Adversarial Attacks On Aerial Vehicle Policies

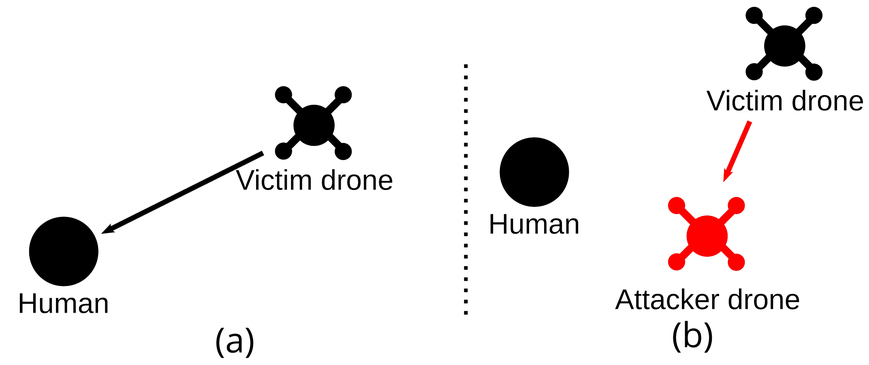
Pia Hanfeld[1,2,3], Wolfgang Hönig[3], Marina M.-C. Höhne[4], Michael Bussmann[1,2]

[1] Center for Advanced Systems Understanding, Görlitz, Germany
[2] Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany
[3] IMRC Lab, Technical University Berlin, Germany
[4] UMI Lab, Technical University Berlin, Germany

Motivation

- **Unmanned Aerial Vehicles** (UAVs), like **quadrotors,** are utilized for **industrial** and **civil** applications
- Adversarial attacks could have severe negative impact on safe operation
- State-of-the-art adversarial attacks mainly focus on autonomous vehicle instead of UAV policies
- Adversarial attacks on UAVs
  - should be **physically realizable**,
  - with a special focus on **low-power AI**,
  - and **exploit the hardware properties** of a quadrotor

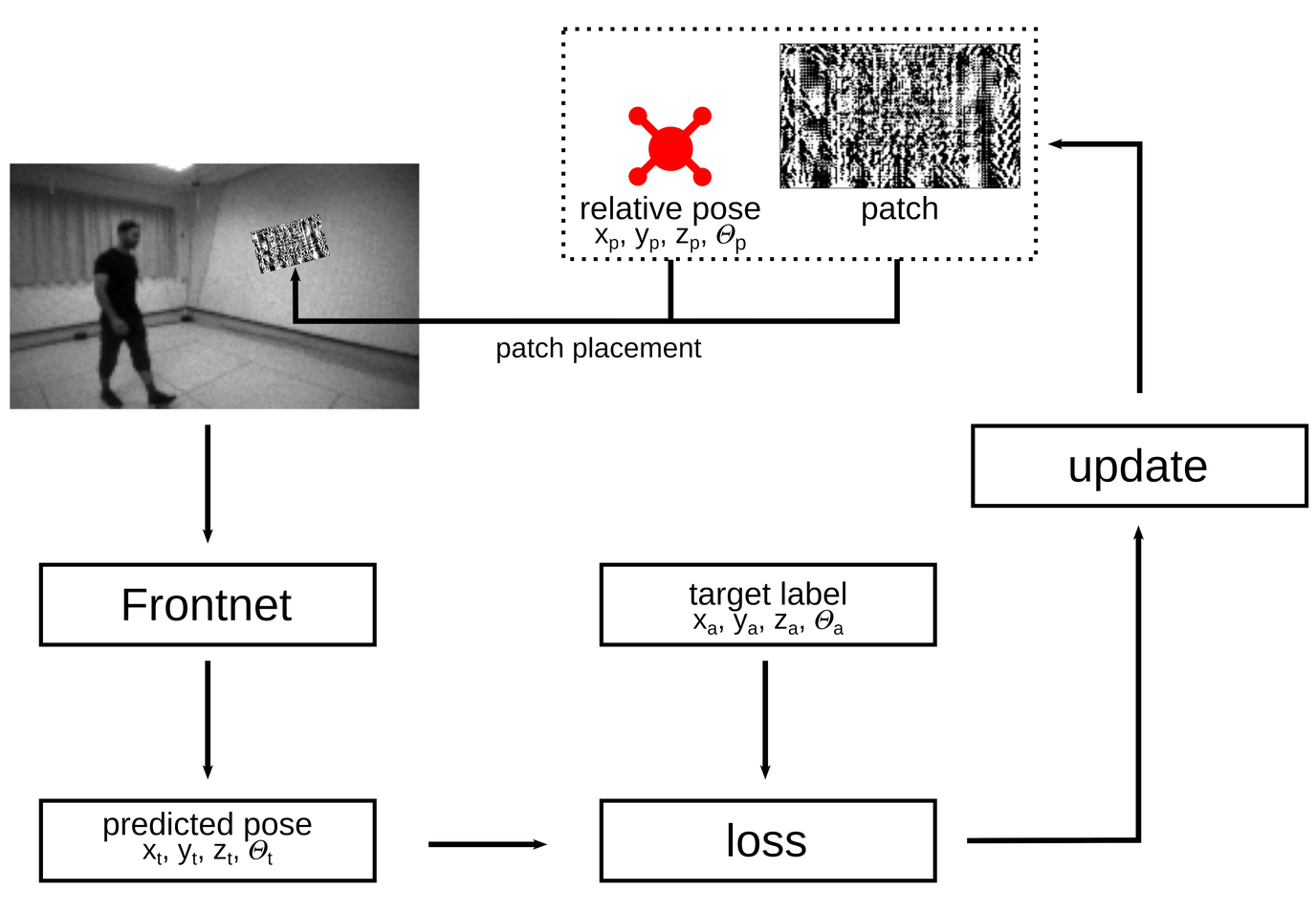
Goal



- Case (a) depicts the **regular scenario**: the victim drone is following a human target
- A neural network is predicting the relative pose of the human from camera images
- The prediction directly influences the control of the victim drone
- Case (b) depicts the **attack scenario**: an attacker drone has **full control over the victim drone**

Adversarial Attack

- We perform a **white-box adversarial attack**: the parameters of the neural network are known
- The adversarial attack will not influence the whole camera image but a small area and thus create an **adversarial patch**
- The fully optimized patch will be printed and attached to the attacker drone
- We both optimize the pixel values of the patch and the **relative pose** of the carrying attacker drone to enable control over it
- Using a patch placement algorithm, we create the artificial, **manipulated input** to the neural network
- We calculate the $\mathbf{l_2}$ **loss** between the **predictions** of the neural network and a predefined adversarial **target label**
- This loss is used to calculate the gradients w.r.t. the patch and relative pose and perform a **gradient decent step to update both**



Future Work

- Simultaneous optimization of multiple patches for full control in x, y, and z direction
- Real-world experiments
- Investigate impact on quantized neural net (low-power AI)

References

[1] Palossi, D. et al. (2022). Fully Onboard AI-Powered Human-Drone Pose Estimation on Ultralow-Power Autonomous Flying Nano-UAVs. IEEE Internet of Things Journal, 9(3), pp. 1913–1929. doi:10.1109/JIOT.2021.3091643

[2] Giernacki, W. et al. (2017). Crazyflie 2.0 quadrotor as a platform for research and education in robotics and control engineering. 22nd International Conference on Methods and Models in Automation and Robotics (MMAR). pp. 37-42. doi: 10.1109/MMAR.2017.8046794

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