Leveraging 5G private networks, UAVs and robots to detect and combat broad-leaved dock (Rumex obtusifolius) in feed production

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Agenda

- Project overview “5G Kaiserslautern”
- Use Case description
- System architecture
  - 5G Network
  - UAV
  - Sprayer Robot
- System workflow
- Why use 5G?
- Summary & Results
- Future works

5G Kaiserslautern

- Funded by BMVI (now BMDV)
- Project goals:
  - Gather and share experience in planning, building, operating and optimizing campus networks
  - Test 5G commercial network hardware and UEs under real-world conditions
  - Develop exemplary applications in Industry 4.0, agriculture, smart city and campus mobility
  - Inform the public about opportunities and applications

5G Kaiserslautern

Gefördert durch:

Bundesministerium für Digitales und Verkehr

aufgrund eines Beschlusses des Deutschen Bundestages

Why Rumex is a Problem?

- Rumex infests the grassland for feed production
- Lower nutritive value than the surrounding grassland
- Displaces grasses and drains nutrients of the soil
- Long lifetime of the seeds (up to 70 years) in the cycle of field - feed - slurry - field
- Complex and time consuming manual control (deep-rooting plant)
- Chemical control either only large-scale application of the spray agent with high ecological impact or direct spraying by famers very time consuming

System Architecture

- Nomadic or fixed 5G SA network
- Control room
- Unmanned aerial vehicle (UAV)
- Sprayer robot

Nomadic 5G Network

- Mobile 5G SA network:
  - 100 MHz bandwidth
  - N78 (3.7-3.8 GHz)
  - 3:7 TDD pattern
- Integrated Control Center
- Edge Cloud Server
- RTK base station for UAV and robot positioning

UAV

- Hexa configuration
- Up to 30 min of flight time
- Camera on gimbal for ground recording
- Raspberry Pi as companion PC
- PixHawk (flight controller), Camera + 5G Modem are connected to the Raspberry Pi
- Downwards facing Lidar for terrain following

Sprayer Robot

- Skid steer chassis
- 2h+ operating time
- Industrial PC incl. Quectel RM500Q-GL 5G modem
- Lidar, GPS, IMU, compass for navigation
- 2 close range detection cameras
- Jetson AGX Xavier for close range AI
- 1.8m working width
- 18 individually controllable nozzles
- approx. 4.2 ml per plant
- 24 L herbicide tank -> approx. 5000 plants

Workflow UAV

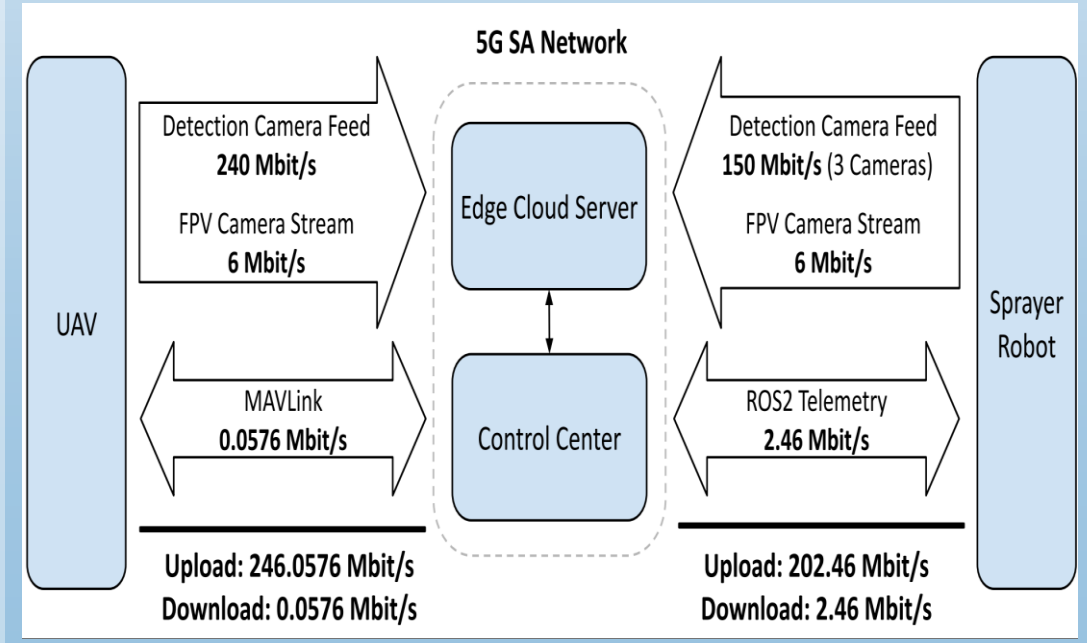
1. Creating mission for UAV
2. Uploading mission to UAV via 5G
3. UAV starts mission and uploads pictures and telemetry data to edge cloud server
4. Pictures are being analysed by AI on edge server
   - detecting rumex
   - tagging each plant with location

Workflow Sprayer Robot

1. Calculates the optimal path to each plant
2. Upload the optimized path to the sprayer robot (SR)
3. Mission start -> Stream all telemetry parameters
4. SR drives to the first plant (1-2 m/s)
5. SR closer to the plant possition -> 0.5 m/s
6. Close range cameras streaming videos to onboard AI
7. When plant detected, AI decides which nozzles have to be open and for how long
8. After spraying plant SR drives to next position (2.)
9. When mission complete, SR returns to home position.

Why use 5G?

- Low latency to control the UAV and to transmit its first person view (FPV) video stream
- High transmission upload bandwidth for outsourcing compute power required
- Long range requirements for large fields



Summary & Results

- Overall system architecture is feasible
- Autonomous system approach saves a lot of time for farmers
- Taking pictures with UAV for detection in edge cloud speeds up workflow significantly in comparison to the sprayer robot driving across the whole field
- Depending on Rumex infestation density significant herbicide reduction

Future Works

- Build second sprayer robot to demonstrate fleet operation
- Implement sensor offloading for sprayer robot
- Optimize data rates for simultaneous operation of sprayer robot and UAV

Thank you