Our overall research goal this past year has been to create constructive networked control architectures for formation control of both quadrotor and fixed-wing aircraft which allows for collision avoidance while maintaining stability. In order to obtain this goal we: 1) developed a constructive non-linear control framework which allows non-linear affine systems such as fixed-wing aircraft to be rendered strictly-output passive; 2) established a networked control architecture to interconnect multiple-agents in order to achieve a formation; and 3) modified a classic collision avoidance algorithm in order to achieve separation of aircraft.

1. Our first result applies to networked control of non-linear affine systems, including fixed wing aircraft, quadrotor aircraft, robotic, thermal, semiconductor manufacturing, alternative energy generation, and active suspension systems. These nonlinear affine systems can be expressed through what we term "m-Triangular Systems". The m-Triangular System renders possible a well-posed, distributed, continuous-time, control law which can be applied to nonlinear affine systems. This control law creates a strictly-output passive system which can then be integrated into a multirate discrete time networked control architecture. This robust architecture permits a discrete time strictly passive lag compensator to determine the desired output of the strictly-output passive system. Thus, we can integrate unmanned jet fighter aircraft into the NextGen system in which the lag compensator is located at the ground-control station. We can now safely control the inertial position of these aircraft despite communication time varying delays and data loss [NK-1a,b,c].
2. Our second result builds on our advanced digital networked control architecture in which passivity is preserved in spite time varying delays and data loss [NK-2]. The key to this architecture is our networking abstraction known as the power-junction and some minor analysis showing that it can be distributed over arbitrary overlay network topologies [NK-3a,b]. The overall architecture then allows for steady-state analysis in order to derive final formations of quadrotor aircraft. These predicted results have been verified using our advanced Simulink based models of quadrotor aircraft in which time varying delays and data loss were simulated using TrueTime.
3. Finally the classical collision avoidance algorithms [NK-4a,b] had to be modified using a non-linear filtering architecture which is described precisely in [NK-1a] and filtering architecture is inspired on the pioneering work of [NK-5a,b,c].

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