GRIFFIN

erc Advanced Grant

Visual servoing and ornithopter simulator progress report

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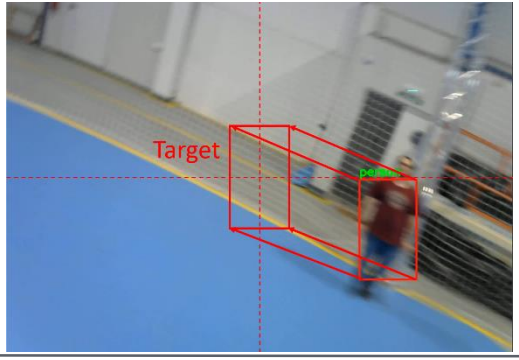
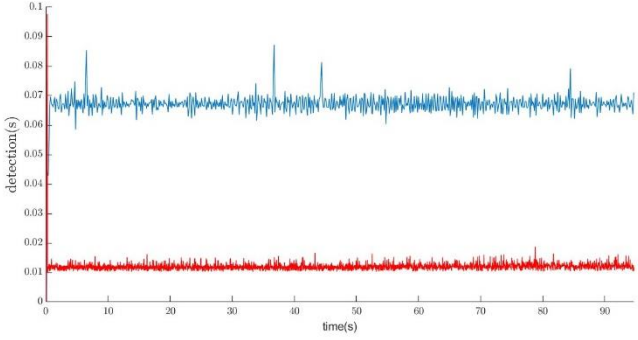
Progress report

- Visual servoing:
  - Real-time detection. Improve Khadas performance.
  - Algorithm to compensate ornithopter “flapping” phase. IMU adaptative filter.
  - Implementation of two new modules in the simulator: Visual servoing and machine learning for testing.
  - Bio-eye design.

Visual Servoing

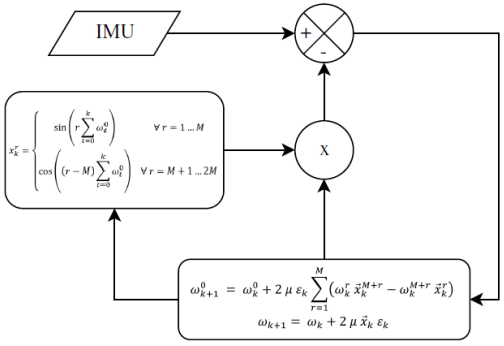
- IBVS algorithm using object detection CNN of Khadas NPU.
- Real-time detection. 20 Hz improved to 50 Hz
- Multiplatform communication.

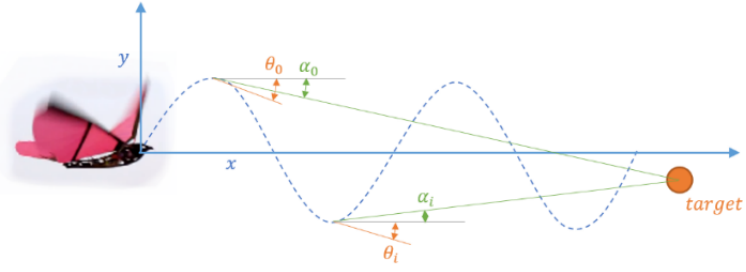




Visual Servoing

- Filter IMU measurements. Weighted Fourier Linear Combiner adaptative filter.
- Estimate next state using ornithopter model. MPC

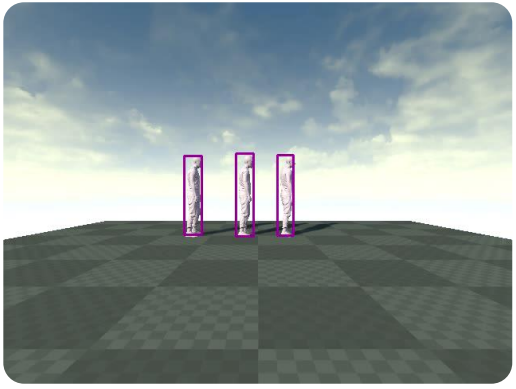




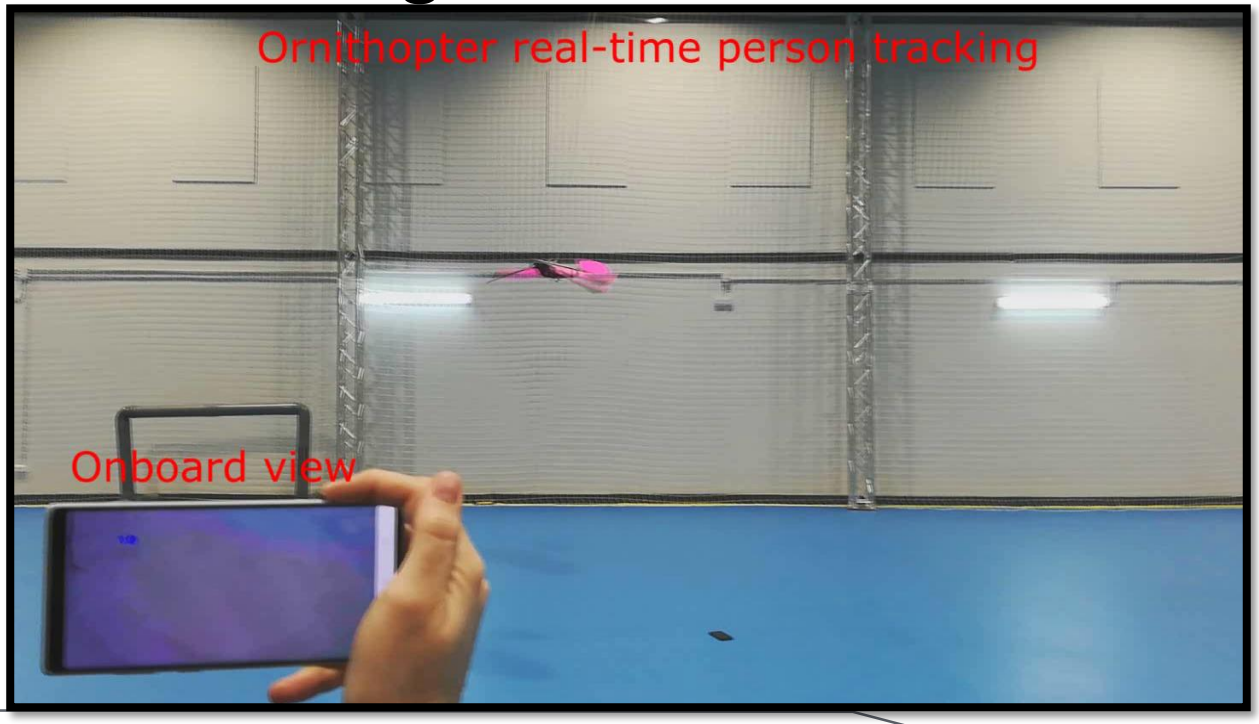
$$
\begin{aligned}
\frac{\mathcal{M}}{\mathcal{R}}\frac{\mathrm{d}u}{\mathrm{d}t} &= [-C_{Di}\cos\beta - C_L\sin\beta - Li\cos\beta \\
&\quad - \Lambda\,(C_{Dit}\cos\beta + C_{Lt}\sin\beta)]\,U_b^2 \\
&\quad + \sin\theta - \frac{\mathcal{M}}{\mathcal{R}}\omega\, w, \\
\frac{\mathcal{M}}{\mathcal{R}}\frac{\mathrm{d}w}{\mathrm{d}t} &= [-C_{Di}\sin\beta + C_L\cos\beta - Li\sin\beta \\
&\quad - \Lambda\,(C_{Dit}\sin\beta - C_{Lt}\cos\beta)]\,U_b^2 \\
&\quad - \cos\theta + \frac{\mathcal{M}}{\mathcal{R}}\omega\, u, \\
\frac{\mathrm{d}\theta}{\mathrm{d}t} &= \omega, \\
\frac{\mathrm{d}\omega}{\mathrm{d}t} &= \chi\mathcal{R}\,[-C_{Di}\cos\beta - C_L\sin\beta \\
&\quad + \Lambda\mathcal{H}\,(C_{Dit}\cos\beta + C_{Lt}\sin\beta)]\,U_b^2,
\end{aligned}
$$

Visual Servoing: Simulation

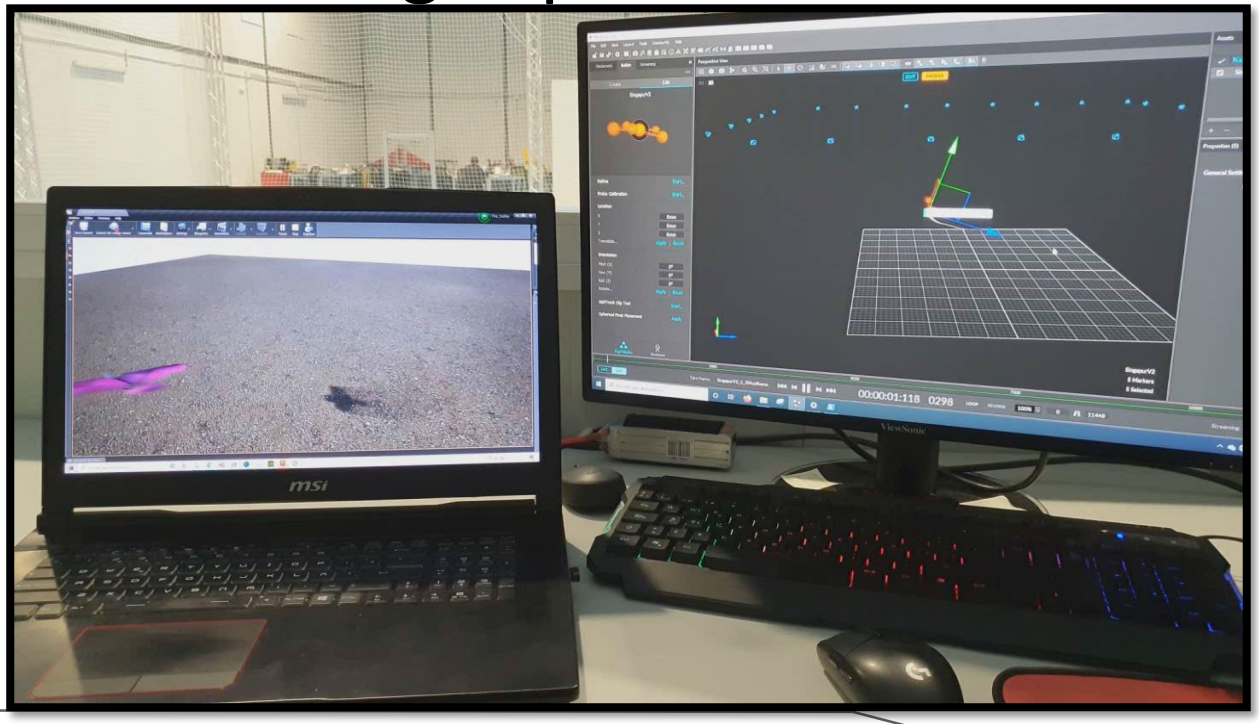
- Testing algorithm to compensate ornithopter flapping phase.
- Two new modules in the simulator.
  - Visual servoing module.
  - Machine learning module: Darknet (Neuronal Network framework) wrapper in C++.
- Easily changeable ornithopter parameters, environment and neuronal networks for object detection.



Visual Servoing: Real-time detection



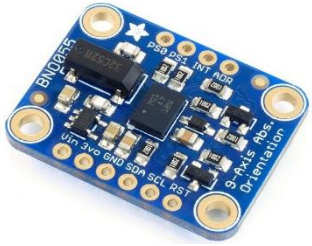
Visual Servoing: Optitrack module



Visual Servoing: Hardware

- Khadas VIM3 implementation. Increase software performance and adapt hardware communication.
- Implementation of three lightweight RGB cameras MIPI/USB interfaces and three small servomotors.

Visual Servoing: Payload



3.4g

10.2g

Total weight:
75.8g

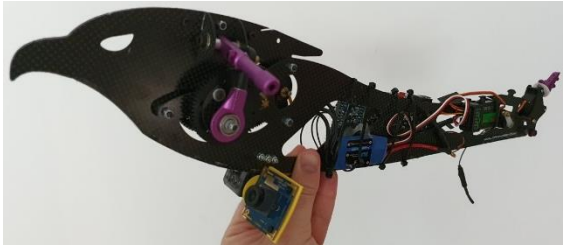
30.2g

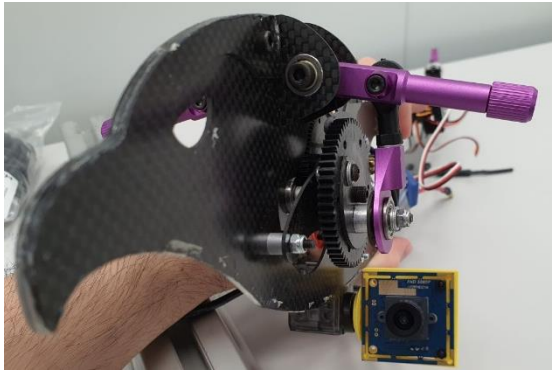
13.6g

18.4g

Visual Servoing: Experiments

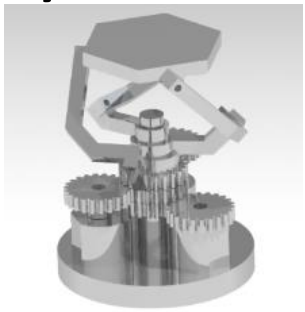
- Using Singapore Ornithopter in Optitrack test-bed is required to:
  - Preserve ornithopter stability. Mass distribution.
  - Avoid camera occlusions.
  - Compare IMU measurements and evaluate the tracking algorithm with Optitrack data.
  - Compare real results with simulated ones.

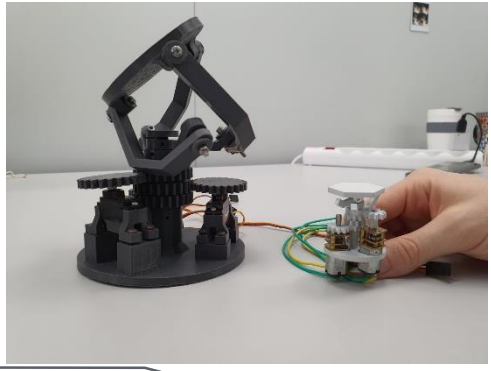




Visual Servoing: Bio-eye

- Spherical Parallel robot with 3DOFs.
- Made of polyamide.
  - Lighter than PLA.
  - Accurate printing.
- Controlled by 3 DC Motors with encoder
- Total weight 8g.





Thank you for your attention