Meet Don, the Autonomous Dice Rolling Machine

Kenneth Lee and **Sione Fuluvaka** with faculty advisor **Dr. Paul Hurst**

Department of Mathematics at Brigham Young University - Hawaii

BYU HAWAII

Abstract

We estimated probabilities for tetrahedral and triangular dice using the sphere projection method and multivariate calculus. To test our results, we printed several dice of varying sizes. After a few thousand initial rolls, we realized that our calculations weren't accurately describing the situation and that bias could have been introduced due to rolling the dice by hand. Therefore, we built a machine to roll the dice. The machine has two stepper motors controlled by an Arduino microprocessor and motor driver.A die slides and falls down a series of ramps to give it some spin and is then dropped onto a hard surface. A mounted camera then takes a picture and the die is loaded onto an elevator and lifted up to be dropped again. The images are evaluated using Matlab image processing tools to determine the resting aspect of the die. This allows to make many dice rolls in a consistent manner and record the results.

Sphere Projection

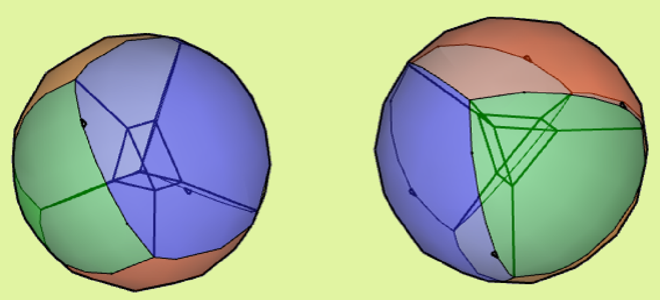

Figure 1: Sphere Projection of Triangular Prisms

Sketchup and 3D Printing

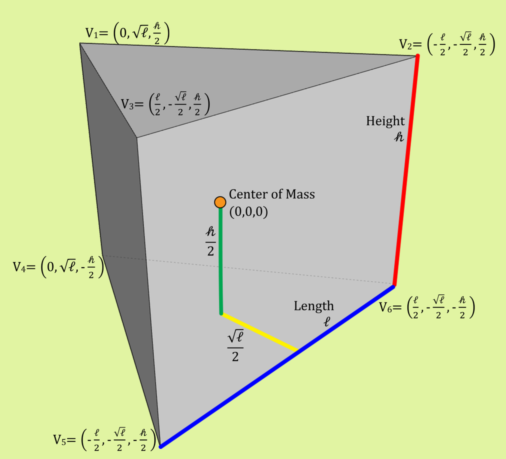

Figure 2: Triangular Prism with center of mass at the origin

- We used graphical software Sketchup to construct 3D images of the dice, which we printed with a MakerBot 3D printer. To obtain uniform density we adjusted the floor setting to be higher than the object height. These technologies allow us to customize different sizes of triangular prisms. One example is shown in Fig.2.
- The dice were printed in white. With painted black sides to help distinguish the sides and the bases of the die through image analysis.
- We also used Sketchup and MakerBot to construct custom machine parts as shown by Fig.3.

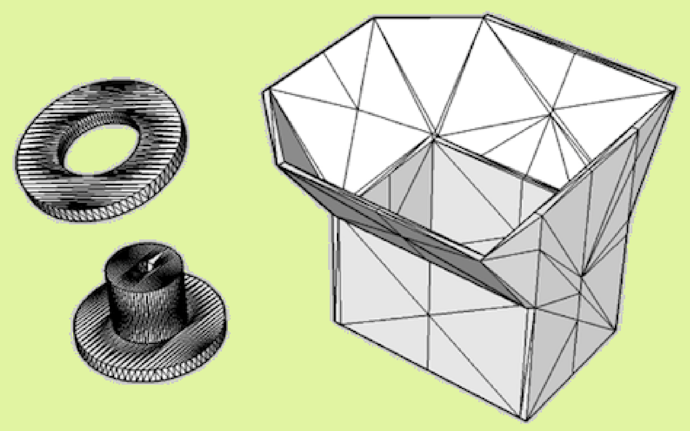

Figure 3: Examples of custom parts made by Sketchup/MakerBot

Autonomous Dice Rolling Machine

Figure 4: By having the machine roll the dice it helps to reduce bias and allows for larger amounts of data to be collected

Arduino, CNC shield and DRV8825

The Arduino is an open source platform used in electronics. It is made up of two parts; the circuit board, which can be programmed to perform various different functions, and the software that allows you to write and edit code to upload to the Arduino. The circuit board is often referred to as a micro-controller. The CNC shield is an extension to the Arduino that allows the control of up to four stepper motors. The CNC shield is often used to control multiple motors at once for 3D printers and other similar devices. The DRV8825 Driver is a device that allows for the Arduino to control the stepper motors. The DRV8825 drivers have adjustable current limiting features that will protect against over-current.

Image Analysis

We utilize the built-in image processing toolbox from a computing software called MATLAB to analyze the dice rolling images with the following procedures:

1. Crop the image (see Fig.5).
2. Take a gray scale from the image (see Fig.6).
3. Convert the gray-scaled image into a binary image to partition it into a foreground and a background (see Fig.6)
4. Invert the image and filling the small regions with disk-shaped background color (see Fig. 8, 9).
5. Calculate centroids for connected components in the image and count the number of the centroids to determine the amount of bases and sides of the dice. (see Fig.10).

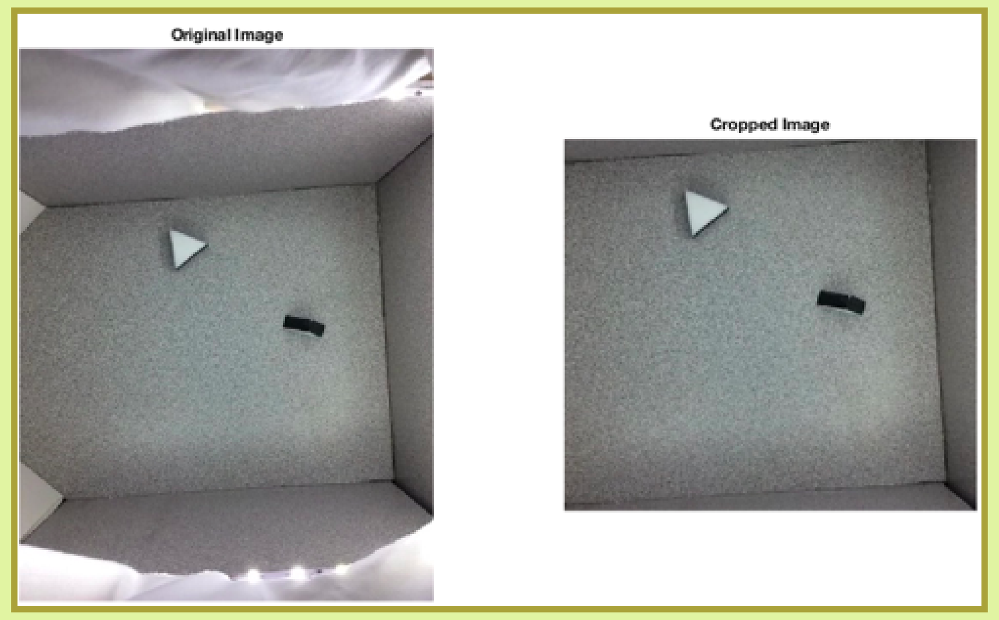

Figure 5: Cropping the image

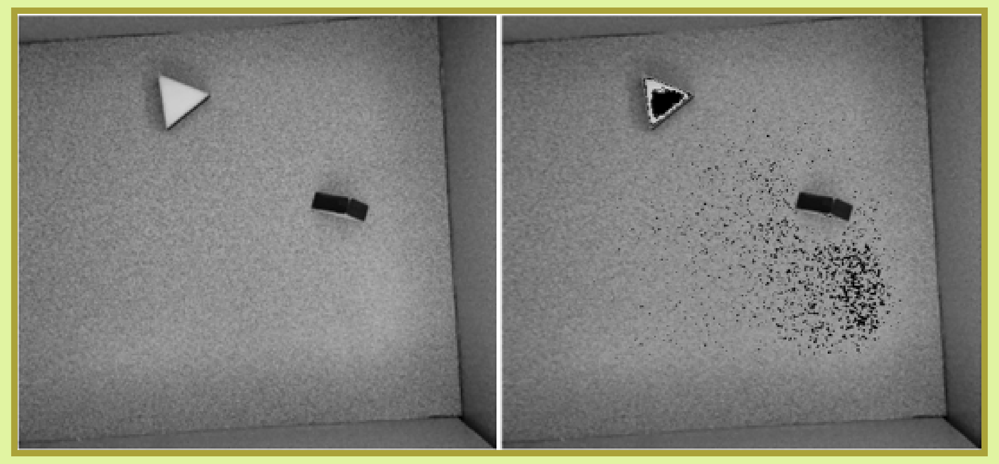

Figure 6: Taking the grayscale image

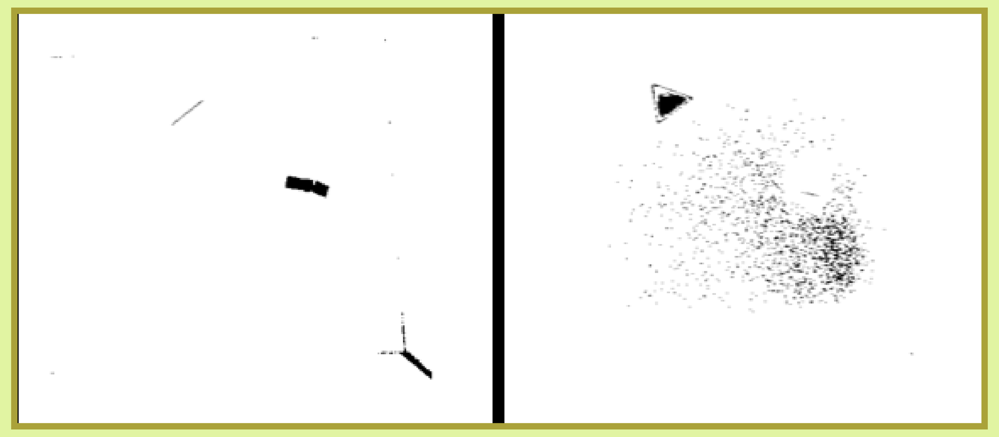

Figure 7: Turning the greyscale image into a binary image to partition it into a foreground and background.

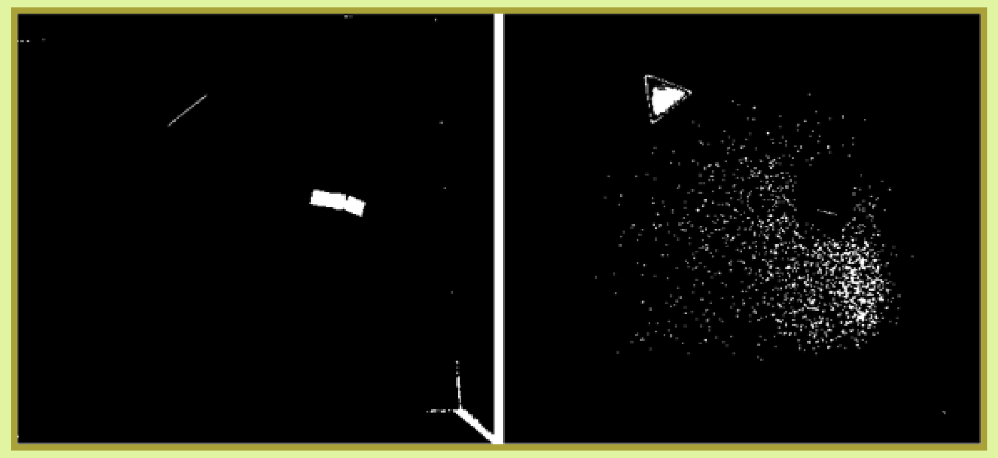

Figure 8: Inverting the image and filling the small regions with disk-shaped background color.

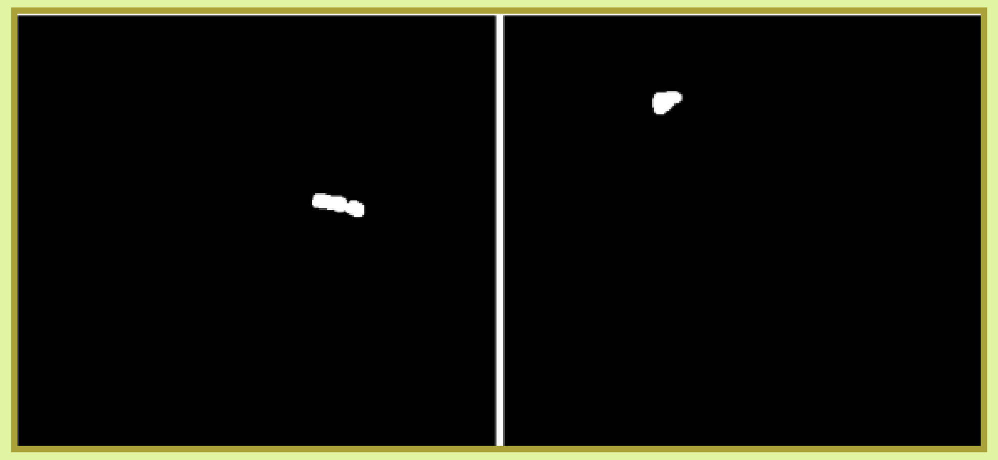

Figure 9: Filling the small regions with disk-shaped background color

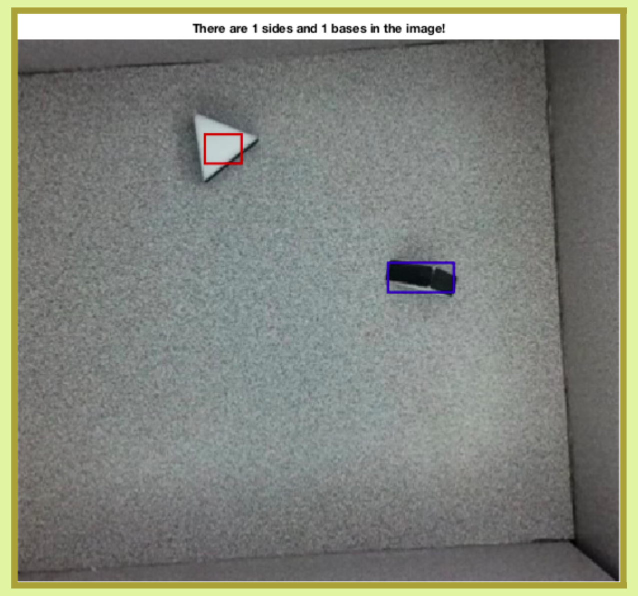

Figure 10: The resulting detection of the sides and bases of the dice.

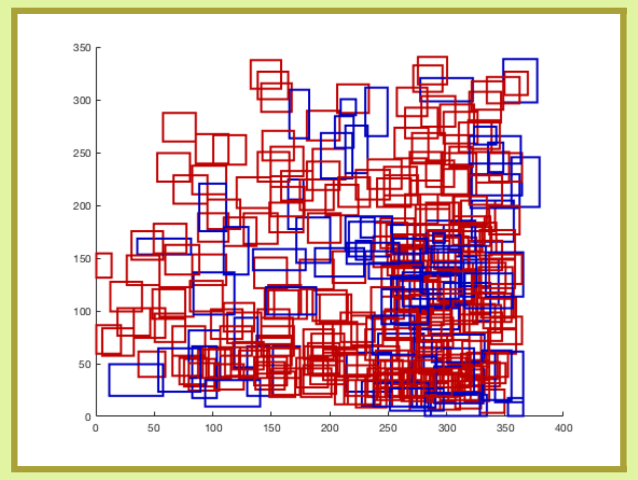

Figure 11: The resting locations (red represents the base; blue represents the side) of the dice after 150 dice roll.

Contact Information

Kenneth Lee: chinhong0513@go.byuh.edu

Sione Fuluvaka: si1mf@go.byuh.edu