RESEARCH INSTITUTE FOR SUSTAINABLE URBAN DEVELOPMENT (RISUD)

News Article for RISUD Emerging Frontier Area (EFA) Scheme

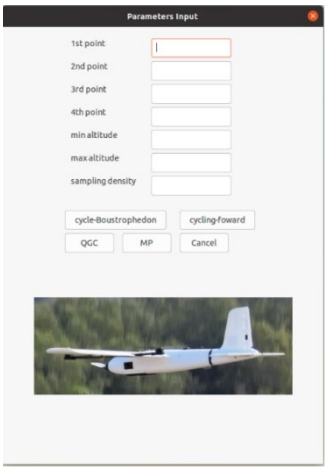
		Name	Department
1.	**Principal Investigator**:	Li-Ta Hsu	AAE
2.	**Name of EFA:**	Safety of Unmanned Airborne System	
3.	**Project Title:**	Resilient Urban PNT Infrastructure to support safety of UAV remote sensing in urban regions	

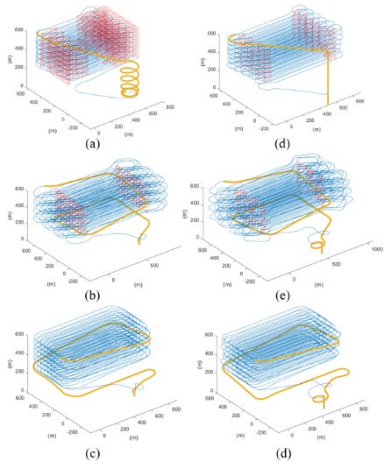
4. **Annual Progress/Achievement** (*in layman's language, no more than two A4 pages, pls attach photos*)

Neural Network Based Model Predictive Control (MPC) for a quadrotor UAV

Precise position control of UAV has been a challenging task, especially for those with complex aerodynamic structures such as tail-sitter and quad-plane. Our department has developed a learning-based MPC control algorithm to improve the position tracking accuracy for a quadrotor. Flight data was first collected with motion capture system Vicon and on-board sensors. A feedforward neural network is trained based on the data to learn the translational dynamics of the UAV. The trained model is then synthesized with the MPC algorithm to achieve precise position control. The proposed algorithm shows good robustness and reduces the average tracking error up to 40%. This method will be further applied to tail-sitter UAVs where the aerodynamics are more complicated than quadrotors.

Development of Fixed-Wing UAV 3D Coverage Paths for Urban Air Quality Profiling





Due to the ever-increasing industrial activity, humans and the environment suffer from deteriorating air quality, making the long-term monitoring of air particle indicators essential. The advances in unmanned aerial vehicles (UAVs) offer the potential to utilize UAVs for various forms of monitoring, of which air quality data acquisition is one. Nevertheless, most current UAV-based air monitoring suffers from a low payload, short endurance, and limited range, as they are primarily dependent on rotary aerial vehicles. In contrast, a fixed-wing UAV may be a better alternative. Based on a quad-plane configuration, our department proposed two path planning methods to conduct 3D air quality profiling missions, where the objectives were to reach a high coverage rate of a chosen ROI. To achieve this, in particular, the Boustrophedon paths were utilized and extended to 3D, whilst the Dubins paths were also included to ensure the dynamic feasibility. To have a higher coverage rate, the circling-forward planner was proposed additionally to observe the difference in the aforementioned metric. Also, the landing strategy was also included to ensure the robustness of the system Furthermore, a user interface was also designed for easy accessibility, which provides a generalized tool module that links up the proposed algorithm, the ground control software, and the flight controller. Simulations were conducted to assess the proposed methods. The result showed that the proposed methods outperformed the existing coverage paths generated by ground control software, as it showed a better coverage rate with a sampling density of 50 m.

Publication: Zhou, Q., Lo, L.-Y., Jiang, B., Chang, C.-W., Wen, C.-Y., Chen, C.-K., Zhou, W., “Development of Fixed-Wing UAV 3D Coverage Paths for Urban Air Quality Profiling,” Sensors, vol.22, 3630, May 2022.

Resilient Interactive Sensor-Independent-Update Fusion Navigation Method

To improve the robustness and reliability of multi-sensor navigation and reduce the uncertainties and complexity of sensor management in challenging environment, a resilient interactive sensor-independent-update method is proposed in this paper. The priority of trust of navigation sensors is introduced into the information fusion in the form of transition probability matrix. Every observable sensor is integrated with the propagated system in an elemental filter with sensor-independent-update structure. The multi-sensor integration is implemented in state estimation domain enhanced by interactive information fusion rather than in measurement domain implemented in traditional filter. The overall estimation is determined by the weighted sum of average from every filter estimate, which is dynamic updated by the prior transition information and posterior model likelihood. The kinematic vehicle experiment in sub-urban and urban canyon environment verified the superiority of the proposed interactive filter method.

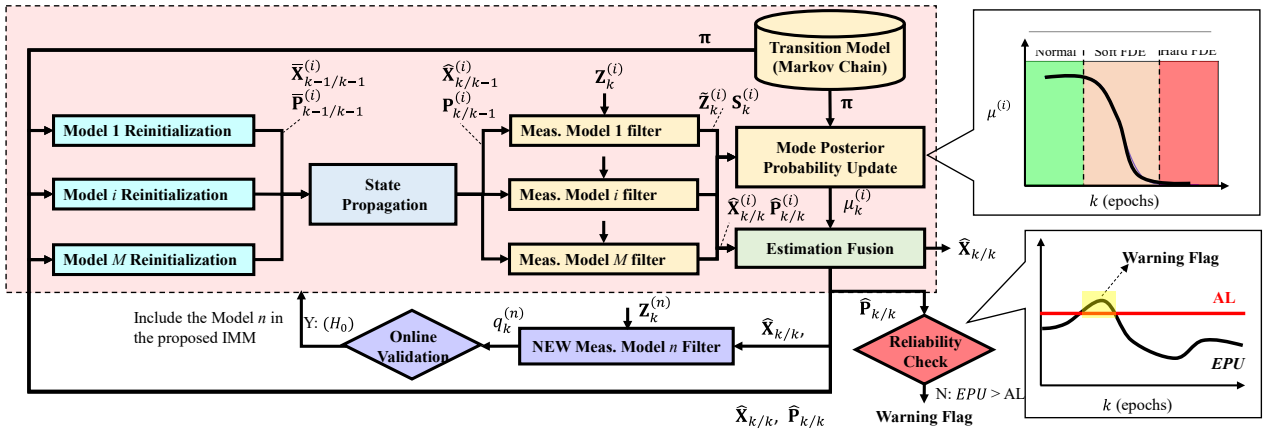


Fig. 2 Framework of the proposed interactive sensor-independent-update (ISIU) method. Q. Meng and L. -T. Hsu, "Resilient Interactive Sensor-Independent-Update Fusion Navigation Method," in *IEEE Transactions on Intelligent Transportation Systems*, doi: 10.1109/TITS.2022.3150273.