Video Measurement of Golf Green Putting Speed Using a Cellphone

H. Joseph Sommer[1], Timothy T. Lulis[2], John E. Kaminski[2]

[1] Mechanical Engineering, The Pennsylvania State University, University Park, PA, USA
[2] Plant Science, The Pennsylvania State University, University Park, PA, USA

- **Technology**

Purpose:
Speed of golf putting greens is typically determined with a USGA Stimpmeter (2012) which measures ball roll distance (BRD) for a golf ball launched from a handheld ramp. This paper provides the scientific background to measure deceleration of a golf ball rolling on a golf green using cellphone video and predict BRD that correlates to Stimpmeter readings.

Methods:
Thirty-six (36) Stimpmeter tests were conducted on flat A4 bentgrass with readings ranging from 9.5 to 11.5 feet. Each Stimpmeter reading required six ball rolls (three in each of two opposed directions). BRD for each of the 216 rolls was recorded. Additionally, videos were captured for all 216 rolls using an iPhone 6 back camera (1920x1080 pixels, 30 fps, 40 inch field of view (FOV), 48 pixels per inch) mounted on a fixed level base 42 inches above the turf. The FOV was placed randomly near the end of the Stimpmeter, in the middle of the expected BRD and near the end of the expected BRD. The end of the Stimpmeter was not visible in any video. A few balls stopped within the FOV. The videos were copied to a personal computer and analyzed using MATLAB.

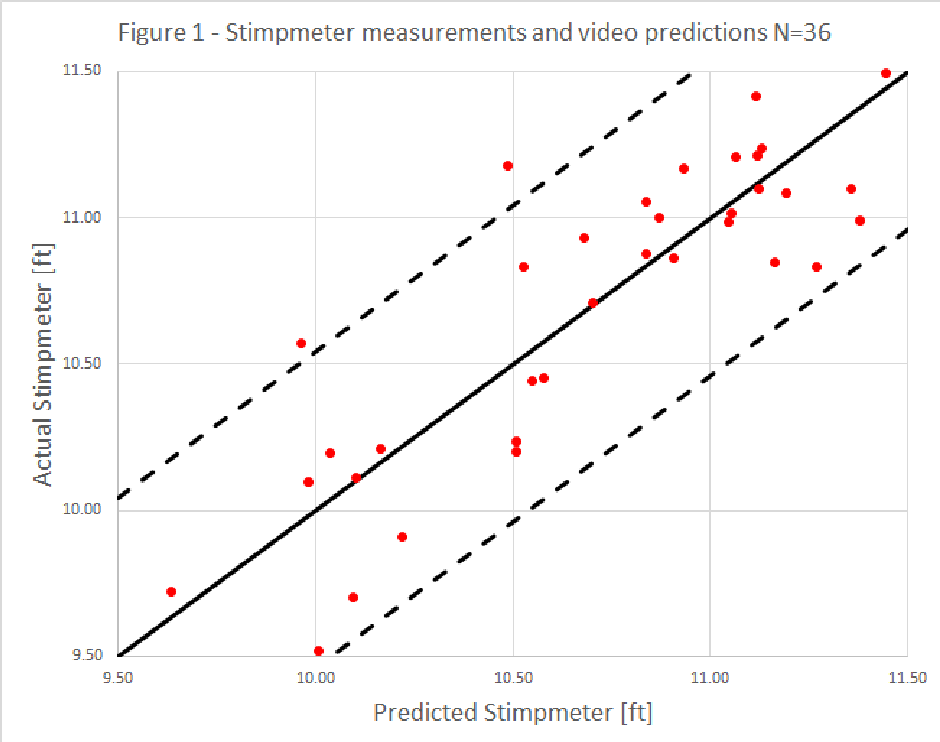
Individual images from the videos were binarized with threshold equal to the mean intensity of the entire image plus two standard deviations. Brighter pixels were classified as the ball. Image processing morphological opening/closing with a 10x10 pixel mask was used to remove noise. Blob object analysis computed object centroid location in pixels and object area in pixels for the ball within each image. This centroid/area information combined with photogrammetry provided X-Y ball location in inches as a function of time and ball diameter.

Ball velocity as a function of time was determined using a Savitsky-Golay seven-point floating interpolant filter. A linear fit for velocity-time determined an estimate of constant deceleration of the ball in each video. A simple constant deceleration kinematic model was then used to predict BRD for each roll assuming constant exit velocity of 72 in/sec from the Stimpmeter (Holmes, 1986).

The shape of the binarized image of the ball was consistent but was not perfectly circular due to shadow. Different thresholding techniques were not able to remove this problem. Concomitantly, curvature of the boundary of the binarized object was computed to ignore regions of noncircular curvature and fit a circle to the border of the binarized ball.

Results:
The 216 predictions for BRD using constant deceleration provided correlation to actual BRD with r^2=0.644 coefficient of determination. These initial results confirmed the findings of Hubbard and Alaways (1999) that deceleration of a golf ball rolling on a green is not constant but actually varies with rolling velocity. Attempts to predict BRD using a quadratic model for velocity-time were not successful due to noise.

Consequently, three parameters were recorded for each roll to help describe nonlinear effects - BRD predicted by constant deceleration, mean velocity and the first coefficient of the quadratic velocity model d^2v/dt^2. Correlation of these three parameters for each roll to the 216 actual BRD had coefficient of determination of r^2=0.822 and allowed video prediction of 36 equivalent Stimpmeter values with standard deviation of 3.2 inches as shown in Figure 1. Dotted lines in Figure 1 show 95% confidence intervals. Videos predicted mean ball diameter of 1.59 inches with 0.14 inch standard deviation. Actual ball diameter is 1.68 inches.



Discussion:
Video predictions of Stimpmeter readings had 95% confidence interval of 6.4 inches which is comparable to the 8 inch tolerance between three rolls in each direction specified in the USGA Stimpmeter instruction booklet (2012). This work appears promising enough to port code for real-time use on iPhone and/or Android platforms.

The videos were collected using a level base at a fixed height. Better estimation of ball diameter is still needed to allow automatic detection of camera height. Additional tests should be conducted to assess how handheld video that is not level may affect results.

Video captures X-Y location of the ball as a function of time while Stimpmeter readings only measure one distance. Initial analysis of lateral ball motion appears to have promise for measuring break and lateral wobble.

Additional tests should be conducted on faster and slower turfgrass to investigate the actual nature of the variation in deceleration as a function of velocity. In particular, other species of turfgrass and rolling/brushing preparations may have significant influence.

Practical Application:
Use of cellphone video to measure the speed of golf greens will not require significant training and/or manual skill to measure reproducible results. Compass and GPS data may be logged with green speed so that past/future measurements can be compared at the same location with the same heading direction.

- **Please consider for either a podium or poster presentation**