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Project Specification

Simulation of baseball in 2D (E or higher grade)

Introduction

I want to simulate a baseball bat striking an incoming ball based on an starting point, contact point and acceleration for the bat. More specifically, variables for the mass, starting velocity, starting angle, starting height and gravitational pull. Based on this an original movement arch of the ball will be calculated. The contact point of the bat and the ball must be on this arch.

Problem

The problem consist of two parts: Calculating collision point of two or more moving objects and apply the forces of the objects once they do collide. The minimum viable product of the simulation is one where the bat's starting point, collision point, mass and acceleration are set by the user. The project can later be extended to calculating collision point for maximizing distance instead of having a set collision point.

Implementation

The trajectory and velocity of the different moving bodies will be simulated using the time-stepping algorithm Explicit Euler. More algorithms may be implemented if there's time to be spared. Gravitational forces will be modelled using the formula for free-fall acceleration. The collision will be modelled in adherence to Newton's third law using `F = ma`. At the start of project, elasticity will be hardcoded to 1.

The time point of the intersection of the ball's and the bat's movement will be approximated by finding the closest point to the chosen collision point in the bats traversal. The bat will start to decelerate once it has passed the collision point. The check for this event will be $(\text{sign}(x), \text{sign}(y))_i = (-\text{sign}(x), -\text{sign}(y))_{i-1}$. The approximated time point for collision will be the time point of these, i, i-1, which has the positional value closest to the collision point.

The simulation will be implemented in Python 3 using Pygame for visualization and Tkinter for GUI.

Tables of objects in simulation and their characteristics

Ball

Characteristic	Priority	Complexity
Has mass	High	Trivial
Has starting height	High	Trivial
Has starting angle	High	Trivial
Has starting velocity	High	Trivial
Has gravitational pull	High	Easy

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Characteristic	Priority	Complexity
These values should not be hardcoded	High	Easy
These values should be changeable in UI	Mid-High	Medium

Ball's original movement arch

Characteristic	Priority	Complexity
Calculated based on ball's variables	High	Easy
Calculated with a time-stepping algorithm	High	Easy
Time-stepping interval should be able changeable in UI	Mid-High	Medium

Bat

Characteristic	Priority	Complexity
Has starting point	High	Trivial
Has collision point	High	Trivial
Has acceleration	High	Trivial
Has mass	High	Trivial
These values should not be hardcoded	High	Easy
These values should be changeable in UI	Mid-High	Medium
The collision point should be on the ball's original movement arch	High	Medium
Starts moving at a time calculated by the simulation based on acceleration, starting point and collision point	High	Medium

Bat's movement arch

Characteristic	Priority	Complexity
Is straight due to gravity not affecting the bat	High	Trivial
Calculated with a time-stepping algorithm	High	Easy
Uses the same time-stepping interval as the ball's movement arch	High	Trivial

Ball's post-collision movement arch

Characteristic	Priority	Complexity

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Characteristic	Priority	Complexity
Calculated the same way as the original movement arch, but with the force of the bat applied to the ball as the starting velocity	High	Easy
Runs until hitting ground no vertical velocity left	High	Easy
~~Implement different elasticity for collision~~	~~Low~~	~~Hard~~

References

Collision between two bodies (No code available)

Simulation of the arch travelled (No code available)

Risks

Risk	Counter-actions
~~Pygame is too limited for good visualization~~	~~Test the visualization part early~~
~~Python 3 is too slow~~	~~Write computationally demanding parts in C. Avoid running the simulation in real-time~~
~~Project is too simple for a pass~~	~~Receive feedback from Chris Peters and TAs early in development. Have ideas of extension of the code ready~~

Degree of simulation

All of the simulation-code will be built from scratch

Blog

Link