Visual-Inertial Telepresence for Aerial Manipulation

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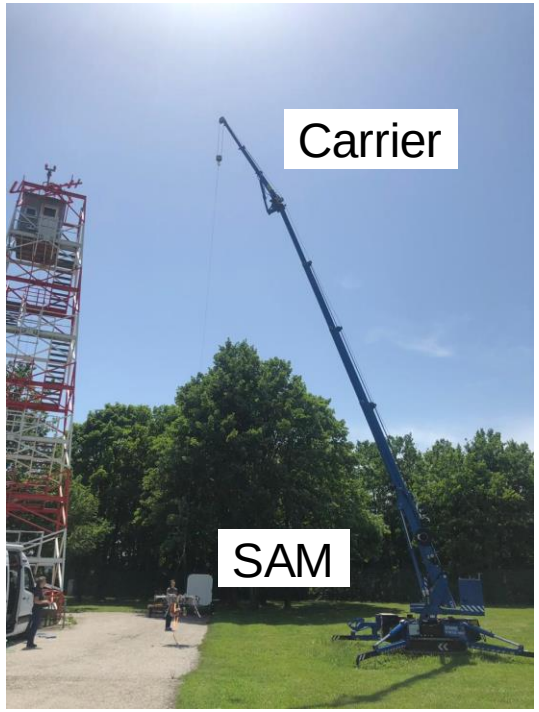
Aerial Manipulation and Applications

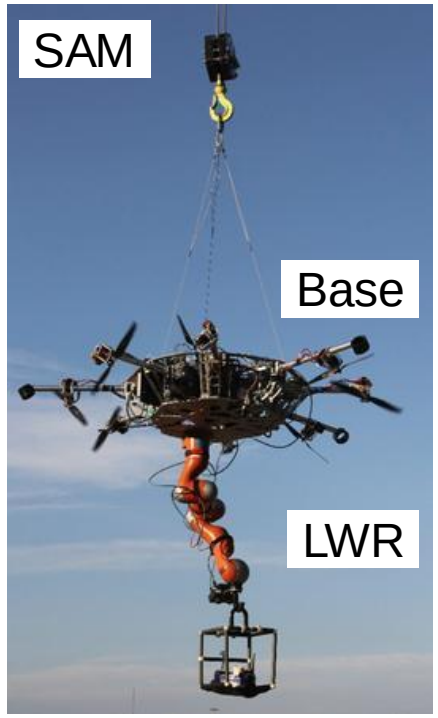
[M. Laiacker et al (2016)]

[Refinery at Wilhelmshaven, Germany]

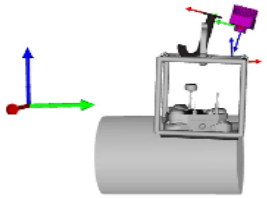
- Manipulation of objects with **aerial systems** endowed with a **robotic arm**.
- Applicable for inspection and maintenance at **difficult-to-reach** areas.

Cable-Suspended Aerial Manipulator (SAM) with a Telepresence System





Suspended Manipulator Concept
[Y. S. Sarkisov et al (2019)]



Virtual Reality

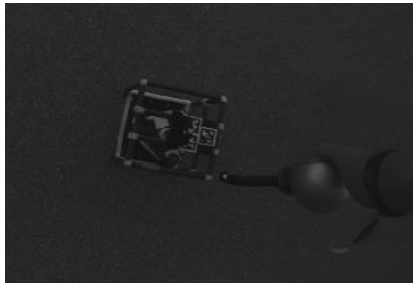
Haptic Device

Proposed telepresence concept
= haptic feedback + virtual reality

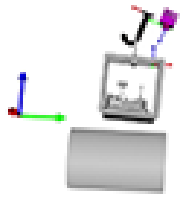
Why do we need Virtual Reality?

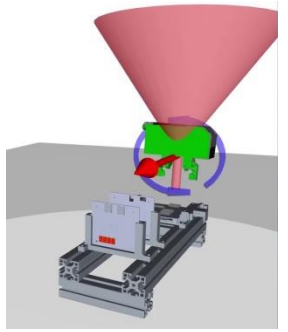
Problem Statement: 3D information is required for a precise manipulation!

Real-world outdoor environment



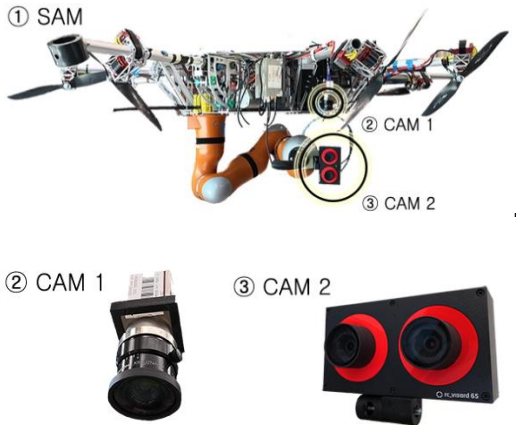
Camera exposures & missing depth

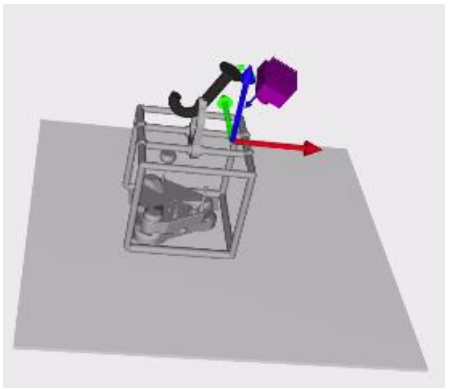




Adaptive sight of view &
haptic feedback [Space factory 4.0]

Approach: Use on-board sensors, object localization and CAD models





1. Take sensor data

2. Estimate object pose

3. Create virtual reality with pre-stored CAD models

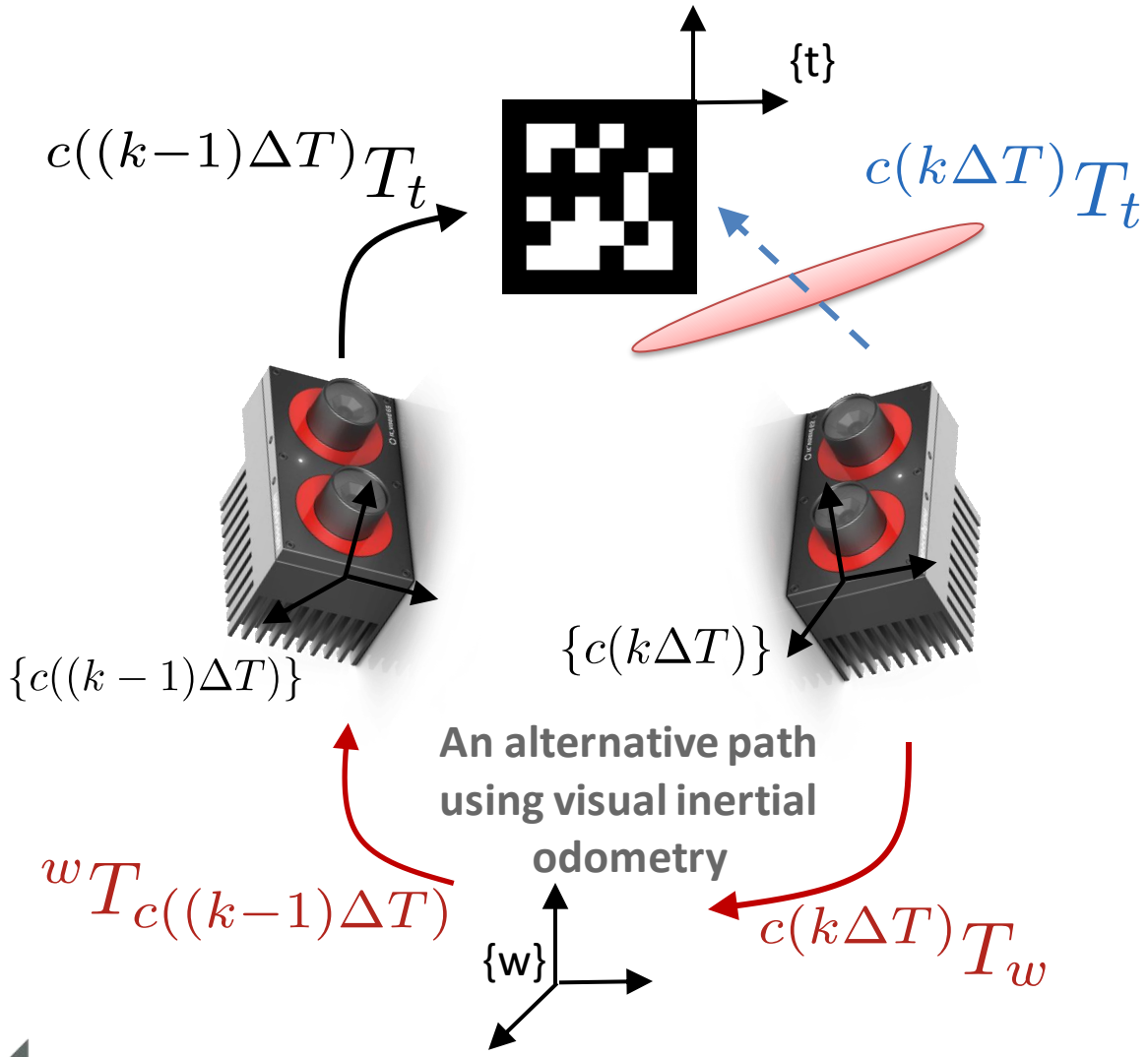
- Based on an **object localization** approach with **known CAD models** of objects.
- Marker based object pose estimation – **ARToolKitPlus [Wagner et al 2007]** with **RANSAC**.
- Software **Instant-reality [Fraunhofer IGD]** for the 3D visualization software.

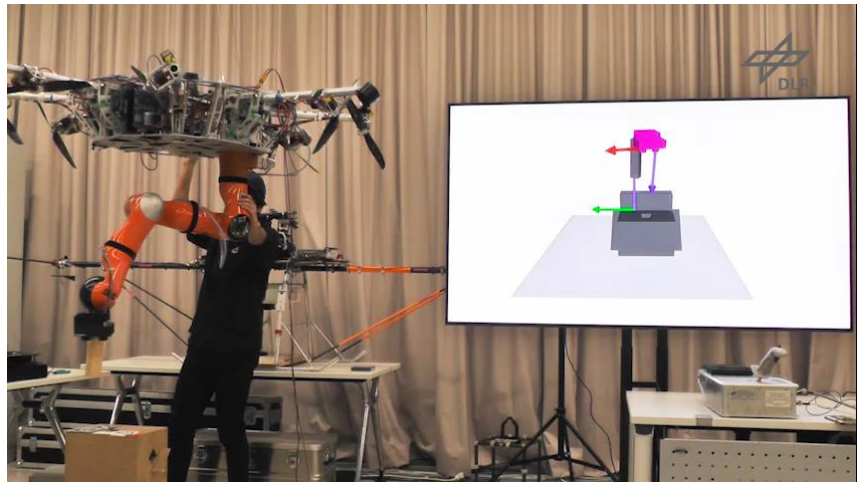
Algorithmic Challenge:
Virtual reality has to closely match the real world!

Important design factors:

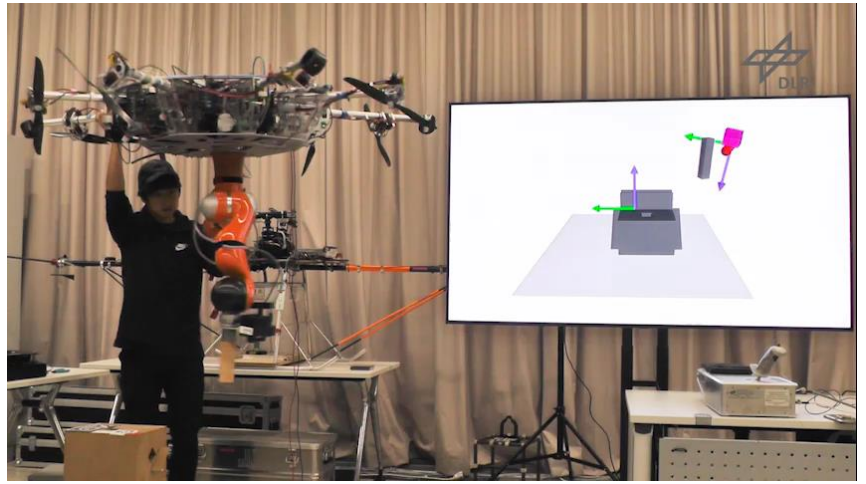
- **Accuracy** ✓
- **Speed** ✓
- **Robustness to loss-of-sight (incl. occlusions)** ✗
- **Time delay (for haptic feedback loop)** ✗

Algorithm: Loss-of-sight Compensation



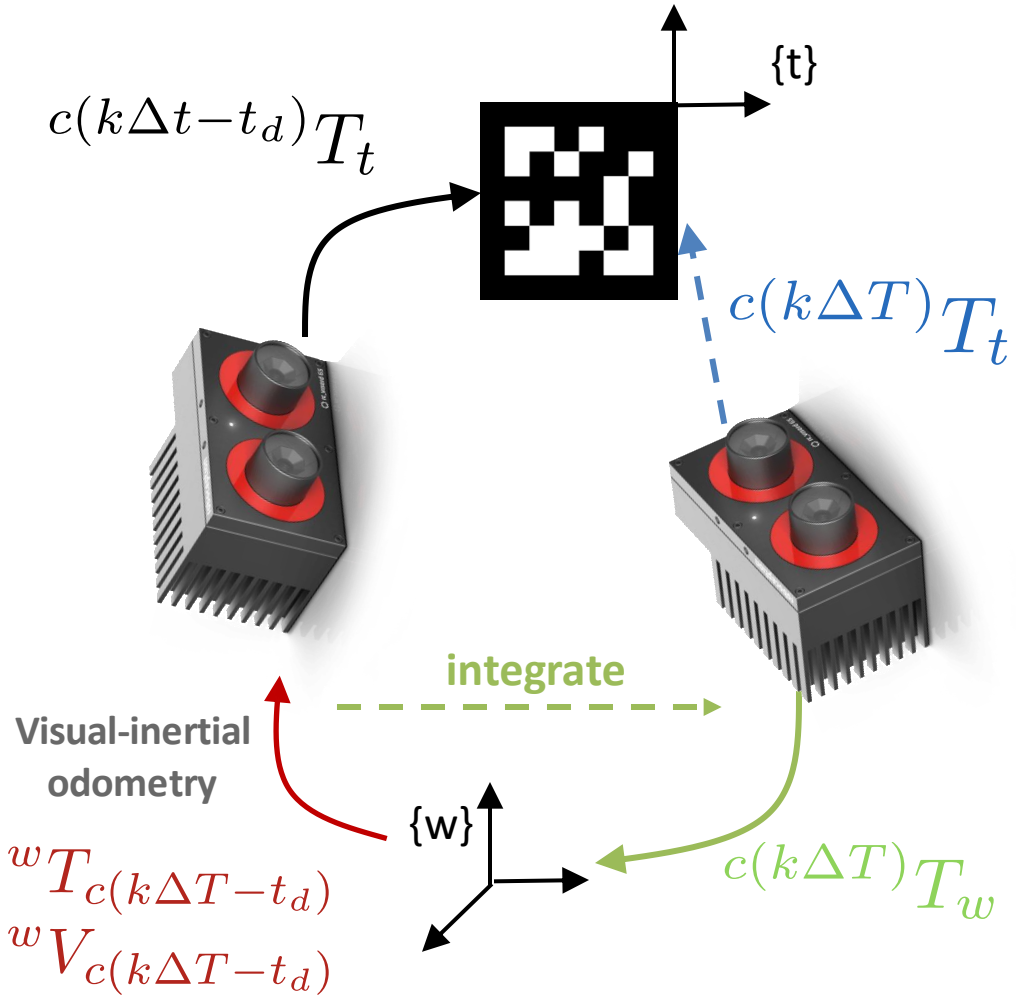


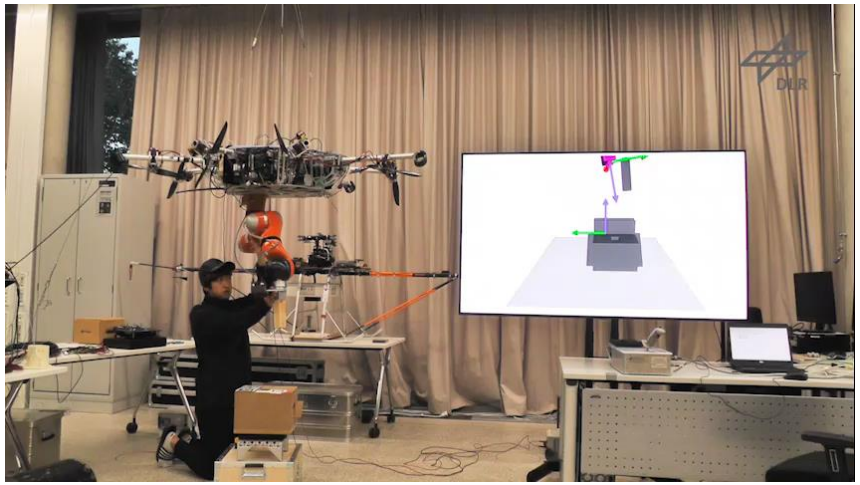
Original



Proposed

Algorithm: Time Delay Compensation





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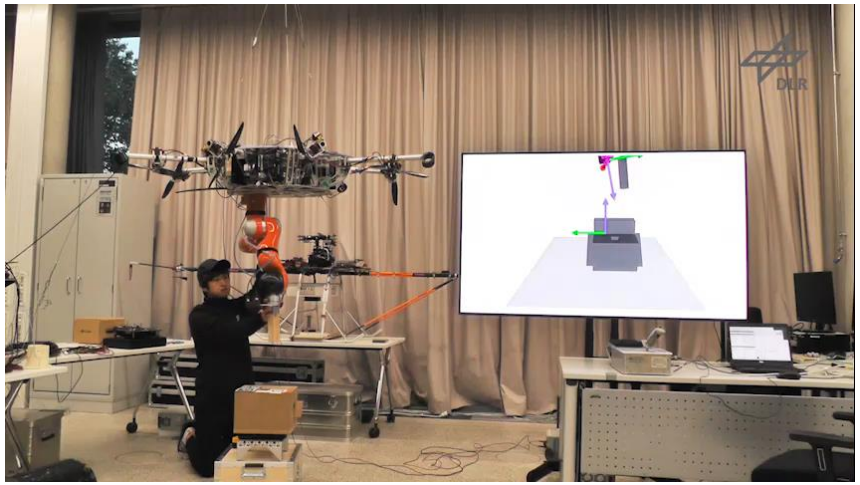

Proposed

Note: detailed algorithm and quantitative analysis can be found in the paper.

SAM performing a high precision aerial manipulation

SAM performing deployment and retrieval of inspection robot

Contributions and lessons learned

- We demonstrate that the overall concept is a viable option for future maintenance and inspection tasks which involves advanced aerial manipulation capabilities.
- Object localization approach is proposed for creating virtual reality of the remote scene in real-time, and algorithmic challenges are addressed using visual-inertial odometry.
- Main lessons learned: For real-world deployment of aerial manipulators with telepresence technology, 3D visualization is a necessary component.