BEACONHOUSE NATIONAL UNIVERSITY

ShotSense

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REQUIREMENT ANALYSIS DOCUMENT

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Introduction

This Analysis Document serves as the cornerstone for our project, which is dedicated to the development of a cricket batting visualization tool. The project's primary goal is to provide supervision tools at the discretion of players, allowing them to analyze their games themselves using features such as ball tracking and shot classification. Additionally, the application will be providing some key statistics related to their playing session. In this context, the purpose of this document is to comprehensively outline the project's requirements and specifications, setting the stage for the subsequent phases of software development.

This Analysis Document encompasses a detailed exploration of various aspects crucial to the project's success. It begins with a literature survey, shedding light on existing technologies and their applications in cricket and other sports, which has inspired our project. The document then delves into the requirement gathering and fact-finding phase, followed by the Software Requirement Specification (SRS) document, which will serve as a blueprint for the software's development.

To provide clarity and enhance understanding, the document includes a Use Case Diagram, User Stories, and a comprehensive list of functional requirements. Each functional requirement, ranging from account creation to viewing shot classification per ball, plays a vital role in achieving the software's intended purpose. Additionally, non-functional requirements and technical details are presented to ensure the software's stability, performance, and compatibility with the intended platforms. This Analysis Document serves as a foundation for the project, encapsulating the project's scope, objectives, and the roadmap to the development of the cricket visualization tool. By addressing the project's requirements in detail, we aim to facilitate a successful and efficient development process that results in a valuable and user-friendly software solution for cricket enthusiasts in Pakistan.

Details of existing system

Street cricket is an integral part of our cricket culture. In this informal setting, players spontaneously assemble teams and engage in spirited matches. Unlike the international broadcast level, where sophisticated technology like Hawk-Eye provides supervision, amateur players must rely on their experience and intuition. The supervision provided by the Hawk-Eye system can be in the form of visualizations to enable players to know how they responded to certain types of delivery (see Appendix B). Despite the profound cricketing passion in Pakistan, especially within the street cricket culture, the absence of accessible coaching resources poses a significant impediment to the growth of emerging talents. Street cricket players primarily rely on self-assessment and occasionally capture their performances on smartphones for later reflection.

The integration of Computer Vision (CV) in cricket, particularly at the grassroots level, will represent a transformative advancement in the sport. CV technology offers the potential to empower amateur players and enthusiasts by providing real-time, data-driven insights that were previously only accessible to elite, professional cricketers. Beyond cricket, Computer Vision has already proven to be a game-changer in various other sports. Notable examples include the use of CV in tennis with the Hawk-Eye system, which tracks ball movement for line-call verification, and in soccer with Goal Decision Systems (GDS) that determine goal scoring through camera and sensor

integration (see Appendix B). Additionally, basketball employs CV systems for player and ball tracking, which has enriched game analysis and provided fans with a deeper understanding of the sport. The utilization of CV in these sports has significantly improved officiating accuracy and enhanced the overall spectator experience.

The motivation behind undertaking the current project is rooted in the dire need to bridge this significant gap in the street cricket ecosystem in Pakistan. By introducing a cricket visualization tool, we aim to empower street cricket players with real-time, data-driven insights that can transform the way they perceive and play the game. The project's scope encompasses the development of a software solution that predicts shot types based on ball trajectories. This endeavor seeks to bring the sophistication of international cricket analysis to the grassroots level, revolutionizing the training and performance assessment of street cricket players in Pakistan.

Literature survey

Introduction

Pakistan holds a significant place in the world of cricket, renowned for nurturing world-class players who often emerge from the vibrant culture of street cricket. The purpose of this literature review is to explore existing research and technological advancements related to cricket coaching and performance improvement. We seek to identify gaps in the literature that our proposed cricket batting improvement application can address, aiming to empower aspiring cricketers and revolutionize street cricket training in Pakistan.

Technology in Cricket

The utilization of technology in cricket is a well-established practice. Advanced technological innovations have had a global presence in cricket broadcasts worldwide. One of the most prominent among these technological advancements is the Hawk-eye system. Hawk-eye technology was created by Dr. Paul Hawkings and it was developed by the engineers of Roke Monor Research Limited [1]. It is the means to determine the LBW (leg before wicket) decision through ball tracking, proving to be a vital part of the DRS (decision review system). The Hawk-Eye system consists of an extensive network of cameras positioned around the entire cricket pitch, complemented by additional motion sensors to precisely gauge the ball's speed [2]. These collected data inputs are then transmitted to a sophisticated statistical algorithm responsible for calculating the ball's trajectory. While immensely effective in cricket analysis, it's worth noting that Hawk-Eye systems are both cost-intensive and intricate, making them less accessible and challenging for the general public to comprehend.

Current Systems and Mobile Applications

Over the years, several coaching options have emerged in the realm of cricket, including mobile applications and websites that provide extensive coaching content through courses and tutorials. Cricuru[3], India's premier online cricket coaching platform, was founded by cricket luminaries Virender Sehwag and Sanjay Bangar. Boasting a repertoire of over 2400 video lessons from 30+ top cricketers worldwide, Cricuru aims to revolutionize cricket learning for aspiring young players globally. Individual courses by top players focus on specific skills like batting, wicketkeeping, and bowling. Cricuru's online coaching model, while effective for structured training, may face

challenges in catering to street cricketers in Pakistan due to the informal and localized nature of their practice. Street cricket often involves dynamic, impromptu sessions with minimal resources, making it less compatible with the structured and formalized online lessons provided by Cricuru. A cricket coach is expected to provide real-time analysis and feedback, which is particularly crucial for refining batting skills in the ever-changing and dynamic context of street cricket. Street cricketers may benefit more from hands-on, immediate feedback and spontaneous learning experiences, which the current online platform may struggle to replicate effectively. Existing applications have yet to incorporate this essential aspect, leaving a noticeable gap in meeting this specific need. An illustrative mobile application, such as fulltrack.ai, demonstrates how simplicity can aid players without overwhelming intricacies [4]. This app, tailored for bowlers, offers real-time ball tracking, measures ball speed, and determines the trajectory, spin, or swing of each delivery. It's apparent that there's a notable lack of an application tailored specifically for cricket batsmen.

A machine learning approach to Shot Classification

Shot classification plays a pivotal role in the analysis and feedback loop that a batsman requires. It serves as a foundational element, a prerequisite, for a more comprehensive understanding of a player's performance. Before delving into detailed analysis or providing targeted feedback, identifying and classifying the various shots a batsman executes during a game or practice session is crucial. By categorizing shots—whether it be a cover drive, pull shot, or a defensive stroke—coaches and players gain insights into the batsman's strengths, weaknesses, and overall batting style. This initial classification sets the stage for a more nuanced analysis of shot selection, shot execution, and areas that require improvement.

Classifying the type of shot played by a player using learning algorithms has always been an arduous task. The factors that contribute to classifying a shot to one and not the other vary slightly in terms of footwork and the players pose.

In 2010, Yao and Fei-Fei presented a paper[5] focused on the interaction activities involving objects and human poses. Their research introduced a novel random field model aimed at encoding human poses during interactions with objects. To address this problem, they formulated it as a learning task for the model. The key components of this approach involved summarizing human activity poses and identifying body parts.

Due to the similarity between different batting shots, manual feature extraction from video frames is tedious. The most effective way of feature extraction is through deep neural networks. When it comes to video analysis, Convolutional Neural Networks (CNN) emerge as one of the most formidable models, akin to their success in image classification. CNN's prowess in classification accuracy surpasses that of traditional video classification algorithms [6]. What sets CNN apart is its ability to automatically extract relevant features from video frames, eliminating the need for manual feature selection—a requirement in many other video classification techniques. CNN employs a variety of layers, including the convolutional layer, which employs moving filters or kernels to traverse the video frames. These filters scan through the 2D matrices representing the frames, performing dot multiplications at specific regions and storing the results in another matrix. This process enables CNN to capture intricate patterns and features within video data, making it a powerful tool for video classification tasks.

Anik Sen[7] introduces a hybrid neural network architecture for classifying 10 distinct cricket batting shots within videos, using a self-created dataset due to the unavailability of a public dataset

with comparable uniqueness and variety. The hybrid CNN–GRU model, adapted from a pretrained VGG16 model, achieved an impressive accuracy of 93%, highlighting the advantages of transfer learning and model fine-tuning when working with limited data. Furthermore, plans are in place to expand the dataset and make it publicly accessible for further experimentation and accuracy enhancements. This dataset, known as the CricShot10 dataset, can serve as the baseline for our development of a deep learning algorithm to classify cricket shots.

Recently, we came across an AI Bowling Machine[8] application that classifies a player's shot and then bowls accordingly. In this project instead of relying on pre-trained deep Convolutional Neural Networks (CNNs) to extract features from individual frames, a two-step process was introduced. The initial step involved predicting human body key points to act as a proxy for the batsman's pose. The Mediapipe's Pose Landmark Detector was enlisted to extract 17 essential body keypoints essential for precise pose estimation. The differences in these key points between frames were computed, effectively capturing the dynamics of the batsman's movements. The second step in the methodology entailed training LSTM models on these keypoint change vectors. The result at the end was a model that predicts the type of shot being played and then feeds that information to a bowling machine to bowl according to the intent of the batsmen. This unique approach, inspired by the work of Ayinaparthi [9], allowed for a more nuanced and adaptive shot classification system, addressing the inherent challenges in cricket video analysis. The sequential nature of LSTM and the use of pose keypoint changes made it a promising candidate for accurately classifying cricket shots.

Computer Vision in Other Sports

The integration of computer vision technology has extended beyond cricket and has found valuable applications in various other sports, transforming how athletes, coaches, and spectators engage with these games.

In tennis, the renowned Hawk-Eye technology is widely employed for ball tracking and line-call verification. This computer vision system uses multiple cameras to track the trajectory of the tennis ball, providing instant and precise decisions on whether the ball is in or out. It has significantly enhanced the accuracy of officiating and enriched the viewing experience for tennis enthusiasts. Moving from the tennis court to the soccer field, we encounter the Goal Decision System (GDS), a compelling demonstration of computer vision's efficacy. The GDS combines an array of cameras and sensors to ascertain definitively whether a goal has been scored. This technology serves as a critical aid for referees in making pivotal decisions, effectively eliminating disputes and fostering a fairer gameplay environment. Basketball, too, has harnessed the capabilities of computer vision systems for player and ball tracking. These sophisticated systems adeptly capture player movements and ball trajectories throughout the game. The data they generate empowers coaches and analysts with valuable insights into player performance, tactical maneuvers, and strategic planning. The National Basketball Association (NBA) has notably adopted such technology, employing it to enhance game analysis and provide fans with a deeper understanding of the sport.

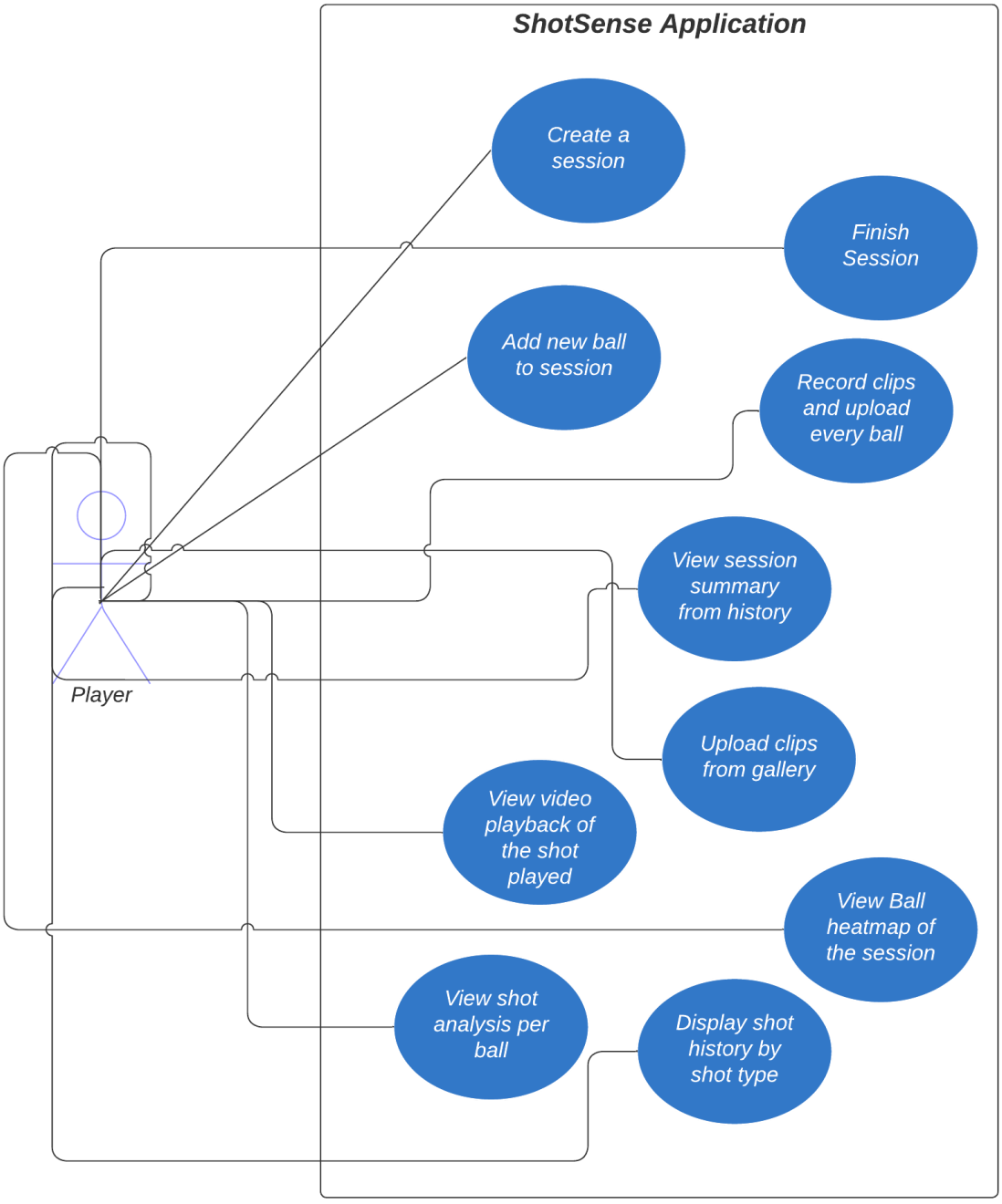
Conclusion

In conclusion, the literature review has provided valuable insights into the utilization of technology in cricket, particularly the Hawk-Eye system, and highlighted the existing gaps in coaching and performance improvement for cricket players, particularly in the context of street cricket in Pakistan. Furthermore, the integration of computer vision technology in other sports, such as tennis, soccer, and basketball, has showcased its transformative impact on officiating accuracy and

spectator experience. As we endeavor to develop a cricket batting improvement application, we draw inspiration from these diverse real-world applications of computer vision to empower aspiring cricketers with tailored, real-time analysis for street cricket training in Pakistan. We have an opportunity to empower aspiring cricketers with a visualization tool that can enhance their understanding of the game, offering real-time insights into shot selection based on ball types. This transition aligns with our commitment to improving street cricket training in Pakistan and addressing the specific needs of players by providing a dynamic and data-driven tool for skill refinement.

Software Requirement Specification (SRS) Document

Use Case Diagram



User Stories

Title	Cricket batting Trainer App
User Story	As a cricket batsman i want to be able to record each ball that I play to get a complete visualization and analysis of my performance
Acceptance Criteria	**1. Session History:** When I launch the app, I expect to see a well-organized history of all the practice sessions I have recorded. Each session should be listed with relevant details like date, and duration. **2. Session Summary:** Upon clicking on a specific session, I should be presented with a comprehensive summary of that session. This summary should include: **Balls Hit Accuracy:** A graphical representation of my shot accuracy, showing the percentage of balls successfully hit. **Heatmap:** A heatmap highlighting areas on the pitch where I played the majority of my shots, helping me identify strengths and weaknesses. **Frequent Shot Types:** A breakdown of the most frequently played shot types, giving insights into my preferred shots. **Overs Played:** A count of the number of overs I faced during that session. **Ball Details:** When I select a particular ball from an over, I should be provided with detailed information about that ball, including: **Type of Shot Played:** Information on the type of shot I attempted, such as cover drive, pull, or sweep. **3. Shots Tab:** In the app's interface, there should be a dedicated 'Shots' tab. Upon clicking on it, I should be presented with a comprehensive list of all the shots I played during all the recorded sessions. Additionally, I should have the capability to filter and categorize these shots based on their type (e.g., defensive, cover drive, lofted), aiding in a more granular analysis of my performance. By meeting these criteria, I'll have the necessary tools to thoroughly assess and improve my cricket performance, helping me become a more skilled and strategic batsman.

Functional requirements

Create a session

Number	FR-1
Name	Create a session
Description	The system shall empower players to assign a name to a session(see Appendix A) currently being recorded and initiate the creation of a new session.
Preconditions	The user has successfully logged in and is currently viewing the application's dashboard.
Postconditions	Following the action, a new session is created with a user-defined name, and the player is granted access to the session page and the ability to add overs to the session.
Primary Actor(s)	Player
Trigger	The player activates the session creation process by selecting the "Create Session" button on the home page.
Details	Upon selecting "Create Session," the system should prompt the user to enter a descriptive name for the session, such as "Practice at the Local Ground."
	The session name should adhere to reasonable character limitations and format requirements.
	After the session name is provided, the system creates a new session record and associates it with the user's account.
	The newly created session should initially display a session page where the user can add balls played.

Add new ball to session

Number	FR-2
Name	Add new ball to session
Description	The system shall provide players with the ability to add ball for recording within a session.
Preconditions	The user is logged in, and at least one session has been created.
Postconditions	Following the action, the player successfully adds an ball to the over in session, facilitating the recording of clips during that over.
Primary Actor(s)	Player
Trigger	The player initiates the process by selecting the "Add" button on the current session

	page.
Details	The system should offer a user-friendly interface that allows players to add balls..
	Once an ball is added, the system should save and display it on the respective session page, enabling the recording of clips during the specified over.
	Ensure that overs are organized and easily accessible within the session, allowing players to review and manage their recorded content effectively.
	Provide options for players to edit or delete added balls as needed.

Record clips and upload every ball

Number	FR-3
Name	Record clips and upload every ball
Description	The system shall enable players to record and upload video clips for processing.
Preconditions	The player has initiated the "Add" action and is prepared to record clips.
Postconditions	After recording and uploading the clips, the user is redirected to the session summary page, where the clips are associated with the specified over.
Primary Actor(s)	Player
Trigger	The user presses “record” on the current section.
Details	Users can initiate video recording for a specified over by selecting the "Record" button within the session interface.
	After the ball is recorded, the system will show the video to the user.
	The user will press the confirm button to complete the ball and send the video for processing.

Upload clips/balls from gallery

Number	FR-4
Name	Upload clips/balls from gallery
Description	The system shall enable players to select videos from photo gallery and upload video clips for processing.
Preconditions	The player has initiated the "Add" action and is prepared to upload clips.
Postconditions	After selecting video and uploading the clips, the user is redirected to the current session page, where the clips are associated with the specified over.

Primary Actor(s)	Player
Trigger	The user presses “Add from gallery” on the current section.
Details	Users can initiate video uploading for a specified ball by selecting the "Upload from gallery" button within the current session interface.
	After the ball is uploaded, the system will show the video to the user.
	The user will press the confirm button to complete the ball and send the video for processing.

Finish Session

Number	FR-5
Name	Finish Session
Description	The system shall allow users to finish a session after they have finished all their overs.
Preconditions	The user is on the session homepage.
Postconditions	The user is displayed a splash screen showing their session summary.
Primary Actor(s)	Player
Trigger	The user presses “Finish session”
Details	The "Finish Session" button should be clearly visible on the session homepage, prompting the user to signal the end of the session when ready.
	After pressing "Finish Session," the system should perform a verification check to ensure that all intended overs have been recorded. If any overs are incomplete, the system should provide a prompt to confirm the user's intent to finish the session.
	Upon the completion of a session, the system should guide the user to a splash screen displaying the session summary in a visually appealing and informative format.

View session summary from history

Number	FR-6
Name	View any previous sessions’ summary
Description	The system shall give users a complete session summary of all the sessions played by the user.
Preconditions	The user has completed at least one playing session.

Postconditions	The user is displayed with a summary of a selected session with all the stats(see Appendix A) of the selected session.
Primary Actor(s)	Player
Trigger	The user selects a specific session from the sessions tab.
Details	The system should provide a "Sessions" tab or section within the user interface, where the player can access their recorded sessions.
	When the user selects a specific session from the list, the system should load the session's details(see Appendix A) and display them.
	The session summary should include key statistics and information(see Appendix A) relevant to the recorded session.
	The system should display statistical data related to the session. The system should provide graphical representations or charts to visualize performance trends during the session.
	The session summary should also include links or thumbnails to access individual video clips recorded during that session for in-depth analysis.

Display shot history by shot type

Number	FR-7
Name	Display shot history by shot type
Description	The system shall allow users to see their shots from all the sessions combined filtered by shot type
Preconditions	The user navigates to the shot history page.
Postconditions	The user is displayed with filtered shot(see appendix A) types
Primary Actor(s)	Player
Trigger	The user selects a specific shot filter from the shots tab
Details	The system compiles videos of shots from all sessions and displays them.
	Users can apply filters like "Cover drive", "Pull shots" or other shot types.
	The displayed shots are categorized based on the selected shot type filter.

View shot analysis per ball

Number	FR-8

Name	View shot analysis per ball
Description	The system shall grant users access to in-depth shot analysis[see appendix A] for each ball played within a selected over.
Preconditions	The user has selected a specific over and is viewing its details.
Postconditions	The user is presented with a comprehensive analysis of each ball, including shot type, video playback etc.
Primary Actor(s)	Player
Trigger	The user selects a specific over from the session page and then selects a specific ball.
Details	The system should present a list of balls played within the selected over, allowing the user to choose a specific ball for analysis.
	Upon selecting a ball, the system should display detailed shot analysis.
	The analysis will include: ● Shot classification(shot type) ● Video playback (which will include ball tracking and pose detection) ● Shot hit or miss.

View Video Playback of Played Shots

Number	FR-9
Name	View video playback of the shot played
Description	The system shall enable users to watch video playback of the shots they played during a session enabling them to check their pose and view ball tracking
Preconditions	The user has completed playing an over, and the overs video footage is available in each balls page.
Postconditions	The user can review and analyze the video footage of their shots, allowing for self-assessment and improvement.
Primary Actor(s)	Player
Trigger	The user selects a specific ball from the over tab and chooses to view video playback.
Details	Upon selecting a ball, the system should present the option to view video playback for that particular shot.
	Video playback should include an informative overlay, offering details such as shot type, ball trajectory and pose.
	The system should seamlessly integrate ball tracking information into the video playback, providing insights into the ball's path.

	The video playback should visualize the point of impact.

View Ball Heatmap for Session

Number	FR-10
Name	View Ball heatmap of the session
Description	The system shall provide users with a visual representation of a ball heatmap for a specific session in the session summary.
Preconditions	The user has selected a specific session from the session history and then selected session summary.
Postconditions	After completing the action, the user is presented with a heatmap that conveys the distribution of shots that were successfully hit and those that were missed during the session.
Primary Actor(s)	Player
Trigger	The user navigates to the session summary after selecting a specific session from the session history.
Details	Within the session summary, the heatmap representation should be prominently displayed, allowing users to easily grasp the distribution of their shots.
	The heatmap should utilize visual cues, such as color-coding, to differentiate between areas where shots were hit and where they were missed.
	Encourage players to use the heatmap as a visual aid for analyzing their performance and identifying patterns or trends in shot accuracy.

Non-functional requirements

Performance

a. Resource Optimization: Efficient use of system resources to maximize performance and minimize resource consumption, this can be done by asking users to trim videos to individual balls and then process the videos.

b. Processing time : ML processing such as ball trajectory and shots classification should be under 5 minutes per over

c. Latency and bandwidth optimization: The application should minimize network latency by using cloud storage along with video downscaling to decrease latency and upload speeds to reduce the amount of data transferred between client and server

Security

a.Input Validation: Validate and sanitize all inputs in the app to prevent wrong data storage and Sql attacks

a. Data Protection: The application must ensure the security and encryption of user data, using Oauth2 for storing and managing user profiles can ensure the security of users stats and recorded videos

b. Authorization: Users should only have access to the features and data they are authorized to use.

Usability(UX)

a. Consistency: Maintain a consistent user interface design and navigation across the application. Users should be able to clearly see all shots played throughout all the session and a separate section for all the individual recorded sessions.

b. Device Adaptability: Ensure that the application adapts and performs well on various devices, including mobile and tablet. All of the content should fit on all types of screen sizes.

c. Validation Feedback and errors: Provide real-time input validation to correct their invalid inputs, The system should also provide appropriate error messages on things such as incomplete overs, invalid session names

Interoperability

a. Compatibility: The application should be compatible with various mobile devices with different camera modules to support a wider range of users

Scalability

a. Scaling: The application should be able to dynamically allocate resources to handle increased user load and increase in the recorded overs

b. Database Scaling: Database systems should be able to scale to accommodate growing video data of users, databases should automatically allocate and manage storage for more users.

Test Cases

Create a Session

ID	TC-01
Title	Create a Session
Objective	To verify that a user can successfully create a session.
Preconditions	The user has successfully logged in and is currently viewing the application's dashboard.
Steps	Select the "Create Session" button on the dashboard.
	Enter a valid session name (e.g., "Practice at the Local Ground","Pull Shots").
	Confirm the session creation.
Expected Results	A new session with the provided name should be created and associated with the user's account.
	The session summary page should be displayed.
Test Data	Valid session name.
Pass Criteria	The test case passes if a new session is successfully created with the provided name, and the session summary page is displayed.
Fail Criteria	The test case fails if the session is not created.

Add New ball to Session

ID	TC-02
Title	Add New ball to Session
Objective	To verify that a player can successfully add a new ball to an existing session.
Preconditions	The user is logged in, and at least one session has been created.
Steps	Select the existing session from the dashboard.
	Click the "Add" button on the session page.
	Buttons for use video and recording is displayed
Expected Results	The system should save and associate the new ball with the respective over in a session.

	The added ball should be organized and easily accessible within the session.
	The user should be able to review and manage the recorded content for the specified ball and press “confirm” to get the prediction.
Test Data	N/A
Pass Criteria	The test case passes if the user can successfully add a new ball to the session.
Fail Criteria	The test fails if there are any issues in adding ball

Record and Upload Clips for a ball

ID	TC-03
Title	Record and Upload Clips for an Over
Objective	To verify that the system allows players to successfully record and upload video clips for an over, associating them with the specified over in the session summary.
Preconditions	The user has initiated the "Add" action and is prepared to record clips.
Steps	Open the application and log in.
	Access the session for which you want to record and upload clips.
	User selects “Take a video” option from the menu
	After recording, the system displays the recorded video to the user.
	User presses “Confirm” to upload the video
Expected Results	The video is uploaded and predictions and visible to the user in the over
Test Data	Test video footage for a ball played in the session.
Pass Criteria	The user can record and upload clips for the over.
	The system successfully records each clip.
	The video is sent for processing without errors.
Fail Criteria	The user is unable to record and upload clips.
	The video confirmation interface is not functional.

Upload clips/balls from gallery

ID	TC-04
Title	Upload clips/balls from gallery
Objective	To verify that the system allows players to successfully select videos from gallery and upload video clips for an over, associating them with the specified over in the current session.
Preconditions	The user has initiated the "Add" action and is prepared to select and add clips.
Steps	Open the application and log in.
	Access the session for which you want to select and upload clips.
	User selects “select from gallery” option from the menu
	After recording, the system displays the selected video to the user.
	User presses “Confirm” to upload the video
Expected Results	The video is uploaded and predictions and visible to the user in the over
Test Data	Test video footage for a ball played in the session.
Pass Criteria	The user can select and upload clips for the over.
	The system successfully uploads selected clip.
	The video is sent for processing without errors.
Fail Criteria	The user is unable to select and upload clips.
	The video confirmation interface is not functional.

Finish Session

ID	TC-05
Title	Finish Session
Objective	To verify that the system allows users to successfully finish a session after they have completed all their intended balls in the over, it displays a session summary splash screen.

Preconditions	The user is on the session homepage.
Steps	Access the session for which you want to finish.
	Ensure that all intended balls in the over within the session have been recorded.
	Press the "Finish Session" button to signal the end of the session.
	Access the session for which you want to finish.
	Ensure that all intended overs within the session have been recorded.
Expected Results	The "Finish Session" button is clearly visible on the session homepage.
	If a complete over is not recorded, the system should provide a prompt to ask the user to finish the over.
	When all overs are complete and the user presses "Finish Session," the system should proceed to a visually appealing and informative session summary splash screen.
Test Data	Session with completed overs.
	Session with some overs incomplete.
Pass Criteria	The user can successfully finish a session with all overs recorded.
Fail Criteria	The "Finish Session" button is not visible on the session homepage..
	The session summary splash screen is not displayed when the session is finished.

View Session Summary from History

ID	TC-06
Title	View session summary from history
Objective	To verify that the system provides users with a complete analytical summary of a selected session, including key statistics, graphical representations, and access to individual video clips for in-depth analysis.
Preconditions	The user has completed at least one playing session.
Steps	Select a specific session from the list of session history.
	Observe the loading and display of session details.
	Review the session summary, including key statistics and graphical representations.

	Attempt to access individual video clips recorded during the session for in-depth analysis.
Expected Results	The "Sessions" tab is accessible within the user interface.
	The user can select a specific session from the list
	The system should load and display the session's details as expected
	The session summary should include key statistics and graphical representations of performance trends during the session.
Test Data	N/A.
Pass Criteria	The user can access and view a session summary from the "Sessions" tab
Fail Criteria	The "Sessions" tab is not accessible in the user interface
	The system does not load or display session details when a session is selected.

Display Shot History by Shot Type

ID	TC-07
Title	Display Shot History by Shot Type
Objective	To verify that the system allows users to view their shots from all sessions combined, filtered by specific shot types.
Preconditions	The user navigates to the shot history page.
Steps	Navigate to the "Shots" tab and access the shot history page.
	Select a specific shot filter, such as "Cover drive" or "Pull shots."
	Observe the display of shots categorized based on the selected shot type filter.
Expected Results	The system compiles shots from all sessions and displays them.
	Users can apply filters for specific shot types.
	The displayed shots are categorized based on the selected shot type filter.
Test Data	N/A
Pass Criteria	Users can access shot history with shots categorized by the selected shot type filter.
Fail Criteria	The system does not compile shots from all sessions.
	Filters for specific shot types are not functional.

	Shots are not categorized correctly based on the selected shot type filter.

View Shot Analysis per Ball

ID	TC-08
Title	View shot analysis per ball
Objective	To verify that the system allows users to access in-depth shot analysis for each ball played within a selected over.
Preconditions	The user has selected a specific over and is viewing its details.
Steps	Access the session page and select a specific over.
	Choose a specific ball from the list of balls played within the over.
	Review the displayed shot analysis, including shot type.
Expected Results	The system should present a list of balls played within the over for user selection.
	Selecting a specific ball should display detailed shot analysis, including the classified shot type.
	The shot analysis should incorporate ball tracking data and post-processed video footage for a comprehensive understanding of the shot.
Test Data	N/A
Pass Criteria	Users can view detailed shot analysis for each ball within a selected over.
Fail Criteria	Users encounter issues when trying to access or view shot analysis.

View Video Playback of Played Shots

ID	TC-09
Title	View Video Playback of Played Shots
Objective	To verify that the system enables users to watch video playback of the shots they played during a session, allowing for self-assessment and improvement.
Preconditions	The user has completed playing an over, and the overs' video footage is available in each ball's page.
Steps	Access the session page and choose a specific over.
	Select a specific ball from the over tab and opt to view video playback.

	Observe the displayed video playback, including shot type, ball trajectory, pose, and ball tracking information.
Expected Results	The system should provide the option to view video playback for the selected shot.
	Video playback should include an informative overlay with details such as shot type, ball trajectory, and pose.
	Ball tracking information should be seamlessly integrated into the video playback, offering insights into the ball's path.
	The video playback should visualize the point of impact.
Test Data	Selection of a specific over.
	Choice of a specific ball for video playback.
Pass Criteria	Users can access and view video playback of played shots with informative overlays and ball tracking information.
Fail Criteria	Users encounter issues when attempting to access or view video playback.
	Video playback lacks information or fails to integrate ball tracking details.

View Ball Heatmap for Session

ID	TC-10
Title	View Ball Heatmap for Session
Objective	To verify that the system provides users with a visual representation of a ball heatmap for a specific session in the session summary.
Preconditions	The user has selected a specific session from the session history and then selected session summary.
Steps	Access the session history and select a specific session.
	Choose to view the session summary.
	Observe the prominently displayed heatmap that conveys the distribution of shots hit and missed during the session.
Expected Results	The session summary should prominently display a heatmap that differentiates between areas where shots were hit and missed using visual cues, such as color-coding.
	Users should be encouraged to use the heatmap as a visual aid for performance analysis.
Test Data	N/A

Pass Criteria	Users can view a session-specific heatmap with shot distribution, and the heatmap encourages performance analysis.
Fail Criteria	Users encounter issues when trying to access or view the heatmap, or the heatmap lacks visual cues to differentiate between shot success and failure areas.

Technical Requirements

Data requirements

User Profile

- Description: This section defines the user profile information collected within the application, providing a personalized experience for users.
- Source: User profile data is sourced from the registration process, user input during account creation, and additional information provided by the stats of the user.
- Format: User profile data is stored in a structured format, including fields such as username, email, sessions played
- Security: User profile data is securely stored with Oauth2 encryption and access controls in place to protect against unauthorized access.
- Storage: User profile data is stored in a dedicated database, which will help create a structure to store videos, stats, analytics, session and over of every individual user

Sessions

- Description: A session in this context refers to a specific period dedicated to honing a particular skill or aspect of the game. For example, a session named "Training Pull Shots" involves a series of overs recorded to create a collection of videos. These series of overs can be tailored for a day of general training or focused on refining techniques for playing a specific type of shot, such as pull shot training.
- Source: Sessions are created and maintained by users during their interactions with the application, where they record, manage, and review their gameplay sequences.
- Format: Sessions are organized as user-specific entities, each containing relevant information, including statistics, shot data, and session heatmaps. Overviews of most frequently played shots, shot accuracy ratios of hit and missed shots, and session hit/miss heatmaps are presented as statistics.
- Storage: Feedback data is housed in a dedicated database, providing seamless accessibility from various devices.

Video

- Description: Videos refer to the video recordings of the shots played by users.
- Source: User.
- Format: Videos are standardized to a resolution of 720p with a frame rate of 30 frames per second (fps). Each video is limited to a duration of 3 seconds to focus on individual shots.
- Validation: N/A
- Storage and Security: The videos will be securely stored in the cloud, ensuring accessibility for users across devices. This approach guarantees that only authenticated users can access their videos through the cloud, maintaining data security.

Processed Video

- Description: Processed videos refer to the video recordings of the shots played by users. These videos are enhanced with ball tracking and other visual overlays to provide a comprehensive shot analysis.
- Source: Mobile application.
- Format: Processed videos are standardized to a resolution of 720p with a frame rate of 30 frames per second (fps). Each video is limited to a duration of 3 seconds to focus on individual shots.
- Validation: The validation process may include checking for video format compliance, ensuring proper synchronization of ball tracking, and verifying video length consistency.
- Storage and Security: The videos will be securely stored in the cloud, ensuring accessibility for users across devices. This approach guarantees that only authenticated users can access their videos through the cloud, maintaining data security.

User Feedback

- Description: User feedback pertains to the evaluation of shot classification by the model. Users can provide feedback on whether the model's shot classification is correct or incorrect. In case of incorrect classification, users can specify the correct shot type.
- Source: User.
- Format: Feedback typically consists of the selection of the correct shot type from predefined options.
- Validation: Validation includes verifying that the provided feedback adheres to the expected format, such as confirming that the user has selected a response from the predefined options
- Storage: Feedback data is stored in a dedicated database, ensuring efficient retrieval for analysis and model improvement.

AI/ML requirements

Shot Classification Model

Description: This model aims to classify cricket shots based on user uploaded videos.
Use Case: The primary purpose is to provide players with insights into the types of shots they are playing.
Algorithms and Models: CNN, specifically VGG16, is employed for robust feature extraction. Custom-designed fully connected layers enable tailoring the model to cricket shot intricacies.
Data Requirements: The model's effectiveness relies on a diverse dataset covering a spectrum of cricket shots, ensuring comprehensive training and accurate classification.
Model Updates: Regular updates are planned to refine the model's accuracy. User feedback, especially when the model misclassified shots, will be crucial for ongoing improvements.
Integration: The model seamlessly integrates into the mobile application through TensorFlow Lite, enabling efficient and real-time shot classification on users' devices.
User Interaction: Users engage indirectly through the application, receiving shot classifications and insights. User feedback on misclassifications actively contributes to model refinement.

Pose Estimation

Description: Pose estimation is a task that involves identifying the location of specific points in an image, usually referred to as keypoints. The key points can represent various parts of the object such as joints, or other distinctive features[10].
Use Case: This model will be used to detect the pose of the batsman after the videos have been recorded. This will help user to check their stance and make informed decisions
Algorithms and Models: Detecting a batsman's pose in recorded videos involves employing bounding boxes, training a single-category object detection model for batsman recognition, annotating key points to mark joints, and utilizing a data annotation platform for efficient labeling, enabling accurate stance assessment for informed decision-making[11]. Algorithms such as YOLO-pose will be used to train the pose of the batsman, specifically ignoring other players.
Data Requirements: For accurate batsman pose estimation, a diverse dataset of pictures featuring various batsman stances is needed. The dataset should include annotated bounding boxes and keypoint annotations for batsmen in different scenarios, lighting conditions, and environments.
Integration: Integrating the model in the mobile app will give users insights into how their pose look like while they play the shot

Ball Tracking

Description: Ball tracking is a computer vision task focused on following the trajectory of an object, typically a ball, in videos or images.
Use Case: Ball tracking is used to monitor the movement of a ball as its being balled to the batsman, this will give the batsman insights into their bat placement and overall style of batting .This will also help in creating a heatmap of the balls bowled in a session.

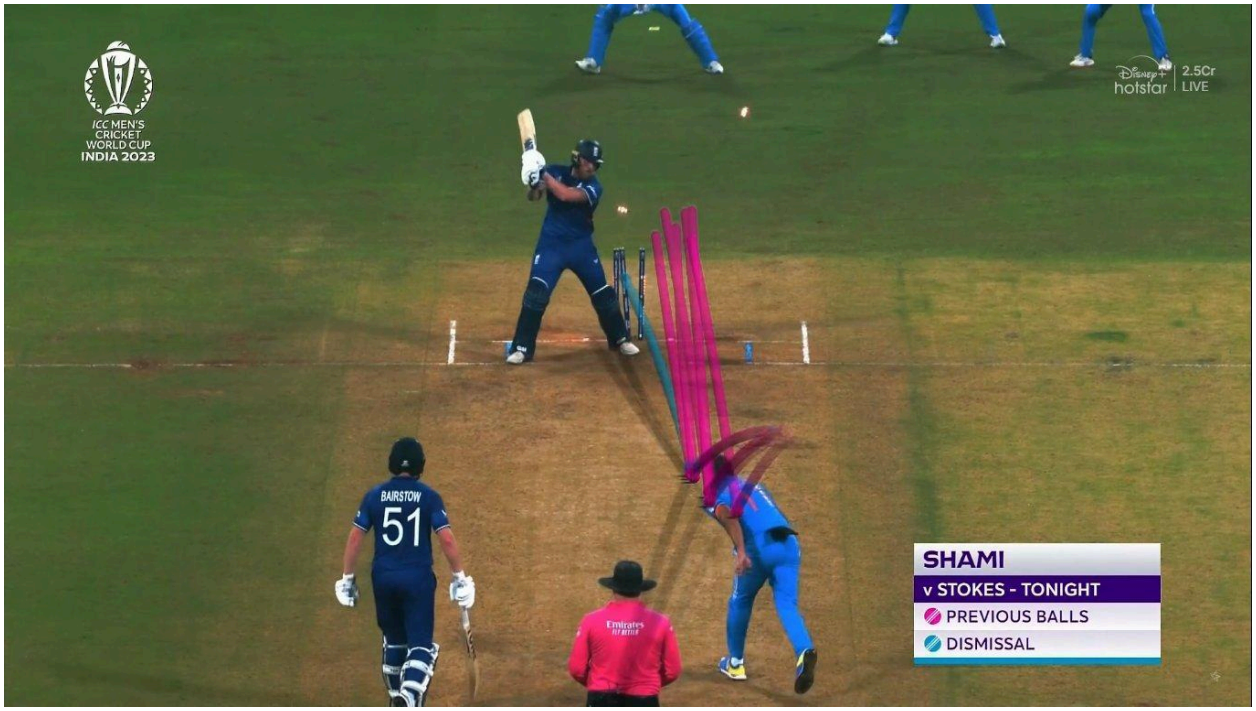
Algorithms and Models: Ball tracking uses object detection and object tracking to create a path of where the object is moved, models such as ByteTrack and YOLOv8 will be used to detect and track the ball being bowled.
Data Requirements: To train and test ball tracking algorithms, a dataset of videos with annotated ball positions is required.
Integration: This model will be Integrated in the mobile app, using this model will help in creating ball heatmaps and video playback to show player segmentation.

Appendix

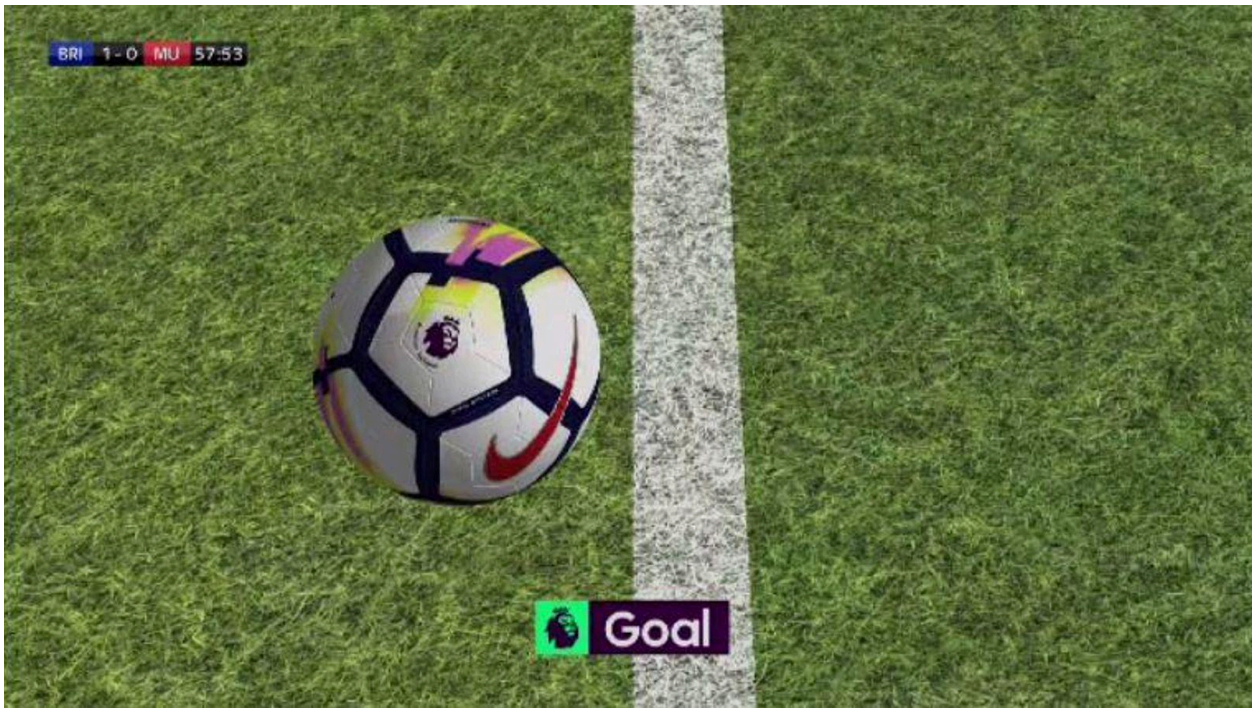
Appendix A: Glossary

Session: A session in this context refers to a specific period dedicated to honing a particular skill or aspect of the game. For example, a session named "Training Pull Shots" involves a series of overs recorded to create a collection of videos. These series of overs can be tailored for a day of general training or focused on refining techniques for playing a specific type of shot, such as pull shot training.
Over: A cricket term used to refer to collection of 6 balls played by a specific batsmen.
Player: Refers to the batsman of whom the video is being recorded for.
Splash screen: Screen that will be displayed after a user completes a session, This page will show the total time in which the session was played and any statistics(refer to **session summary** below) related to it.
Session Detail/Summary: Overviews of most frequently played shots, shot accuracy ratios, and session hit/miss heatmaps.
Session History: A tab/screen in the app which will house all the recorded sessions of a particular user, user can scroll through all the sessions they have recorded to review the progress they have made.
Shot Analysis: Shot analysis means the analysis for a single ball bowled/shot that is played which will comprise of shot classification(shot type), video playback (which will include ball tracking and pose detection), shot hit or miss.
Ball tracking: Object detection of the ball and creating a track of where the ball travels through till it reaches the bat, wil be used to create hit/miss heatmaps.
Pose/Pose estimation: Detection of a players movements of limbs and arms to emphasize the stance when the shot was played.
Statistical data/visualization of performance trends: This refers to the data in the session details where it will be shown in a graphical format and charts.
Shot types: The type of the shot that is played by the user (e.g. cover drive, pull shot, defense).
Filtered shots/filtered shot types: The feature which filters out all the videos of a single shot type that is played.

Appendix B: Examples



An example of how hawk eye is used for analysis



Goal Line Technology used in football

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