Retrofitting an Existing Bicycle for Individuals with a Unilateral Lower Extremity Amputation

Team 25

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Abstract

- This project aims to improve the mountain biking experience for right-legged amputees through a pedal-locking system and custom oblong chaining.
- The pedal-locking system can support a 200 lb rider landing flat from a 5 ft drop. The chaining can support a Tour de France rider in full sprint.
- The custom oblong chaining achieves a 20.7% increase in pedaling efficiency from baseline, as measured by power to heart rate ratios during testing.
- Through innovative design and testing, this project enables a more enjoyable and accessible mountain biking experience.

Introduction

Amputee mountain bike riders confront substantial challenges that current solutions inadequately address. Two pivotal challenges impede accessibility for amputees: insufficient power for steep ascents and pedal positioning during descents, corners, and jumps. Our solution focuses on developing an oblong chaining to optimize the rider power curve to:

- Increase power output on the downstroke.
- Minimize resistance on the upstroke.

Additionally, a pedal-locking system allows the rider to keep the pedals level which mitigates the risk of bottoming-out and improves body positioning and handling. Our design differentiates itself from sit-down bikes and electronic enhancements by:

- Seamlessly retrofitting to standard bicycles.
- Maintaining the traditional mountain biking experience.

Results

The oblong chaining was tested using a Garmin Tackx Trainer in an isolated environment which yielded:

- A 20.7% improvement over its standard circular counterpart.
- An average power output increase from 188 W to 234 W while constantly maintaining a 100 bpm heart rate for 5 minutes.

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Discussion and Conclusions

- Dog clutch gear mechanism interlocks a free and fixed gear utilizing a lever mechanism.
- The design requires backpedaling to disengage the fixed gear from the free gear, prioritizing safety and ease of use for the target users.
- Compatibility with existing mountain bike frames and components is ensured, with accessibility and user feedback guiding iterative improvements throughout the design process.

Future Work

- Modify the design for bilateral retrofitability to accommodate both left and right legged amputees.
- Improve the disengagement mechanism so that the pedals can be unlocked without backpedaling.
- Incorporate bidirectional locking to accommodate various riding styles.
- Upgrade the lever actuation mechanism to electronic control to improve user experience.
- Design the pedal-locking mechanism to be compliant to reduce impact forces on the rider’s leg.

Acknowledgements

Thank you to our faculty advisor Dr. Ahmad Ghasemloonia for his critical feedback and suggestions. Thank you to our industry sponsors Ivan Chow, Ben Primeau, and Doug Murphy, for their technical and manufacturing support.

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Methods and Materials

Python was utilized to develop the chaining shape based on the instantaneous radius method. The power output of the rider was scaled across an 80 - 115 mm chainring diameter. Using tangent splines, the chaining shape was smoothed into a consistent profile.

SolidWorks was used to generate detailed models of the functional system. Through static simulations, finite element analysis, and a topology study, the design was further revised for strength and weight reduction.

Physical testing identified unseen issues, which were modified to meet project requirements. A combination of 7075 and 6061 aluminum alloys were chosen to provide a high strength-to-weight ratio, and prevent surface corrosion.

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FOS - 2.0

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