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Ian Suo

Professor Stacy Suver

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Methodologies and Anomalies in Flight Simulation Research

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Flight simulators set many limiting conditions and strictly follow mathematical models. This raises the concern whether some outcomes in real life circumstances are overlooked.

In modern aviation, flight simulation plays a huge role in mitigating risks and cutting the cost of a real flight. It’s used for training pilots, testing the performance of a new technology, or even providing military pilots an advantage during combat. Many defense contractors and aviation companies have jumped on the simulation train. Military organizations today are really sensitive to flight simulators since they understood the benefits of such fairly costly technological devices, capable to “replicate the response’’ of 5TH generation fighters which are typically very expensive to operate. (Simulation and Training Bosses 36)

The current trend in the research of flight simulation focuses on setting limiting conditions as input, building mathematic models based on the input, transforming it into computer algorithms and finally visualizing the output using various software. Thus this field overlaps greatly with the areas studied in computer science. The output of these simulators may be a simple graph that analyzes data, or a fully simulated virtual environment.

In the research done by Frantis and Cuzzolin, they implemented a mathematical model using existing inputs such as latitude and longitude information gathered by the onboard Inertial Navigation System (INS), angle of attack gathered by the pitot, predicted aircraft movement in fly-by-wire systems, gathered by the joystick and rudder pedals. By using trigonometry and matrix math equations, they were able to develop an algorithm that visualizes these data in an augmented vision system that aids the pilot during her flight. On the software engineering side, they picked a modular approach that processed the data in two functions, one for terrain visualization, and one for augmented visualization of avionics. C++ was their chosen programming language for the short processing speed needed for this real-time environment using embedded devices.

The research paper also pointed out that, non-linear aerodynamic forces and moments as well as extreme angle of attack conditions are overlooked. (Frantis and Cuzzolin 67) What that means is, in emergency situations where a steep climb, a steep dive, or spin recovery is required, this system will not reflect accurately and the gut instincts of a pilot will have to take over.

In the drone industry, high fidelity flight simulation research is critical since there is no pilot in the cockpit and the computer runs everything. Now move that computer program to a simulated environment, and you can get a pretty close prediction of what would happen in the air. In the research done by Xu et al., a fully simulated environment is developed in Unity3D to test the algorithm of unmanned formation

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flight. The test environment has assumed vision to be the only available input and employed the same communication rate between the sensors and formation flight controllers. Measurements of the leader position and flight path can be calculated from the vision input. And thus, if the algorithm works correctly, the “Wing man” would autonomously follow the leader of the formation flight without the leader plane’s explicit command. (Xu 265)

Like the research done on embedded avionics, matrix math is also used to denote positions, velocities, size, and accelerations as vectors for the algorithm of the formation flight. The research also points out that the Unscented Kalman Filter (UKF) model used for the vision feedback simulations is very good even in dynamic environments. However, it does state that the position and attitude accuracy could use some further smoothing out with some model based filtering scheme in a dynamic environment. (Xu 266)

Some researchers are incorporating the risks involved with real conditions in the air and hoping to predict them in the simulation model. A Fault-Tolerant Control strategy (FTC) uses a linear dynamical model of a business jet aircraft subjected to actuation faults. As a baseline controller, an optimal linear quadratic tracker was designed to control some selected aircraft motion variables. Faults due to the loss of effectiveness were assumed. Then, the FTC was built upon a compensation of faults into the dynamical equations. The complete system was tested using nonlinear simulations of the aircraft dynamics. The results demonstrate the ability of the FTC strategy to maintain the stability of the system and to improve the tracking performance for a large scope of faults. (Almutairi 671)

Results of this research showed that the system without FTC, managed to handle some actuation faults with magnitudes up to 70% with some lack of stability and performance. At higher faults extents, the system became dynamically unstable and completely lost the tracking performance. However, when applying FTC, the system brought back to stability and the tracking performance significantly improved. But it is noted that this kind of technique only applies to aircraft actuator faults. (Almutairi 676)

While flight simulators are mostly done in mathematical models and computer programs that resemble video game engines, Chihyung Jeon’s research in flight simulation and the pilot’s identity sheds a new light in this topic. By studying the Army helicopter pilot’s attitude towards the Link device, a legacy flight simulator, Jeon points out that most pilots still prefer to simply train in the flight line and up in the air than in the simulator because the conditions posed in the simulator are in effect, not the flight conditions, but cockpit conditions. However, the more modern flight simulators provide a much more vivid flight experience that could simulate precisely a plane in flight by manipulating the perceived motion on the screen and the friction of various devices in the cockpit. The feeling of thrust, drag and altitude effects to fuel rates in the cockpit were to be experienced and simulated. In another word, the flight simulator has become the forefront of virtual reality development. (Jeon 50)

In conclusion, flight simulation research will continue setting limiting conditions so the environment variables are controlled. Because of this, some unpredicted outcomes during flight that could be critical to safety may be overlooked. The researchers are quite aware of this as they point out in their studies, all of the variables that could be considered but currently unfeasible due to technological limitations. As more research is done in the area, these holes in the system will slowly be filled.

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Works Cited

1. Almutairi, Saif H., s.almutairi@cranfield.ac.uk, and Nabil1, n.aouf@cranfield.ac.uk Aouf. "Design And Non-Linear Simulations Of A Fault-Tolerant Flight Control." *Advanced Materials Research* 1016.(2014): 671-677. *Applied Science & Technology Source*. Web. 27 Oct. 2015.
2. Chihyung Jeon. "The Virtual Flier: The Link Trainer, Flight Simulation, and Pilot Identity." Technology and Culture 56.1 (2015): 28-53. *Project MUSE*. Web. 11 Oct. 2015. <https://muse.jhu.edu/>.
3. Frantis, P., and A. Cuzzolin. "Real-Time Flight Model For Embedded Simulator." *Advances In Military Technology* 9.1 (2014): 59-68. *Academic Search Complete*. Web. 11 Oct. 2015.
4. "Simulation And Training Bosses (SATB) Series." *Military Technology* 38.12 (2014): 36-41. *Computer Source*. Web. 28 Oct. 2015.
5. Zhendong Xu1, 2, xzd6806665@163.com, et al. "A Virtual Environment For Simulation Of Formation Flight." Applied Mechanics & Materials 713-715.(2014): 263-266. Applied Science & Technology Source. Web. 11 Oct. 2015.