Robust Collision Avoidance for BVLOS flight of UAS

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Objectives

The main objectives of this research proposal involve setting up **autonomous obstacle avoidance** system, the **evaluation framework** to compare available technologies and operating conditions and the **integration** of collision-avoidance system with other control layers. Other objective is developing and validating robust flight control and artificial intelligence algorithms that will allow drones to operate safely **BVLOS** and to react fast enough in dynamic environment. Finally, overall system needs to be integrated and validated. **Fail-safe operation** must be ensured and failure routine established.

Problem Definition

The future prospect for UAS operation is predicted to be unprecedented in terms of innovation, diversity and production rate. Just in the recent years interest in commercial market for UAS has grown tremendously since UAS technology found its application in a broad spectre of areas. Since it is expected that UAV technologies used for civilian applications will become very present in the future within the aviation market, autonomous behaviour beyond visual line of sight (BVLOS) is required to fully exploit a number of the new applications and possibilities for their placement. An important way to enable BVLOS flight and the new uses of UAVs is in the new **hierarchical control architecture** ranging from low-level reactive obstacle-avoidance control to the sophisticated path-planning algorithms. Integration of the UAVs into airspace shared with manned aircraft puts emphasis on obstacle detection and avoidance strategy and requires multiple, complementary sense-and-avoid mechanisms.

Materials and Methods

Research phases:

- Analysis of available sensors technologies
- Choice on sense-and-avoid strategy
- Collision avoidance algorithm
- Integration of onboard systems
- HW integration and flight demonstration

Verification methods:

- Simulation
- Component bench-test
- System bench-test
- Flight test and performance evaluation

Results 2

Onboard systems providing autonomous flight BVLOS.

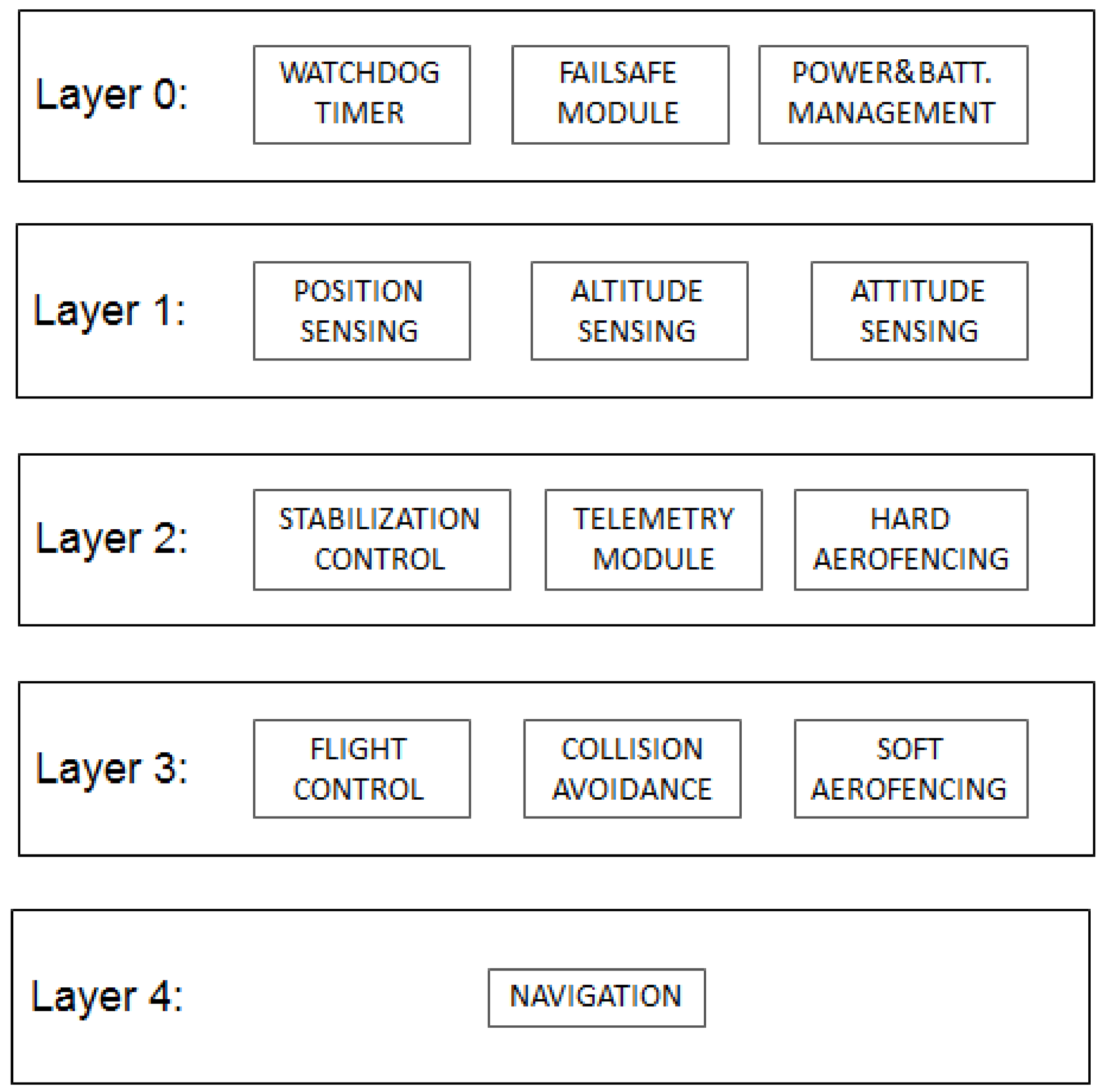

Figure 3: Aerial system architecture

Results 1

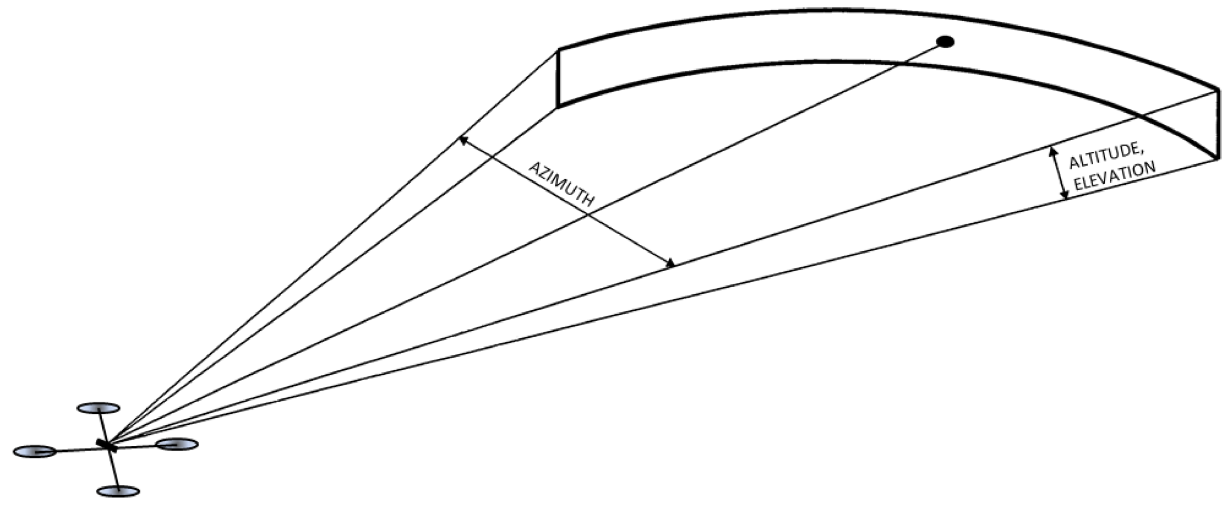

Figure 1: Sensor Field of View

It is expected that combination of visual-based and radar-based servoing will be desirable approach providing sufficent FOV and quick response in unstructured indoors and outdoors environment. Instead of sensor data fusion, the sensory systems will be kept detached to improve robustness and responsivness. Processed output of the sensory system will be used in adaptive and robust control module, as well as other onboard systems.

The control architecture will be realised in several layers sharing the same actuation. The **reactive control** algorithm continuously monitors the surrounding of the aircraft and in case of approaching object it interrupts the higher-level programs so it can initialise the avoidance routine. **Flight control** has a task of disturbance rejection and set-point tracking. The high-level layer is used for planning, object recognition, mapping, locali- sation or conflict resolving which makes it closely related to the mission type. On top of the listed layers, there is **trajectory planning** which is producing the control-related set-points at low frequency.

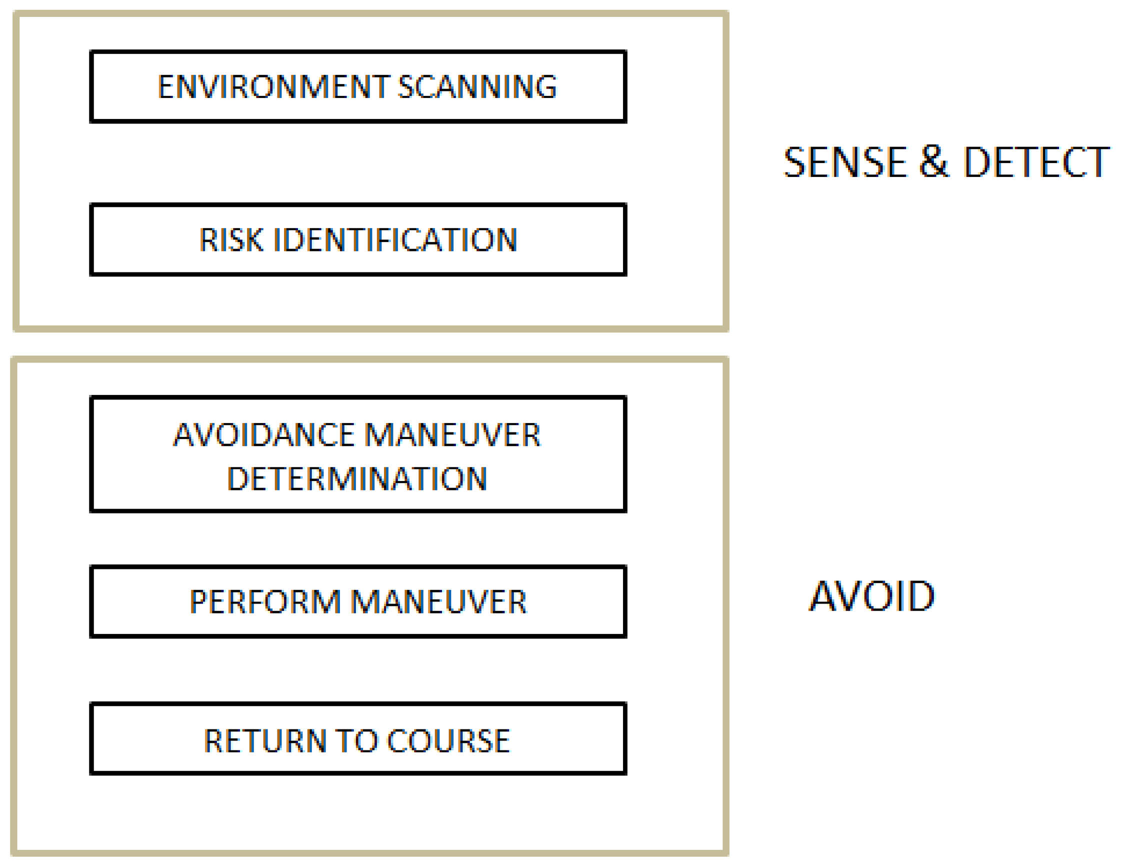

Figure 2: Sense-and-avoid

Conclusion

- Integration of the UAVs into airspace will require multiple, **complementary sense-and-avoid** mechanisms.
- The main demands for the development of the sensing technology is that it is suitable for **small** UAV implementation, **sensitive** enough to detect other obstacles and **intelligent** enough to differentiate between them
- This research proposal will address the topic of robust aerial avoidance by simultaneously developing sensing strategy, avoidance algorithms, control synthesis and perfor- mance evaluation.
- A novel bio-inspired aerial avoidance solution that is cost-effective, lightweight and resource-friendly will be developed enabling BVLOS flight

References

[1] R. A. Larcher, D. R. Maroney and A. D. Zeitlin *Unmanned aircraft collision avoidance technology assessment and evaluation methods. 7th Air Traffic Management Research and Development Seminar*, , 2007.

Future Research

Introduction of radar-based **identification** and **visual-cue extraction** enabling more details about the environment. Development of potential missions in cluttered environment. Joining the capabilities of heterogeneous platforms and diverse airborne sensory. Optimizing RTOS performance.

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