Micro Aerial Vehicle Landing Pad for Marsupial Ferry on Unmanned Ground Vehicles.

Abstract: This project aims to develop a landing pad for Micro Aerial Vehicles (MAVs) to be ferried and integrated onboard Unmanned Ground Vehicles (UGVs). The envisioned landing pad should allow for the MAV to land securely on it, contain a mechanism to allow it to be released and integrate supporting electronics that would assist the MAV landing process. Indicative examples may involve an up-facing camera system capable of tracking the relative position of the MAV and communicating this information to the robot, appropriate patterns to be detected by the sensors onboard the flying vehicle, or other methods. Communication from and to the landing pad from the MAV is also required.

Outline of Tasks: Towards the successful execution of the project, the following tasks should be followed.

Task 1: Literature survey on relevant designs

Indicative papers to study:

Falanga, D., Zanchettin, A., Simovic, A., Delmerico, J. and Scaramuzza, D., 2017, October. **Vision-based autonomous quadrotor landing on a moving platform.** In 2017 IEEE International Symposium on Safety, Security and Rescue Robotics (SSRR) (pp. 200-207). IEEE.

Beul, M., Nieuwenhuisen, M., Quenzel, J., Rosu, R.A., Horn, J., Pavlichenko, D., Houben, S. and Behnke, S., 2019. **Team NimbRo at MBZIRC 2017: Fast landing on a moving target and treasure hunting with a team of micro aerial vehicles.** Journal of Field Robotics, 36(1), pp.204-229.

Araar, O., Aouf, N. and Vitanov, I., 2017. **Vision based autonomous landing of multirotor UAV on moving platform.** Journal of Intelligent & Robotic Systems, 85(2), pp.369-384.

Ghommam, J. and Saad, M., 2017. **Autonomous landing of a quadrotor on a moving platform.** IEEE Transactions on Aerospace and Electronic Systems, 53(3), pp.1504-1519.

Task 2: Conceptual design

The clear set goal of this project is on how the Landing Pad will support the aerial robot in order for it to a) be stable when ferried on it and the Unmanned Ground Vehicle is driving over rough terrain, and b) be able to land safely with as much support from the Landing Pad as possible. This includes extrinsic sensing of the relative position of the flying robot to the landing pad (and communication of this information), providing visual markers for the robot to track with its onboard camera and more options to be discovered in the framework of the project.

Task 3: Proposition of Hardware System and Research Direction

Provide a clear hardware system tentative design and set goals for what algorithmic or mechanisms design is required to develop the envisioned landing pad. Accompany this deliverable with a clear timeline of project execution.

Further utilize literature on methods that could be relevant such as those in the papers above or within the rather more generic bibliographic references below:

Wang, J. and Olson, E., 2016, October. **AprilTag 2: Efficient and robust fiducial detection.** In 2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) (pp. 4193-4198). IEEE.

Krogius, M., Haggenmiller, A. and Olson, E., 2018**. Flexible Layouts for Fiducial Tags.**

Baker, S. and Matthews, I., 2004**. Lucas-kanade 20 years on: A unifying framework.** International journal of computer vision, 56(3), pp.221-255.

Task 4: Hardware prototype implementation

Implementation of the Landing Pad in terms of its overall hardware design. This task should be concurrent with Task 5. Delivery no later than November 20 2019.

Task 5: Algorithm prototype development

Implementation of the Landing Pad in terms of its overall software. This task should be concurrent and aligned with Task 4. Delivery no later than December 5 2019.

Task 5: Method and system verification

Collaboration with researchers at the Autonomous Robots Lab (in particular Nikhil Khedekar, e-mail: nkhedekar@nevada.unr.edu) to perform a flying robot mission

that takes off from the Landing Pad and lands on it to derive data allowing to evaluate the design.

Task 6: Extensive evaluation and report

Documentation of the overall solution and delivery of report combined with the relevant CAD files, hardware components list, and software. Further delivery of the Landing Pad prototype. Deadline by December 10 2019.