Development of radar systems for UAS

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Overview

► Flight mission objectives
► Polarimetric soil characterization
► 3D (SAR) radar
Flight mission objectives

► Added value of radar

- Largely independent of daylight, weather etc.
- Diffraction, reflection: See „through“ things, e.g. plants
- System works without calibration, „ready-to-go“
- Small, light modules that can be integrated with other sensors
Flight mission objectives

- Typical flight mission

- UAV height: 25 m
- UAV load: < 1 kg
- UAV flight time: 20 min
Flight mission objectives

► Plant height estimation
  ▪ Use IMST’s 2-channel radar
  ▪ Reflection from plant top
  ▪ Reflection from soil
Flight mission objectives

- Plant height estimation
Flight mission objectives

Polarimetry

- Well known from satellite systems
- Characteristic for types of vegetation
- Can we transfer this to small RPAS?

Source: DLR
Flight mission objectives

► What is the challenge for a radar system?
  ▪ Greatest difference to optical system: Pixel size
  ▪ Radar antenna opening angle is one of the most important parameters for flight missions on small RPAS
  ▪ Typical values: 30 deg to 60 deg
  ▪ Smaller opening angles → antenna gets too large or too heavy
  ▪ Use multichannel data to decrease pixel size

► Smart Inspectors objective: Create an 8 channel radar capable of SAR processing
Polarimetrical characterization

- Electric field is approximated as a planar wave
- Travels in z-Direction
- On each xy plane along the z-axis, the field will cause an electric force
- This direction (over time) is called polarization
Polarimetrical characterization

► Creating a polarimetry radar

- Send in right-hand circular polarization, receive in right- and left-hand
Polarimetrical characterization

► Soil roughness – Total power parameter

![Graph showing Soil roughness – Total power parameter](image-url)
Polarimetrical characterization

Soil moisture
Polarimetrical characterization

► Work is still in progress
  ▪ Radar hardware is ready
  ▪ Software / Analysis scripts are ready
  ▪ First test on different soils were performed

► Coming next:
  ▪ Methodical acquisition of test data
  ▪ Optimization of target tracker
  ▪ Evaluation of polarimetric parameters
  ▪ Integration into RPAS
3D (SAR) radar

► Multichannel radar solution

- 8 complete receivers / downconversion channels
- Multi-Core processing unit for online FFT processing / data compression
3D (SAR) radar

► Implement a „Digital Beam Former“
  ► A virtual antenna beam is steered over the surface
  ► 8-channel system: virtual antenna beam width is smaller (factor 8) than the individual channel (here: ~ 7,5 deg)
  ► Needs extensive calculation power
  ► Offline processing is planned as a first step
3D (SAR) radar

- Increased flying height possible
  - Polarimetry radar: 30 deg beamwidth
    - 25m height, 10 m/s, 20 min
    - 168 000 m² covered, 14 m beamwidth on ground
  - 3D (SAR) radar: 7,5 deg beamwidth
    - 100 m height, 10 m/s, 20 min
    - 1 256 637 m² covered, 13.1 m beamwidth on ground
- Or: Scan area x 2, scan resolution x 4
3D (SAR) radar

► Synthetic Aperture Radar (SAR)
  ► Increases resolution even further
  ► Theoretically not limited
  ► Requires stable flight platform or exact knowledge of flight path
  ► Complex method, will not be addressed within Smart Inspectors
3D (SAR) radar

Currently work on the system is still in progress

- Hardware is finished
- Multi-core firmware is being developed
- Calibration schemes are researched

Planned:

- First test flights on RPAS
Thank you for your attention!