Enabling Multimodal Sensing, Real-time Onboard Detection and Adaptive Control for Fully Autonomous Unmanned Aerial Systems

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The goal of this proposed research project is to achieve true onboard autonomy in real time for UAVs in the absence of remote control and external navigation aids. Very low power and light weight machine intelligence techniques are investigated to achieve multi-modal sensing, onboard detection, and adaptive control in real-time. We formulate and solve the detection, optimization and control problems in an autonomous UAV using deep neural networks (DNN) and deep reinforcement learning (DRL). Ultra-low power and high-performance DNNs is obtained using effective weight pruning.

Challenges

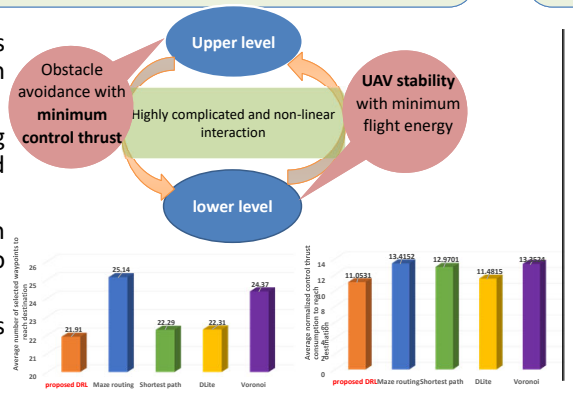
- Extremely large state and solution space, uncertainty in the environment and delayed reward/penalty
- Need to maintain both stability, energy efficiency and obstacle avoidance in UAV operation
- Limited computing power, onboard energy constraint, high complexity of DCNN

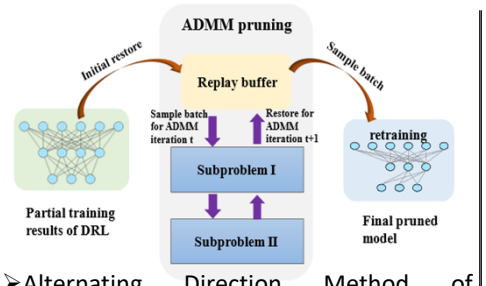
Scientific Impact

- Hybrid control framework learns how to partition large optimization problem into subproblems
- Gives trajectory 13% more energy efficient and 6% less complex
- ADMM based structured pruning removes 60% of the storage and provides 40.8% speedups

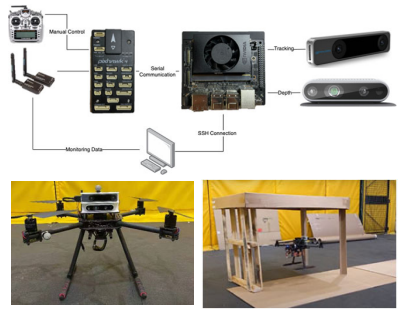
➢Autonomous trajectory generation aims at reaching destination with minimum control thrust and obstacle avoidance

- Upper level: way points planning ensures obstacle avoidance and global minimum of control trust
- Lower level: LQR based location trajectory generation between two way points
- Use DRL to learn the dynamics between the two levels





➢Alternating Direction Method of Multipliers (ADMM) based pruning reduces storage by 60% and inference time by 40%



➢Tested on real UAV platform

Impact on society

- Truly autonomous UAVs may enable many novel applications
- Will benefit industry/researcher working on building inspection, hazard detection, surveillance, environment data collection, etc.

Education & Outreach

- Courses on deep learning, nonlinear control and image processing were developed
- Mentor of regional champion team in FLL LEGO Robot competition

Potential Impact

Reducing thrust energy by 13%

Lowering the complexity by reducing the number of waypoints

Reducing storage complexity by more than 60% and accelerating inference by 40% with little or no impact on the success rate of trajectory planning

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