Busy as bees ...

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WHAT? AND WHY?

- Using a swarm of unmanned, small scale helicopters will mean a qualitative improvement in solving tasks in the field of Disaster and Crisis Management.
- Repairs, maintenance and flights for manned aerial vehicles (MAV) are very expensive.
- UAVs do not need a qualified pilot on board and can therefore enter environments dangerous to human life.
- UAVs can perform operations in complete darkness and very close to the ground where MAV operation is too dangerous or not possible at all.
- Immediate results, no time delay!

Why use unmanned aerial vehicles (UAVs)?

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Why use a swarm of helicopters?

- Increase spatial coverage
- Increase reliability of the overall system due to redundancy
- Simultaneous intervention in different places
- Training of specialized UAVs possible

Why use helicopters?

- Vertical takeoff and landing capability
- Ability to maintain a position in the 3D space (hover)

What applications?

- Inspection tasks (buildings, dams, industrial plants, …)
- Surveillance tasks
- Search and Rescue Tasks:
  - Situation and damage assessment after a disaster
  - Locate people
  - Create high resolution and up to date aerial photographs of destroyed landscapes or buildings
  - Forest fire alarm confirmation, localization and monitoring
  - Retrieve data measurements of points in the 3D space:
    - Chemical plume tracking
    - Measure emissions of industrial plants
    - Measure emissions and/or gas concentration (e.g. around an active volcano)
    - Mobile communication relay station

Obstacle Detection

- Detect obstacles around the helicopter (not only in front of the helicopter)
- Visualize the detected obstacles in a 3D simulation / the ground control software

Research Opportunities

- 3D obstacle detection with low-cost and lightweight sensors:
  - Acoustic approaches (Ultrasonic sensors, Frequency Shift, Doppler Shift, …)
  - Radar
  - Laser range finder
  - (for precise distance measurements in the direction of flight)
  - Computer Vision
  - Laser range finder
  - (for precise distance measurements in the direction of flight)

Level of autonomy

- Stabilization
- Obstacle Avoidance
- Collision Avoidance
- Decisional Autonomy
- Level of autonomy
- Stability and Obstacle Avoidance
- Level of autonomy
- Visualize the detected obstacles in a 3D simulation / the ground control software
- Detect obstacles around the helicopter (not only in front of the helicopter)
- Obstacle Detection
- Obstacle Avoidance
- Stabilization

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Mission Planner

The mission planner enables the swarm to autonomously execute larger missions (e.g. by splitting the overall mission into subparts)

Research Opportunities

- Swarm Rules, Swarm Behavior
- Planning Algorithms
- Networks, Distributed Systems

Level of autonomy

- Decisional Autonomy

Communication between swarm members

A reliable communication link between the swarm members is established

Research Opportunities

- Communication Systems
- Networks, Distributed Systems
- Swarming

Level of autonomy

- Autonomous Flight, Obstacle Avoidance, Swarm Takeoff and Landing

Collision Avoidance

Enable the swarm members to avoid collisions with each other even without having a reliable communication link between them

Research Opportunities

- Communication Systems
- Networks, Distributed Systems
- Swarming

Level of autonomy

- Autonomous Flight, Obstacle Avoidance, Takeoff and Landing

Autonomous takeoff and landing

- The main focus of this task is the precise landing on a well adapted landing pad
- Due to the anticipated tasks in the field of Disaster and Crisis Management, the solution must be very robust even in rough environment

Research Opportunities

- Computer Vision

Level of autonomy

- Autonomous Flight, Obstacle Avoidance, Takeoff and Landing

Obstacle Avoidance

Support the operator by detecting obstacles in the environment around the helicopter and restrict the movement of the pilot towards the obstacles to prevent the helicopter from bumping into them

Research Opportunities

- Reactive, 3D obstacle avoidance algorithm which comprises the dynamics of the helicopter and can cope with dynamic environments

Level of autonomy

- Stabilization and Obstacle Avoidance

Fly autonomously to a specified destination

- The helicopter flies autonomously to a specified GPS coordinate and avoids crashing into obstacles during the operation
- A planner ensures that prohibited flight zones (areas in which people might be standing, car parks, lakes and creeks …) are avoided

Research Opportunities

- Path planning algorithm which calculates a valid trajectory under specified constraints (shortest path, most energy efficient path, altitude, attitude and speed at destination, …)

Level of autonomy

- Autonomous Flight and Obstacle Avoidance

Steps towards a swarm of autonomous helicopters

- The mission planner enables the swarm to autonomously execute larger missions (e.g. by splitting the overall mission into subparts)
- A reliable communication link between the swarm members is established
- Enable the swarm members to avoid collisions with each other even without having a reliable communication link between them
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Research Opportunities

- Computer Vision
- Communication Systems
- Networks, Distributed Systems
- Swarming