Optimizing Additional Weight for Free-Formed Marching Rifles

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Abstract

In marching band performances, the spinning of marching rifles when thrown into the air affects the technical difficulty level directly. However, the current marching rifles have a limited shape variation (i.e., rifle or saber) since it is too difficult to balance between the visual design and the spin quality. In this paper, inspired by [1][2], we implement a system that enable users to design free-formed marching rifles with the excellent spinning functionality.

Keywords: Marching-rifle, additional weight, optimization

1. Introduction

Marching rifles are non-firing replicas used by marching band performances, and their shape and spinning plays a pivotal role for ceremonial precision. To improve the spin quality, performers often place metal weights, named "additional weight," inside the rifle model for adjusting the center of mass, but this process must be repeated until the performer is satisfied, making their design remains highly time-consuming and knowledge-intensive task.

To address these problem, we propose a method to optimize a location of additional weight for marching rifles.

2. Proposed Method

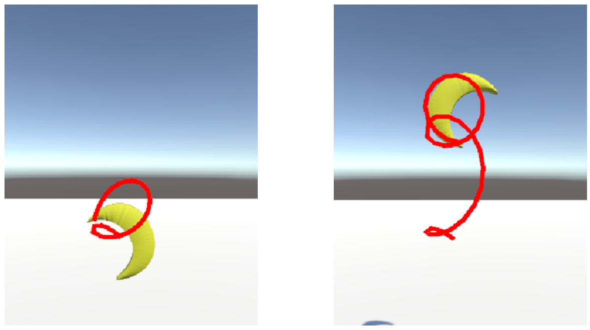
First, we draw a freehand stroke that represents a closed contour of marching-rifle from the side view, and generate the voxel-format shape of marching-rifle X where the mass of the generated model is m_r. Next, we set locations of hand grip $\vec{x}_h$ and the mass of additional weight m_A. The system then searches the locations of the additional weight $\vec{x} \in X$ that maximizes the spin quality $E_{spin}(\vec{x})$ as follows:

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

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

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

where ω is the angular velocity, t is the hang time, g is the magnitude of gravity (= $9.81[m/s^2]$), d is offset distance (= $|\vec{x}_g - \vec{x}_h|$), $\vec{x}_g$ is the center of mass, I is the moment of inertia, and E_t and E_r are the translational and rotational energies computed from a video of an actual performer throwing. To maximize the spin quality, we employ a standard greedy algorithm, which is easy to compute and enables us to set the weight locations almost instantly.



(a) (b)

Figure 1: An example of optimizing locations additional weight for free-formed rifle design (Crescent Moon). (a) Random setting ($E_{spin} = 1.475$) and (b) Our method ($E_{spin} = 4.226$).

3. Results

Figure 1 shows examples of free-formed marching rifle performance on a rigid body simulator. Note that the spin trajectory is visualized as red strokes. From the result, the spin quality has improved compared to the baseline when the additional weights were set randomly.

In the current implementation, we need to set a heavier weight m_a for handling the center of mass $\vec{x}_g$ in the user-designed shape, making it difficult for the performer to throw. In the future, we will explore ways to optimize the internal structure by combining a hollowing algorithm [3].

4. References

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