Towards Smart Farming by Location-aware Agricultural Vehilces

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Outline

- Group's General Research Interests
- Project: Lawn In Order
- Project: Automation of a Mobile Sprinkling Machine
- Conclusion

System Software and Distributed System Group

General Research Interests

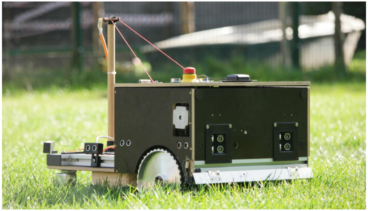
- Distributed Systems
- Distributed Algorithms
- Dependability, Fault Tolerance
- Replication, Self-Stabilization, Region Adherence
- Dependability Measures, Performance, Energy Efficiency
- Scalability, Dynamics, Graceful Degradation, Consistency Notions
- Sensors for Environmental Phenomena

Lawn In Order

Problem to solve:

Lawnmowing is a time-consuming and repetitive (boring) task
→ perfect for automation by

- calculation of a covering path
- locating relative to the path
- follow path as precisely as possible
- handling unexpected obstacles

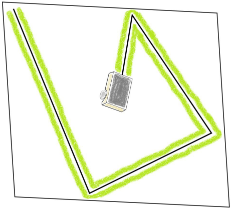


Roadmap:

1) Diploma Thesis: Draft and Simulation of an Autonomous, Fault-Tolerant Lawnmower
2) Diploma Thesis: Design and Construction of an Autonomous, Fault-Tolerant Lawnmower
3) Bachelor Thesis: Draft and Implementation of a Localization-Strategy for Autonomous Lawnmowers
4) Master's Projectgroup: Lawn in Order (cooperation of 11 Master Students)

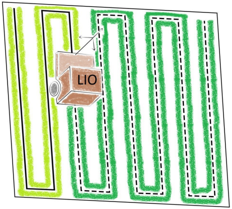
Why should we go smart?

naive solution



+ simple algorithm
+ simple hardware
- too many path intersections
- long lawnmowing time
- 100% coverage not guaranteed, even in infinite time
- time-consuming setup

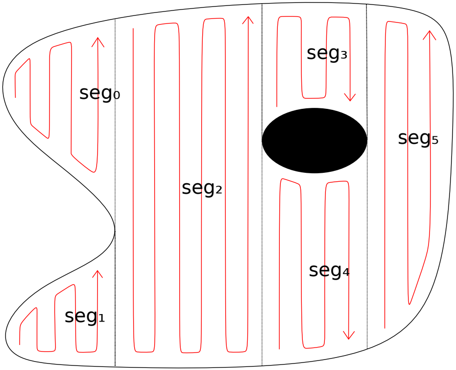
smart solution



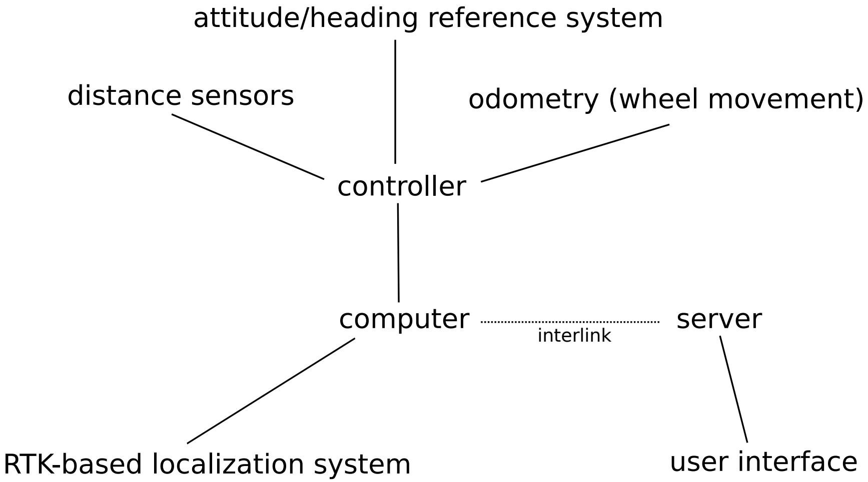
- complex algorithm
- complex hardware needed
+ efficient due to few path intersections
+ short lawnmowing time
+ shape independent processing
+ simple setup

Path calculation

1) lawn borders and stationary obstacles have been previously mapped
2) fragmentation of lawn into segments $seg_0 \ldots seg_n$
3) calculation of an optimized operating sequence of the fragments



Components

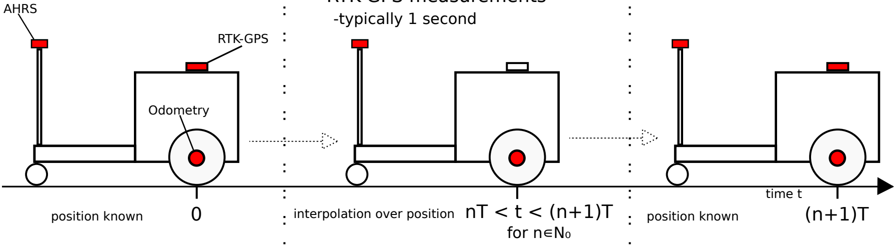

attitude/heading reference system
distance sensors
odometry (wheel movement)
controller
computer
interlink
server
RTK-based localization system
user interface

Localization technique

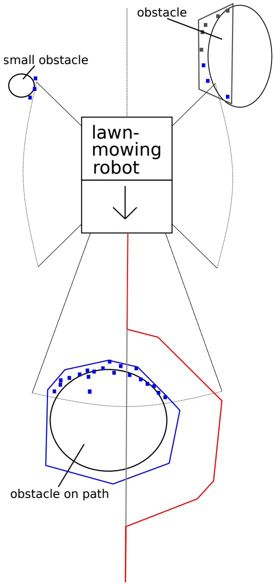
- start position measured by RTK-GPS
- absolute measurment

- fusion of differential sensor data
- addition to last known position
- T is intervall of RTK-GPS measurements
  - typically 1 second

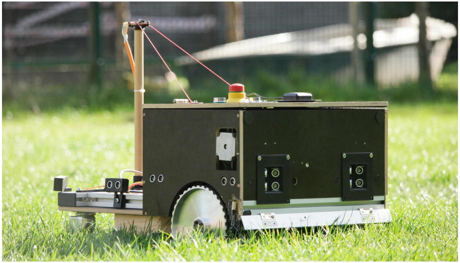
- fusion of entire sensor data

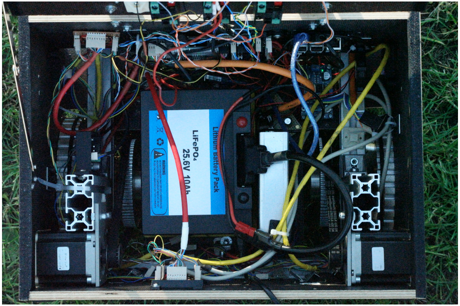


Handling of unexpected obstacles



1) distance sensors capture an obstacle (blue dot)
2) multiple blue dots get aggregated to larger obstacle (blue polygon)
3) system forgets blue dots after time (grey dots)
4) robot dynamically calculates a way to circumvent obstacle
5) robot aims to rejoin path as soon as possible

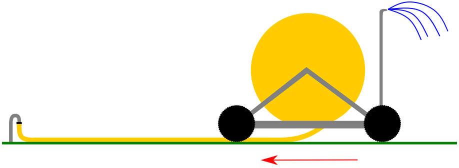



Lithium Battery Pack
$LiFePO_4$

Automation of a Mobile Sprinkling Machine

Problem to solve:
Operating a mobile sprinkling machine is a time-consuming and repetitive (boring) task, too

- machine drags itself forward by pulling along hose
- machine stops when the hose is wounded up
- multiple repositions necessary to sprinkle larger area
- repetitive task every few hours (even at night)
- manual repositioning is imprecise $\rightarrow$ uneven water distribution



Ongoing projects:

- 2 Master Theses: Automation of a Mobile Sprinkling Machine
  - 2 Master's students in cooperation with a small-sized company

Why should we go smart?

pure mechanical solution

+ simple and bulletproof hardware
+ no algorithms or electronics needed
+ no preparation of agricultural area
− high workload due to repositioning
− less efficient sprinkling in case of bad repositioning
− no notification at error/accident
− no remote control
− no scheduling

smart solution

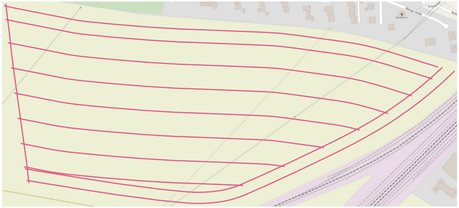
− complex and water-sensitive hardware
− complex algorithms
− agricultural area has to be mapped
+ no repositioning after setup
+ efficient sprinkling due to avoidance of overlapping sprinkling areas
+ error handling and notifications
+ remote start/stop
+ time-/event-controlled start/stop

Steps to get smart:

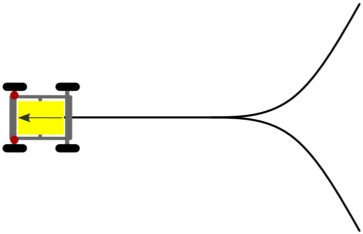
- reuse LIO's localization-system
- add a propulsion for reversed direction movement
- add motors/battery/sensors/electronics to control machine
- implement LIO's hardware-/software-architecture

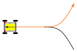
Concept

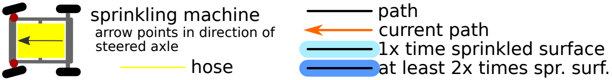
- user defines paths on agricultural area
- machine follows a selected, connected sequence of paths



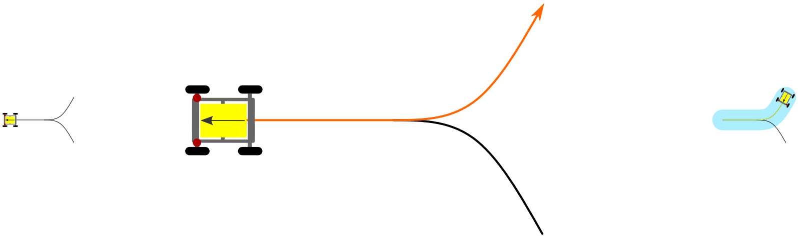
Smart machine movement (1/9)

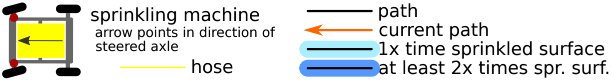




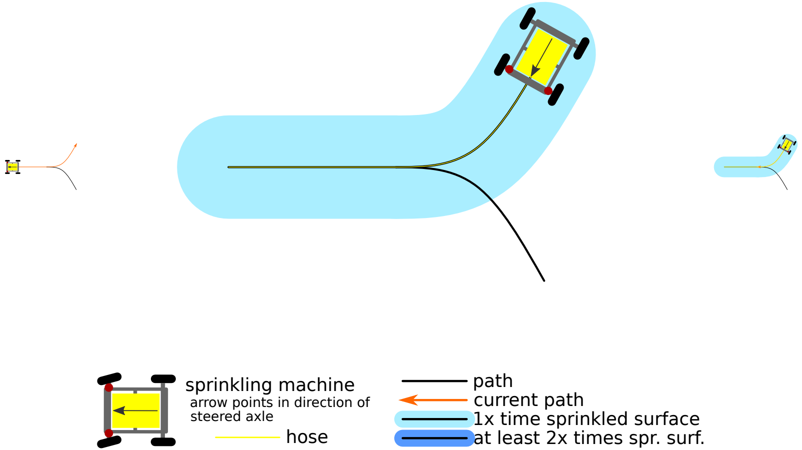


Smart machine movement (2/9)

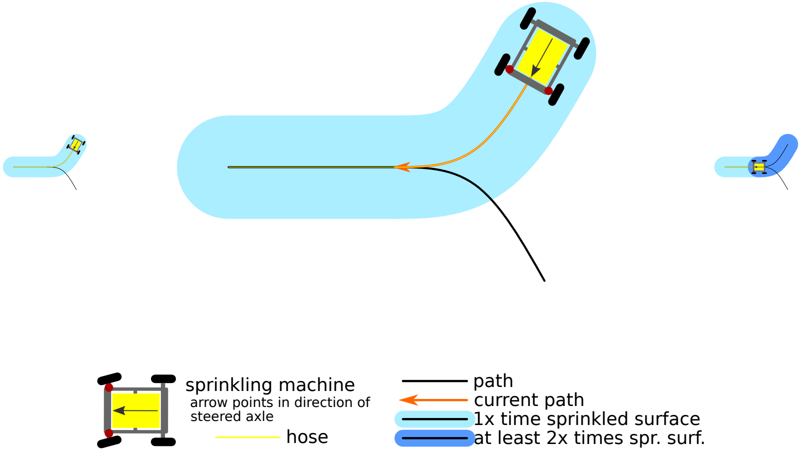




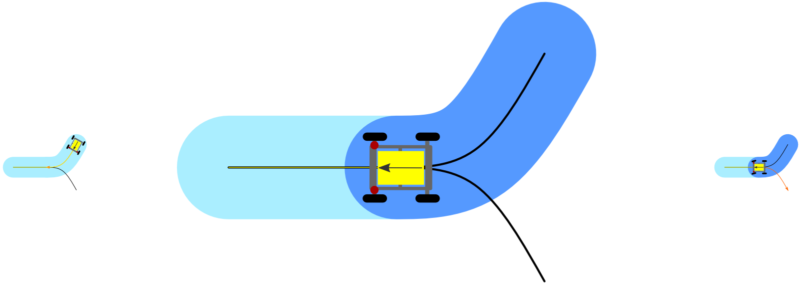
Smart machine movement (3/9)

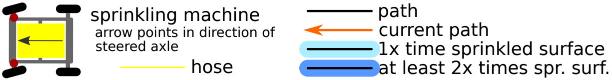


Smart machine movement (4/9)

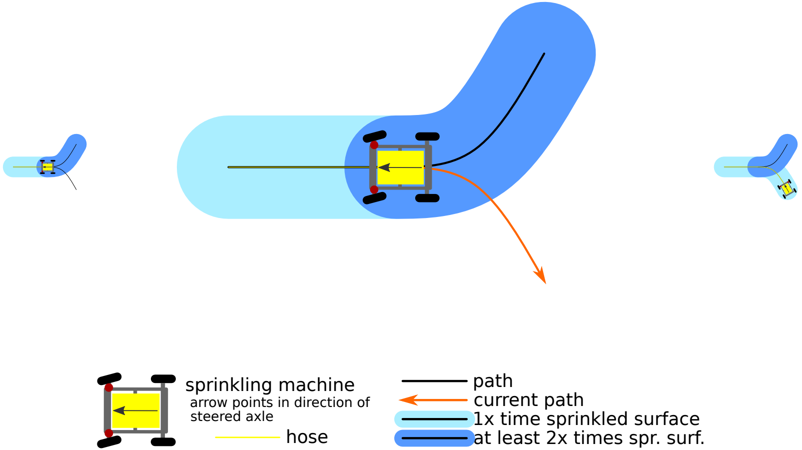


Smart machine movement (5/9)

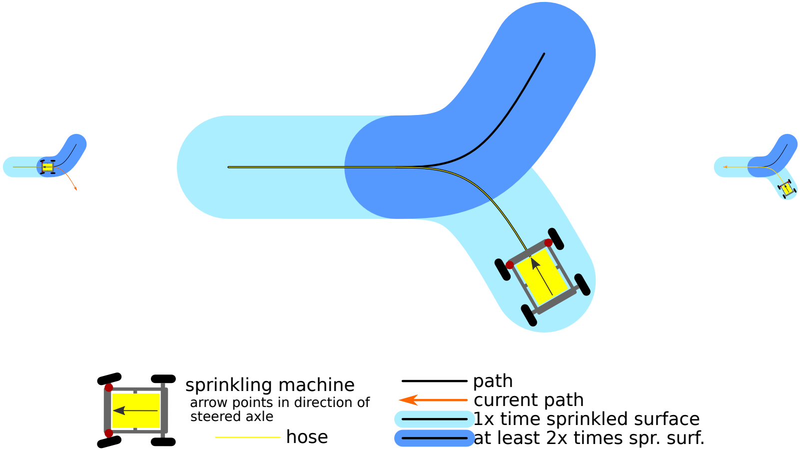




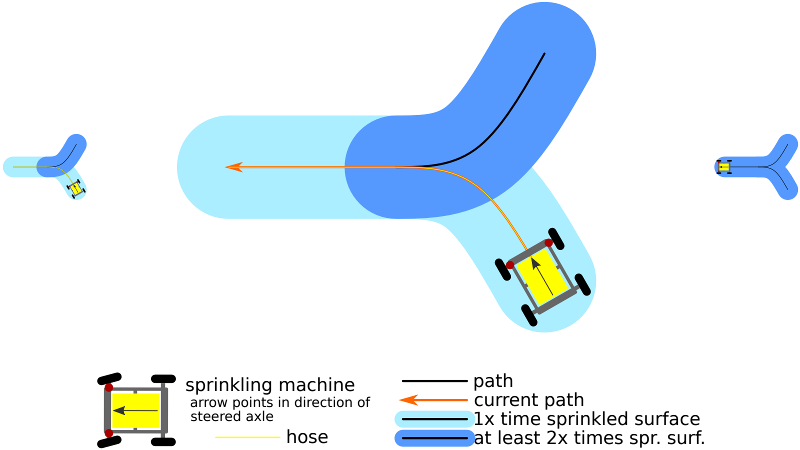
Smart machine movement (6/9)



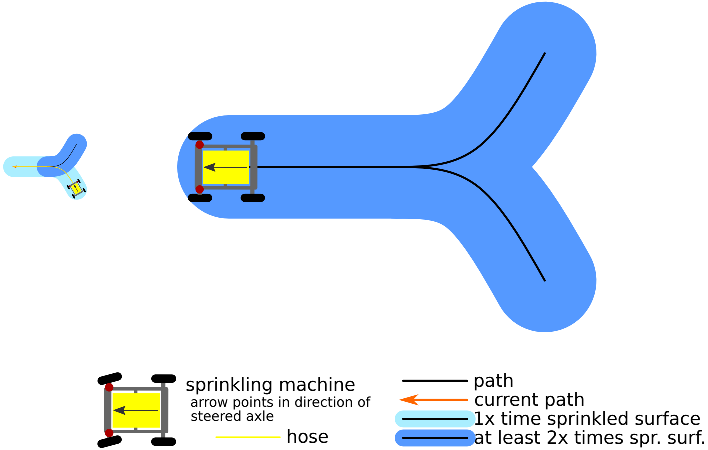
Smart machine movement (7/9)



Smart machine movement (8/9)



Smart machine movement (9/9)



Conclusion

- method of path-definition varies
- hard-/software architecture is similar
- precise localization-technique is essential, latest RTK
  - about $2cm$ resolution at good GPS-Signal-Quality
  - atmospheric effects must be compensated by a reference station

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Thank you for attending :)