THE UNIVERSITY OF ALABAMA
COMPUTER SCIENCE

Mobile Video Velocity Estimation (MoVVE)

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Background:

ESPN's use of K-Zone during Major League Baseball broadcasts is a well-recognized application of computer vision. K-Zone uses three cameras and multiple computers running a complex algorithm to track the flight of a baseball and obtain its velocity. Computer generated graphics are then overlaid on the viewers television screen to illustrate the ball's flight path and where it crosses the strike zone.

MoVVE's Objective:

The goal of MoVVE is to investigate software algorithms for mobile devices that estimate the speed and tracks the location of a thrown baseball using video obtained from a single mobile digital camera.

Velocity will be calculated by knowing the distance of the baseball from the camera at specific times. The time will come from the frame rate of the camera, and the distance will come from the image size of the ball.

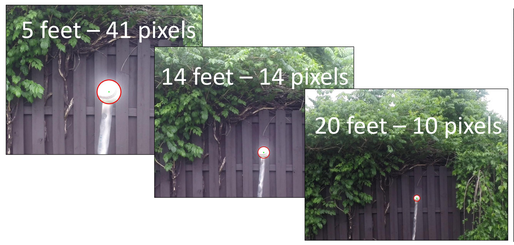
Hardware / Software:

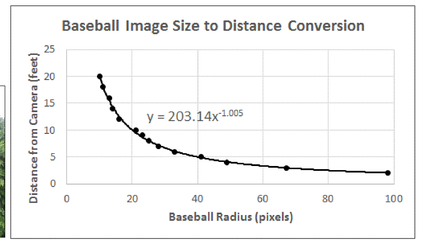
•Language:	C++
•Compiler:	Windows Visual Studios
•Camera:	GoPro 3 Black, IPhone5s
•Frame Rate:	60 Frames Per Second
•Resolution:	1080p Narrow

MoVVE uses OpenCV image processing libraries to allow access to certain functions related to object recognition (Hough Circles, Gaussian Blur).

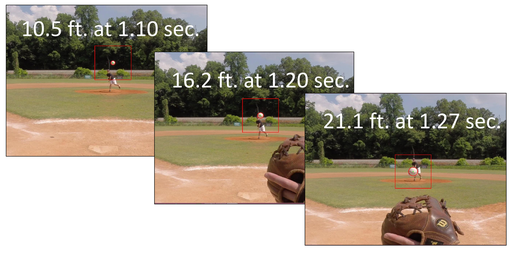
How MoVVE Works:

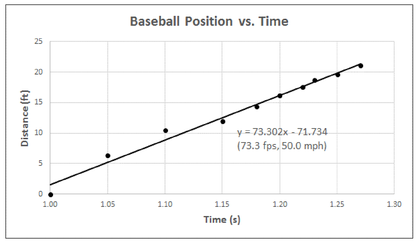
MoVVE relies on its ability to detect a baseball in a video still image, and the fact that the ball size within the image will be larger the closer the ball is to the camera. To locate the baseball in the image, MoVVE uses OpenCV's Hough Circles function. The relationship between ball image size and position relative to the camera was determined by using the OpenCV Hough Circles function to measure the ball radius at different known distances from the camera. The data collected was used to calculate an equation that converts ball radius (px) to distance (ft).



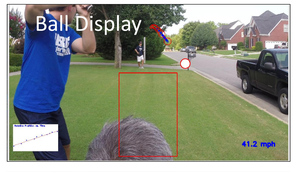


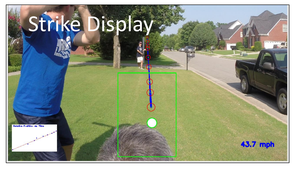
MoVVE searches all frames within the video to be analyzed for the presence of a baseball, using ball color, ball size, and reduced region of interest to eliminate false positives. For every positive detection, MoVVE collects the ball radius, which is converted to relative position based on the equation defined above, and the associated time that is determined from the camera frame rate. The velocity of the ball can then be determined by fitting a straight line to the position versus time data, with the velocity being equal to the line slope.

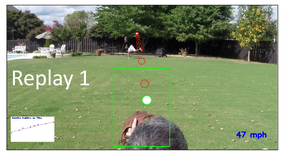


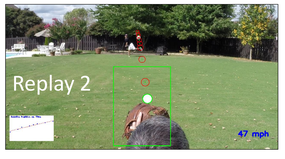


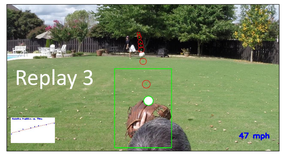
Having collected baseball position versus time data and calculated the ball velocity, MoVVE redisplays all Hough Circles data, producing a graphical display of the baseball flight path. This flight path is compared to a strike zone, allowing for a determination of pitch balls and strikes. MoVVE also provides for video replay of the pitch combined with flight path graphics.

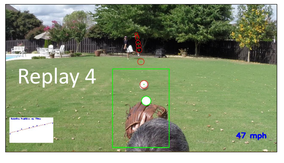






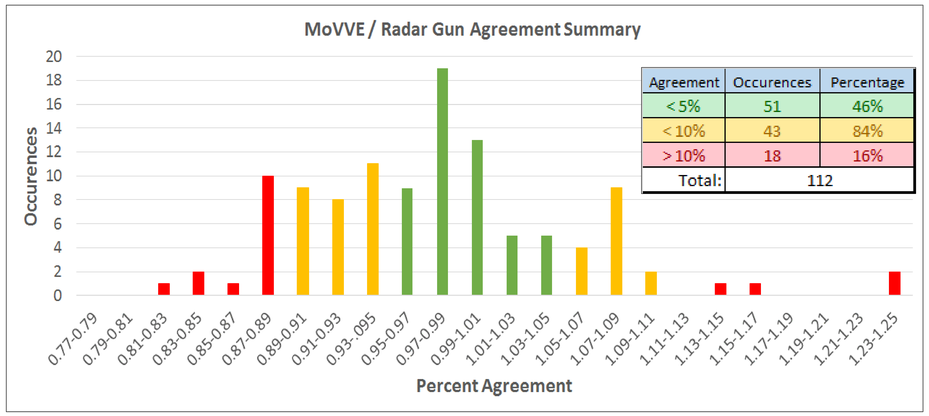




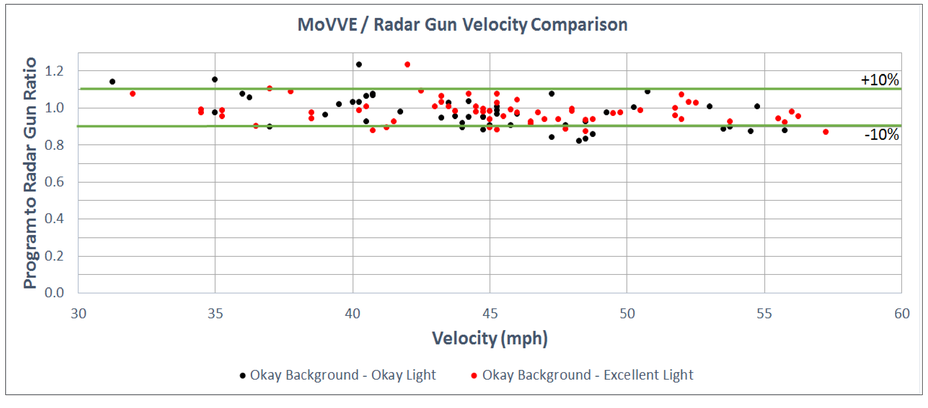


Testing and Results:

The accuracy of MoVVE was assessed by comparing its results with those obtained from a radar gun. Out of 112 pitches, MoVVE and the radar gun agreed to within 10% on 94 pitches and to within 5% on 51 pitches.



The following graph shows that MoVVE and the radar gun agreed throughout a wide range of velocities (30 mph to 60 mph). The green lines show the bounds for ± 10% agreement.



Conclusions and Future Work:

Conclusions:

- MoVVE was successful in detecting and tracking a baseball under varying conditions.
- Extensive testing has shown MoVVE to be highly accurate in estimating velocity.
- MoVVE demonstrated that computer vision can be integrated into mobile technology.

Future Work:

- Explore modifications for use with other sports involving a round ball.
- Incorporate logic enhancements allowing for more flexibility in camera placement.