been a notable surge in interest concerning the realm of video summarization and the automatic generation of highlights, especially in the context of sports. This study introduces a novel dataset, termed SNOW, specifically designed for detecting umpire poses within the game of cricket. This dataset is positioned as an initial resource to facilitate the development of systems aimed at autonomously generating cricket highlights. Within the realm of cricket, the umpire holds significant authority in making critical decisions pertaining to on-field events. These decisions are communicated through distinctive hand signals and gestures. This research focuses on the classification of four such events – SIX, NO BALL, OUT, and WIDE – by leveraging the identification of umpire poses from frames within cricket videos. To extract relevant features, pre-trained convolutional neural networks, including Inception V3 and VGG19, are chosen as the primary feature extraction candidates. The results are attained through the application of a linear SVM classifier. The most promising classification performance is observed with the SVM trained on features extracted from the VGG19 network. These preliminary outcomes strongly indicate that the proposed system serves as an effective solution for the task of generating cricket highlights [8].

### *B. 2.2 Understanding from Survey:*

The existing methods predominantly use machine learning and image processing techniques to predict no-balls. The study critically evaluates the effectiveness of these methods.

### *C. 2.3 Challenges of Current Methods*

The challenges faced by the current methods and their limitations are discussed in detail. These include problems with data accuracy, selection bias, and difficulty in identifying no-balls in the live-action environment.

## III. PROPOSED METHODOLOGY

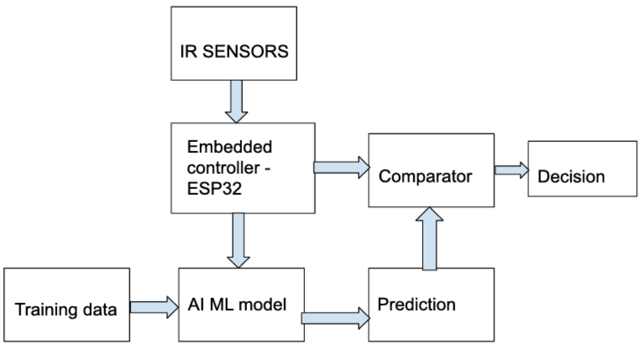


Fig 1: Flowchart for proposed model

As the flowchart shown in Fig 1 illustrates, a clear description of the methodology is provided. It encompasses the entire process, starting from the sensing of the foot using an IR Sensor, all the way to making a decision regarding whether it is a no ball or a legal ball. This is done comprehensively.

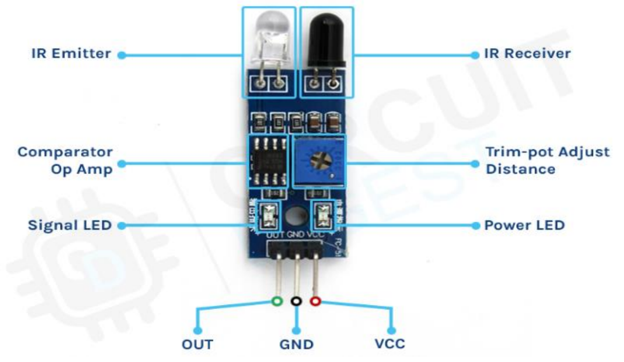


Fig 2: IR Sensor chip configuration

IR sensors, short for Infrared sensors, are devices that are designed to detect and measure infrared radiation (IR) in their surroundings. Infrared radiation is a type of electromagnetic radiation that has longer wavelengths than visible light, making it invisible to the human eye. As our proposed methodology is to detect the motion the IR Sensors can be used for the motion detection as mentioned below.

Motion Detection: Infrared motion sensors are widely used in security systems and lighting control. They can sense changes in heat patterns within their field of view and trigger an alarm or activate lighting when motion is detected.

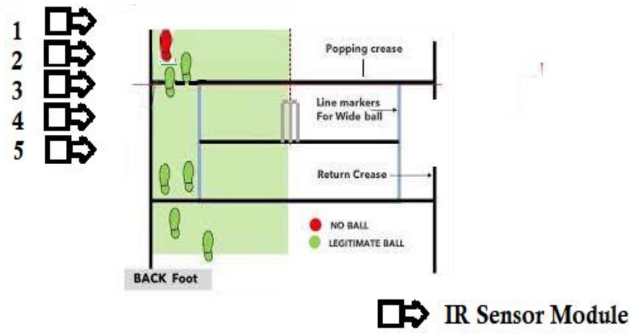


Fig 3: Illustration on working of IR Sensors Module

The Fig 3 provides a comprehensive illustration of how an IR sensor is positioned near the pitch to detect the movement of the bowler's foot during bowling. It can distinguish between the different positions of the foot, categorizing them as the back foot and front foot. Legal deliveries are represented in green, while no-balls are indicated in red.

In the realm of perception-altering technology, Infrared (IR) sensors have emerged as transformative instruments, reshaping our interactions and awareness of the environment. These extraordinary devices leverage the electromagnetic spectrum beyond human visual capabilities, rendering valuable insights across diverse domains. From safeguarding systems to medical diagnostics, IR sensors have entrenched themselves as indispensable assets within contemporary technology.

Functionally, IR sensors detect the emanating thermal radiation of objects, operating beyond the boundaries of the visible light spectrum. This radiation embodies thermal energy discharged by entities with temperatures surpassing absolute zero. By capturing this radiation and converting it into electrical signals, IR sensors transmute subtle temperature fluctuations into perceptible data, extending beyond human sensory capacities.

A prominent application of IR sensors resides in motion detection systems. These sensors are ubiquitously adopted in security setups, automated entrances, and even illumination control mechanisms. By identifying alterations in the infrared radiation blueprint caused by moving entities, these sensors initiate apt reactions, such as activating alarms or illuminating spaces. Their efficacy is bolstered by their aptitude to function regardless of ambient luminosity conditions.

In the medical sphere, IR sensors undertake a pivotal role in contactless temperature measurement. They find utilization in thermometers, fever detection systems, and even in overseeing apparatus temperatures during surgical interventions. This facet is especially advantageous, circumventing the necessity for direct contact and reducing discomfort and contagion risks.

Moreover, IR sensors exhibit applicability in environmental surveillance. Detecting temperature surges, they facilitate rapid identification and containment of forest fires. Additionally, they enrich weather predictions by scrutinizing atmospheric temperature trends, enhancing the precision of climate models.

The ascent of autonomous vehicles has furnished another arena where IR sensors excel. Infrared cameras heighten the perceptual competencies of these vehicles, particularly in inclement conditions like fog, rain, or darkness. Detecting thermal signatures from pedestrians, obstacles, and other vehicles, IR sensors amplify the safety and dependability of autonomous driving.

Yet, despite their manifold utilities, IR sensors are not bereft of constraints. Their precision can be influenced by extraneous variables such as dust, humidity, and interference from alternative heat sources. Moreover, their range is delimited, and they may grapple with identifying distant objects.

In summation, IR sensors inaugurate a new epoch of perception, granting access to hitherto concealed realms of data. Their reach spans security, healthcare, environmental oversight, and autonomous vehicular operations. Leveraging the potency of infrared radiation, these sensors empower decision-making, heighten safety, and streamline convenience across myriad technologies. As comprehension of IR technology evolves, an anticipation of novel applications shaping industries and augmenting our lifestyles emerges.

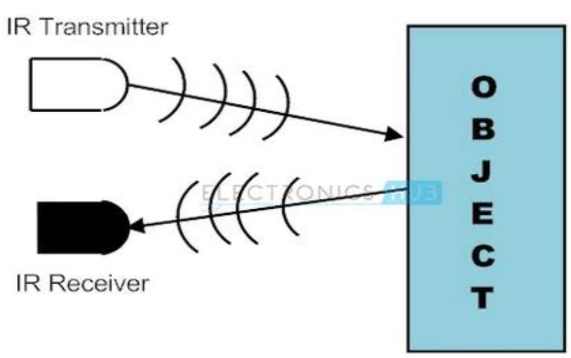


Fig 4: - Actual connection the for motion detection of IR Sensors

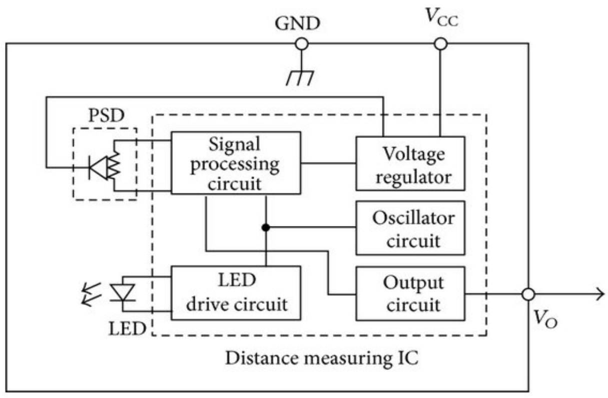


Fig 5: - Overview on the proposed module

The Fig 4 & Fig 5 depict the actual connections within the proposed module, illustrating how the IR Sensor receives and transmits signals to detect objects for the review decision process. The connection components predominantly include Position Sensing Detectors (PSD), Signal Processing, Voltage Regulators, LED (for indicating light), LED Driver Circuit, Oscillator Circuit, and Output Circuit with VCC and Ground connections. Motion detection is achieved through a transmitter and receiver, with objects being detected in the process.

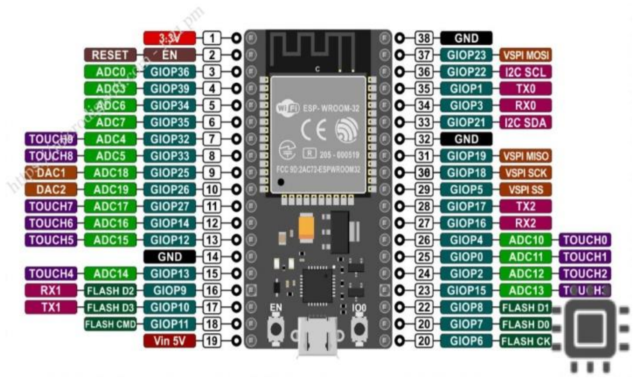

Fig 6: Pin Description of general-purpose ESP 32 microprocessor

The Fig 6 represents a complete pin description of a general purpose ESP32 microprocessor. The ESP32 stands as a transformative component in the realm of embedded systems and the Internet of Things (IoT). Engineered by Espressif Systems, this dual-core microcontroller has gained remarkable attention for its exceptional capabilities, marking a new era of wireless communication and connectivity.

At its core, the ESP32 boasts two powerful Xtensa 32-bit LX6 microprocessors, enabling multitasking and efficient processing. Its integrated Wi-Fi and Bluetooth modules offer seamless wireless connectivity, bridging the gap between devices and the digital world. Moreover, the ESP32 supports a range of communication protocols, including Wi-Fi Direct, Bluetooth Classic, and BLE (Bluetooth Low Energy), enhancing its versatility for diverse applications.

One of the standout features of the ESP32 is its low power consumption. This attribute is crucial for battery-operated devices, which are a cornerstone of the IoT landscape. The microcontroller's adaptive sleep modes and fine-grained power control enable optimal energy utilization, extending device lifetimes and contributing to sustainable IoT solutions.

The ESP32 has found substantial application in various sectors. It empowers smart home automation by facilitating remote device control and data exchange. Industrial automation leverages its real-time capabilities and connectivity to enhance efficiency and productivity. Moreover, the ESP32's integration of various sensors and peripherals simplifies the development of sensor nodes for environmental monitoring and data collection.

The ease of development for the ESP32 is a significant advantage. With a rich ecosystem of development tools, software libraries, and community support, even those new to embedded systems can swiftly create functional prototypes. Furthermore, its compatibility with platforms like Arduino and MicroPython broadens its accessibility to a wider audience.

Despite its numerous strengths, the ESP32 does have its limitations. Security remains a concern, as with any connected device. Ensuring robust encryption, authentication mechanisms, and regular firmware updates is essential to mitigate potential vulnerabilities.

In conclusion, the ESP32's integration of processing power, wireless connectivity, and energy efficiency has propelled it into the forefront of IoT and embedded systems development. Its impact on diverse applications is evident, from smart homes to industrial automation. As the world becomes increasingly interconnected, the ESP32's role in shaping the digital landscape is set to expand, offering solutions that bridge the physical and virtual realms.

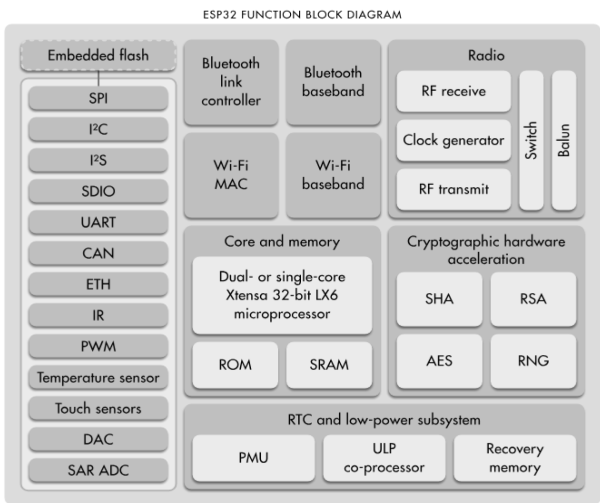


Fig 7: Functional diagram of general purpose ESP32 microprocessor

The general purpose ESP32 Microprocessors has got may features such as: Bluetooth, WIFI, UART, DAC, ADC'S, Core and Memory, Ethernet, Program Counters (PC), ROM, SRAM, Clock Generator, Etc.

## IV. Conclusion and Future Directions

This comprehensive review provides a detailed overview of various no-ball prediction methods, their strengths, limitations, and the challenges they face. The future direction of research focuses on reducing computational power and cost, developing sensors' accuracy, and finding ways of incorporating multiple technologies. Our study provides a foundation for future research into no-ball prediction, which can ultimately improve the quality and safety of cricket matches.

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