Development and progress of the simulator.

Predictive Visual Servoing for Ornithopter.

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Simulator: Unreal Engine 4

- Frameworks
  - OpenAI
  - Airsim
  - DJI simulator
  - Matlab

We collected data from various warehouses created by professional designers,

ChangeSim
Simulator models

- Blueprints
  - New models
    - 3D Modelling: Blender
    - Animations: AutoCAD 3DS Max
    - Physic parameterization
Simulator code update

- Code -> Airsim 1.5
  - Adapt Ornithopter physics engine to new standard.
  - Weather improvements -> wind simulation
  - Moved third party deps outside Airsim
    - Fastcom: Communication between applications made easy with c++ and python interfaces.
    - Darknet: Open source neural network framework written in C and CUDA.
  - Reorganize necessary dependencies
    - Boost.Math: Includes several contributions in the domain of mathematics like Hankel function.

YOLOv4 inside Airsim
Simulator: What's next

- Unity 3D
  - Flightmare
  - Flightgoggles
- Unreal Engine 5

![Photo-realistic Environments](image1.png)

Flightmare

![Flightgoggles](image2.png)

Flightgoggles
Image-based visual servoing for landing/perching spot tracking

- Predictive visual algorithm to compensate flapping motion while tracking the perching spot.
- Convolutional Neuronal Network (CNN) for perching spot detection
  - IBVS features
- Real-time detection on lightweight edge TPU (tensor processing unit).
Visual Servoing. Perching spot tracking

- Kalman filter for motion prediction and CNN output filter
- Assignment problem solved with Hungarian algorithm
- Self-estimated frequency using a weighted Fourier linear combiner
- Lightweight hardware setup
  - On-board computer: Khadas VIM3 Pro
  - Servo system
    - Dynamixel XL-320 + U2D2 controller
  - Global shutter and high-speed camera
  - BNO055 IMU
**Visual Servoing. Test-bench experiments**

- Vertical sinusoidal movement simulation.
- Model predictive control:
  - Ornithopter dynamic model.
  - Gliding & flapping.
- Servomotor gimbal system for tracking.

![Camera stabilization](image)

Uncontrolled  Controlled

Pitch simulation
Visual Servoing. Outdoor experiments I

- Performance on an open field scenario
  - Real-time detection: 50 Hz with YOLOv3-Tiny on Khadas VIM3 Pro
  - Optimum detection range between 0.5 – 5m
  - The servo system avoids dynamics disturbances.
Visual Servoing. Outdoor experiments II

Perching spot

Outdoor experiments
Thank you for your attention