# PickHits: Hitting Experience Generation with Throwing Motion via a Handheld Mechanical Device

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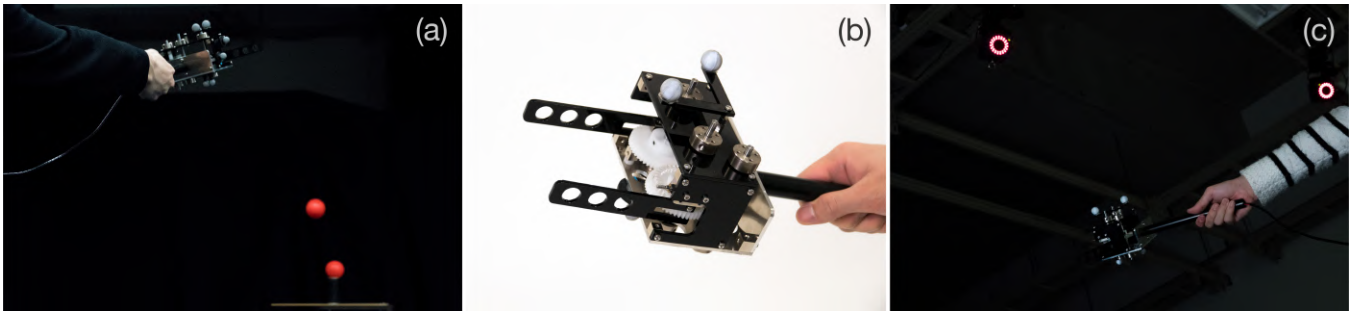


**Figure 1: (a) PickHits system provides hitting a target experience computationally. (b) Handheld-type mechanical device to release an object towards a target. (c) The developed system tracks and predicts the throwing motion in real time.**

## ABSTRACT

Experiences of hitting targets cause a great feeling. We propose a system for generating this experience computationally. This system consists of external tracking cameras and a handheld device for holding and releasing a thrown object. As a proof-of-concept system, we developed the system based on two key elements: low-latency release device and constant model-based prediction. During the user's throwing motion, the ballistic trajectory of the thrown object is predicted in real time, and when the trajectory coincides with the desired one, the object is released. We found that we can generate a computational hitting experience within a limited range space.

## CCS CONCEPTS

• **Human-centered computing** → **Interactive systems and tools**; • **Computer systems organization** → *Sensors and actuators*; Real-time systems.

## KEYWORDS

hitting a target, throwing, motion prediction, human-in-the-loop system

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## 1 INTRODUCTION

Experiences of hitting a target or making a goal cause a great feeling, for example, basketball shot, shooting games, and even throwing garbage into the trash can. On the other hand, in order to hit the target, a certain degree of skill is required. If that difficulty level goes up, it will fail out of the goal and make us annoyed in many cases.

In this paper, we propose a system for generating experiences of hitting a target computationally. The system consists of external motion tracking cameras and a handheld mechanical device to hold and release a *bullet*: a thrown object. While the user is performing throwing motion, this system is running the calculation of the ballistic trajectory of a thrown object in real time. At the timing when the trajectory of the object matches the desired one, the mechanical hand is opened with the electric trigger signal, and the object is thrown into the air. In other words, the object is not


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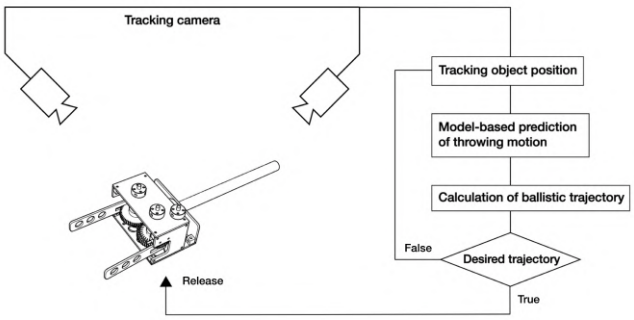


**Figure 2: (a) A proof-of-concept system overview. While tracking the object position, the system is calculating the ballistic trajectory of a thrown object in real time. Model-based motion prediction is implemented to suppress error due to the system delay.**

released while doing a motion that misses the target. In this way, the system allows the user to throw an object at the desired target.

Itoh et al. proposed the system visualizing the ballistic trajectory for supporting human performance [Itoh et al. 2016]. Our system focuses on enhancing the dynamic ability such as throwing motion. Our goal is to construct a human-in-the-loop system where computational fast-loop and user's slow-loop are integrated such as The SmartTool [Nojima et al. 2002].

## 2 SYSTEM

Figure 2 shows the architecture of the developed proof-of-concept system. The position of the handheld device is tracked at 300 Hz by externally placed motion tracking cameras, and the velocity of the object held in the device is estimated based on this information. This system has two key elements: 1) low-latency release hand implemented as the physical handheld device, and 2) constant model-based prediction to suppress the error due to the system delay.

### 2.1 Low-latency release hand

We designed a simple hardware device with one degree of freedom as a proof-of-concept model. This device employs a holding hand closed using a ratchet mechanism, and when the pawl, which prevents movement of the ratchet, is unlocked by a solenoid actuator, the hand is opened by the elastic energy stored in the torsion spring. This mechanism is designed with the aim of minimizing the delay time from when the trigger signal is received until the hand opens by eliminating intermediate elements such as gears in the actuator and applying sudden force in a moment with storing energy. Generally, if the time horizon of motion prediction increases, the prediction accuracy gets worse. Therefore, by minimizing the delay, the accuracy of the motion prediction described next section can be improved.

### 2.2 Constant model-based prediction

We measured the time from getting the position of the tracked object to the release of the object held in the device hand as the delay of the whole system, and we found that this delay is about 50 ms. Since human throwing motion is highly dynamic movement, the position and velocity of the device can change by an amount sufficient for the ballistic trajectory of the thrown object to change significantly within 50 ms. In this paper, we predict the user throwing motion on the assumption that the arm movement can be regarded as constant acceleration motion in a short time. The system calculates the ballistic trajectory with the predicted 50 ms ahead motion.

We developed the system based on the above two elements and carrying out a feasibility study. We found that we can generate a computational hitting experience withing a limited range space.

## 3 USER EXPERIENCE

At SIGGRAPH 2019 Emerging Technology exhibition we will demonstrate PickHits system with the proposed external tracking system and the handheld device. Attendees can select the targets and the thrown objects, and experience a pleasant feeling with hitting the target. This system can also allow users to access to remote places or high positions. By employing a handheld device, we found that this system could give the users a sense that the generated hitting experience was caused by themselves to a certain extent, even though the release was triggered computationally. Therefore, this system will give attendees the experience as if the user cooperate with the computational system. Attendees can perform difficult tasks without the system such as no-look shot and hitting the moving target.

## 4 LIMITATION AND FUTURE WORK

In the current system, the predicted ballistic trajectory and the actual trajectory do not match in the order of a millimeter. It is considered that this is caused by various factors such as measurement error, user motion difference, release noise and so on. In order to increase the system accuracy, it will be necessary to implement stabilization like gimbal mechanism and control of active releases support.

## ACKNOWLEDGMENTS

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