Program Summary

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1 Model Choice

Due to the physical property of projectile, we can use the following equations to describe the motion of it.

$$x = v_x \cdot t \tag{1}$$

$$y = v_y \cdot t - \frac{1}{2}gt^2 \tag{2}$$

where v_i is the velocity along the i axis, g is the gravity acceleration and t is time with unit 10 ms.

We find that the position x and y is linearly proportional to v_x, v_y, t^2, t and 1, so I came up with the method of multiple linear regression. To implement it, we need to establish a linear equation matrix.

$$Y = \begin{pmatrix} [x_0, y_0] \\ [x_1, y_1] \\ ... \\ [x_n, y_n] \end{pmatrix} \tag{3}$$

$$X = \begin{pmatrix} [v_x t_0, v_y t_0, t_0^2, t_0, 1] \\ [v_x t_1, v_y t_1, t_1^2, t_1, 1] \\ ... \\ [v_x t_n, v_y t_n, t_n^2, t_n, 1] \end{pmatrix} \tag{4}$$

$$Y = XB \tag{5}$$

where X is the input matrix containing all necessary parameters and Y is the output matrix containing the information of position. B is the least square solution. Notice the braces should not be in a matrix representation but it might be more clear to illustrate what happens in data structure.

2 Fitness

The linear relationship between positions and the input parameters would fit the model reasonably. As shown in result, the program fits what we expect very well.

3 Evaluation

Since we know exactly how projectile moves, we can have exact trajectory of the motion. So we can calculate the mean square root error between the expected points and the output points.

4 Prediction in other cases

Yes, it can calculate out the trajectory based on different input angles and velocities.

5 Assumptions

We assume there is no air resistance and we consider the time interval between the first two points is very short so we can approximate initial velocities along x and y axis of the projectile.

6 Changed Precondition

Yes, we establish the model based on the real physic model. It I were not told this was a projectile, the model need to be re-built.

7 Reference

I refer some documentation about how to use numpy.linalg.lstsq at https://numpy.org/doc/stable/reference/generated/numpy.linalg.lstsq.html#numpy.linalg.lstsq

8 Further improvement

Due to the assumption made in this project, I might calculate the initial velocities by more accurate approximation.