Development of a motion capture system for motorcycle and rider.

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Summary

To quantitatively evaluate the operating ability of motorcycle riders with varying skill levels, we developed a motion capture system with built-in sensors. 6-axis force sensors were placed in all parts of rider contact, and sensing devices for throttle angle, steering angle, front wheel rotation speed, front wheel brake fluid pressure, rear wheel brake torque rod tension, vehicle body IMU, and GNSS were installed. We calibrated the brake sensors to accurately estimate the deceleration forces generated on the tires contact surfaces.

Introduction

Motorcycles require more complex operations than cars due to the balancing operations required. Therefore, accurate recording and analysis of these complex operations are necessary when quantitatively evaluating the operating ability of riders. Ishii et al. placed force sensors in all parts of rider contact to evaluate operating skill [1], however, partially reduced the degree of freedom of the sensors. This is thought to be based on the assumption that the rider's load direction is constant in advance, but this approach seems limited in capturing the unexpected maneuvers of riders, from novices to experts. Therefore, the aim of this study was to develop a system that captures all the forces applied by a rider to motorcycle and the resulting behavior of the motorcycles, and to quantitatively evaluate the operating ability of riders of a wide range of ability levels.

Methods

On the Wave125i (Honda Motor Co., Ltd.), we installed 6-axis force sensors in grips, under steps and under a seat to capture all the forces applied by a rider to motorcycle, and also installed throttle, front wheel brake fluid pressure, and rear wheel brake torque rod tension sensors to capture acceleration or deceleration inputs. In addition, we installed steering rotary encoder, front wheel rotary encoder, IMU and GNSS to capture the motion of motorcycle. Since the mounting part of the 6-axis force sensor is subjected to a strong force due to the rider's weight, we confirmed the achievement of the strength requirement by CAE. Among the force sensors, we considered the reliability of the grip strength related to steering to be the most important for safety. Particularly for the right-hand grip, which has a complicated structure due to the throttle mechanism, we created a real model with the same structure and conducted a strength test to demonstrate that the strength requirements were achieved. The values of the front wheel brake fluid pressure and rear wheel brake torque rod sensors do not exactly match the braking force applied to the contact of the tires with the ground. Therefore, we calibrated the brake sensors using the following procedure to accurately estimate the deceleration force generated on the tire contact surfaces. The deceleration from a speed of 40 km/h to just before stopping was measured for two riders of different weights under conditions with only the front wheel brake, only the rear wheel brake, and no brakes. Then, using this data, we obtained an estimation formula for the first-order linear sum that calculates the braking force exerted by the front and rear tires individually from the values of the fluid pressure sensor and the torque rod sensor.

Results and Discussion

Figure 1 shows the completed system. The system enabled us to fully obtain the rider's forces and evaluate all maneuvers mechanically. Due to the function of this system, it is also possible to establish an equation of motion for a motorcycle alone without the human model, or conversely, to establish an equation of motion only for the human side. Figure 2 shows the result of calculating the margin ratio with respect to the friction limit of the tire during braking task that the subjects were instructed to decelerate at a constant rate from 40km/h to a stop at 12m. The margin ratio difference between an expert and a novice was clearly shown mechanically.

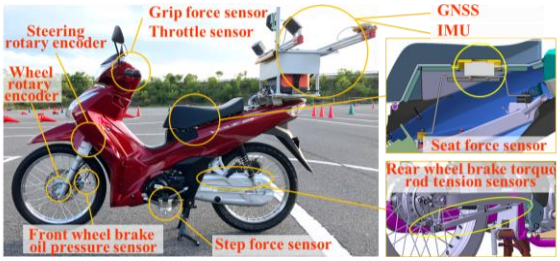

Figure 1: Motion capture system for motorcycle and rider.

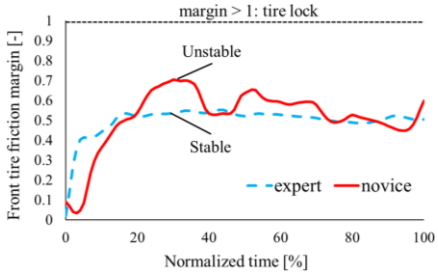

Figure 2: Features of fluctuations in friction margin.

Conclusions

We developed a system to quantitatively evaluate riders' operating abilities by capturing all forces applied to a motorcycle and its resulting behavior.

References

[1] W Ishii et al. (2017). *Yamaha Motor Technical Review*. Dec. 53: 102-109