GENERATING THE OLLIE

Trajectory optimization and its application to skateboarding

By Nicholas Anderson

1. Introduction

Skateboarding

Skateboarding has been rapidly growing since its inception in the 1940's, and in response to this, it has been included at the 2020 Tokyo Olympics. The "Ollie" is the fundamental manoeuvre in skateboarding which can be performed while stationary (SO), rolling (RO), up onto an object (OU), or down (OD).

Trajectory Optimization

In its application to skateboarding, the trajectory optimization problem seeks to find a set of input forces and torques applied by the skateboarder in order to perform the ollie. The solution should satisfy a set of constraints while minimizing the terms in the cost function - the applied forces and torques.

The Purpose

Using trajectory optimization to generate the ollie has the potential for the development of injury prevention and performance enhancement strategies. Therefore, this study aims to replicate the motion of the ollie and the ground reaction forces (GRFs) acting on the skateboard.

2. Modeling

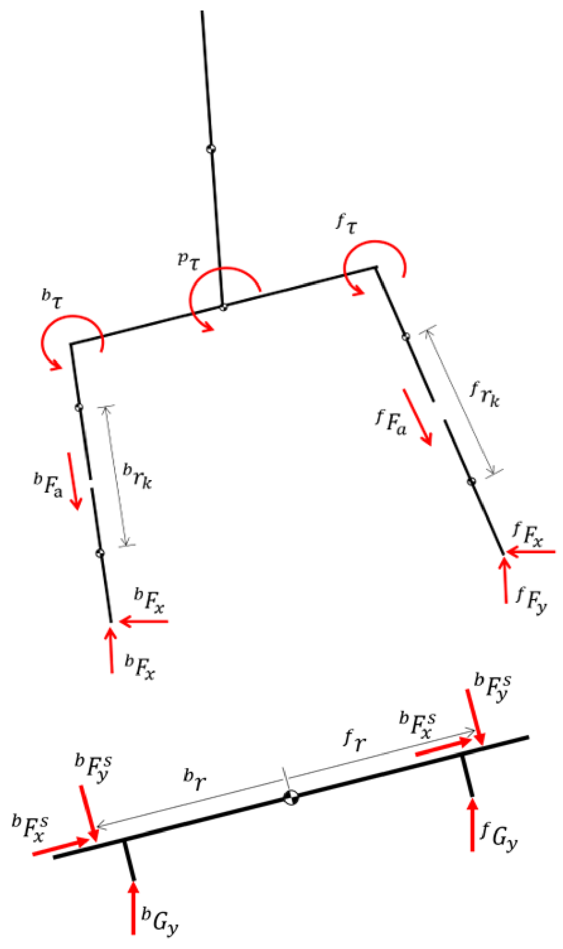
The system was broken down into subsystems and the various contacts and collisions involved in the ollie. The major challenge of this project was to formualte the multi-body contacts into the problem. To achieve this, the elastic collisions were modeled using the **hybrid dynamics method**, and the inelastic collisions using the **contact-implicit method**.

The foot-deck contact
Friction and normal force
Inelastic, unscheduled

The tail-ground contact
Elastic, scheduled

The wheel-ground contact
Normal force
Elastic, scheduled

The variable ground
Step-up or step-down

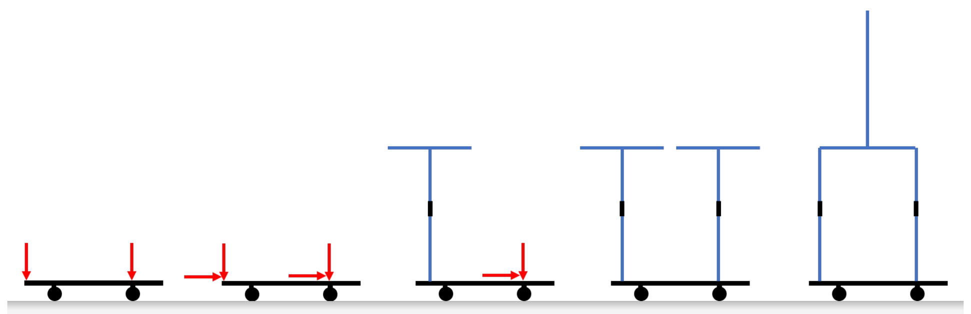


The skateboarder model
A biped modelled as an open chain of rigid-links with two legs, a pelvis and a torso. The legs were modelled as prismatic joints.

The skateboard model
A rigid-link with massless wheels and wheel bearings.

3. Formulating the Problem

MODEL → FORMULATE PROBLEM → IMPLEMENT & TEST

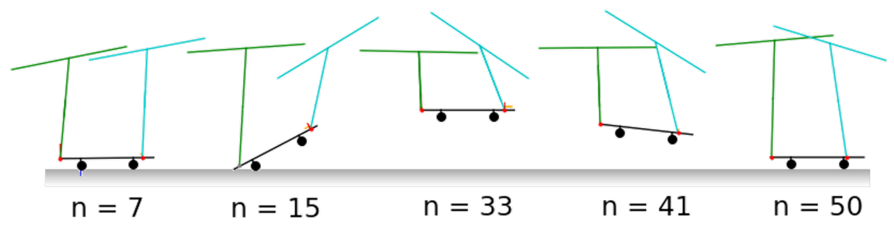


The Objective Function

$$J = \sum F^2 + \sum \tau^2 + \sum p$$

Constraints

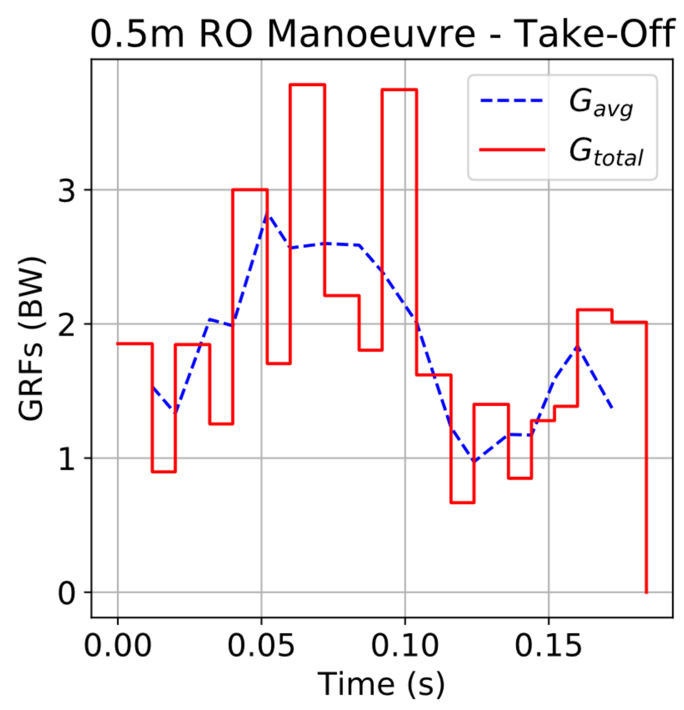
$$@t = t_1:\ board\ height = 0.5m$$

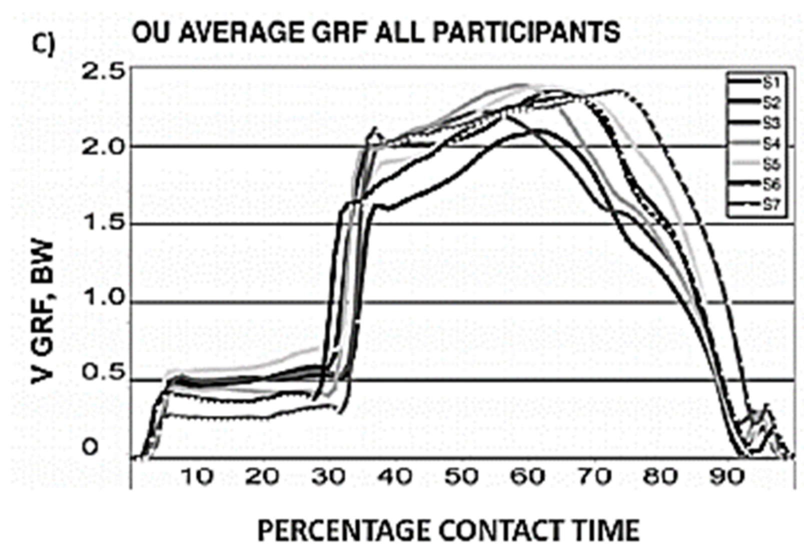


Once the contact methods had been implemented, the isolated aspects were integrated and the system was iteratively developed with increasing complexity.

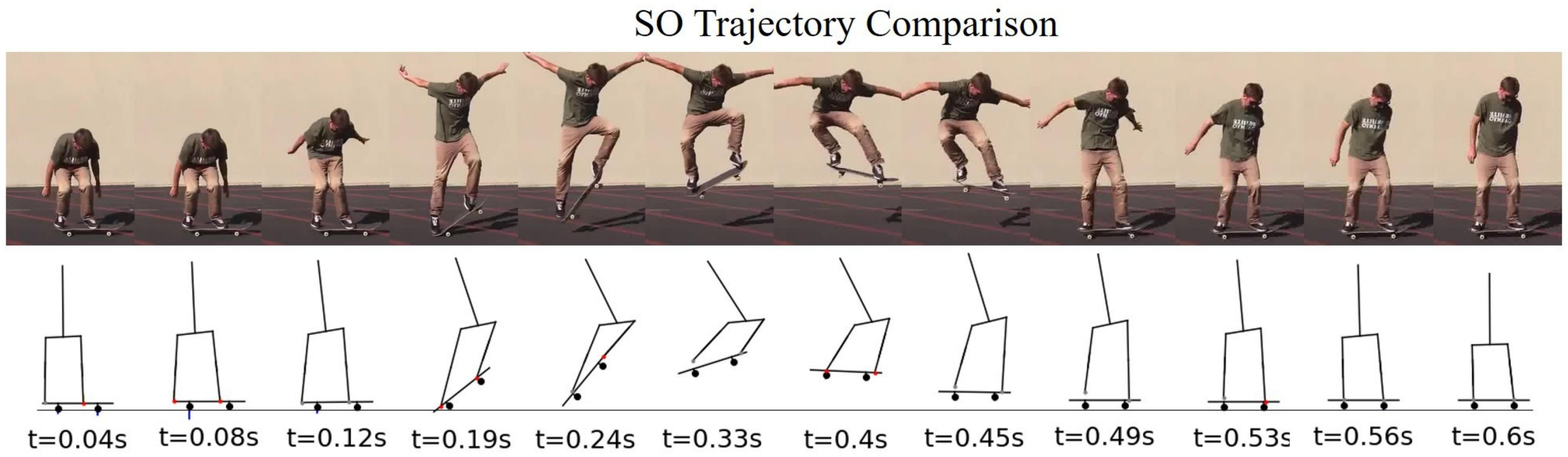
4. Results

The results for the SO, RO and OD manoeuvres were compared to the real observed motion of the ollie and the measured GRFs from literature - two of the comparisons are shown. The SO motion noticeably replicates the real ollie motion, and the same is true for the RO. A moving average of the GRFs of the RO and OD resembles the measured results from literature, however, to a far lesser extent. Under the time constraints of the project, the OU probelm was not successfully implemented.





SO Trajectory Comparison



5. Conclusions

It was concluded that, although the visual motion of the modeled system replicated the real ollie manoeuvre, the system needs further development to replicate the GRFs experienced by the skateboard. It is recommend that the complexity of the model of the leg should be increased.

Images:
https://sidewalkmag.com/skateboard-tricks/beginner-tricks/how-to-ollie-sidewalk-basics.html/2
https://www.youtube.com/watch?v=OrOZxOTIv-g

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