Decision Review System

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Abstract - *A fair decision is crucial in any sport to give justice to the game. Any wrong decision due to human misperception may fate the result of the game. Computer vision and Image processing techniques use multiple cameras for demonstration. This project focuses on a system which helps in making the decisions to assist the umpire in taking the decisions such as determination of winner in a race, not- out/out in cricket, foul or goal in football etc. with just the help of smartphone camera of good quality.*

The Decision Review System (DRS) which is to be developed inthis project aims to give decisions like run-out and stump-out. Tkinter will be used to develop the Graphical User Interface (GUI) of DRS. Tools such as OpenCV library, Python Imaging Library, Imutils will be used for the implementation.

Key Words: Tkinter Library, OpenCV library, Python Imaging Library, Imutils

1. INTRODUCTION

With technology taking over every aspect of life, it was only amatter of time before it was utilized to the advantage of sports. Technology in sport is used with an objective to eliminate human errors that may have earlier affected the course of the game drastically. The Decision Review System was introduced across various sports, to give the players anopportunity to review such errors from the on-field umpire.This project identifies and examines the use of officiating technology and it impact across different sports such as badminton, rugby, tennis and cricket [1]. In addition to this, statistics collected within various sports have proved time and again that umpiring decisions have been more accuratewith DRS than without. It is silly to argue that we should nothave DRS unless it has 100% accuracy—you anyway cannot get 100% accuracy without using technology. It is enough that DRS improves the accuracy percentage—as it doubtlesshas, from 90.3% to 95.8%—for there to a strong case for its use. Furthermore, the DRS also has other things going for it.As the Guardian's Rob Smythe has pointed out, it is changing the game in some fundamental ways, and definitely for the better. It has made the game even more competitive and fair.[3]

1.1 Background

Technology within sports is forever advancing due to the evolving world that is today. The technology i.e., DRS assists match officials to make the correct decision in a game that has the potential to change the final outcome of that game/match. The first use of a decision review system within sports took place in the NFL as far back as 1985. Theyused instant replay technology to monitor the game inside the stadium to allow the officials to be more accurate and also add another dimension to officiating. However, this technology held many bugs and often caused delays, as well as only being able to review an incident with indisputable visual evidence. This technology was the birth of decision review systems used in the modern day. Majority of sports have developed and evolved over the last decade by implementing this type of technology to advance the sport itself. These technologies are able to improve the athletes' performance by thoroughly analysing their performance, produce optimum sportswear to give athletes an advantage, improve the refereeing decisions using decision review systems. [2]

1.2 Aim and Objective

Our aim is to create a Decision review system (DRS) with theobjective of eliminating the howler – the poor decision takendue to nuances missed with the naked eye, which with assistance of this technology can be avoided. Our project willprovide aid with decisions like run-out, stump-out, net-cross,declaring a winner etc. Tkinter will be used to develop the Graphical User Interface (GUI) of DRS. To detect the decision or occurrence of event of the sport from the video we will be optimizing and using various functions such as frame subtraction using an inbuilt python module called OpenCV library. [4]

2. LITERATURE SURVEY

2.1 Umpire Decision Review System in Cricket

This paper aims to produce a very cost effective and affordable computer mechanism that supports and facilitates the cricket umpire, runs at a low budget, has lower technical (software and hardware) requirements, and can be used in cricket tournaments at local district level, this indeed will train the network as well as improve the efficiency of the game from a grass root level.

The module uses tools like Python, Tkinter for GUI, Pillow, OpenCV and Imultis packages for Python. In this project specifically, live feed of the instance can be fed through the camera as an input stream for the software and thus decisions can be carried out in an instance, for the live audience. Ultimately saving precious time.

Without any fancy equipment and with the help of just a computer system and a camera this system can run efficiently, thus making it compatible for all scale tournaments. This project is only an infant and there is always room for various kinds of improvement and modifications. [5]

2.2 Goal detection in football by using Support VectorMachines for classification

In the proposed paper focus is primarily based on the problem of detecting 3D objects by using the image which they project on the sensing plane of a camera. The occurrence of the event is established detecting the ball and comparingits position with respect to the location of the goalpost in image.

In the first test batch the detection rate was of 98.3% with a false positive rate of 0.2%; in the second test batch, where occluded footballs were considered too, the detection rate was observed to be 76.2% with a false positive rate of 2.6%. A particular instance of this general problem is the detection of a ball in images at the aim of detecting goals during a footballmatch. The system can be seen as an electronic linesman which helps the referee to establish whether a goal has occurred or not. [6]

2.3 Use of Technology in Tennis, Football and Cricket

This paper proposes the idea of Line Review System used in Hawk-Eye ball tracking systems in tennis. In each frame sentfrom each camera, the system identifies the group of pixels which corresponds to the image of the ball. It then calculates for each frame the position of the ball by comparing its position on at least two of the physically separate cameras atthe same instant in time. A succession of frames builds up a record of the path along which the ball has travelled. It also predicts the future flight path of the ball and where it will interact with any of the playing area features already programmed into the database. The system can also interpret these interactions to decide infringements of the rules of thegame.

Although, of all the challenges made by the players that have been created, succeeding rulings made by the Hawk-Eye system have shown that only 46% of the decisions made are correct. French Open have thus far refused to use this technology, as the unique characteristics of the clay court doesn't warrant it. Every ball played in the match will make a mark on the clay surface, it is possible for the match official to get out and have a look at the place where the ball was struckto work out if the ball was in or out, therefore avoiding the necessity of hawk eye.

While the Football version of the system has substantially trailed and has performed effectively in the test environment.The Hawk-Eye system there, uses three cameras targeted on every goal-line, and each of them take video footage at 600frames per second. Thus, it has means to grant a conclusive decision on whether the football has fully crossed the goal line or not and transfer this information to the main refereeless than one second. [7]

2.4 Decision making using image processing

This paper proposes a new approach for detecting the run out using stump detection and from the intersection of the bat and the crease line, named Artificial Intelligent third Umpire (AITU). The accuracy of decision making is improvedthereby reducing the third umpire work.

If the on-field umpire within a fraction of a second was not able to make a decision, then the decision from the third umpire is sought. Then the third umpire views various TV replays at various angles and will declare the result as 'out' or'not out'. If the umpires are not sure about the decision that a batsman is 'out' or not, as they are deficient with more convincing evidence, the standard practice is to set free thebatsman, known as "the benefit of the doubt". However, thismay possess certain problems includingdelayinmatch whichmay prove to be critical.

The input to the proposed module is a video. A digital videoencompasses a succession of digital images displayed in quickprogression. The match video is processed to get the frames which are then used for making the decision. The foreground is extracted by performing background subtraction. Initially pre-processing is done to enhance the image quality. Frame segmentation is process of changing the representation of theimage to make it easier for analysis. It is done on video frames to locate object boundaries like lines, curves, etc.

While the following system proves to be an accurate model to provide decision for run out without human intervention, unfortunately the same cannot be said for decision such as LBW detection and Catch detection. [8]

2.5 Public understanding of technology with special reference to Hawk Eye

This paper aims to introduce the DRS and especially Hawk- Eye for the understanding of the public. It provides an insightto Hawk-Eye, which is a video processing system combiningseveral cameras and a computer to store and process the data. By combining the trajectory of the ball with the model of the pitch and the database of rules, the path of the ball can be reconstructed against the background of the main features of the playing area as a virtual reality and the decision is given. The reconstruction of which can be shown to television viewers.

It also talks about DRS as a decision aid to the umpire rather than decision maker for the umpire as well as the Automated Decision Principle. If it were followed, and with the increasing speed of computation potentially making automated decision devices more accurate and more capable of analyzing and presenting, in real time, the magnitude of uncertainty associated with any reconstruction, the future for the technology as an aid to human judgment, seems bright.[9]

2.6 Decision Review System in Cricket

This paper suggests that the most common instances of referrals are for caught behind and Leg Before Wicket (LBW). As the final decision rides on chance of agreement of the field umpire along with, the DRS algorithms since this technology predicts the nature of the trajectory of the delivery and such factors are dealt in very small measurements (in millimeters). Various errors included may change the final result for the same delivery if replayed again. The paper put forth the mainidea that is to have a continuous real time feed clicked from the six cameras strategically placed in the stadium each operating at the specific frame rate which is enough to capture the pitched delivery to provide data points for mapping the virtual trajectory of the ball. Though, there is always a question of the accuracy with which the technologyworks as its decision cannot be referred again and is considered final. Hence, the accuracy of the technology used is limited to a certain range, but along with the human intervention in the decision making, this review system is bound to be the perfect solution to such a problem. [10]

3. EXISTING SYSTEM

3.1 Decision Review system in Cricket

The decision review system in cricket comprises of various components such as Hotspot, Hawk-Eye, Snickometer, Ultra- Edge, etc. For the Hawkeye, the main goal is to have a continuous real time feed clicked from the six cameras strategically placed in the stadium each operating at the specific frame rate which is enough to capture the pitched delivery to provide data points for mapping the virtual trajectory of the ball. The third umpire refers to this technology when a referral for a LBW is sent upstairs to verify whether the ball was going on to hit the stumps if notinterrupted by the batsmen leg.

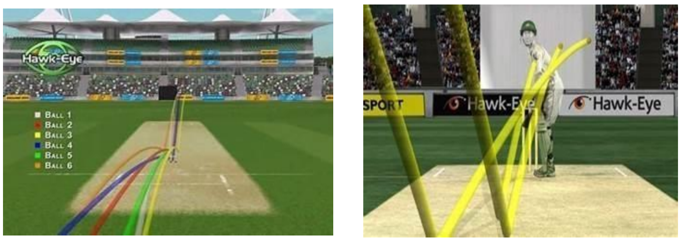


Figure 1: Decision Review system in Cricket

3.2 Decision Review system in Tennis

All Grand Slam tournaments of tennis provide line review system which uses Hawk-Eye ball tracking system. The players can use this system to evaluate debatable line calls. All Hawk-Eye systems are based on the principles of triangulation using visual images and timing data provided by a number of high-speed video cameras located at different locations and angles around the area of play. The tennis hawk eye system uses up to ten cameras. The system rapidly processes the video feeds from the cameras and balltracker. The system uses something called data store which is used to store a 3D blue-print model of the playing area/ court and also stored in it are the rules of the game.

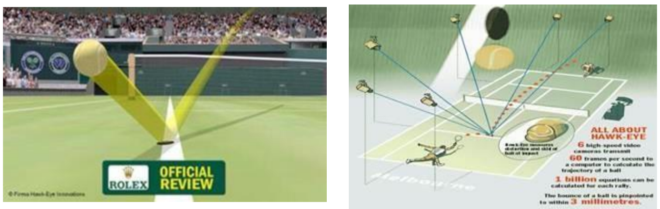

ROLEX
OFFICIAL REVIEW
ALL ABOUT HAWK-EYE
6 high-speed video cameras transmit
60 frames per second to a computer to calculate the trajectory of a ball
1 billion equations can be calculated for each rally.
The bounce of a ball is pinpointed to within 3 millimetres.

Figure 2: Decision Review system in Tennis

3.3 Decision Review System in Football

Decision Review system in Football comprises of various systems such as smart ball system, Goal Ref System, Hawkeye System, etc. The system which has had a very successful trial and is the leading candidate out of all the other system is the Hawkeye system. Primarily used in the English Football league, Premier League the Hawk Eye system uses three cameras targeted on every goal-line, andeach of them take video footage at 600 frames per second. Hawk-Eye has the means to grant a conclusive decision on whether the football has fully crossed the goal line or not and transfer this information to the main referee in less than a second.

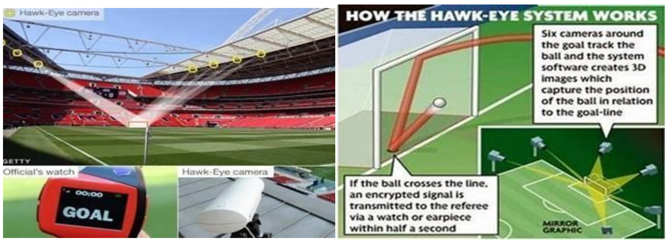

Hawk-Eye camera
GETTY
Official's watch
00:00
GOAL
Hawk-Eye camera
HOW THE HAWK-EYE SYSTEM WORKS
Six cameras around the goal track the ball and the system software creates 3D images which capture the position of the ball in relation to the goal-line
If the ball crosses the line, an encrypted signal is transmitted to the referee via a watch or earpiece within half a second
MIRROR GRAPHIC

Figure 3: Decision Review system in Football

4. PROPOSED SYSTEM

Traditionally, in various sports the final judgement is given by the referee or the umpire. While usually most of these decisions are correct, often there are discrepancies behind these decisions since human judgement is involved which has the potential to change the final result of the game. Our System is basically an aid to the umpire in case of such discrepancies where in only a good quality camera and a system to operate the software is needed. What this human aid does is, it operates on frame rate to give a clear picture ofthe exact moment where the decision needs to take place and the final call is given by the referee themselves.

For the module:

Our project will be implemented using Python and Tkinter, OpenCV library, Python Imaging Library, Imutils, Pillow module etc. Decisions like stump out, run out etc. can be decided by altering the source video's frame rate for the which, we will be optimizing and using frame subtraction using OpenCV library.

4.1 GUI of DRS:

Tkinter is used to make GUI of the Decision Review Systemand various computer vison algorithms that give decisions based on different criteria. Python offers multiple options for developing GUI (Graphical User Interface). Out of all the GUImethods, Tkinter is the most commonly used method. Beinga Python binding to the Tk GUI toolkit, it gives standard Python interface to the Tk GUI toolkit, and is Python's de facto standard GUI. Tkinter also includes standard GNU/Linux, Microsoft Windows and mac OS installs of Python.

4.2 Frame Subtraction:

Frame subtraction will be done using OpenCV (Open-Source Computer Vision Library) which is a library of programming functions mainly aimed at real-time computer vision. OpenCV is an open-source library which is very useful for computer vision applications such as video analysis, CCTV footage analysis and image analysis. OpenCV supports a widevariety of programming languages like Python, C++, Java.It can process images and videos to identify objects, faces, oreven the handwriting of a human. OpenCV is written by C++ and has more than 2,500 optimized algorithms. When we create applications for computer vision that we don't want to build from scratch we can use this library to start focusing on real world problems. There are many companies using this library today such as Google, Amazon, Microsoft and Toyota. Many researchers and developers contribute.We caneasily install it in any OS like Windows, Ubuntu and Mac OS. With reference to our project, OpenCV library will be majorly used to bring changes to the frame i.e., increasing or decreasing the frame speed.

4.3 Python Imaging Library:

Python Imaging Library (expansion of PIL) for which Pillow module is to be installed, is the de facto image processing package for Python language. It incorporates lightweight image processing tools that aids in editing, creating and saving images and with respect to our project, it will load images from an array.

4.4 Imutils Module:

Imutils which is basically a series of convenience functionsto make basic image processing functions such as translation, rotation, resizing, skeletonization, and displaying images easier with OpenCV will also be used for the implementation.

Hardware Requirements

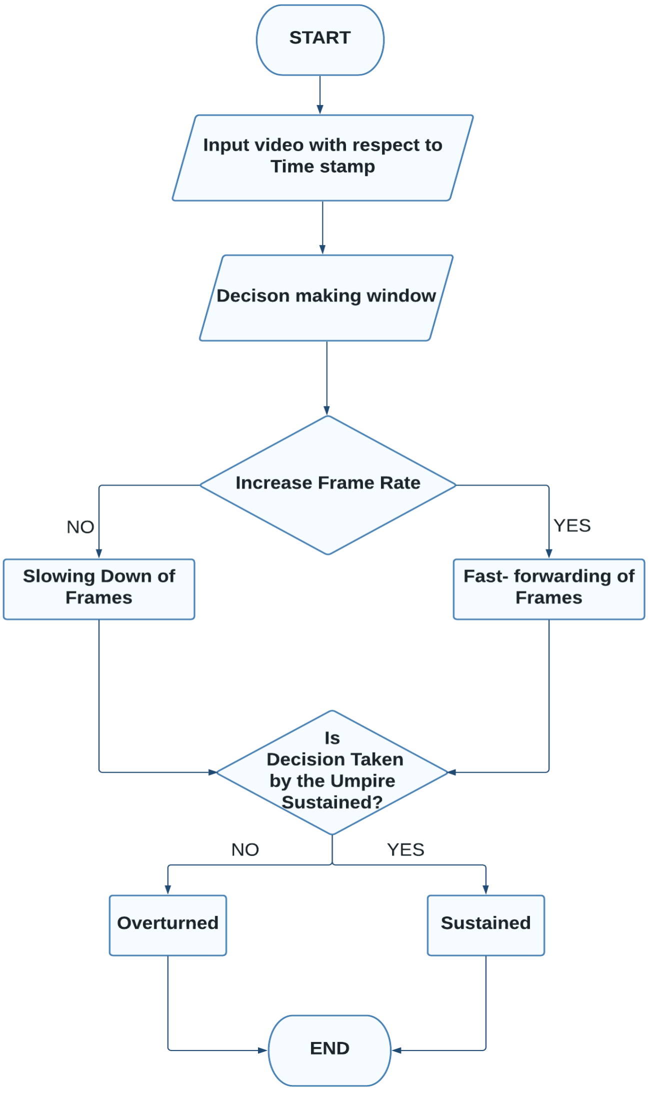
i. A Camera of decent quality
ii. PC - Modern Operating System: 32- or a 64-bit Windows 7, 10 or 11, Mac OS X 10.11 or higher, 64-bit Linux: RHEL 6/7, 64-bit (almost all libraries also work in Ubuntu) x86 64-bit CPU (Intel / AMD architecture) 4 GB RAM 5 GB free diskspace.

Software Requirements

i. OpenCV Library - 32- or a 64-bit computer, Windows 7,10 or 11, macOS X 10.11 or higher, or Linux RHEL 6/7, Python2.7, 3.4, 3.5 or 3.6.

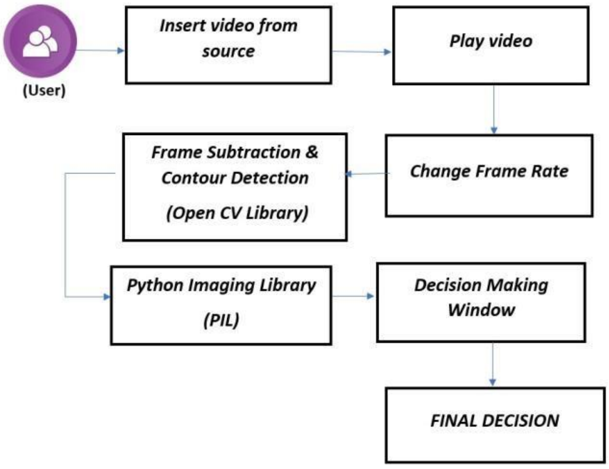
ii. Tkinter (8.6. 11)
iii. Imutils - Open CV Library, Python 2.7 or 3.Visual Studio Code IDE (1.61.1)

5. DESIGN OF THE SYSTEM


START
Input video with respect to Time stamp
Decison making window
Increase Frame Rate
NO
YES
Slowing Down of Frames
Fast- forwarding of Frames
Is Decision Taken by the Umpire Sustained?
NO
YES
Overturned
Sustained
END

Flowchart 1: Approach

In the system, the video will be added according to the time frame where in the decision making is required. Then the sport is to be selected accordingly following which a decisionwindow pop-up will appear where there will be options to slow or make the video go faster by altering the frame rateand thus it will be decided if the decision made by the umpire is to be sustained or overturned. System Architecture



Flowchart 2: Block Diagram of Decision Review System

The project has been implemented using tools like Tkinter for GUI, Pillow, and OpenCV. Tkinter is a GUI framework thatis built into the Python standard library that has been usedfor the front end. For the backend the python programminglanguage has been used.

At first the user will be selecting a sport for which the decision has to be made. Then a video will be inserted from the source destination. Once inserted we can play the video with different frame rates available. This could be done usingvarious modules and tools as mentioned. OpenCV is a hugeopen-source library for various sectors which has been primarily used for image processing. It will be used to process images and videos.

Further Tkinter also relies on Pillow for working with images. Pillow is basically a fork of the Python Imaging Library and can be imported in a Python console as PIL. It incorporates lightweight image processing tools that aids in editing, creating and saving images. Hence by slowing downthe frame rate a collective decision (Human Aided) could be made. A decision-making window will appear which would have several options depending on the sport which had been chosen earlier and the final decision will be displayed.

6. RESULT AND DISCUSSION

6.1 Observations

Using our application, we have thus created a Decision Review module. While most of the process was done using our application, a variety of images as well as Graphics Interchange Format (GIFs) were developed using Canva software. It took us 5-6 days to figure out a proper framework for the whole module including all the features which we wanted to implement after studying up on the modules and previously developed projects on the same. Since the libraries used for this project were available withinpython and only required us to import or needed to be imported from modules which were installed using pipinstall command, made it easier and a less of a pain-staking process when it came to libraries. Online tutorials are available on how to do this. Regardless, our process involvedthe following steps:

6.1.1 Development of GUI

For the development of Graphical User Interface (GUI) we used the Tkinter library of python in which around 18 windows were created catered to specific functions in whichthe breakdown is as follows:

The Starting Window followed by Select Sport window. Theselect sport window comprises of three sports:

Football:
Football → Upload Video → main decision window frames are altered → Choose Decision → GIF pop-up window → Display of decision

Athletics:
Athletics → Upload Video → main decision window frames are altered → GIF pop-up window (Since Decision has to begiven manually)

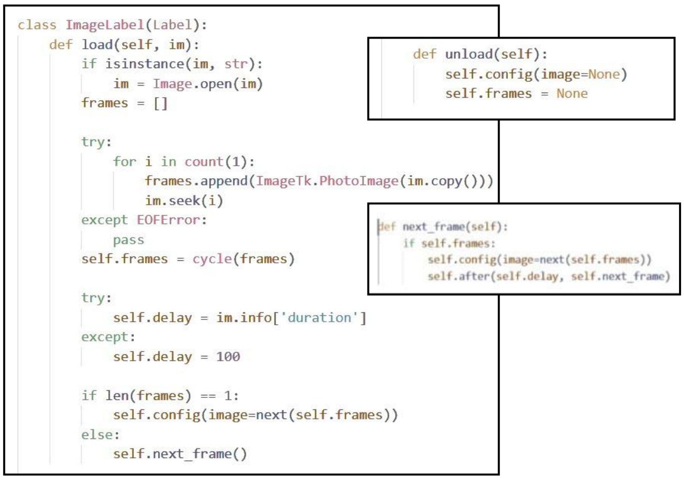
Cricket:
Cricket → Upload Video → main decision window frames are altered → Choose Decision → GIF pop-up window → Displayof decision

Following which appropriate images and GIFs were developed on Canva for background as well as buttons.

6.1.2 Creation and Association of Callback Function

Buttons are standard widgets in a GUI. They come with thedefault Tkinter module and can be placed in the window. APython function or method can be associated with a button.This function or method is named the Callback function. If the button is clicked, the callback function is called.

Since we wanted to customize the buttons, images were created for these and were placed inside the buttons. Following which, functions were created catered to each button.



```
class ImageLabel(Label):
    def load(self, im):
        if isinstance(im, str):
            im = Image.open(im)
        frames = []

        try:
            for i in count(1):
                frames.append(ImageTk.PhotoImage(im.copy()))
                im.seek(i)
        except EOFError:
            pass
        self.frames = cycle(frames)

        try:
            self.delay = im.info['duration']
        except:
            self.delay = 100

        if len(frames) == 1:
            self.config(image=next(self.frames))
        else:
            self.next_frame()
```

```
    def unload(self):
        self.config(image=None)
        self.frames = None
```

```
def next_frame(self):
    if self.frames:
        self.config(image=next(self.frames))
        self.after(self.delay, self.next_frame)
```

Fig 4: Creation and Association of Callback Function

6.1.3 Selection of File from memory

To select a input file or video from the user's device's memory we will be using the command, file=filedialogue.askopenfilename(). The function askopenfilename() will basically open a window which willallow the user to select any file from their memory. It is a dynamic way of inputting any file of the user's choice into the decision review module.

6.1.4 Development of the Main Decision Window usingFrame Manipulation

A final decision would be given by manipulating the frame rate of the video in the give decision window. For this Open CV library will be used primarily for image processing. In addition to this, Tkinter also relies on Pillow which is a forkof the Python Imaging Library that will aid in editing and altering the frame rate of the video accordingly.

6.1.5 Collection of Sample Input data

A video will be inserted as a sample input. In our case, we have taken sample videos from YouTube. The video has to beselected in such a manner that it is focused on just one view or is in a 1 person POV so that an appropriate decision can be given. In addition to this, the video should be clear and ofgood quality to avoid tearing of the video while altering theframes.

6.2 Step by Step Working of the module

On running the module, we first come across the starting window where the user can either exit the application or click on next which will take us the next window.

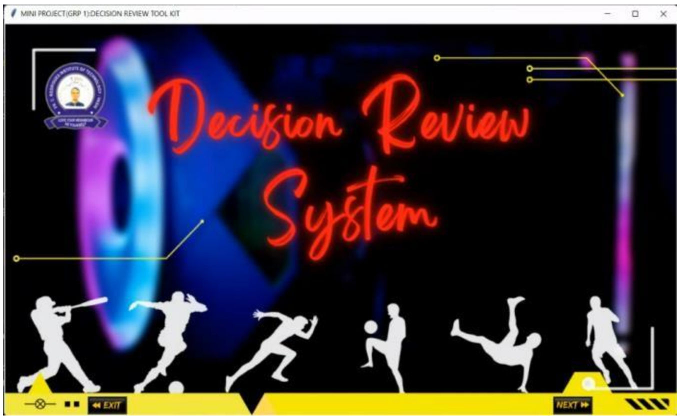


Figure 5: Starting Window of Module

The next window is the select your sport window where theuser will select the sport according to their need.

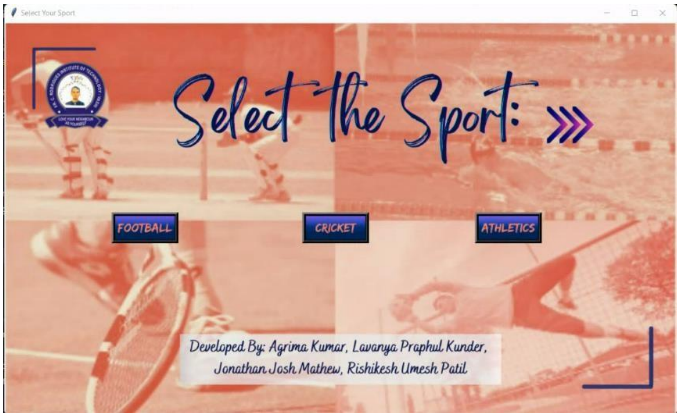

Select Your Sport
Select the Sport:
FOOTBALL
CRICKET
ATHLETICS
Developed By: Agrima Kumar, Lavanya Praphul Kunder, Jonathan Josh Mathew, Rishikesh Umesh Patil

Figure 6: Select the Sport Window

Suppose if the sport football is selected, it will take us to the football window where the user can either go back which will take them or click on the upload button where they can select the appropriate file from their device's memory.

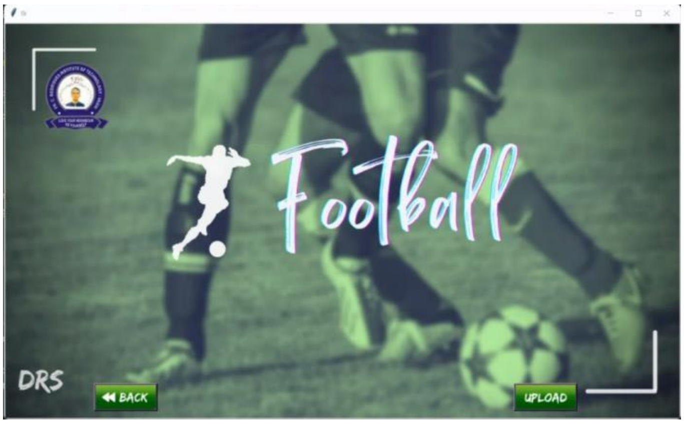


Figure 7: Football Window

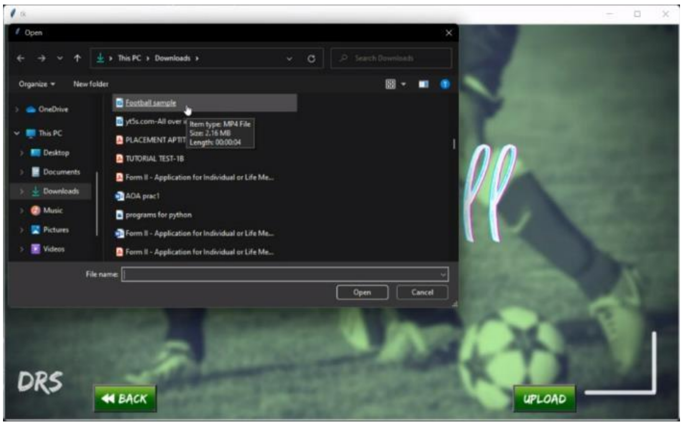


Figure 8: Uploading football sample video

On clicking upload, the user is directed to the main decision-making window where they can go back to the football window or manipulate the frame rate as going back 1FPS, 5FPS, 25FPS or moving forward 1FPS, 5FPS, 25FPS. When the decision has been clearly reflected and the users know the decision, they can click on proceed.

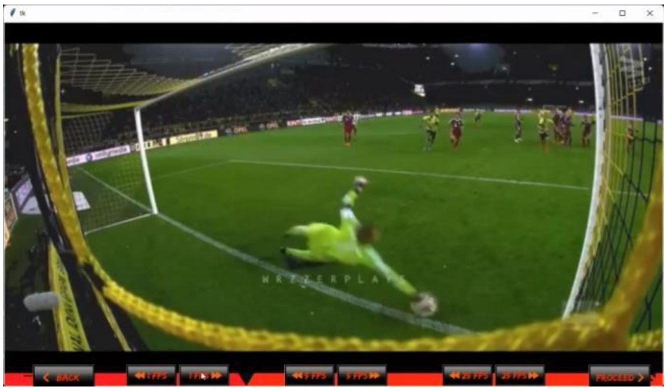


Figure 9: Main decision - making window

The user then proceeds to give decision accordingly.

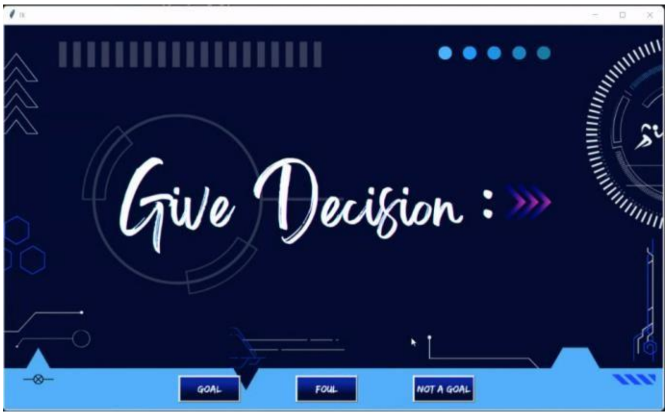


Figure 10: Sample Give Decision Window

The next window is the pop-up window where a Decision pending GIF will appear. The user is then supposed to click on the Give decision window following which the corresponding decision GIF will appear.

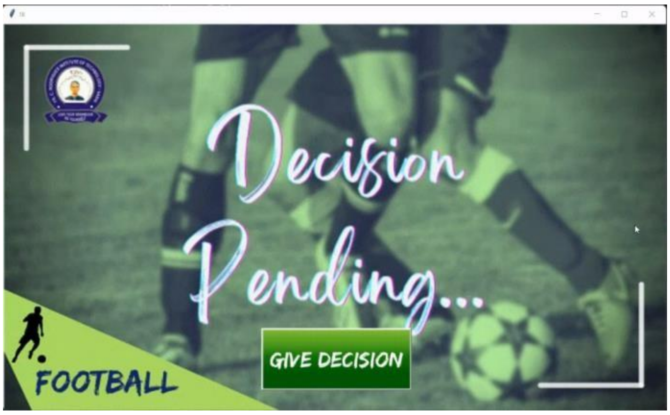


Figure 11: Decision Pending Window

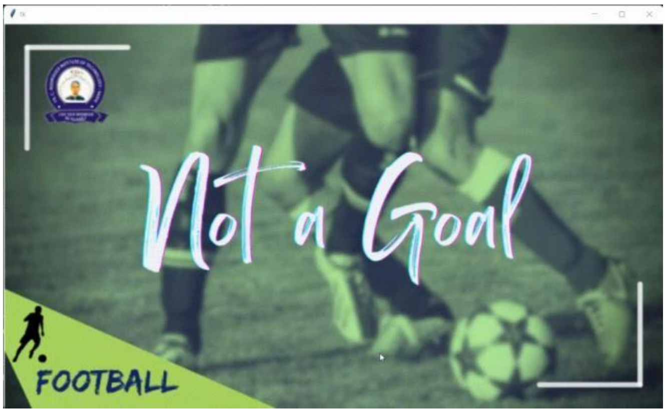


Figure 12: Decision Display Window

1.1 6.3 Important Code Snippet

```
 Video = capture video
 from file;play(speed)
{
  select and import video;
  Frame = get video's first frame;
  Frame = set video's (first + speed)
  frame;grabbed;
  Frame = video.read;
  resize video according to
  frame;reset color in RGB
  format; Display Frame in
  canvas;
}
```

7. CONCLUSION

Traditionally in sports, the final judgment is given by the referee. While usually most of these decisions are correct, often there are discrepancies behind these decisions since human judgment is involved which has the potential to change the final result of the game.

Hence, we have built a comprehensive approach to this problem which consists of a combination of various modules and libraries in python that have been used to help create a user-friendly system which has a flexible and easy to use interface and enables the operator to give decisions. We understand that user of the system may not have technical expertise and therefore the system is designed in such a way that they are not burdened with technical jargon. This application works by altering the video speed and frame rate and requires only a good quality camera to capture the feedthus giving a sense of technology similar to the one used insports at professional levels.

8. FUTURE SCOPE

At present, this system works when the exe. File along with python are installed in the device. Further, a feature of live camera feed along with a website can be implemented for the module to work on devices which don't necessarily havepython installed in them.

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