Collaborative Unmanned Aerial Vehicles

ALPEN-ADRIA UNIVERSITÄT KLAGENFURT

Christian Bettstetter and Bernhard Rinner

Lakeside Labs Research Days, July 2010

Institute of Networked and Embedded Systems

Lakeside Labs

Outline

ALPEN-ADRIA UNIVERSITÄT KLAGENFURT

Lakeside Labs

- Technology and application of unmanned aerial vehicles (UAV)
  - Small-scale UAVs
  - Disaster management
- Mission planning
- Arial Imaging
- System Integration

Battery-powered UAVs

- **Quatcopter** platform with onboard sensors and electronic for flight stabilization
- Attached cameras for sensing the environment
- GPS receiver for autonomous **waypoint flights**
- **Limitations** on payloads, flight time, weather conditions

www.microdrones.de

www.asctec.de

Disaster Relief with UAVs

General idea

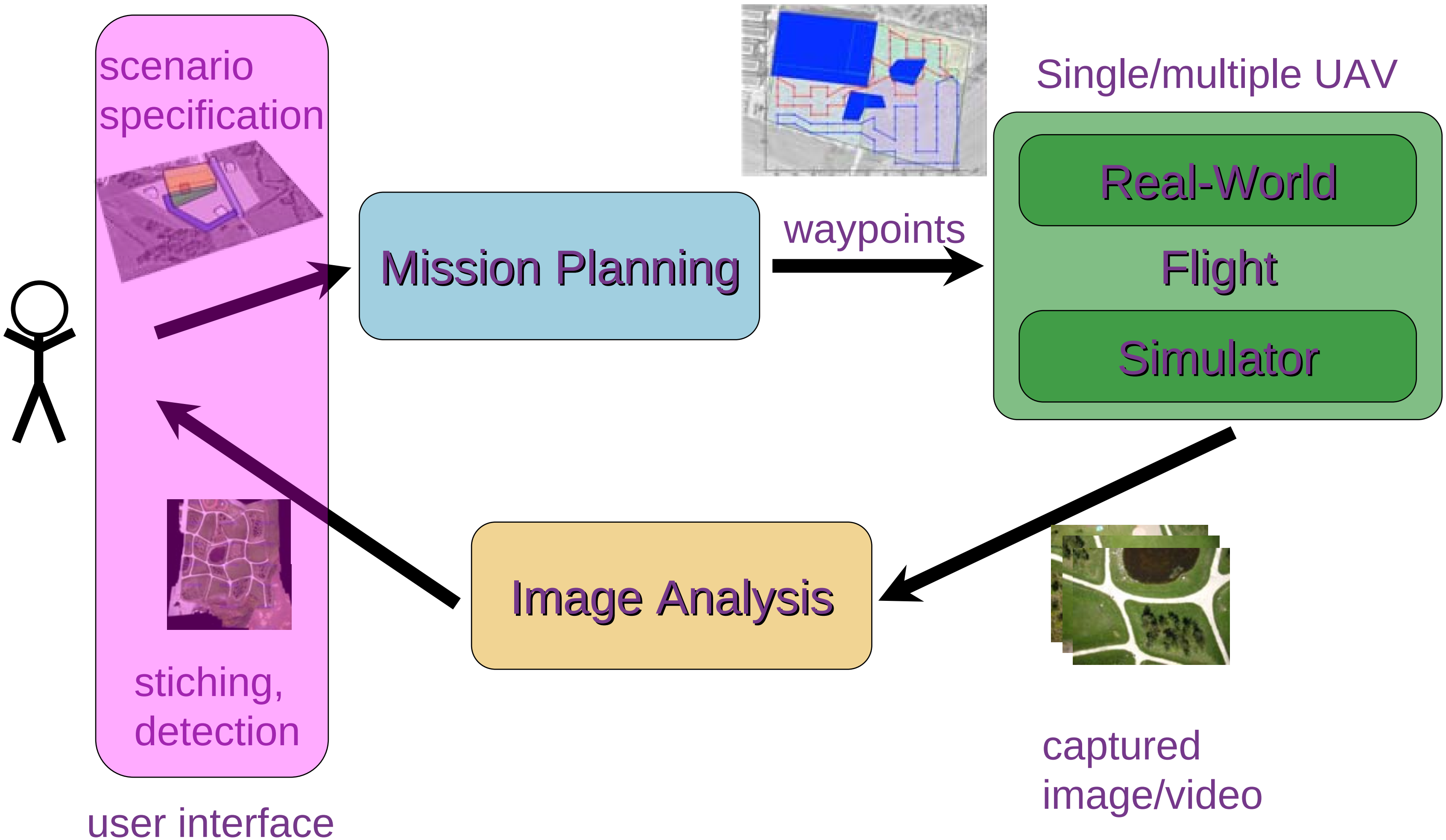
- Support first responders in disasters with multiple UAVs
- Provide latest and relevant information about the scene
- Autonomously fling, networked, collaborating UAVs

Use case: Generate overview image

- Cover the disaster area and take images at individual points
- „Stitch“ individual images to generate scene overview (mosaic)
- Provide intuitive user interface

Autonomous UAV Operation

ALPEN-ADRIA UNIVERSITÄT KLAGENFURT
Lakeside Labs



Issues

ALPEN-ADRIA UNIVERSITÄT KLAGENFURT
Lakeside Labs

1. How to **generate & adapt movement routes** for the UAVs?
   – Achieve multiple optimization goals
   – Deal with changes in the environment
   – Compare centralized versus distributed approaches
2. How to **stitch the individual images**?
   – Apply incremental image stitching
   – Tradeoff between good geo-referencing and visually appealing overview
3. **System integration and demonstration**

1: Generation of Routes

ALPEN-ADRIA UNIVERSITÄT KLAGENFURT
Lakeside Labs

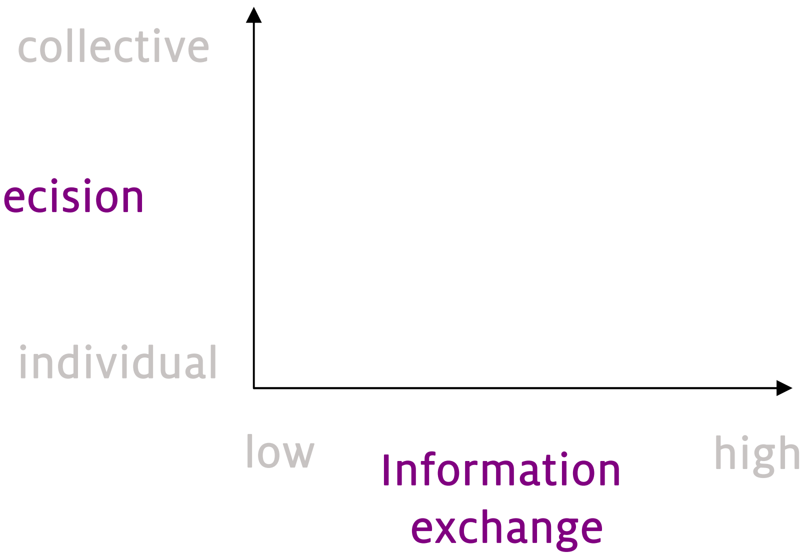
	Non-cooperative	Cooperative
Deterministic	UAV has a **predefined route** that is **independent** of other UAV paths.	UAV has a **predefined route** that **depends** on other UAV paths.
Dynamic	UAV has an *a priori* **unknown route** that is **independent** of other UAV paths.	UAV has an *a priori* **unknown route** that **adapts** to other UAV paths.

Adaptive Routes

ALPEN-ADRIA
UNIVERSITÄT
KLAGENFURT
Lakeside Labs

Meeting event

How to adapt the route?

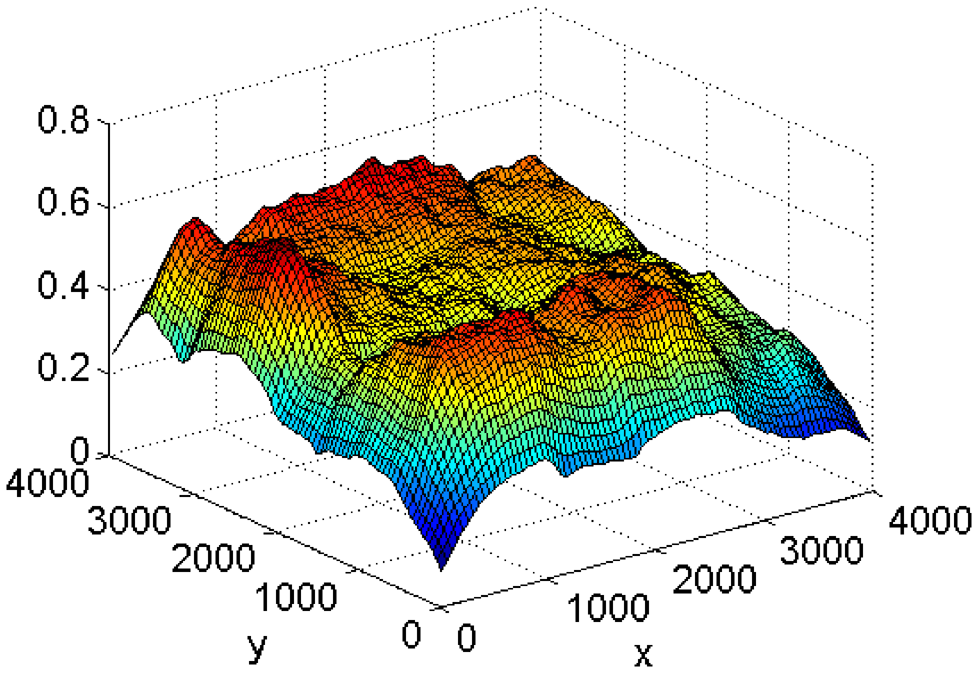


Analysis of the Area Coverage

ALPEN-ADRIA
UNIVERSITÄT
KLAGENFURT
Lakeside Labs

Approaches

- Simulation-based studies
- Discrete stochastic processes



2: Image Mosaicking

- Problem definition
  - Given n individual images Ii, find **image transformations** Ti for each Ii

$$I_{overview} = \bigcup_{i=1}^{n} T_i(I_i)$$

which maximizes some quality function $\lambda(I_{overview})$

- Two fundamental approaches for finding the transformations
  1. Exploit auxilliary data, i.e., camera‘s position and orientation (**meta data based approach**)
  2. Exploit corresponding points within image overlaps (**image based approach**)

Challenges for Mosaicking

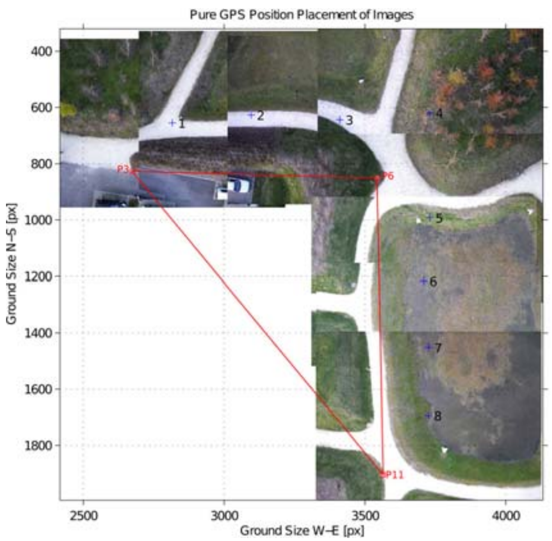
ALPEN-ADRIA UNIVERSITÄT KLAGENFURT
Lakeside Labs

- **Low altitude** and **non-planar surface** introduce high perspective distortions
- Light-weight UAVs are vulnerable to wind resulting in **non-nadir view**
- **Inaccurate position and orientation** data due to small, low-cost GPS, IMU and altimeter sensors
- Strong **resource limitations** wrt. onboard processing, power, communication etc.

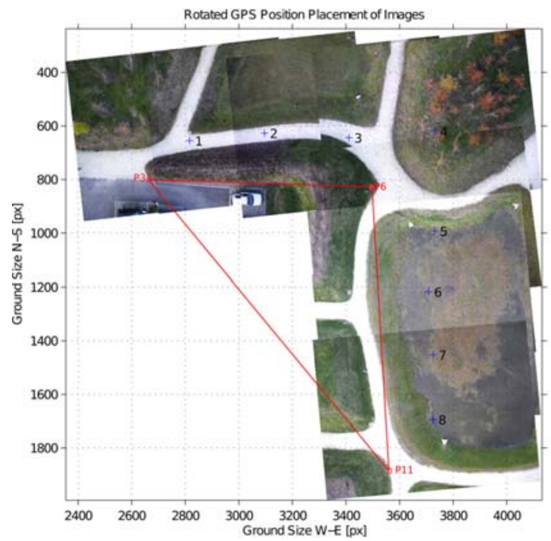
Incremental Image Mosaicking

ALPEN-ADRIA UNIVERSITÄT KLAGENFURT
Lakeside Labs

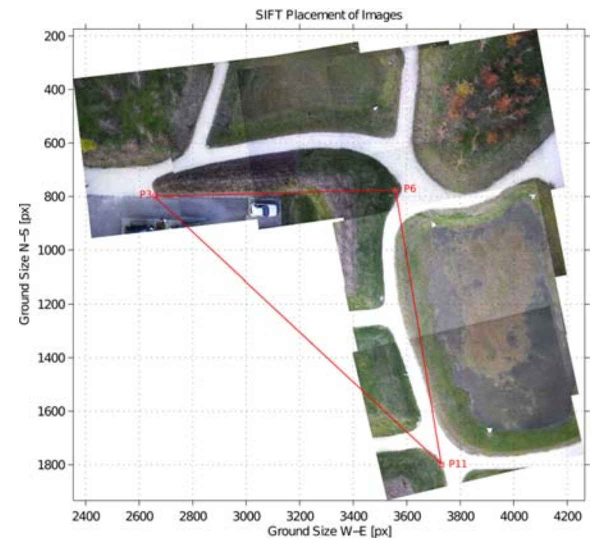
- Start with meta data approach, refine with image-based approach



Position data



Position&orientation data

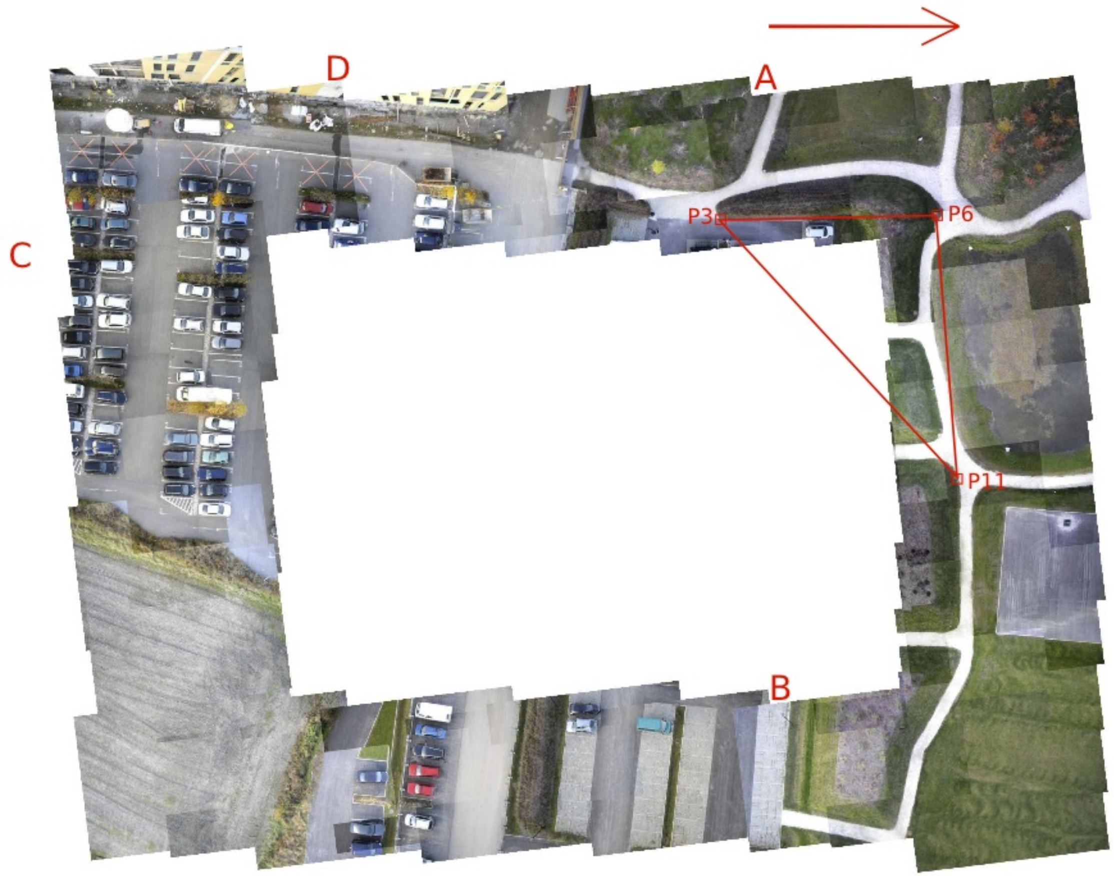


SIFT feature image points

Overview image

ALPEN-ADRIA
UNIVERSITÄT
KLAGENFURT

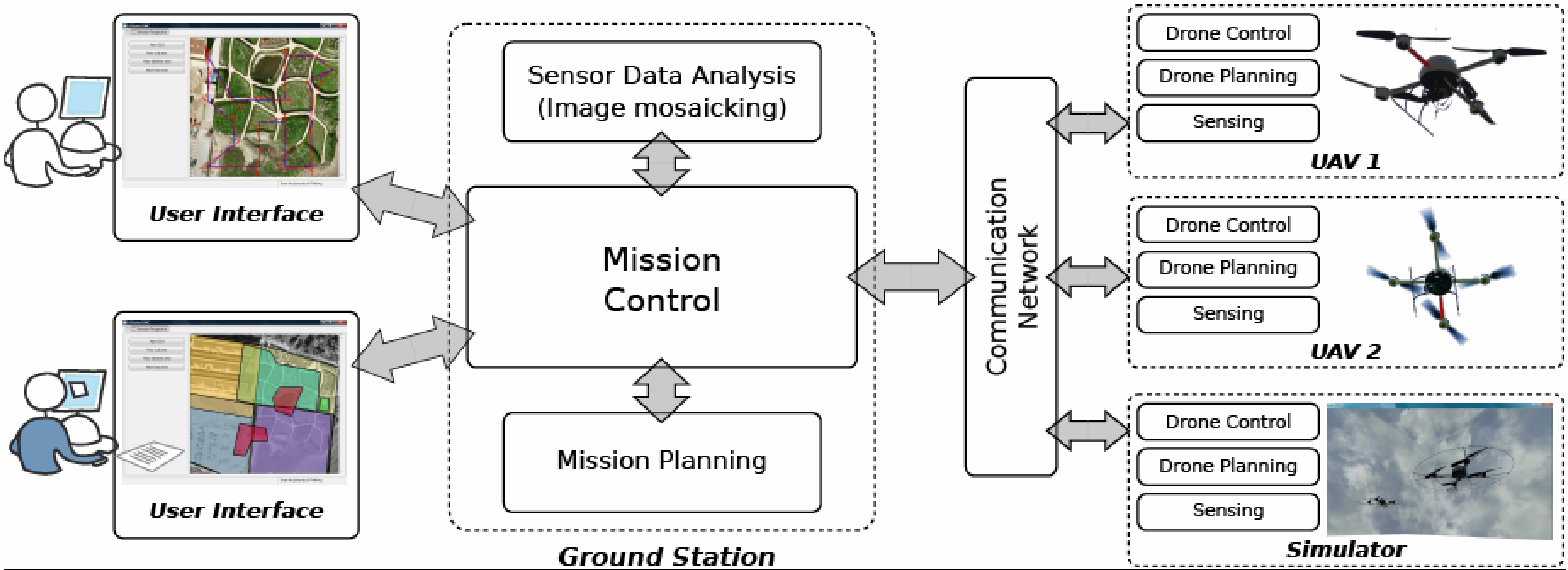
Lakeside Labs



3: System Integration

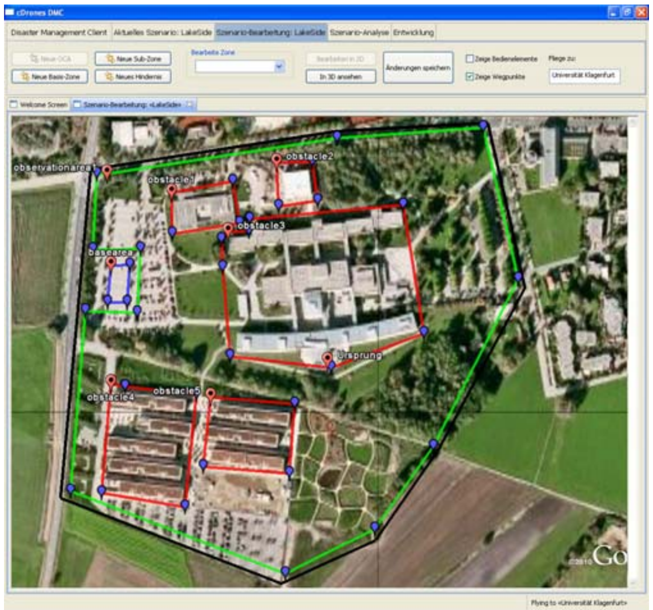
ALPEN-ADRIA
UNIVERSITÄT
KLAGENFURT
Lakeside Labs

FAMUOS - Fully Autonomous Multi-UAV Operation System

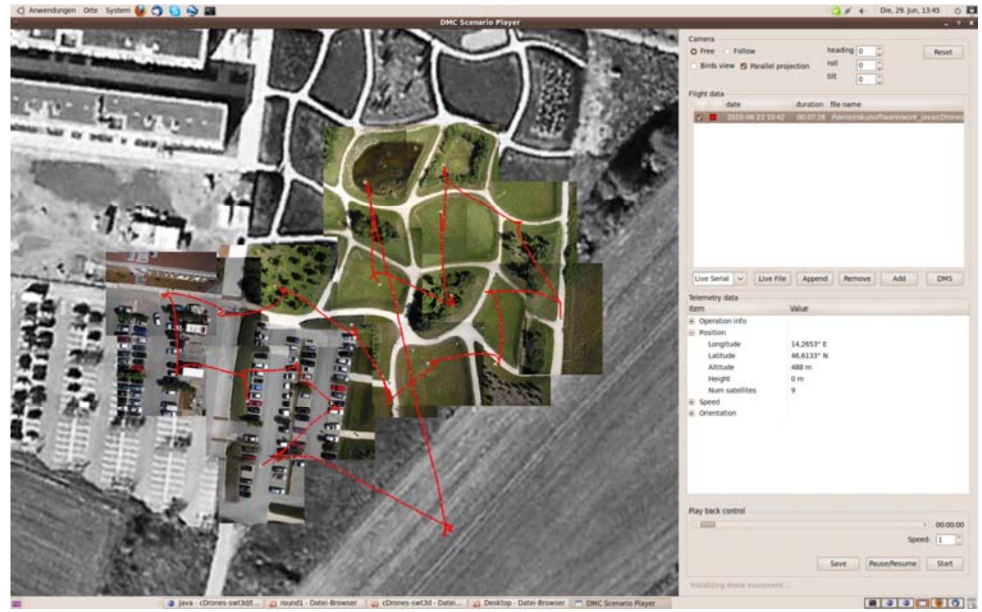


„Google-like“ User Interface

ALPEN-ADRIA
UNIVERSITÄT
KLAGENFURT
Lakeside Labs



Specifying the **scenario description**

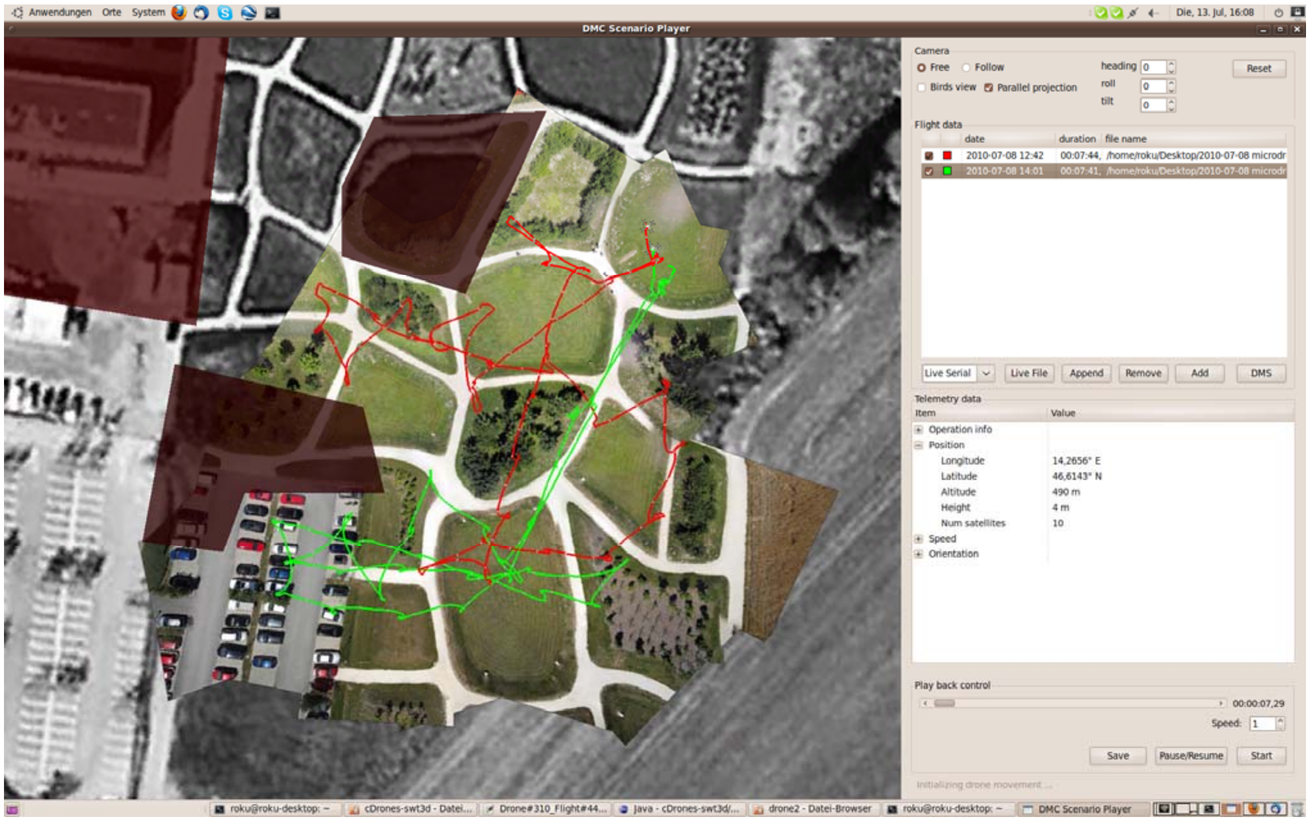


Visualizing the **latest overview image** and the flight route

Demonstration

ALPEN-ADRIA UNIVERSITÄT KLAGENFURT

Lakeside Labs



- Check also: http://pervasive.uni-klu.ac.at/cDrones