Intelligent Systems and Informatics Lab.
http://www.isi.imi.i.u-tokyo.ac.jp/
東京大学 THE UNIVERSITY OF TOKYO

Transitional Buckling Model for Active Bending Effect in Pole Vault

***Toshihiko Fukushima, Satoshi Nishikawa, Kazutoshi Tanaka, Yasuo Kuniyoshi**
Intelligent Systems and Informatics Laboratory, The University of Tokyo

Abstract

Tool-use enables us to achieve tasks that would be otherwise impossible to complete. That will be able to say in robotics. Pole vault is a method to exchange vaulter's horizontal energy to vertical energy. Well-trained athlete actively bends a pole while pole planting phase and flying phase, so he get higher. However, previous pole vault model is not include the active bending effect. Therefore, in this study, we proposed "Transitional Buckling Model" which accounted for athlete's active bending on the pole by combining Euler's buckling model and previous model. In addition, we found out how the robot should actuate the pole.

Introduction

- **Tool-use** enables robot to **achieve tasks** that would be otherwise impossible to complete.
- Pole vault can **exchange horizontal** kinematic energy **to vertical** potential energy.
- Athlete's **active bending has a large effect** to enhance vaulting height.

Proposed Model

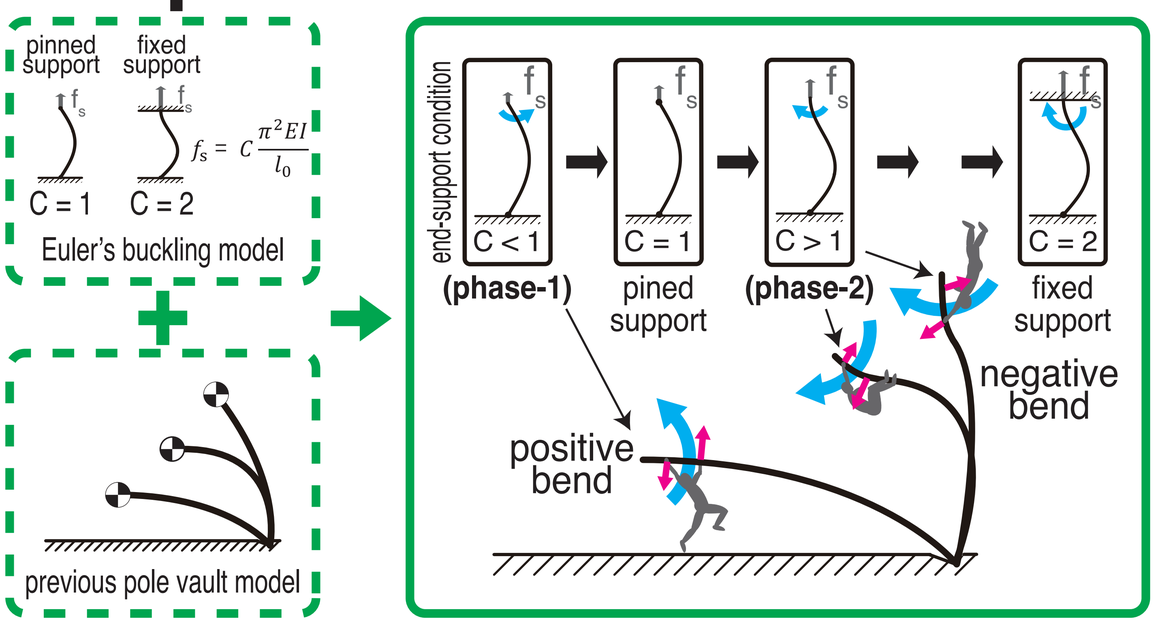

Fig1. Transitional Buckling Model (TBM)

<Transitional Buckling Model (TBM)>

Treat active bending effect by varying end support coefficient C

(phase-1)
Planting phase: active bend -> increase C

(phase-2)
Straightening phase: negative bend -> decrease C

Experiments & Results

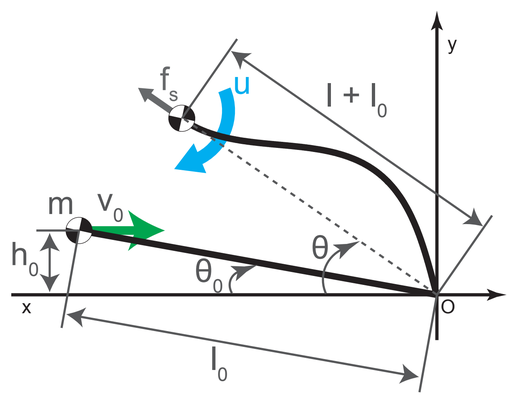

Fig2. Simulation model

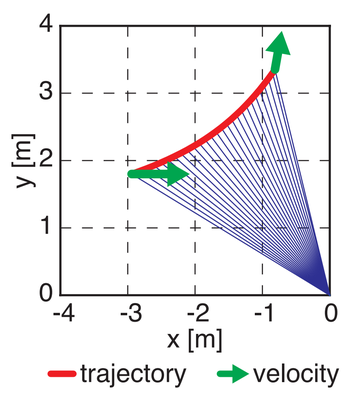

Fig3. Simulation result

<Pole vault Simulation>

2D simulation by solving equation of motion.

- Compare TBM with previous model
  - Compare the vaulting height at each initial velocity
- Analyze bending strategies for vaulting higher
  - Explore timing and speed of changing bending direction

Advantage of Active Bending

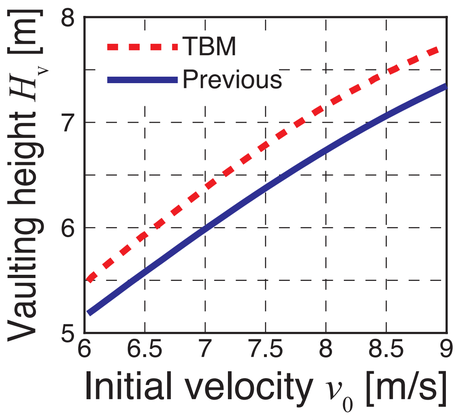

Fig4. Vaulting height

Active bending improved performance of pole vault.

Usage of hysteresis:
Change virtual spring constant in pole bending and straightening

Skill of Active Bending

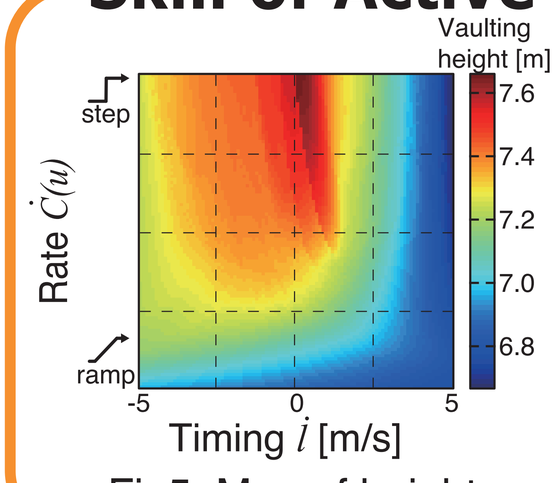

Fig5. Map of height

<How to bend>

Timing:
when pole was bent maximally

Rate:
like a step input

Conclusion

- Transitional Buckling Model was able to **account active bending effect**.
- Input bending moment **improved the vaulting performance**.
- We presented one of the way to **use skillfully** the flexible and complex tools.