Master Thesis

Development of output simulator for baseball-type accelerometer

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Abstract

We developed an output simulator for a baseball-type accelerometer including the sensor unit consisted in one low-acceleration and three high-acceleration sensors. From the outputs of this ball-type sensor, it is possible to estimate the rotational characteristics such as the axis of rotation and angular velocity. However, a method for estimating the translational acceleration occurred at the center of gravity of the ball-type sensor has not been established yet. Then, we assumed the sensor configuration in the sensor unit as a rigid body and formulate mathematically the acceleration in its translational and rotational motion.

In the simulation of rotational acceleration, we verified the output data of straight and curved pitches obtained from flight experiments. We used the angular velocity and rotation axis of the ball-type sensor as the inputs to the simulator. The rotation axis was simulated under two conditions, in one of which the inputs varied with time while in the other these kept constants. As a result, the sensor outputs were good agreement with the simulated results under the former condition. We summarized the error between the simulated results and the original sensor output for each nine data of two-pitch types and confirmed that the errors under the former condition were smaller than those under the latter condition. This fact indicated that the rotation axis of the ball-type sensor changed in flight.

For the output of the translational acceleration, we used the simulator in order to perform parameter study of the drag and lift coefficients that could not be obtained directly from the output data. In the simulations in which the drag and lift coefficients were varied, the horizontal and vertical distances of calculated trajectories changed. In the output of acceleration, it was confirmed that the amplitude became larger with increasing the coefficients and that the phase sifted depending on the position of the sensor. Also, in the simulations where the ratio of the drag and lift coefficients was changed, it was found that the output phase changed according to the direction of the aerodynamic force.

Using the developed simulator, we attempted to estimate the aerodynamic force acting on the ball-type sensor from the translational acceleration of the sensor output. As a result, the aerodynamic force in the inertial coordinate system was obtained from the periodic output of translational acceleration. The aerodynamic force was also simulated by assuming the initial velocity and aerodynamic coefficients, and the result showed similar tendency of the estimated results.

In the present study, we formulated the acceleration output measured by the ball-type sensor, and we developed a simulator for the translational and rotational acceleration. By using this simulator, it became possible to estimate the aerodynamic force acting on the center of gravity of the ball-type sensor in the case of straight balls where the correspondence between the initial configuration of sensors and the inertial system is rather simple. The present simulator, therefore, is effective in order to clarify the aerodynamic characteristics of a body in flight.