Effect of Leg Mass on Kicking Velocity

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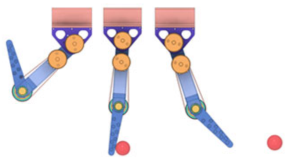
Introduction

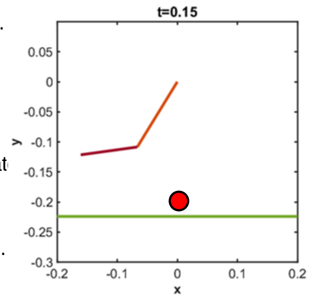


Does adding mass to the end of a kicking leg increase ball speed?

How does the effect of leg mass change as ball mass changes?

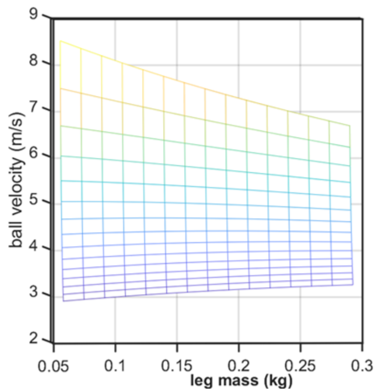
Simulation Methods

- Dynamic model of 2 DOF leg and ball.
- Kicking control scheme operates motors at full power with time delay between activation
- Ball collision simulated using conservation of momentum to calculat initial velocity of ball
- Sweep across a parameter space of:
  - 0.00 - 0.25 kg of added leg mass.
  - 0.002 - 0.200 kg of ball mass



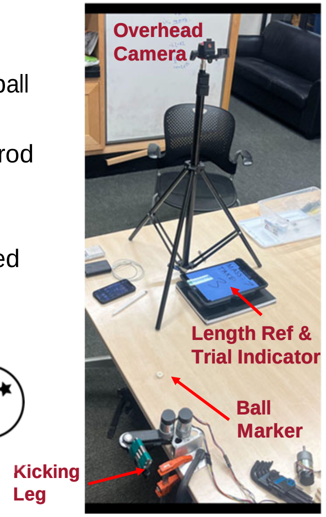
Simulation Results

- There was no ball mass which led to a distinct local maximum as leg mass was varied.
- We decided to proceed forward with the experimental hypothesis that a lighter leg is best for a lighter ball, while a heavier leg is best for a heavier ball.



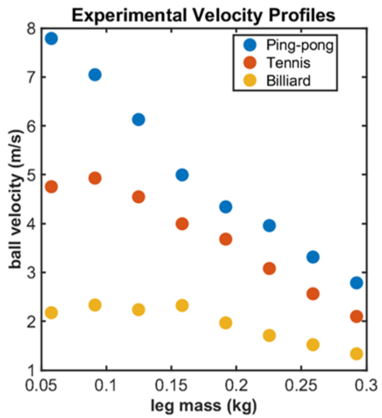
Experimental Methods

- Used 3 representative balls
  - tennis ball (~50g), ping-pong ball (~5g), billiard ball (~180g)
- Vary lower leg masses with steel rod segments
  - 0 g to 0.2 kg of added mass
- Video analysis to extract ball speed



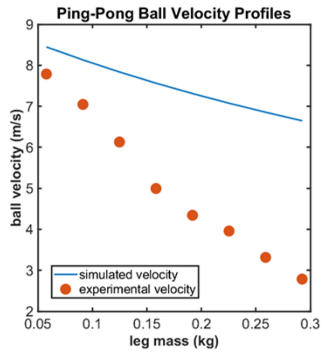
Test Balls

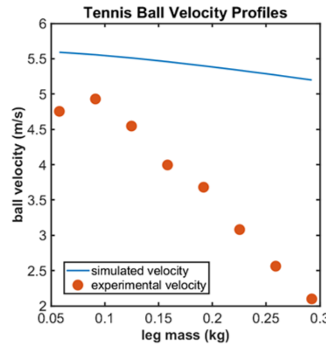
Experimental Results

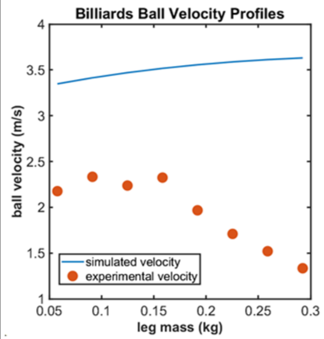


- As expected, the lighter balls have higher velocity.
- Weight of the leg has effect ball velocity significantly
- Velocity trends change with mass of the ball
- For the tennis and billiards balls, there is a local maximum of ball velocity.
- Leg masses > 0.158kg decreased ball velocity for all ball masses.

Discussion







- The experimental results show significantly lower ball speeds than in simulation.
- For the tennis and billiards balls, there is a local maximum of the ball velocity; this was not seen in the simulation.
- Large leg masses significantly reduced ball velocity; this was not seen in simulation.

Conclusion

There are some discrepancies between our simulation and experiments. This could be attributed to several factors including:

- Added leg mass results in added friction in system
- Added legg mass affects the timing of the two leg segments
- Inaccurate COR or simplification of collision dynamics
- Imperfect modeling of motor dynamics

Based on experimental results, changing the leg mass can result in a local maximum in ball velocity for balls of larger mass.