Technische Universität Braunschweig

Study Thesis

Automatic Tuning of Extended State Observer using Fuzzy Logic System for ELISSA Testbed

The ELISSA testbed is a laboratory at the Institute of Space Systems (IRAS) developed to emulate the motion of satellites in orbit during rendezvous and docking and also validate relevant software and hardware. It consists of a 4m x 7m active air-bearing table with blowers, a motion capture system, several mockups, and the relevant software for its operation. The mockups can move freely on the air-bearing table with air cushions generated by the table. There are, however, many external disturbances affecting the mockups during their motion. One example is the residual acceleration due to the fact that the air-bearing table is not perfectly flat. Another example is that, when the robotic arm onboard the mockup moves during 3D printing, the movement of the robotic arm will have influence on the movement of the mockup. In order to reject these external disturbances, extended state observer (ESO) can be used to estimate them in real time and the estimate of disturbances can then be used to cancel their influences (see Figure 1). As external disturbances can vary at different locations of the air-bearing table, automatic tuning of parameters of ESO in real time is desired to have a good performance. To achieve the purpose of automatic tuning, fuzzy logic system (FLS) is a possible solution. For example, when we consider the translational motion of the mockup, a fuzzy logic system can be designed to take the error signal of the position and its derivative as inputs and calculate proper parameters of ESO as outputs (see Figure 1).

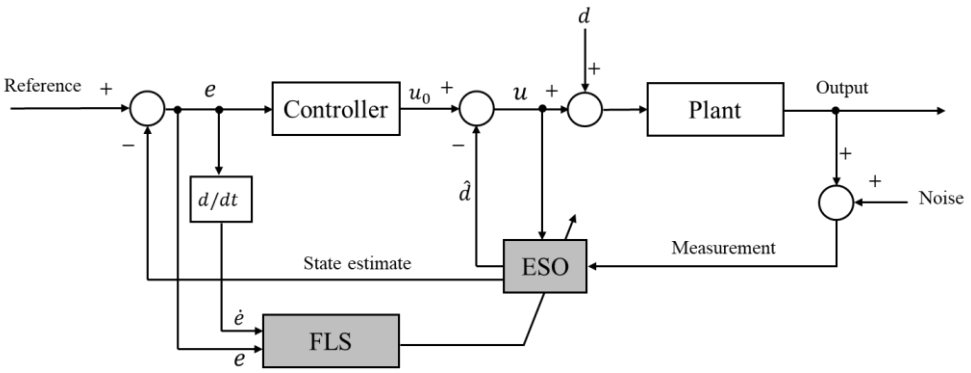

Figure 1. Block diagram of control loop with fuzzy logic system (FLS)-based extended state observer (ESO)

The focus of this thesis is to implement fuzzy logic system to tune parameters of ESO in real time and validate the developed algorithm on the ELISSA testbed. This thesis includes the following tasks:

1. Get familiar with extended state observer and fuzzy logic system
2. Get familiar with ELISSA system and its operation
3. Develop the fuzzy logic system for the ESO in ELISSA testbed
4. Write codes (in C++ and/or Python) for the developed FLS-based ESO with the relevant library of fuzzy logic
5. Demonstrate the developed algorithm numerically using the relevant simulation environment
6. Demonstrate the developed algorithm using ELISSA testbed with hardware in the loop

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