Research Methodology-Assignment 1

Inian Kaviyanban A V - CB.SC.P2CSE24005

Paper Title: Democratizing Drone Autonomy via Edge Computing

Authors: Mihir Bala, Thomas Eiszler

A 'LOOK' INTO THE PROBLEM STATEMENT:

- ➔ The research explores the potential of a fully autonomous flight using low-cost, lightweight commercial off-the-shelf (COTS) drones, highlighting their ability to revolutionize various use cases that involve real-time computer vision.
- ➔ The strength of this research lies in its innovative use of affordable and lightweight components to achieve functionalities that are generally associated with more advanced and costly drones. This approach could democratize access to drone technology, enabling a broader range of applications in real-time computer vision.

A BRIEF DESCRIPTION OF THE RESEARCH:

- ➔ The goal of this research is to democratize drone autonomy by developing a lightweight, low-cost flight platform capable of performing complex computer vision tasks without human intervention.
- ➔ This approach allows drones to remain lightweight, addressing safety and regulatory concerns associated with heavier drones.
- ➔ The paper makes three key contributions: This is the first paper to emphasize weight as a critical design consideration for autonomous drones.

- ➔ It demonstrates how edge computing can enable autonomy in unmodified, ultralight COTS drones.
- ➔ It confirms the feasibility of using such drones to meet real-time requirements for active vision.

PROPOSED SOLUTION:

- ➔ The solution is designed to address the limitations of existing drone systems, particularly in terms of weight, cost, and computing power.
- ➔ Key elements of the proposed solution include using a lightweight Parrot Anafi drone, a Samsung Galaxy Watch as a processing center, and offloading compute-intensive tasks to a ground-based cloud via 4G LTE connectivity.
- ➔ The Parrot Anafi drone was selected due to its lightweight design (320 g), affordable price, and programmability via the Parrot Ground SDK API.
- ➔ However, the drone lacks native cellular connectivity, which is supplemented by connecting a COTS device that supports both Wi-Fi and 4G/5G.
- ➔ The Samsung Galaxy Watch is used as a lightweight and portable processing center.
- ➔ Weighing only 26 g, the watch manages communication between the drone and the cloudlet, while offloading computationally intensive tasks.
- ➔ This configuration is necessary to maintain the lightweight design of the drone while achieving autonomy.
- ➔ Edge computing integration: The solution relies heavily on edge computing, where the cloudlet processes data downloaded from the drone in real time.
- ➔ This approach allows the drone to perform tasks such as object detection, tracking, and obstacle avoidance without the need for heavy onboard computing hardware.

STRENGTHS AND WEAKNESSES:

Strengths:

- ➔ *Innovative Use of Edge Computing:* The research effectively leverages edge computing to overcome the limitations of light drones, allowing them to perform tasks typically reserved for larger, more powerful drones.
- ➔ *Profitability:* The low cost of the platform is a major advantage, making drone autonomy accessible to a wider audience.The use of COTS components ensures that the technology can be easily replicated and scaled.

- *Security and Regulatory Compliance:* By maintaining a lightweight design, the platform complies with security regulations, reducing the need for complex approvals and facilitating its deployment in urban environments.

Weaknesses:

- *Thermal limitations:* The reliance on LTE transmission, which leads to thermal limitations, is a significant limitation. The wearable device used in the study, a smartwatch, experienced thermal shutdown when attempting to transmit data at higher frame rates, affecting the overall performance of the system.
- *Latency issues:* The end-to-end latency of the processing pipeline, on average per second, limits the versatility of the drone, especially in dynamic environments. This latency affects the system's ability to track fast-moving targets and avoid obstacles in real time.
- *Limited real-time capabilities:* While the platform successfully demonstrated basic autonomy, its capabilities were limited by the low frame rate (0.7 FPS) that the system could support without experiencing thermal issues. This limited the platform's effectiveness in more demanding scenarios.

CONCLUSION:

In conclusion, while the current implementation represents a significant step forward, future advances in hardware and software will be critical to fully exploiting the potential of lightweight, autonomous drones.

The results of this study suggest that with continued innovation, it is possible to create affordable, autonomous drones that are capable of operating safely and efficiently in a variety of environments.

REFERENCES:

- ALOIMONOS, J., WEISS, I., AND BANDYOPADHYAY, A. Active vision. InternationalJournal of Computer Vision 1 (1988), 333–356.
- ALSALAM, B. H. Y., MORTON, K., CAMPBELL, D., AND GONZALEZ, F. Autonomous UAV with vision based on-board decision making for remote sensing and precision agriculture. In 2017 IEEE Aerospace Conference (2017).

➔ BIRATTARI, M., LIGOT, A., BOZHINOSKI, D., BRAMBILLA, M., FRANCESCA,G., GARATTONI, L., RAMOS, D. G., HASSELMANN, K., KEGELEIRS, M., KUCKLING, J., PAGNOZZI, F., ROLI, A., SALMAN, M., AND ST ¨UTZLE, T. Automatic Off-Line Design of Robot Swarms: A Manifesto. Frontiers in Robotics and AI 6, 59 (July 2019).