Optimizing Additional Weight for Free-Formed Marching Rifles

Tsukasa Fukusato Haruki Yasui
Waseda University

Purpose

◆ Current Marching Rifles

- A limited shape variation (i.e., rifle or saber)
- difficult to balance between the visual design and the spin quality.

◆ Our Approach

By optimizing a location of additional weight

- free-formed marching rifles
- excellent spinning functionality

Method

◆ STEP1: Shape Generation

User draws a freehand closed contour (2D side view).
The system generates a 3D voxel-format shape X with mass m_r.

◆ STEP2: Initial Setup

User specifies the handgrip position $\overrightarrow{x_h}$ and the mass of the additional weight (m_a) to be placed inside the rifle.

◆ STEP3: Optimization

We maximize the spin quality $E_{spin}(\vec{x})$ using a greedy algorithm. The system searches the locations of the additional weight $\vec{x} \in X$ that maximizes the spin quality $E_{spin}(\vec{x})$ as follows:

$$E_{spin}(\vec{x}) = \frac{\omega t}{2\pi} \quad (1)$$

$$t = \frac{2}{g}\sqrt{\frac{2E_t(d)}{m_r + m_a}} \quad (2)$$

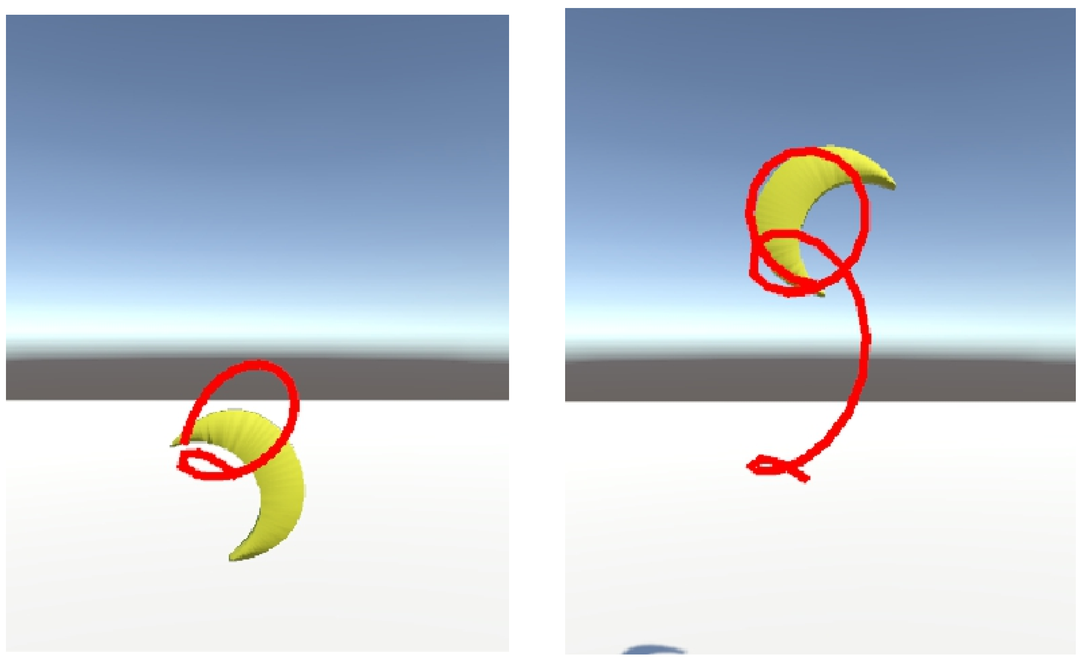
$$\omega = \sqrt{\frac{2E_r(d)}{I}} \quad (3)$$

E_t *and* E_r are the translational and rotational energies computed from a video of an actual performer throwing.

Result

◆ Comparison

To evaluate the effectiveness, we compare a baseline to randomly set an additional weight on a rigid body simulator. The input model is free-formed marching rifle, Crescent Moon. Note that the spin trajectory is visualized as red strokes.



(a) Random setting (b) Our method

Method	Spin quality E_{spin}
Random setting	1.475
Ours	**4.226**

From the result, our system can improve the spin quality compared to the baseline.

Future Work

- Fabricating free-formed marching rifles using 3D printer or laser cutter, and evaluating their actual movements.
- integrating a hollowing algorithm [3] to optimize the internal structure, reducing total weight while maintaining the desired moment of inertia.

Reference

[1] M. Nakamura et al.: “An Interactive Design System of Free-Formed Bamboo-Copters,” Computer Graphics Forum, Vol.35, No.7, pp.323–332 (2016).
[2] T. Fukusato et al.: “Interactive Design and Optimization of Free-Formed Returning Boomerang,” ACM SIGGRAPH ASIA 2018 Technical Brief, No.10, pp.1–4 (2018).
[3] M. B¨acher et al.: “Spin-it: optimizing moment of inertia for spinnable objects,” ACM Transactions on Graphics (ToG), Vol.33, No.4, pp.96:1–96:10 (2014).