Position-based dynamics

Žan Terplan

I. Introduction

This report documents the implementation of a position-based dynamics cloth simulation. The system models a grid of particles connected by distance constraints, with gravity as the only external force. Two corners are pinned to create a sweeping motion as the cloth falls.

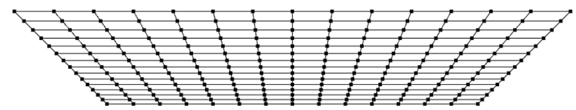

Figure 1. The initial (horizontal) state of the cloth.

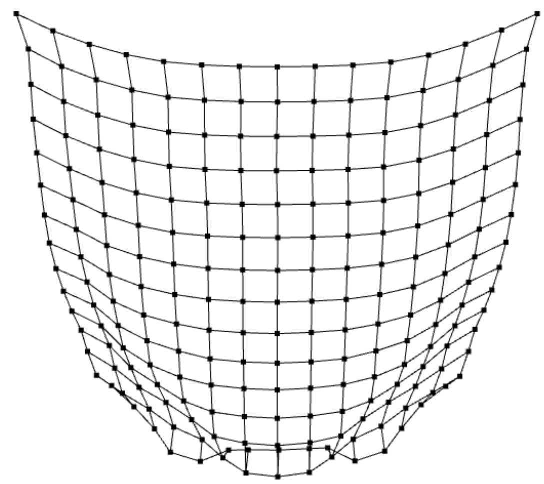

Figure 2. The swinging motion of the cloth (with a grid of 15×15).

II. Experiments

To evaluate the performance of the cloth simulation, we measured the average simulation time per frame under two varying conditions: cloth resolution and number of substeps. The simulation was executed in a WebGL context, and timing was captured using JavaScript's *performance.now()* function. Each setup was run for several frames and averaged to obtain consistent results.

Resolution (N×N)	**Average time per frame (ms)**
5×5	19.40
10×10	30.40
15×15	50.20
20×20	90.60

Table 1. Average simulation time per frame for different cloth resolutions (at fixed 10 substeps).

As shown in Table 1, the average simulation time increases with higher cloth resolution, but the time per particle actually decreases as resolution increases, indicating that the simulation scales more efficiently at higher resolutions. Since the number of particles grows quadratically with resolution (i.e., $(N+1)^2$), and the number of constraints increases similarly, both computations and rendering become heavier.

Substeps	**Average time per frame (ms)**
1	5.80
2	10.10
5	25.10
10	49.20

Table 2. Average simulation time per frame for different numbers of simulation substeps (at fixed 15×15 resolution).

Table 2 shows how simulation time scales with the number of substeps while keeping the cloth resolution fixed. Each substep involves a full simulation, making the time grow linearly with the number of substeps. Higher substep counts improve numerical stability and constraints, but they come at the cost of increased computation time per frame.

III. Conclusion

We successfully implemented a real-time cloth simulation using position-based dynamics in a 3D WebGL environment. The results show how simulation performance is influenced by the resolution of the cloth and the number of substeps. Optional features such as interaction and tearing were not implemented, but could be added to extend realism and user control in future work.