A Graphic Algorithm for the Effect of Rubber Band

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Abstract. The rubber band has a certain elasticity. In the elastic limit, when subjected to external forces, the elongation of the rubber band will be proportional to the elastic force. In this paper, we present a practical graphic algorithm for the effect of rubber band, which has a small amount of computation, but the simulation results are very realistic. This algorithm is suitable for games or VR software.

Introduction

The effect of the rubber band is shown in Figure 1. When subjected to external forces, the rubber band is stretched and deformed. At the same time, rubber band will produce elastic. Within the elastic limit, the elongation of the rubber band will be proportional to the elastic force. There are many kinds of algorithms to achieve the "rubber band" graphics. Because the game (especially the 3D game) or the virtual realization software program needs to carry on the real-time computation, the too complex graph algorithm will increase the CPU computation, thus reduces the software movement speed. This paper presents a practical algorithm, using this algorithm can achieve a more realistic "rubber band" graphics, and the algorithm computational complexity is small, especially suitable for application in games or virtual software.

The Algorithm of "Rubber Band" Effect

Analysis on the Deformation Process of Rubber Band

In this paper, the deformation process of the rubber band is analyzed by taking the collision between a small ball and a rubber band as an example.

When the rubber band is not subjected to external forces, it forms a line, as showed in Figure 2. For the convenience of narration, the line is called the "original line".

When the ball hit the rubber, the rubber band will be stretched, stretching direction is the direction of movement of the ball (that is, the direction of the force). At the same time, the rubber band has a reverse elastic force on the ball, and the elastic direction points to the center point of the "original line" from the contact point. As showed in Figure 3 (1).

In the elastic limit, the rubber band will be stretched more and more long, and its elasticity is also growing. The elasticity causes the ball to slow down until the speed is zero. As showed in Figure 3 (2). Since then, under the effect of the elastic force, the ball will reverse movement, the rubber band has begun to shrink, and finally return to the initial shape.
Realization of Algorithm

The program flow of the graphic effect of the "rubber band" is shown in Figure 4.

![Figure 3. The Rubber Band is Stretched.](image)

![Figure 4. Program Flow Chart.](image)

The specific ideas of the key parts of the flow chart are as follows:
(a) The two endpoints of the original line of the rubber band are \( P_1 (X_1, Y_1, Z_1) \) and \( P_2 (X_2, Y_2, Z_2) \), then the line equation corresponding to the original line is:
\[
X (X_2 - X_1) + Y (Y_2 - Y_1) + Z (Z_2 - Z_1) = 0
\]
(b) The center point of the original line of the rubber band is \( P_{center} (X_{center}, Y_{center}, Z_{center}) \), and there are:
(b) When the rubber band is under tension, through the center coordinates and radius of the ball and the direction of motion, we can get a point coordinates (it is the intersection of the ball and the rubber band), the coordinate is denoted as Pctr (Xctr, Yctr, Zctr).

According to the radius of the ball, as well as the direction of the "original line", we can get a vector V (Xv, Yv, Zv), the size of the vector is the radius of the ball, the direction of the vector along the direction of the original line.

Then, using the following formula, we calculate the coordinates of two reference points Pref1 (Xref1, Yref1, Zref1) and Pref2 (Xref2, Yref2, Zref2).

\[
X_{center} = \frac{(X1 - X2)}{2} \\
Y_{center} = \frac{(Y1 - Y2)}{2} \\
Z_{center} = \frac{(Z1 - Z2)}{2}
\]

In the above formula, the value of factor K is as follows:
\[K = \text{distance (Pctr, Pcenter)} \times 0.01;\]
Among them, "distance (Pctr, Pcenter)" indicates that the distance between two points.

(c) According to the first endpoint of the "original line", and the Pref1, and the tangent point, we can draw a Bessel curve. According to the second endpoint of the "original line", and the Pref2, and the tangent point, we can draw another Bessel curve. So we can draw the figure of the stretched rubber band.

(d) According to the center of the "original line" (Pcenter) and tangent points (Pctr), we can calculate the elastic of the rubber band, the vector expression of the elastic is as follows:

\[
\text{Vforce} = (Xforce, Yforce, Zforce)
\]
\[
Xforce = (X_{center} - Xctr) \times kf
\]
\[
Yforce = (Y_{center} - Yctr) \times kf
\]
\[
Zforce = (Z_{center} - Zctr) \times kf
\]

Where kf is the rebound coefficient, generally set to 2.

Finally, we can calculate the acceleration of the ball according to the rebound force, so as to calculate the ball position in the next moment.

Summary

The algorithm proposed in this paper can realistically simulate the effect of the "rubber band", and the algorithm has less computational complexity, and has been successfully applied to a variety of game software.

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References


