UNIVERSITÄT HOHENHEIM

AUTONOMOUS FIELD NAVIGATION FOR DATA ACQUISITION OF WIRELESS SENSOR NETWORKS

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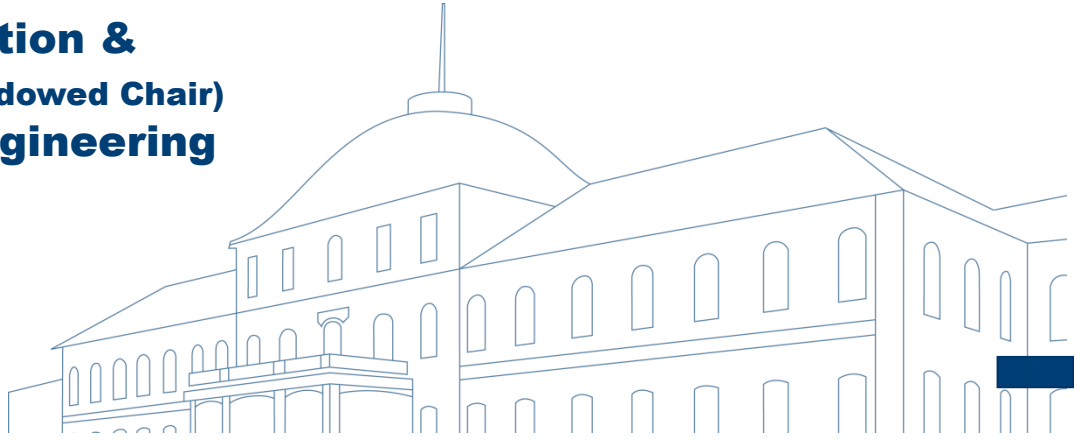
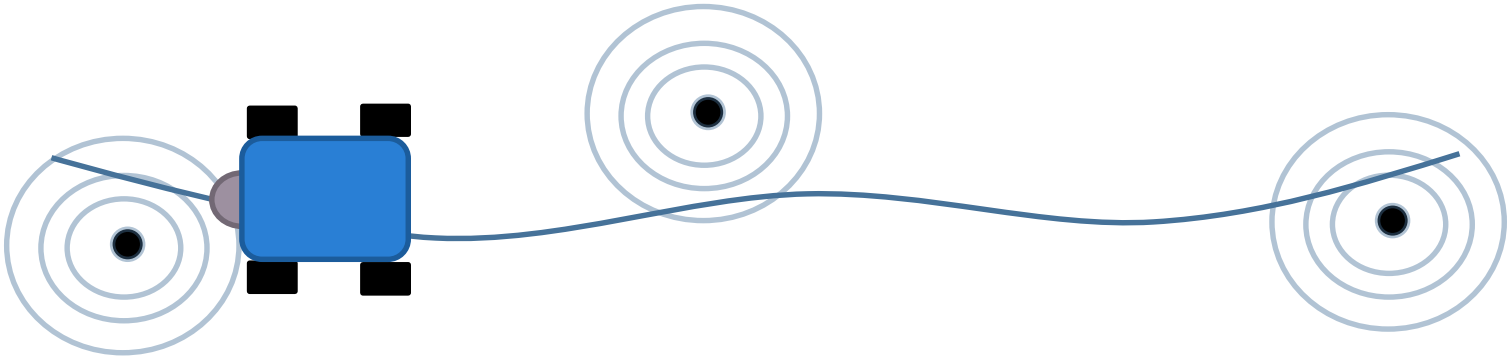


Introduction

- Data Acquisition goes wireless (Industry 4.0)
  - New Sensors with low cost, low power consumption
- Attached sensors can provide useful information
  - Like canopy, temperature, soil moisture
- Must be done automatically
- A gap free Wireless Sensor Network (WSN) is still costly and insufficient
- Sensors could be placed at the points of interest
- The robot is collecting the useful data autonomous

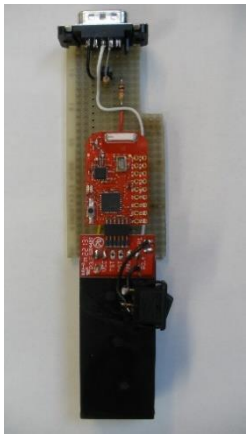


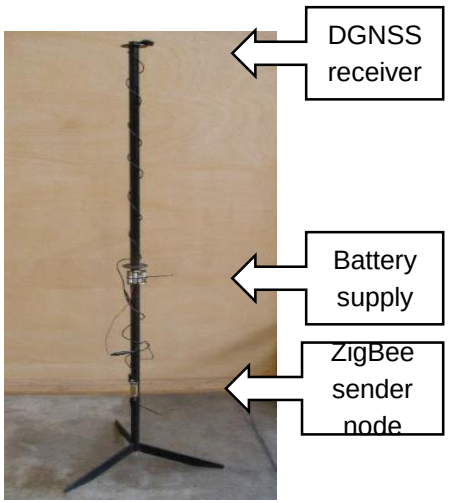
Aim and Objective

- How does the received signal strength indication (RSSI) of wireless sensor nodes behave in a vineyard?
- Is a DGNSS position sufficient to find the position of a sensor node and collect the data?
- How can this information be used to optimize the path planning of a autonomous robot?

The Sensor Network

- eZ430-RF2500 from Texas Instruments, ZigBee Standard (IEEE 802.15.4)
- 4 wireless sensors, communicating with one master node
- DGNSS system (NL-603P serial MD6 GNSS receiver)
- Communication via RS232
- streaming 1 Hz





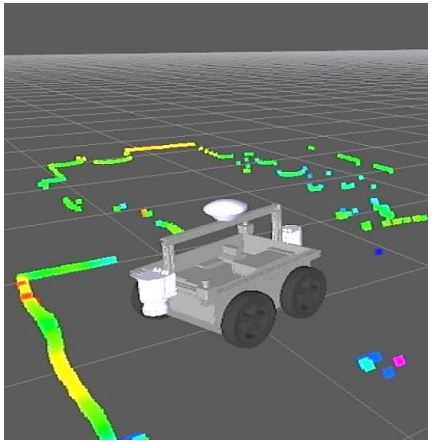
The Sensor Network 2

- 4 Poles
  - Height 2 m
  - ZigBee sender at 0.5-0.7 m
- Each Message included
  - Time stamp
  - RSSI Value
  - Node Id
  - NMEA-GGA string (DGNSS)
- Easy extendable to other sensor values

```
14:12:09.642: 041%:02:4842.59083
14:12:09.689: 042%:02:912.794092
…
```

The Robot

- A small 4 wheeled robot was used
  - 2 laser scanners
  - 4 Motors
  - Encoders
  - IMU
  - RTK-GNSS
  - Receiver node of the WSN
  - ROS Middleware



Experiments

ZigBee range evaluation:

- Ideal conditions
- Artificial canopy wall, moistened
- Evaluation of RSSI values of the sensors
- The necessary spatial separation of the poles was evaluated

Experiments 2

Test area:

- Experimental vineyard of the University Hohenheim (48.710115N, 9.212913E)
- Size 85 x 60 m
- 33 grape rows (1.5 m separated)

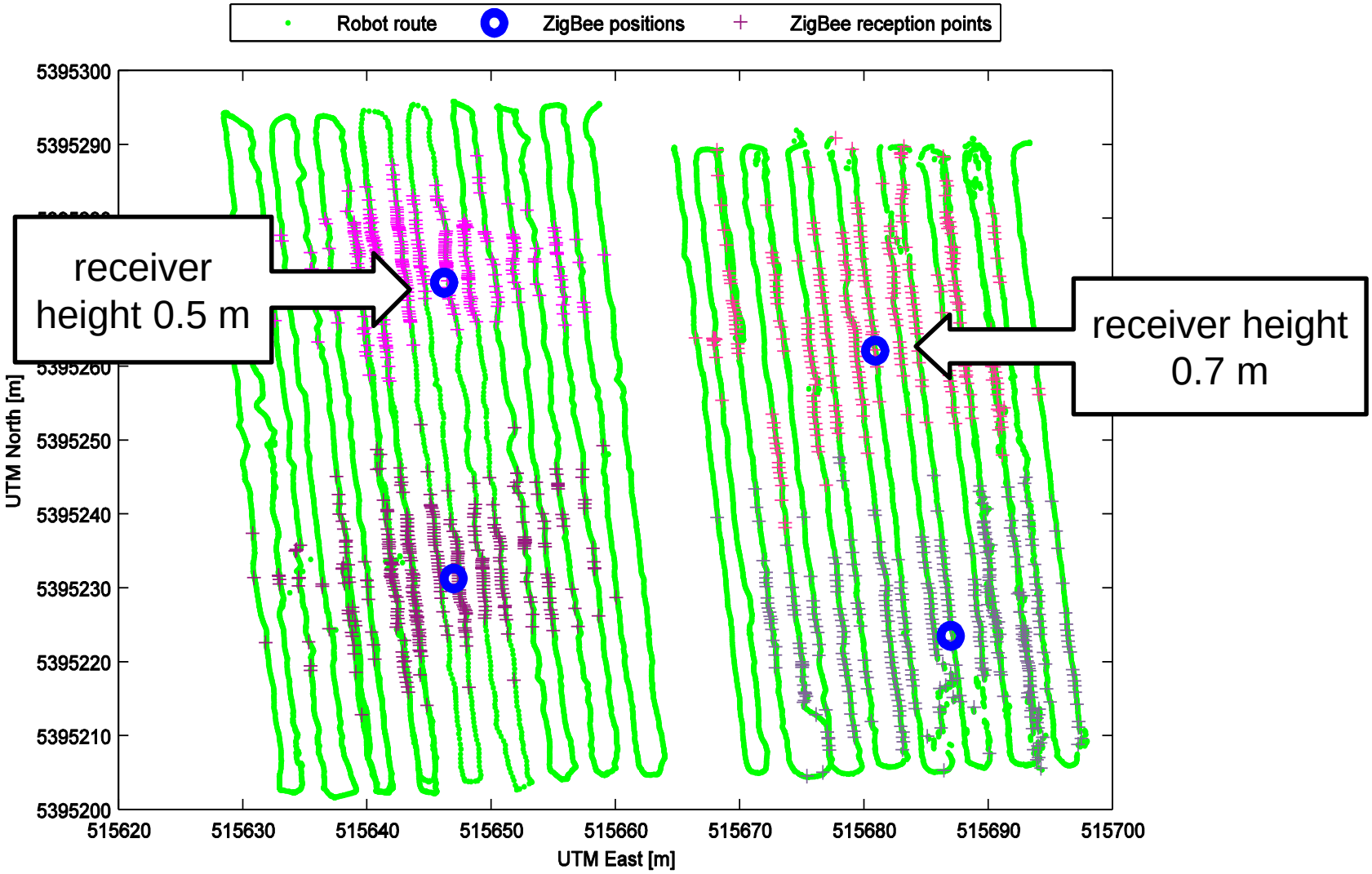
Sensor pole positions:

- spatial separated with 30 meters

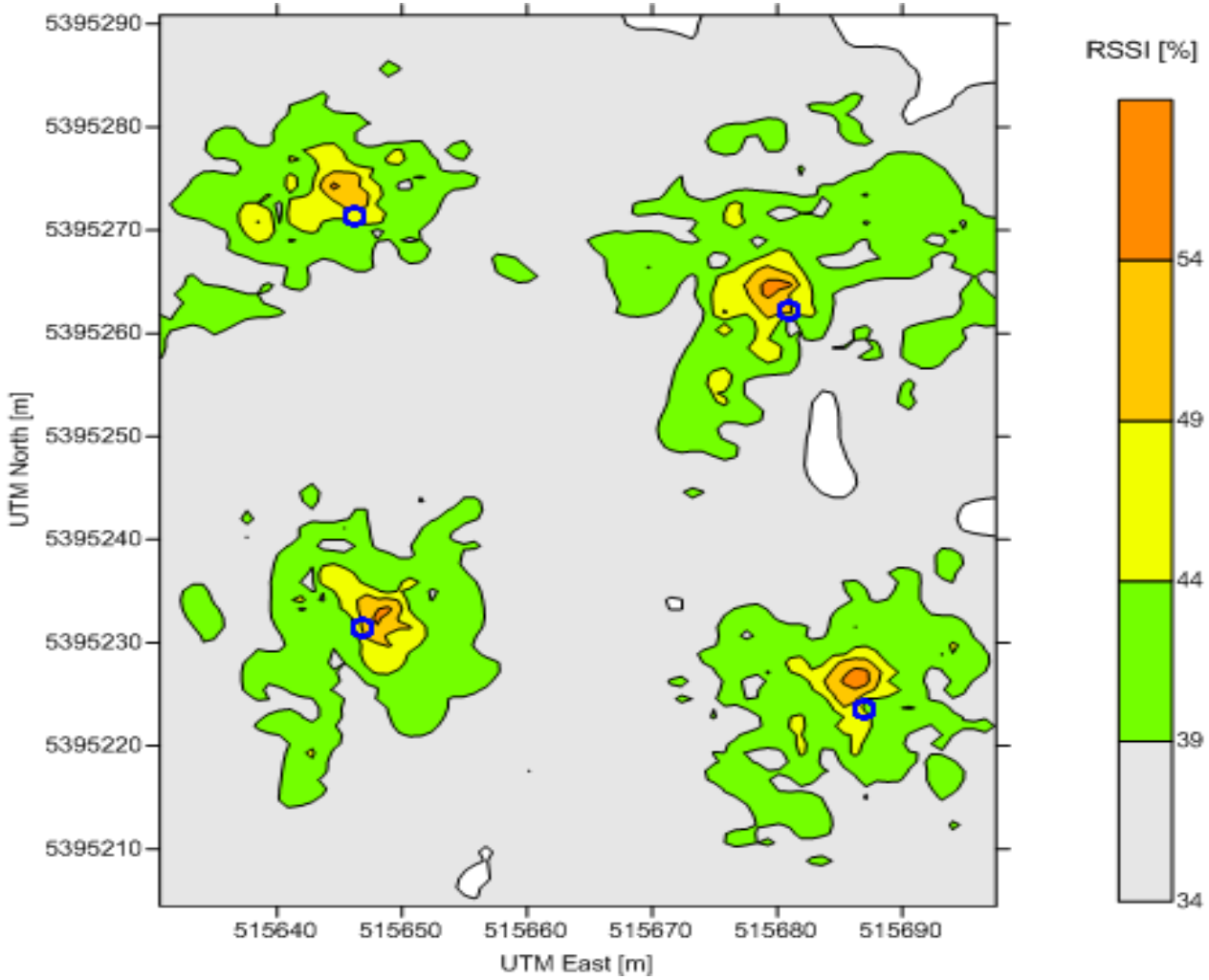
Tests:

- All grape rows had been passed once by the robot (deterministic)
- Robot speed 0.5-0.8 ms^{-1}
- Afterwards the robot drove to the points with highest RSSI value (reactive)

Results

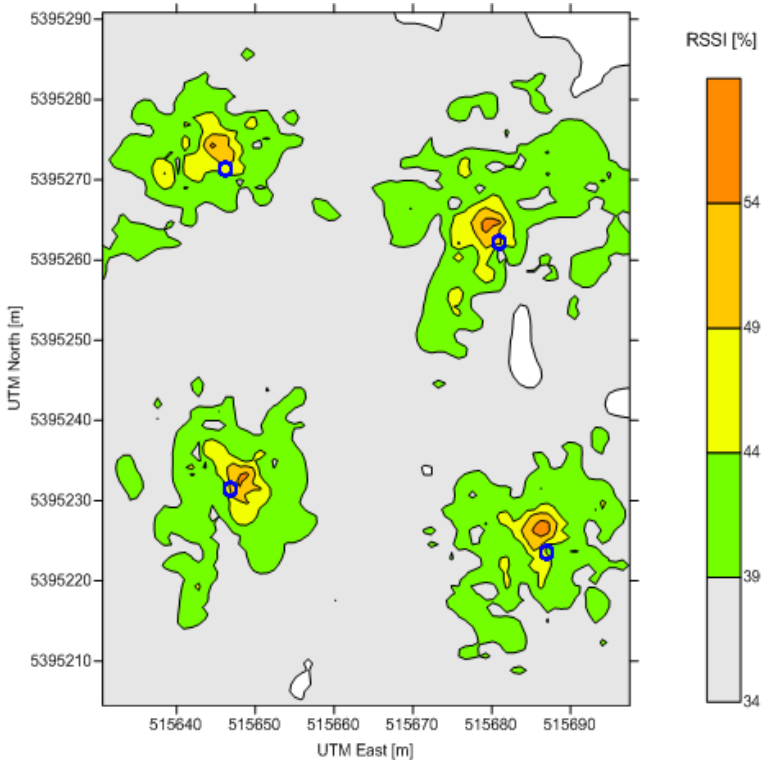

Robot route
ZigBee positions
ZigBee reception points
receiver height 0.5 m
receiver height 0.7 m
UTM North [m]
UTM East [m]
5395300
5395290
5395260
5395250
5395240
5395230
5395220
5395210
5395200
515620
515630
515640
515650
515660
515670
515680
515690
515700

Results


5395290
5395280
5395270
5395260
5395250
5395240
5395230
5395220
5395210
UTM North [m]
515640
515650
515660
515670
515680
515690
UTM East [m]
RSSI [%]
54
49
44
39
34

Results

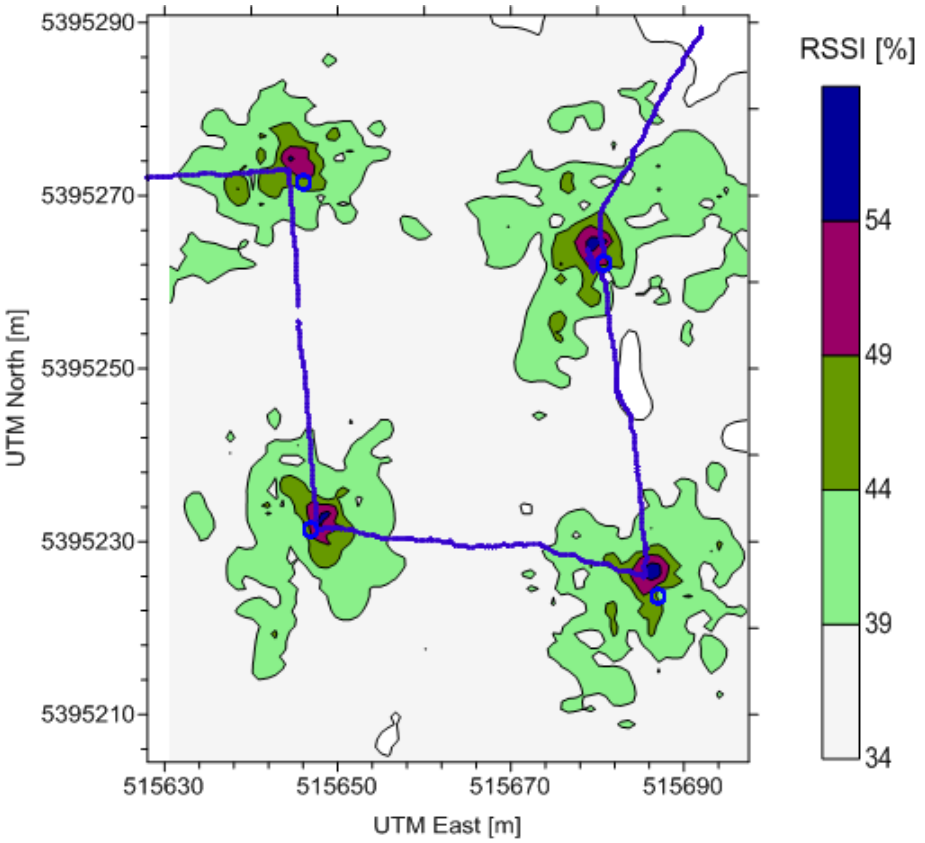
- Kriging interpolation used
- Distance traveled around 3000 m
- Driving Time around 1 hour
- Spatial difference between DGNSS position and highest RSSI value



Results

What if we use a robot to move direct to the sensor poles?

- reactive control to avoid collisions
- Distance traveled 200 m
- Driving time around 4 minutes
- Faster performance with a factor around 15
- Node localization just by RSSI value possible



Conclusion

- Good performance in detecting an servicing all transmitter nodes by passing the rows
- Direct movement between the nodes possible with small machines
- Minimizing of the travelled distance at the second run about the factor 15
- DGNSS localisation is enough to find the nodes with a mobile robot
- Geo-reference of sensor values with DGNSS possible
- Geo-reference just by RSSI value possible

THE END

Thank you for your attention!