Load Sensing Device for Speed Climbing Hand Holds

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INTRODUCTION

This project aims to create instrumented speed climbing holds capable of precise multiaxial force measurement without interfering with the wall or the athlete's perception of the climb. The device will help optimize physiological development regimens and improve the meticulous climbing technique of athletes in relation to the sport of speed climbing.

PROBLEM

The United States Olympic Committee (USOC) does not have a current method to accurately measure speed climbing performance kinematics and applied loads on each of the route's 20 hand holds.

- Must function like a normal hold.
- Must measure forces in all three dimensions.
- Must not alter the wall.

	METRIC	UNITS
A	Force and torque from all three axes within 5% of actual	N, N·m
B	Data can be viewed within a minute and can be easily collected and interpreted by coaches	seconds
C	Athletes cannot detect instrumented holds maximum of 3 mm offset from wall allowed	mm
D	Instrumented holds can be installed on different speed walls using standard spacing of bolt holes	mm
E	Instrumented holds can be installed at all orientations using standard spacing of bolt holes	mm

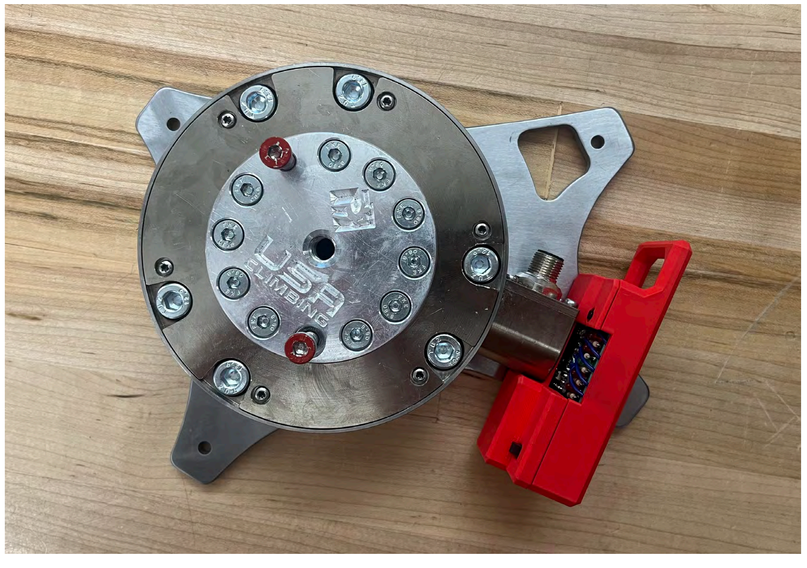

Fig. 1. Load plate, load cell, flange assembly

METHOD OVERVIEW

1. Selected precision force/torque (F/T) sensor according to strength, load range, resolution, and sampling rate.
2. Milled official International Federation of Sport Climbing (IFSC) hand hold interior to house F/T sensor.
3. Designed a plate to mount F/T sensor on speed wall T-Nut.
4. Designed a flange to interface between F/T sensor and hold.
5. Fabricated data/power cables to pass through existing bolt holes to remain hidden.
6. Developed hands-off data acquisition/visualization software.
7. Validated output with other supplied athlete performance data.

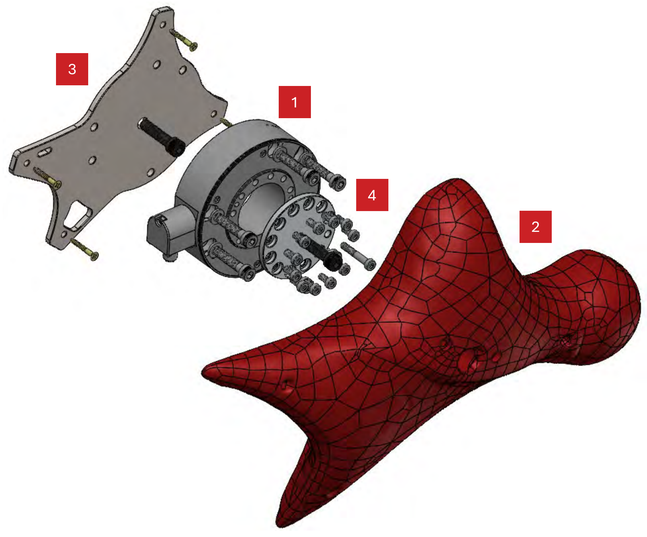

Fig. 2. Exploded view of full assembly

METHOD DETAILS

1. Commercially-available, DC-powered, ethernet output F/T sensor selected: ATI Axia130-M300.
2. Hand hold interior manufactured with abrasive CNC milling.
3. Load plate fabricated via water-jet, cut from 6mm carbon steel. Mounts to speed wall with one ⅜"-16 bolt through designated T-Nut alongside four #10 set screws.
4. Interface flange milled from 6061-T6 aluminum. Nine LP M6 bolts attach flange to F/T sensor; one ⅜"-16 bolt attaches hold to flange with three M6 locator bolts.
5. Custom 8-pin, A-coded M12 to M8 cables were spliced to fit through existing bolt holes and connect to M12 and splitter (i.e., M12 to ethernet and DC power) cables. Noise and signal attenuation analyses were performed.
6. Data acquisition (DAQ) software provides hands-off F/T sensor calibration, data reception, data processing (i.e., mapping, filtering, trimming), and results visualization.
7. System installed and tested on all hold orientations for live data collection with USA Climbing athletes.

RESULTS

	METRIC RESULTS	
A	Force and torque from all three axes are within 1.4% of actual	✓
B	Data is viewed within 3.8 seconds and is easily collected and interpreted by coaches	✓
C	Athletes confirmed imperceptibility of instrumented holds; 2 mm maximum offset of hold from wall	✓
D	Instrumented holds are easily installed on different speed walls using standard spacing of bolt holes	✓
E	Instrumented holds can be installed at all orientations using standard spacing of bolt holes	✓

The data collected from the instrumented holds are mapped over time by the visualization software. The first peak on the graph is the athlete's hand pulling on the hold, with the second peak being the athlete's foot pushing milliseconds later. The location of the hand and foot contact is calculated and mapped based on the max values of the force and torque data.

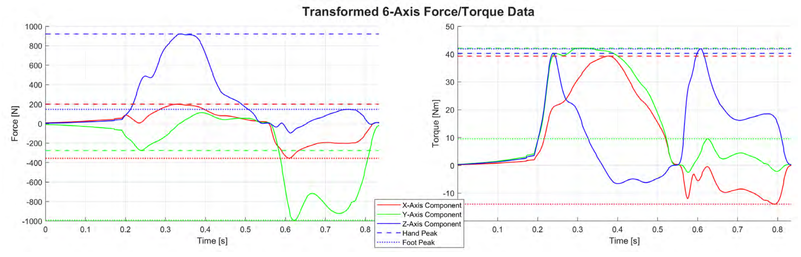

Fig. 3. Force and torque data in each direction

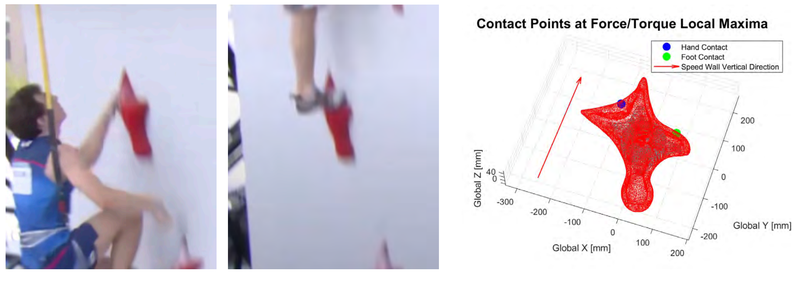

Fig. 4. Hand and foot contact point calculated with the force and torque data

CONCLUSION

This solution will provide critical data to athletes and coaches that can be used to inform more optimal climbing techniques and training regimes. This advantage will aim to bring Team USA the gold medal for men's and women's speed climbing events in the Los Angeles 2028 Olympics, as well as improved athlete performance in other competitions for years to come.