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Basketball Moves with Mobile Phones to Improve Players Skill.

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Abstract

Basketball, a famous and very popular sport worldwide can benefit greatly from the integration of Artificial Intelligence and Machine Learning. Using the Accelerometer and Gyroscope data of dribbling moves, a formidable machine learning model is created which can be used to aid users in improving their dribbling skills.

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# Introduction

Basketball is a global sport with millions of participants worldwide. In the years 2021/22, 1.18 million children and young people in the UK play basketball on a weekly basis, the highest it’s been in 5 years (Basketball England, 2023). However, traditional skill development methods often lack personalized feedback and accessibility. This study explores how Artificial Intelligence (AI) and Machine Learning (ML) can be integrated into basketball training to improve player skill development.

Although AI has begun to revolutionize basketball in areas like player performance analysis, its application in personalized skill development remains limited. This limitation is highlighted in a study by Bin Li et al, stating the Application of AI in basketball is still in its infancy (Li & Xu, 2021). The potential for AI's broader impact in basketball is also emphasized in an article by David Finlay (Finlay, 2023).

Bridging the gap between AI and basketball would directly address the limitations of traditional training methods, namely the lack of personalization, real-time feedback, and cost. By integrating AI and gamification principles such as a scoring system, training could become more targeted to the player's specific needs and motivate them to become better, offering an accessible and engaging learning experience with only a mobile phone. This overcomes the limitations of traditional methods such as needing coaching or paying for drills which can cost money and may not satisfy the specific user’s needs.

Other aspects that were considered included coaching and shooting analysis, however this project focuses on using a mobile application with AI and ML functionalities to improve a player’s dribbling skills. Dribbling is a fundamental skill in basketball and a strong foundation for offensive moves. By providing real-time feedback and personalized drills, the mobile application aims to bridge the gap in accessible and personalized basketball skills development tools.

The research aims of this project include whether dribbling moves can be classified with ML models, and if they can be applied to real-life context by use of the mobile application.

A mobile application was chosen as it would be easy to install, cheap and accessible. It is also necessary for the player to directly interact with the mobile app when performing the movements.

The Research Method I'll be using will be the Direct Observation Method. I chose a Qualitative method as I want to further understand the experience of the participants using the application. This would help in looking out for further criticisms on the ease of use of the application (with the User Interface and being able to play the game), the enjoyment / motivating factor through gamification as well as any other criticisms, whether it be extra features etc. A Quantitative Method wouldn't help me as much when trying to cater towards the type of people using the application. I believe that the type of application I am making, and the people I am making it for would benefit more from a Qualitative Approach.

This report will first explore existing literature on AI integration in basketball, highlighting the research gap in mobile application-based dribbling skill development. It will then delve into the design and functionalities of the mobile application and its potential benefits for users. Finally, the report will address legal, social, and ethical considerations, followed by an evaluation of the project’s effectiveness.

# Literature Review

## Current State of Machine Learning and AI in Basketball

The problem labelled in this study can be highlighted through David Finlay’s article on the future of basketball with AI, and Bin Li et al academic study on the state of AI and basketball.

David Finlay discusses that AI will undoubtedly play a significant role in shaping basketball, discussing its potential in the sport. Within Bin Li’s et al study, they derived to a conclusion that the Application and AI & ML was still in its ‘infancy’, hinting at the immense potential this area of technology could have onto Basketball. They analysed different ways other studies have applied AI & ML into basketball, such as Tian C’s identification of basketball strategies(Tian et al., 2020), or Mangiarotti’s utilisation of wristbands to detect player gestures(Mangiarotti et al., 2019). These two studies cover a great range of what basketball is about, with Tian revolving around strategy in a 5v5 which can be used to assist coaches during play, and Mangiarotti’s usage of wearable systems to directly detect a player’s movement.

However, these studies both lack the direct involvement of actual players and/or coaches using the software(s) created by the two authors, as well as any feedback from them. They both labelled how accurate their models are in achieving their results, but this wouldn’t help in indicating its usefulness in a real-life scenario.

There is only limited practical sources which combine AI with Basketball from a casual-user standpoint, such as HomeCourt AI (Nex, 2019), an application used to enhance a players skill level in basketball. However, this is only available in Apple products, and advanced AI features are locked behind a paywall. Despite this, it’s a good example of the potential AI can have in Basketball.

Getting direct feedback from participants, to cater towards users of their software could help further display its practicality and support the argument for AI being beneficial to basketball which is what we aim to strive for with this deliverable. This deliverable aims to close the gap by creating an application using AI in the context of basketball to advance the field, and will be focused on providing a user friendly and accessible interface, taking into account feedback from all stakeholders.

## Data Collection & Sensor Integration

Data Collection & Sensor Integration are essential when accurately generating data to discern specific moves that the user performs.

Nathan Kulman et al. (Kuhlman & Min, 2021)uses triaxial accelerometer data to classify different shooting forms. The authors also mention that in their future work, implementing gyroscope would have improved their classification. Mangiarotti uses triaxial accelerometer and gyroscope to assist in classifying a player’s gestures. These two studies are in similar fashion in terms of using real-time data generated from players to classify their movement, which encourages this studies decision in utilizing accelerometer and gyroscope in the deliverable. The success of both authors usage of accelerometer and gyroscope is shown through their high model accuracy, with Nathan’s 86.3% and Mangiarotti’s 99.46%.

Both authors also used some form of wearable wristband device to generate this data. This allows for precise data generation to increase their model’s accuracy. To imitate this, the use of a mobile device paired with an armband is used to generate data instead. Although the performance may not be up to par, this approach is a lot more cost friendly and available to low-income users without having to pay for a smartwatch.

## Machine Learning Algorithms in Basketball

Choosing the correct ML algorithm is essential to get the best accuracy when identifying the basketball moves performed. Some algorithms are much better suited than others depending on the data used, including how it is used.

Many authors within the Basketball & AI field have utilized various algorithms. Mangiarotti used a combination of the K-Nearest Neighbours and Support Vector Machine (SVM) algorithm to achieve a 99.46% accuracy. Nathan used a Linear SVM to achieve an 86.3% accuracy. However, when catering towards this study, compatibility issues arise when using these algorithms with mobile devices. As a result, a different approach was recommended.

To choose a ML Algorithm, this project takes influence from Salah Eddin Adi et al (Adi & Casson, 2021) and Abhilash Pati (Bera et al., 2023) approaches to capturing human activity recognition (HAR) on a smartphone. Both studies use LSTMs in their approach, using TensorFlow Lite for compatibility with mobile devices. Abhilash achieved a 97.85% testing accuracy using LSTM + Convolutional Neural Network (CNN), with Salah et al achieving a 92.7% with only LSTM. With this, this project took the LSTM + CNN approach.

## Gamification & Player Skill Improvement

Gamification is essential to ensure that the player is not only is engaged with the product but can witness themselves improving overtime. An academic study done by Haowei Zheng which observes the Visualization and Usability issues in building a fitness training application, including gamification(Zheng, n.d.). The author mentions that gamification is essential for sports tracking software, especially to provide feedback to the users as it does influence improvement in performance. This can be further supported by a commercial product, Fitbit, which can be used to promote fitness amongst other criteria in health (Google Fitbit, 2018). Gamification is used in this app to encourage walking more, by clearly displaying the steps (used as a score) made each day and notifying when they have broken a personal record. This helped the project take the approach of using a score-based system to provide the user something to strive towards, encouraging play and increasing performance.

## Mobile App User Interface

Prioritizing UI/UX is very important to ensure a user-friendly, accessible, and easy to use product. This is emphasized by Nasrullah Hamidli’s Introduction to UI/UX Design: Key Concepts and Principles(Hamidli, 2023). This author greatly describes how essential UI/UX is in mobile app and web design, explaining key principles to provide a satisfactory experience for the user. This study heavily inspired this project in terms of choice in typography, layout, imagery, font size as well as how to approach the development of the UI/UX. The key concepts and principles are also shown through the Fitbit app mentioned previously, which explains its success through the number of downloads and high Play Store reviews.

To conclude the literature review, using the familiar data collection and sensor integration methods from Nathan and Mangiarotti should ensure a proper way of discerning different dribbling moves for my ML algorithm. Pairing that with a suitable ML algorithm inspired by Abhilash’s LSTM+CNN Approach, we can attain a high accuracy for our mobile application to identify moves performed by the users. With the core foundation of the application being settled, implementing a suitable gamification approach along with a user-friendly and accessible UI/UX design should finalize this project’s deliverable with aims of creating an innovative basketball training tool.

# Legal, Social and Ethical Issues

It is important to address the Legal, Social and Ethical issues regarding both the problem and the solution, to ensure that the participant and consumer’s protection and safety are considered throughout this process. Transparency on what is required and used by our deliverable is essential especially when handling with the user’s information.

Due to the nature of our problem and solution, not many issues are to be covered.

## Legal

Following the General Data Protection Regulation’s (GDPR) is very important when ensuring that data is handled appropriately and with consent and transparency. With our solution, no data is necessary from the user for the application to work or function as intended.

The solution does not use any Third-Party libraries or tools that would need licensing.

Accessibility is very important to consider allowing for a variety of users to use the application. Due to this app being very interactive requiring a lot of movement, some inclusivity is naturally inhibited. However, to aid visual impairments we made sure that buttons and text are very clear to read in terms of size, typography, and colour in reference to WCAG 2.1. Buttons are big and responsive enough to be pressed, especially through an armband.

## Social

Social issues can include accessibility regarding income level, cultural sensitivity, and user dependency.

This application was intended to be used by all users regardless of income level or cultural background. Armbands to hold the mobile device are relatively inexpensive and cater to many devices.

The required sensors for the mobile application to function are the Accelerometer and Gyroscope sensors. This may be an issue as older devices may not be compatible if they lack these sensors. I have taken this into account; however, I could not find an alternative solution to this matter. Almost all modern devices have these sensors, so this issue is minor.

## Ethical

Ethical issues include transparency of data in terms of what it’s using and how it will be used and any potential biases in the app’s actions.

As mentioned previously no data is being used by the application and as such transparency, although important, is not needed in this case.

Technically speaking, the only ‘data’ collected is the movement of the mobile device when performing the dribbling moves to be identified. Although this information is not sensitive, to reduce unnecessary usage of this information being generated from the device the sensors are only activated during the playing stage of the game and are immediately turned off after stopping the game or completing it.

Biases in how the application functions can include how the application discerns different dribbling moves from others, depending on how the user performs them. This is a valid point, and the application would benefit from having multiple users perform these moves to support as training data for the model. To add on to this, the application does not have any biases regarding the build of the user such as: height, weight, or gender. The identification of dribbling moves is strictly focused on how the user performs the move.

To cover the participants who tested this application, no personal data was necessary to be collected for the application. They were kept anonymous throughout the research, and only their answers through the questions and feedback where considered.

# Evaluation of the Finished Product

To evaluate the quality of this deliverable, I will go through my MoSCoW requirements, and weigh them against the deliverable to ensure that the requirements have been met. Naturally, meeting the MoSCoW requirements would also include testing the quality of the UI/UX to ensure that the proper functions can be performed and accurately displayed on the screen.

The chosen machine learning model will also be evaluated. The models training and testing accuracy will be used for this. This is in reference to how the previous studies (such as Nathan Kulman et al.) mentioned also evaluated their machine learning model.

This evaluation will also include Unit Testing the model through real-time usage, ensuring that the accuracy of the model after being tested against the dataset, is somewhat reflected in its performance when used in the mobile application.

Using this evaluation strategy to assess the quality of my deliverable, we have found that the deliverable does meet the ‘Must have’ and ‘Should have’ requirements, making it suitable as a solution for the problem we have chosen to solve. However, it does fall very short in the ‘Could have’ area in the MoSCoW (Figure 1).

In terms of the ML model, it achieved a 97% accuracy which is suitable for the application. The Confusion Matrix (Figure 2) (Table 1) shows it is very capable of identifying moves from the dataset, with slight struggle between a few classes.

The conclusion of the unit testing (Table 2) led to a satisfactory performance from the ML model in its ability to discern different moves from one another, providing a satisfactory performance.

**Figure 1**

*MoSCoW Evaluation*

A yellow and white checklist

Description automatically generated

Figure 1

**Figure 2**

*Confusion Matrix Results*

A blue squares with white text

Description automatically generated

Figure 2

*Note. This figure displays the amount of identifications the ML model makes for each class, including ones that it misinterpreted.*

**Table 1**

*Results of each individual class of the ML Model*

Table 1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Activity | Accuracy | Recall | Precision | F1 Score |
| Crossover | 98.8% | 98.8% | 84.6% | 91.2% |
| Between the Legs | 92.3% | 92.3% | 97.4% | 94.8% |
| In and Out | 88.3% | 88.3% | 98.9% | 93.3% |
| Overall | 93.3% | 93.3% | 94.0% | 93.3% |

**Table 2**

*Unit Testing of the ML model*

Table 2

|  |  |
| --- | --- |
| Class (Dribble Move) | Accuracy |
| In and Out | 90% |
| Between the Legs | 78% |
| Crossover | 75% |

*Note. This is the result of the Unit Testing and does not cover all tests that were conducted due to the number of tests. The Unit Testing consists of each classes performance when solely focused on during actual testing of the application.*

To critically reflect on the quality of this assessment, this project will go over whether if the choice of methods were appropriate, and if they were conducted effectively.

For this project, we believe that the methods chosen to assess the quality of the deliverable were appropriate and fit for purpose. Using MoSCoW was great to ensure that potential client demands were being met with the application. Gauging accuracy via training & testing data and unit testing of the ML model was an effective choice in finding out whether the model would be up to standards for the application.

The way these methods were conducted in this project could do with more work. Each MoSCoW requirement should have had specific steps to ensure that the way in which the requirement was fulfilled was done in a precise manner. This would include the process of opening the app and traversing through any necessary screens or functions to fulfil the requirement.

The UI of the application was also not properly assessed. Although the application was functional, some graphical errors were apparent (Figure 3). Properly committing to a UI Unit Test, as well as including Non-Functional Requirements could have fixed this problem.

**Figure 3**

*UI Errors; Emulation vs. Actual Device*

A screenshot of a phone

Description automatically generated

Figure 3

*Note. Left image is the UI through emulation; seemingly correct. Right image is on the actual device; text is cut off and slightly offset.*

The finished product could be improved by fulfilling and making a better attempt on the ‘Could have’ requirements set in the MoSCoW. This would allow for more features to increase the gamification aspect of the application, shown in the ‘I want to be able to compare my scores with other players’ requirement.

Implementing more personalization features would be a great benefit to this product. Although adding dribbling moves would not be possible, giving them the ability to choose out of the already existing three would give them more freedom to choose what moves they want to work on.

To extend on this idea, simply creating more classes to allow for more dribbling moves would also be of great value, to increase the variety of dribbling moves for the user.

And finally, catering the product towards Apple products would most definitely be of great benefit to users, making it accessible to all mobile devices.

# Conclusion

Influenced by the studies mentioned, the methods and algorithms used lead to a suitable and functional product which can help aid users in increasing their player skill in dribbling in Basketball. Future work for this project would include an increase in dribbling moves, more personalization and fulfilment of MoSCoW requirements.

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