TRAX: Shoe Traction Testing Machine

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Abstract

Over $70 billion are spent annually on slip and fall related injuries in the workplace. The lack of an adequate shoe traction testing standard has prohibited accurate and reliable shoe traction measurements. The Heeluxe Shoe Traction Testing Team has revolutionized this standard in designing TRAX, a modular, mechanical system founded on the biomechanical principles of the human gait. With the ability to control the ankle angle, leg angle, walking speed, and total mass, this system is guaranteed to outperform the oversimplified methods used by the leading competitors in shoe traction testing.

Table 1: Engineering Characteristics

Engineering Characteristic	Standard	TRAX
Ankle Angle (7°-22°)	X	✔
Leg Angle (10°-20°)	X	✔
Walking Speed (1.1-1.3 m/s)	X	✔
Total Mass (130-180 lbs)	X	✔

Human Gait Analysis

TRAX models the human stepping motion as an inverted pendulum with its weight concentrated at the center of mass. Adjustable center of mass speed and weight result in a more biomechanically accurate stepping motion and therefore more accurate impact forces and COF data.

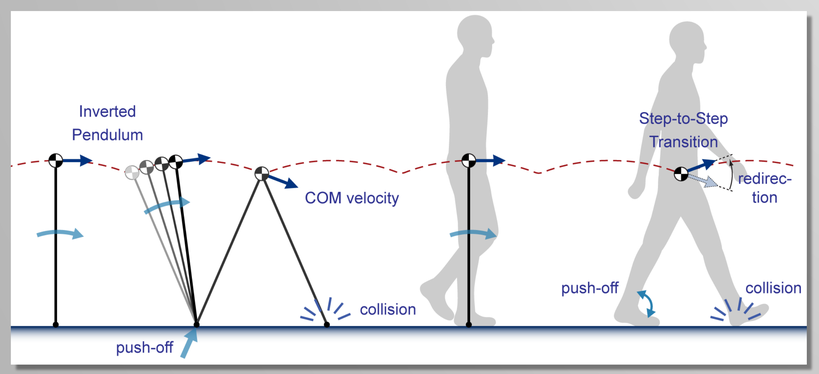

Figure 1: Inverted pendulum model for human gait

TRAX Machine

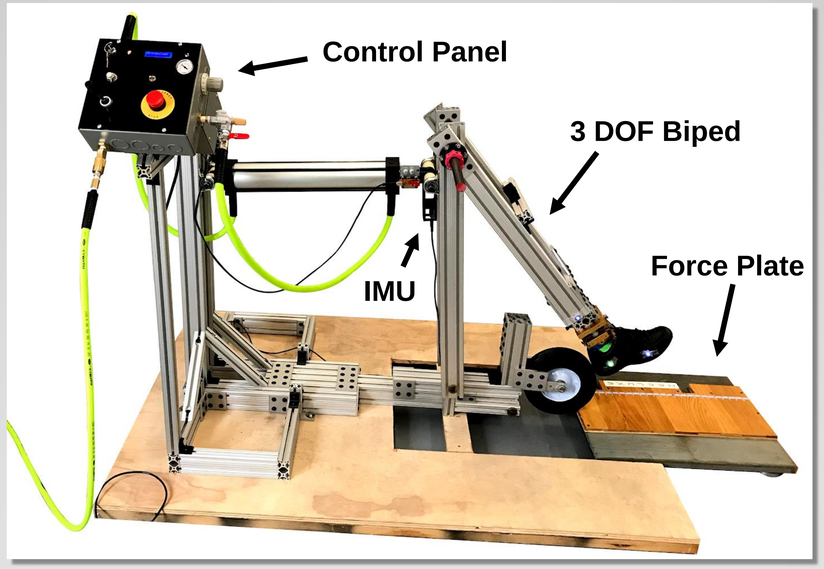

Figure 2: TRAX Machine

Key Components

3 Degree Of Freedom Biped

A double acting piston drives a 3 DOF biped through an inverted pendulum motion resulting a dissipative collision between the shoe sole and the ground. The back ankle allows push-off after the collision to simulate the post-impact stepping motion. Body weight, walking speed, leg angle, and ankle angle are easily adjustable.

Control Panel

Pneumatics and electronics are controlled through one user-friendly interface at a safe distance from moving parts.

Force Plate

A force plate measures the forces in the vertical and horizontal directions that combine to result in a non-dimensional horizontal force scalar known as the coefficient of friction.

Inertial Measurement Unit Sensor

An IMU sensor measures the angular speed of the center of mass which is converted to horizontal walking speed.

Force Plate Testing

TRAX was designed to respond to impacts as a human does so shoe COF can be studied throughout different stages of the human gait. Testing showed TRAX's ability to replicate the general loading profile of a human step (Fig. 3A) while also being able to differentiate between various shoes (Fig. 3B). A 10 test repeatability study showed TRAX measures COF within ± 4.6% error (SD=0.0095).

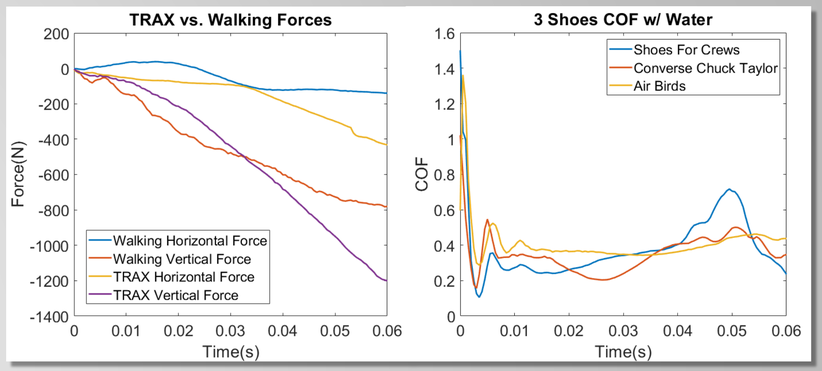

Figure 3: (A)TRAX vs human forces, (B) 3 shoes COF

Motion Tracking

TRAX is capable of matching the ankle and leg angle of impact to that observed in real-life walking scenarios.

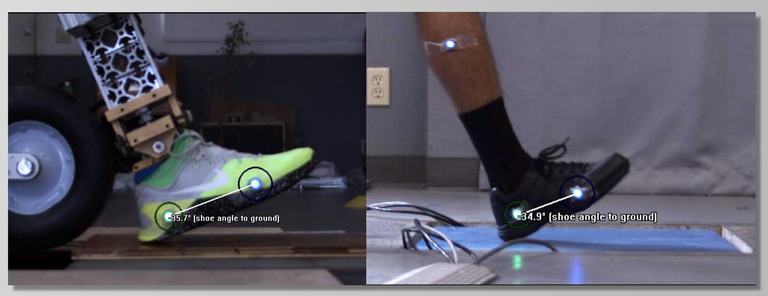

Figure 4: Motion tracking comparison for TRAX and human

Conclusion

TRAX's modular design allows for a broader range of testing which can provide overall better understanding of shoe traction to the industry. TRAX has the potential to set a new standard for shoe traction testing and help companies make better shoes.

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