



# UNIVERSITÄT LEIPZIG

Smart Farming Lab



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## Tractor Perception Dataset

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### Abstract

Agricultural environments pose unique perception challenges for autonomous robots, including dust-induced sensor degradation, strong lighting variations, and diverse terrain, yet datasets capturing these conditions remain scarce. We present a **multimodal tractor dataset for outdoor robotics**, recorded from a roof-mounted sensor platform during a range of farming operations under varying weather conditions, crop types, and ground surfaces. The dataset comprises **60 h (40 TB) of field recordings** and **19 h (13 TB) at farmyards**, supporting research on **robust perception and autonomous navigation in challenging outdoor environments**.

### Related Work

|                         | FieldSAFE [1]            | RELLIS-3D [2]          | GOOSE [3]            | Tartan Drive [4]       | Ours                          |
|-------------------------|--------------------------|------------------------|----------------------|------------------------|-------------------------------|
| Year                    | 2017                     | 2020                   | 2024                 | 2024                   |                               |
| Vehicle                 | tractor                  | warthog robot          | SUV                  | ATV                    | tractor                       |
| Context                 | mowing pasture           | off-road driving       | off-road driving     | off-road driving       | operating on field + farmyard |
| Sensors                 | LiDAR, RGB, Thermal, INS | LIDAR, RGB, RGB-D, INS | LiDAR, RGB, NIR, INS | LiDAR, RGB, RGB-D, INS | LiDAR, RGB, RGB-D, INS        |
| Duration                | 2 h                      | 21 min                 | 17 min               | 7 h                    | 79 h                          |
| Annotations (LiDAR/RGB) | Yes                      | Yes (13,556 /6,235)    | Yes (10000 /10000)   | No                     | Planned in 2026               |

### Applications of the Dataset

Safety-critical perception

- free space detection
- obstacle detection (humans, machines, unknown objects)
- negative obstacle detection (ditches, holes)
- visibility range estimation (signal degradation due to conditions of sight, sensor occlusion)
- sensor fault detection (dropouts, misalignment, failure)
- depth estimation (distance to objects)
- semantic segmentation for agricultural scenes

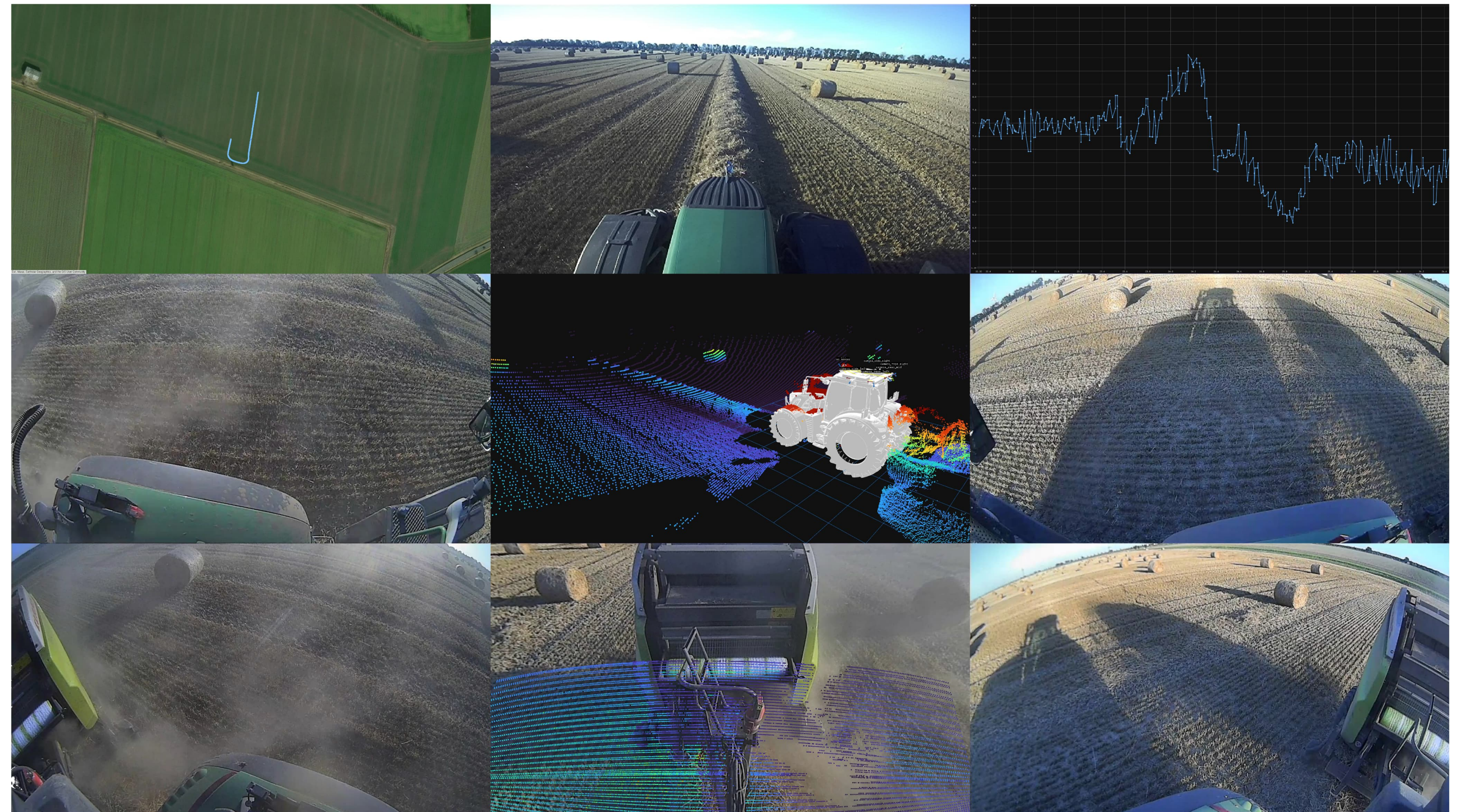
Navigation and path planning:

- traversability estimation (soil support, terrain, wheel ruts)
- learning semantic-aware navigation policies (humans, overhanging branches, corn stubble)
- structure-aided navigation (crop rows, windrows, field boundaries)

Execution of agricultural operations

- implement monitoring (clogging, wear, failure)
- process monitoring (field coverage, misses)
- imitation learning of operator implement usage (lifting / lowering at turns)

### Dataset

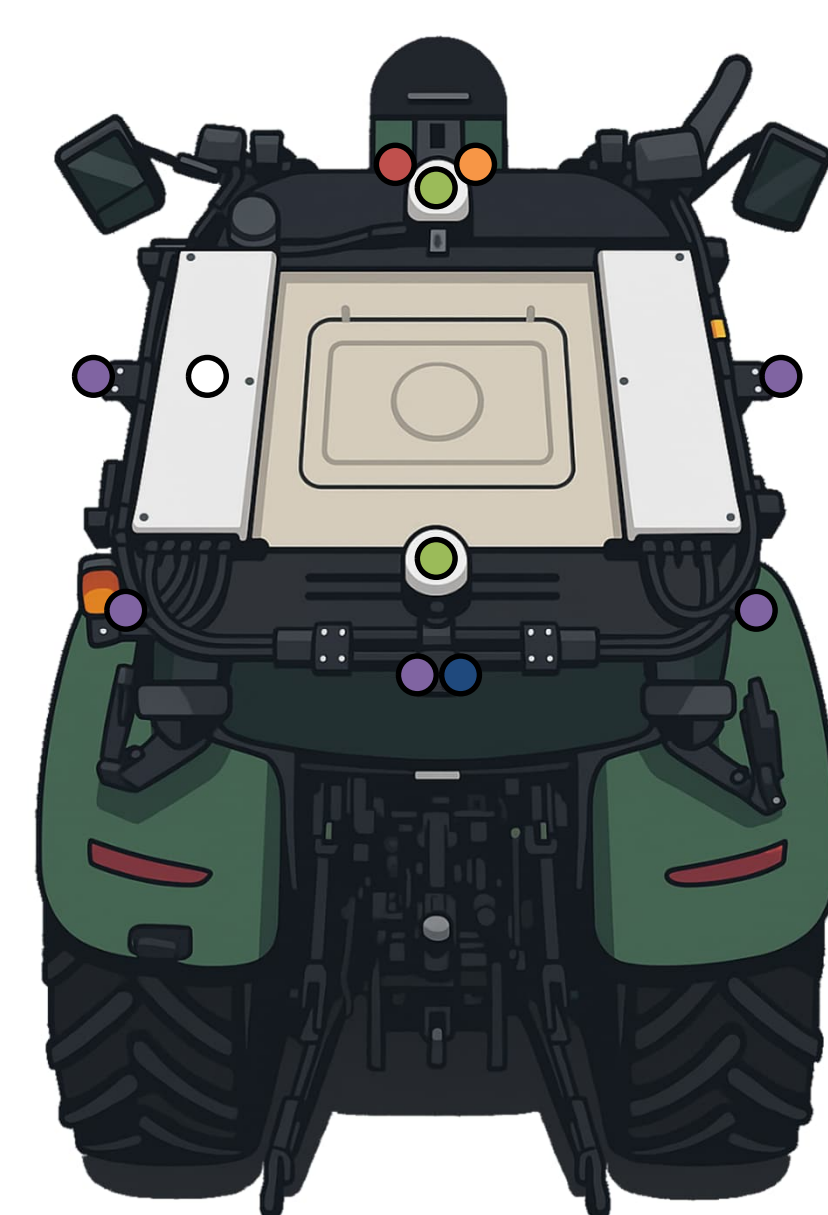


Multimodal sensor data captured during hay baling Left-right, top-bottom: GNSS trajectory; forward camera view; longitudinal acceleration (IMU); left camera view; fused LiDAR point clouds (height-colored); right camera view; rear-left camera view; rear view with LiDAR intensity overlay (dust-degradation); rear-right camera view

### Sensor Platform Overview



Platform mounted on the roof of a Fendt 724 tractor



- LiDAR: Ouster OS0-12 (20 Hz)
- LiDAR: Blickfeld Qb2 (7 Hz)
- Stereo camera: Stereolabs ZED 2i (30 Hz)
- Mono camera: ArkVision (120°) (25 Hz)
- GNSS: NovAtel OEM7 (10 Hz)
- Compute: Nvidia Jetson AGX Orin

Data recording:

- ROS2 Humble
- ros2 bag format: .mcap (20 s per file)
- recording data rate:  $\approx 200$  MB/s

### Future Improvements

Sensor platform:

- stereocameras for spacial surround view
- second spinning lidar in the rear
- thermalcamera in the front
- syncing frames with electrical triggers
- add machine data via ISOBUS

Dataset content and quality:

- automatic calibration routine for valid transform trees
- labeled datasets for various applications
- improved image quality (less compression)
- further recordings during the agricultural season 2026
- scene compositing for dataset augmentation

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### References

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