CSC 500 [Research Methods] - Research Proposal

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1. Research Issue Statement

The research aims to develop advanced visual autonomous navigation for ultra-low-power nano-drones with limited onboard processing capabilities. The goal is to eliminate the need for offloading computation to a remote base station, which currently results in high power consumption, latency, communication distance limits, and reliability issues due to channel noise. The authors plan to achieve this by creating a method for running complex deep neural networks directly on the nano-drones, which have very limited resources and consume minimal power.

2. Research Motivation

The research aims to make ultra-low-power nano-drones suitable for IoT applications by developing advanced visual autonomous navigation systems. Currently, these drones are limited by their onboard processing capabilities, but they have significant potential in areas like precision agriculture, environmental monitoring, and disaster response. To maximize their IoT potential, the authors plan to create a technique for running complex deep neural networks directly on the resource-constrained milliwatt-scale nodes of nano-drones, enabling closed-loop end-to-end DNN-based visual navigation.

3. Research Methodology

The paper's research methodology focuses on developing a comprehensive approach to run complex deep neural networks (DNNs) in parallel on resource-constrained milliwatt-scale nodes. The authors use the GAP8 embedded processor to implement a specialized DNN called DroNet for nano-drone visual navigation. They begin by describing the original CNN to determine resource needs. Then, they optimize the CNN mapping process using software tools to meet real-time requirements while considering on-chip and onboard limitations. Finally, they evaluate the method's effectiveness and energy usage, comparing it to state-of-the-art approaches.

4. Anticipated Results and Evaluation

The paper's expected outcomes are evaluated using three main metrics: meeting real-time deadlines, staying within the power budget, and achieving accurate closed-loop control for obstacle detection. The authors experimentally evaluate their optical navigation system using the PULP-Shield configuration. They measure performance and power consumption by switching between operating modes on the GAP8 processor. Accuracy is assessed by comparing their results with recent research. The goal is to enable nano-drones to perform closed-loop DNN-based visual navigation, enhancing their potential for IoT applications.

5. References:

[1] D. Palossi, A. Loquercio, F. Conti, E. Flamand, D. Scaramuzza and L. Benini, “A 64-mW DNN-Based Visual Navigation Engine for Autonomous Nano-Drones”, in IEEE Internet Of Things Journal, vol. 6, issue:5, pp. 8357-8371, 15 May 2019.