Conquering Chaos: Can Engineering Design Be Applied To Prove Coin Flips Are Not Random?

Hindman, Abigail (School: Saint John's School)

Flipping a coin is accepted as an unbiased method to produce a random 50:50 outcome, but kinematics suggest a coin flip should be deterministic, and therefore predictable. I tested whether I could design and build a machine to replicate a thumb-flip that could produce consistent, predictable results. I used CAD software to refine my initial design, but further refinement was necessary once testing began. Three required design changes included: 1) added an axle of rotation on the machine to mimic an index finger in a thumb-flip, 2) switched to a lengthened spring configuration that would deliver a consistent 0.81 lbs of elastic potential energy at the release point when the cam released, and 3) developed a landing bed of fluffed almond flour to absorb the coin's impact and prevent bouncing. The study showed that coin flipping is not random when conditions are controlled and chaos is mitigated. I flipped the same coin 1,500 times by hand and 1,000 times with my machine (in each case beginning with a heads up orientation). Flipping by hand resulted in tails 50.6% of the time. Machine flipping resulted in tails 96.3% of the time. Using my machine and the prescribed flip procedure produced predictable, statistically significant results with a p-value <0.00001; I am 95% confident the true proportion of tails my machine would get for many flips is between 95.13% and 97.47%. Further enhancements to mitigate remaining chaos could include adding a servo motor to rotate the handle more consistently and replacing hand-cut wooden parts with precisely machined metal parts. I would like to apply this technique of controlling conditions to show that other processes are not random from dice rolling to behavioral applications such as teaching/learning.