Final Project Report

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Project:

Basketball shotting problem with one arm.

(Please look carefully and don't lose the two links which are in red and green respectively in the simulation, because the practical size of them are much smaller than the ground size but they contain a large part of the project!)

Details:

Simplification: Suppose a person using one arm to shot a basketball to the basket in a half basketball court. Ignore the influence from the air, the basket net and the human body except the arm.

Motion: The arm will move to give the ball the initial state when separating from the hand, and the basketball will move towards the basket. The ball may hit the backboard or basket or both of them. Finally the ball will fall down to the ground.

Simulation: Choose the initial location of arm as well as the torques added on the arm. Calculate motion of the arm and simulation the motion of basketball until it hit the ground.

Some important assumptions or suppositions:

1, All the impacts are elastical and there are no energy loss when shotting, especially the moment when the basketball separate from the hand.

Reason: To simplify and satisfy the motion equation which we learned.

2, The arm is regarded as two connected links.

Reason: To simplify the inertia of the body.

3, The finesse can freely change the direction of the velocity of the basketball when it separates from the hand without and energy cost. The angle is shown by β in the figure below.

Reason: We cannot take the velocity of the tip of the arm as the initial velocity of the basketball

when separating from the hand, which can be realized when we try personally.

4, The moment when the basketball separates from the hand is supposed to be equal to the moment when the two links move into one straight line.

Reason: The separating moment is hard to decide and the moment quoted seems reasonable and simple.

5, The basket is simplified into a loop instead of a ring.

Reason: Though the configuration of a ring can be found as

$$[x*(1-R/sqrt(x^2+y^2))]^2+[y*(1-R/sqrt(x^2+y^2))]^2+z^2=r^2$$

Or

$$x=(R+r*cosu)cosQ$$

$$y=(R+r*cosu)sinQ$$

$$z=r*sinQ$$

Problems may occur when using the function “WhenEvent”.

6, The two torques added on the two links respectively is supposed to change linearly.

Reason: To simplify the calculation and initial input of the simulation.

7, The direction of shotting is supposed to face the basket, as shown by the angle α in the figure following below. The plane decided by this angle always crosses the z axis.

Reason: To simplify the calculation and avoid the calculation singularity. (e.g. tan[q] when q approaches to Pi/2)

Data which are given:

The sizes of the ground including the sizes and position of the basket, the sizes of the basketball and the gravity.

Data which can be changed:

The torques added on the two links, the position of the body and the shotting angle. (Optional: The qualities and lengths of the links and the height of the arm.)

How the simulation works:

When the added torques given, the motion of the two links can be simulated using the knowledge of rotation inertia. Then as the initial velocity direction is given, the basketball separating from the hand can be simulated. The ball motion includes some impacts of the wall and the basket.

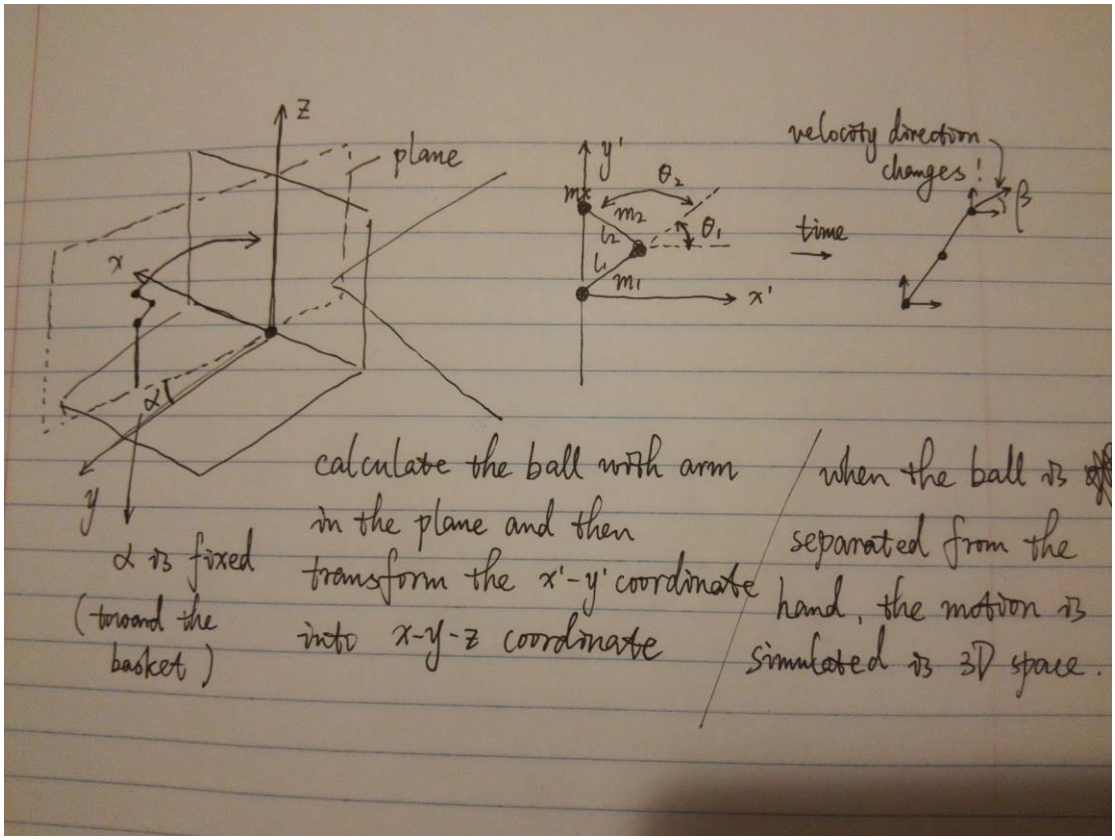

Figure: The analysis of the problem. Notice that α is not actually fixed. The word “fixed” means that the angle changes to make the plane always cross the z axis.

Differences from the proposal:

1, I tried to use the motion state of the basketball when separating from the hand to figure out the torques needed at the beginning of the motion of the links, which is similar with the problem about inverse dynamics. But unfortunately I failed because I cannot use the NDSolve or Solve to the complex equations which are beyond the solving scales of these functions.

2, More assumptions added to make the complex problem easier than before.