Istrobotics

Robotour 2017, 17.9.2017

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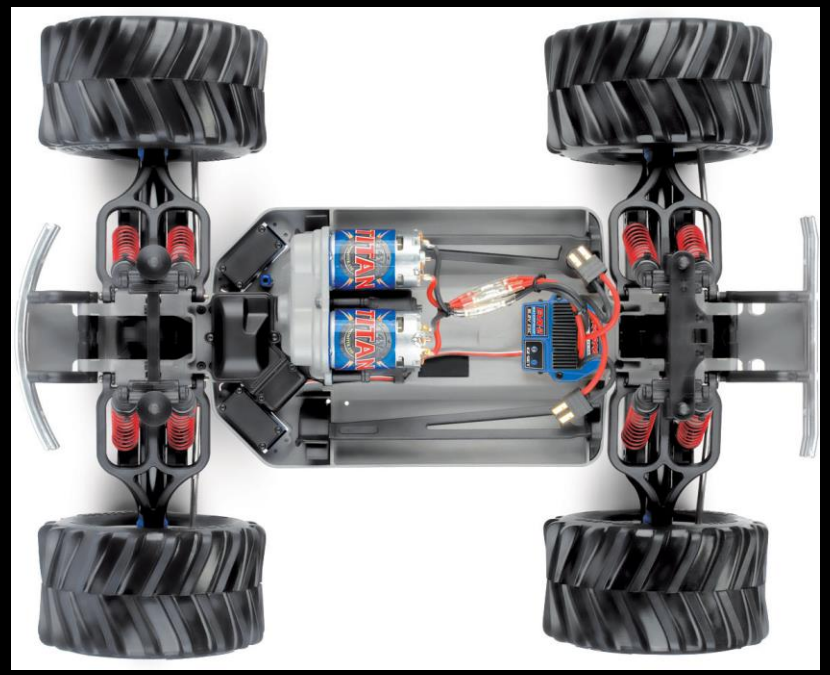
2016

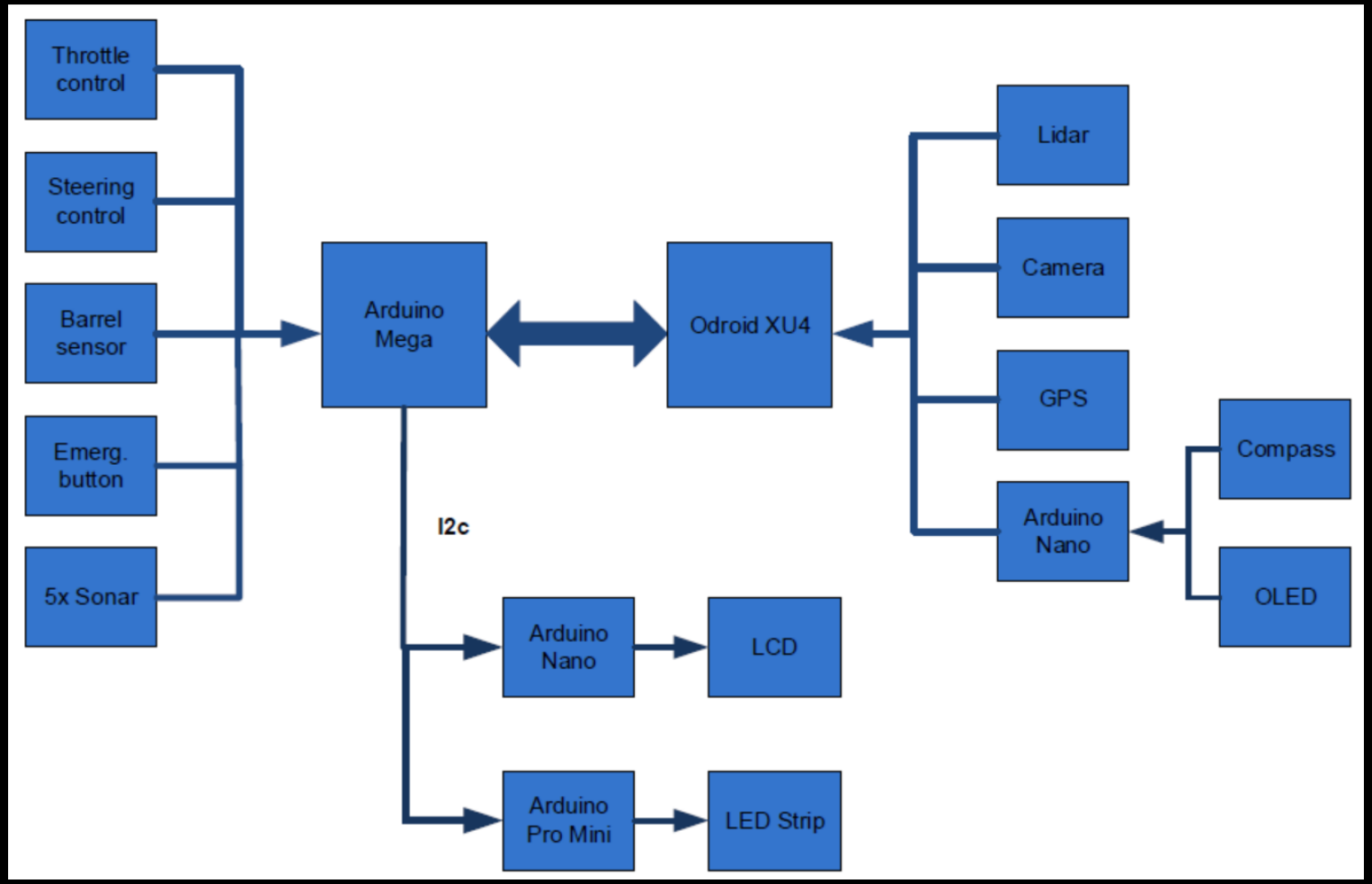
2017

ROBOT CHASSIS

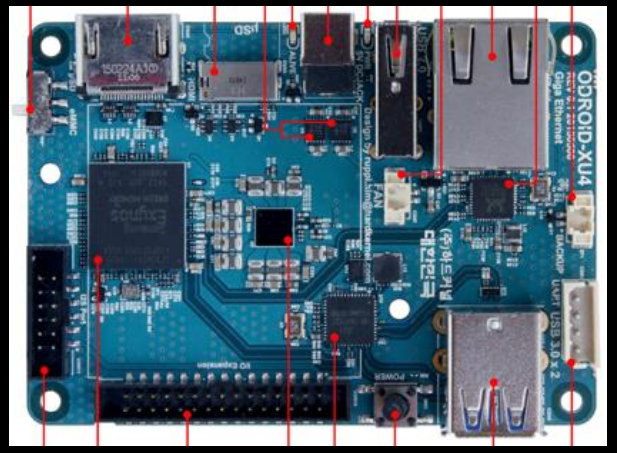


- RC model: Traxxas E-Maxx 4x4 monster truck
- Top Speed: 48 km/h
- Waterproof electronics, servos

HARDWARE DESIGN



HARDWARE

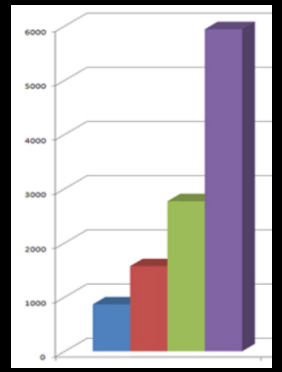


- **Odroid-XU4: 2GHz 8-core, 2GB RAM**
- Arduino Mega: 16MHz, 8KB RAM
- 2x Arduino Nano: 16MHz, 2KB RAM
- Arduino Pro Mini: 16MHz, 2KB RAM
- 2D Lidar: RoboPeak RPLIDAR 360 ($400)
- Camera: Odroid USB Cam (640x480, 60 FOV)
- Mouse type GPS/Glonass: Holux M-215+
- Compass: Bosch BNO055
- **5x Sonar**: HC - SR04
- LCD & OLED displays, **8x LED**

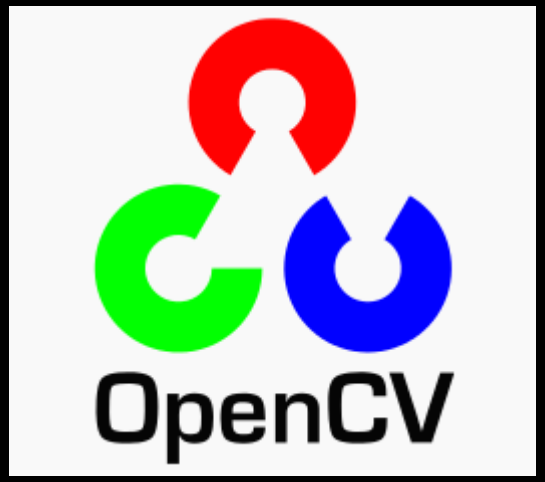
Odroid-XU4 vs Raspberry Pi3

	Raspberry Pi3	Odroid-XU4
CPU	ARM Cortex-A53	Samsung Exynos5422 Cortex
Clock	1.2 GHz	2 GHz
Cores	4x	8x
RAM	1GB LPDDR2	2GB LPDDR3
Flash	microSD	eMMC5.0 HS400
Ethernet	10/100 Mbit	1 Gigabit
USB	4× USB 2.0	2x USB 3.0 1x USB 2.0

	R-Pi2	R-Pi3	O-XU4
Image processing	164,4 ms	167,3 ms	26,5 ms
JPG/PNG writing	-	-	3x faster
Processing lag	12 sec	2 sec	100 ms

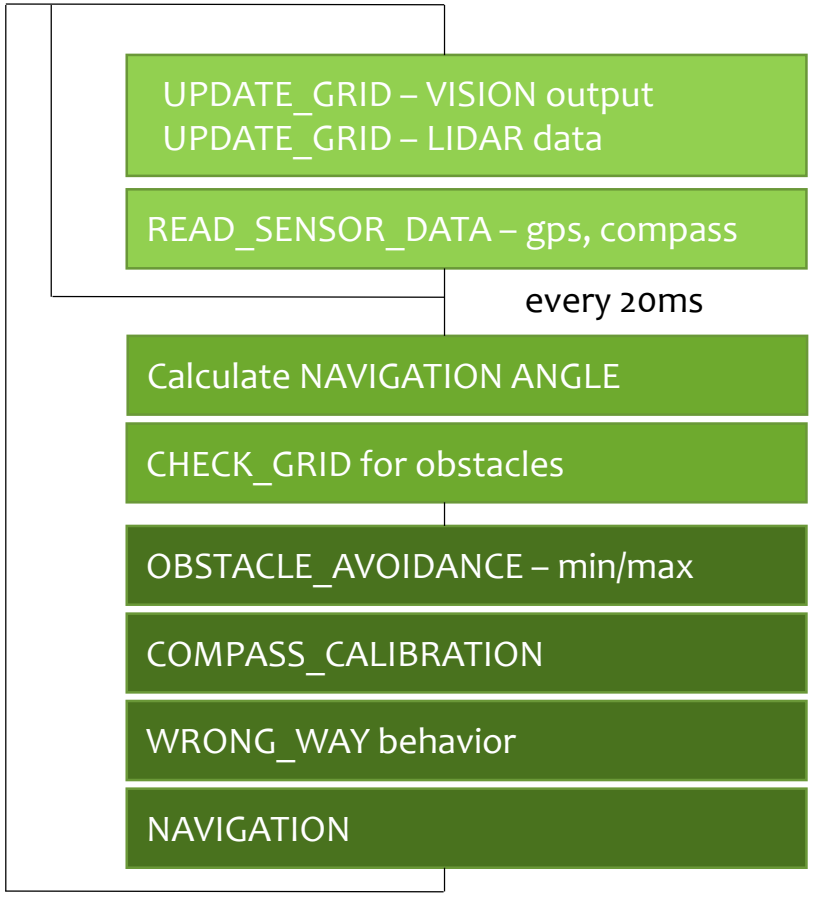


SOFTWARE



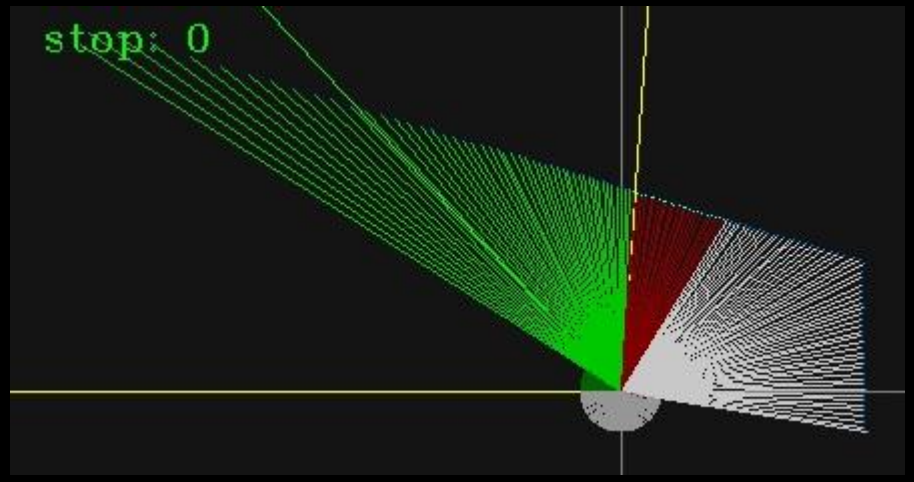
- Operating system: Ubuntu 16.04 Mate
- Source codes: C++, 340kB (2016: 180kB)
- Vision library: OpenCV
- Geo library: GeographicLib
- Logging framework: Apache log4cxx
- Main application + 8x pthreads
  - 4x sensors (Camera, Lidar, GPS , Compass)
  - image capturing + vision processing
  - output: image saving (1GB of data/ round)
  - control board (Compass)

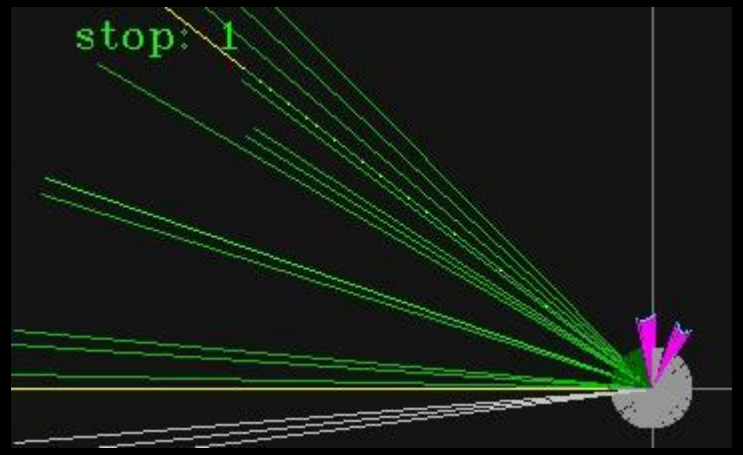
SOFTWARE DESIGN – PROCESSING



- LIDAR data capture – 7x /sec
- CAMERA capture – 30 fps
- VISION processing – 35 ms
- GPS data capture
- CONTROL BOARD comm.
- SAVE images to disk – 3x /sec

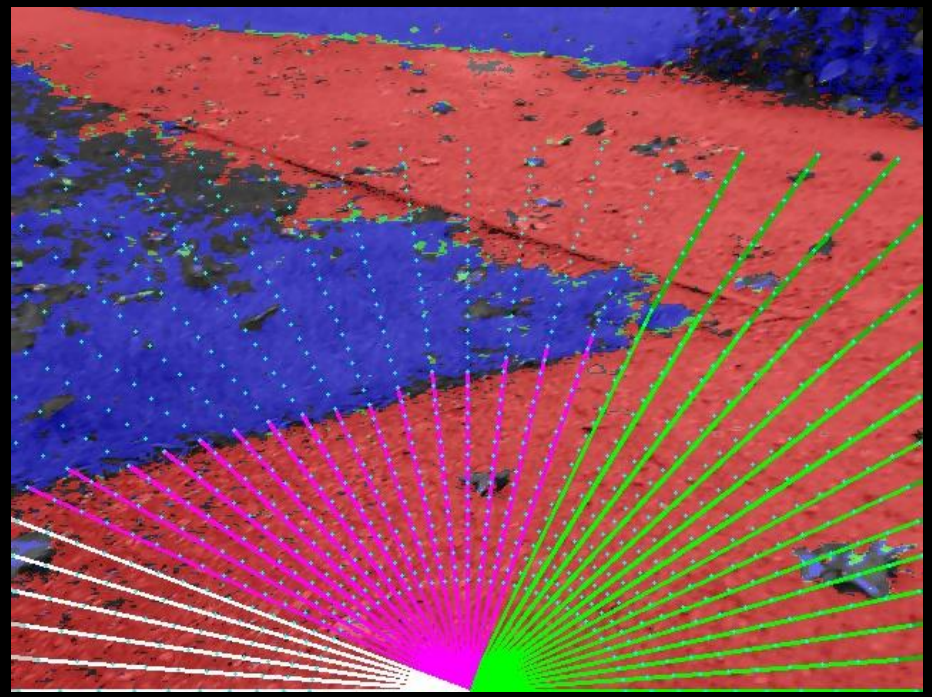
LIDAR – obstacle detection





- Obstacle detection condition (red):
  - If distance is < 100 cm
  - Filtering: distance < 1cm (grey)
- Stop condition (pink):
  - Check angle: -45 to +45 degrees
  - If distance is < 50 cm at 3 diff. degs
  - Sonars were also used (rain issue)
- Obstacle avoidance (green/white)
  - Find OK intervals of > 20 degrees
  - Choose the closest to going straight

VISION – approach

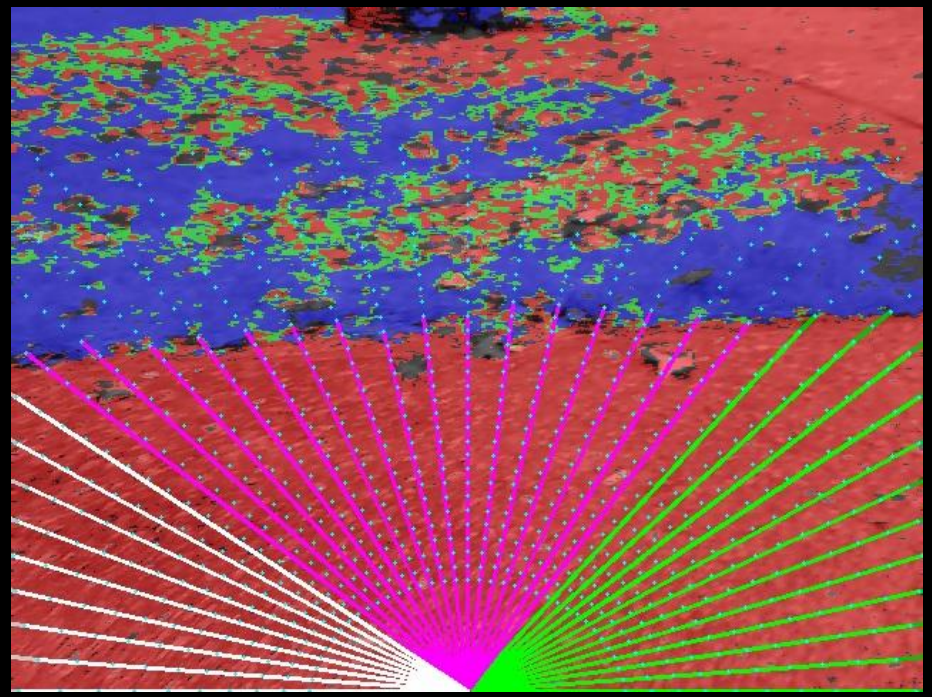


- Our approach: **lidar-like local map**
  - For any seen angle is obstacle closer than 1 meter?
  - 1 meter or to the image border
- Algorithm:
  - Pixel color classification
  - Evaluate grid points
  - Calculate distance to obstacle
  - Find OK intervals – same like LIDAR

VISION – Pixel color classification

- Approach:
  - Choose sample pixel blocks (32x32) from training images
  - Calculate 4 clusters centers in color space (OpenCV kmeans)
  - Calculate cluster radius (histogram based)
  - Repeat for 2 classifiers : road and off-road (grass)
- HSV color space + Euclidian distance
- Tool was developed - to define pixel blocks and evaluate images

VISION – Algorithm

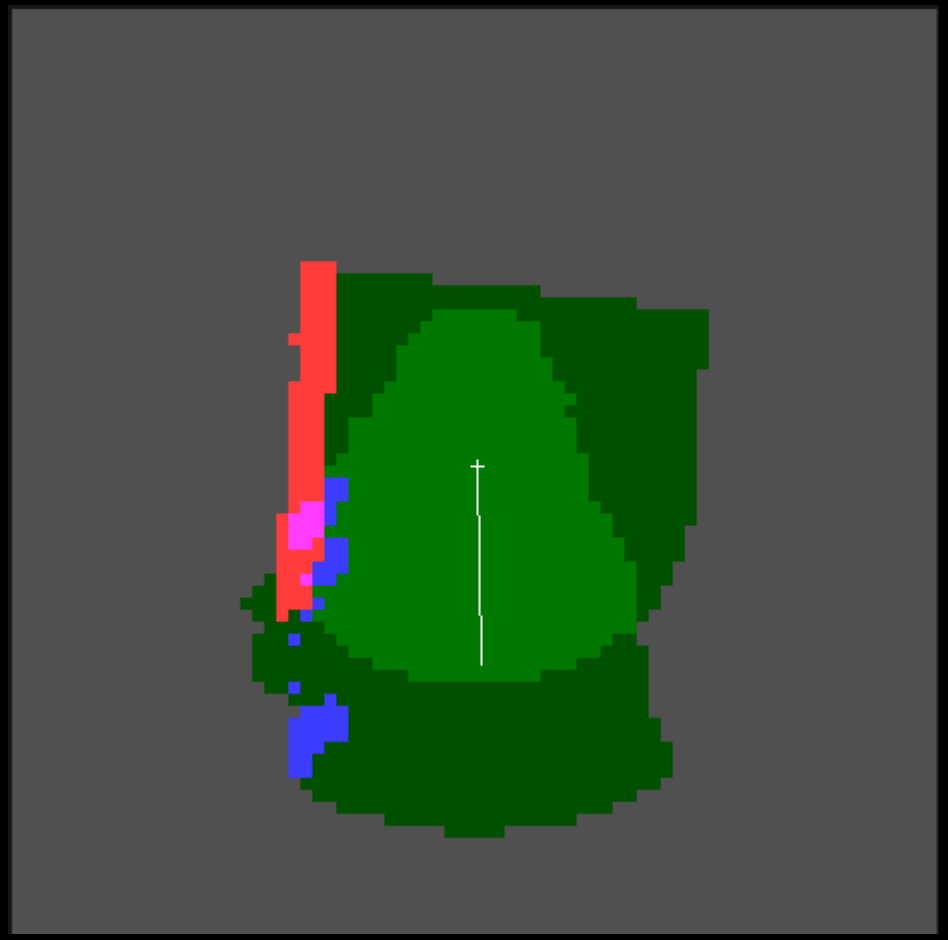


- Pixel color classification - 4 results:
  - Road (red)
  - Off-road (blue)
  - Both (green)
  - None (grey)
- Evaluate grid points
  - Cca 1000 points in 37 lines (5 deg)
  - Evaluating nearby pixels (80x80)
  - Majority of “Road” pixels is checked
- Calculate distance to obstacle
- Find OK intervals + merge with LIDAR

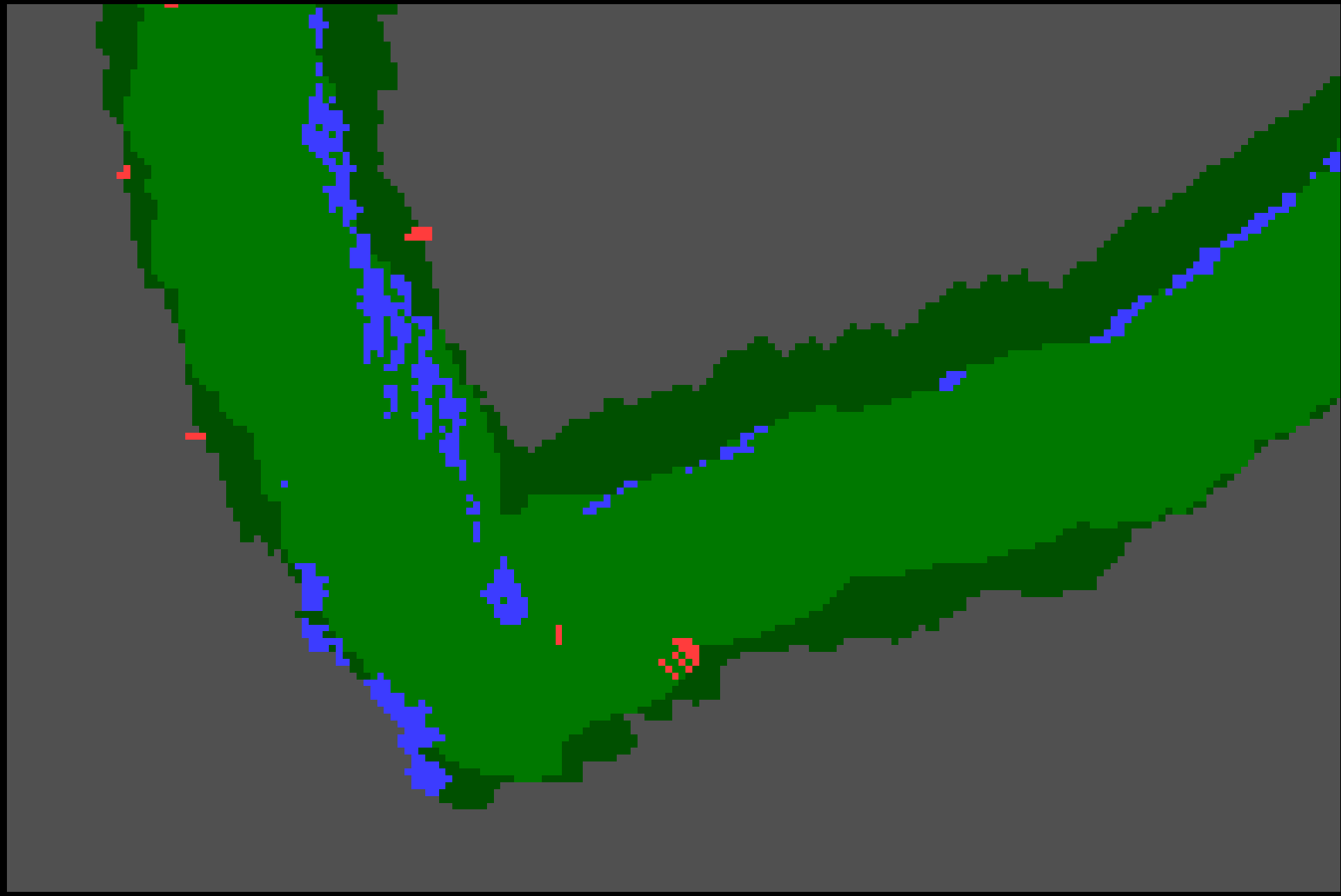
WAYPOINT NAVIGATION

- Navigation points: 26 manually defined points
- GPS positions taken from OpenStreetMap
- Pickup and dropoff points in arrays (navig.cpp)
- Navigation path – defined by a string **“N2N1 *1 M4M5N7M3M8 *2 M7M2M3N7M5N3”**
- Compass calibration:
  - interval of 7 seconds - robot is moving straight
  - gps and compass azimuths to be fixed
  - performed every 30 seconds – 3 minutes

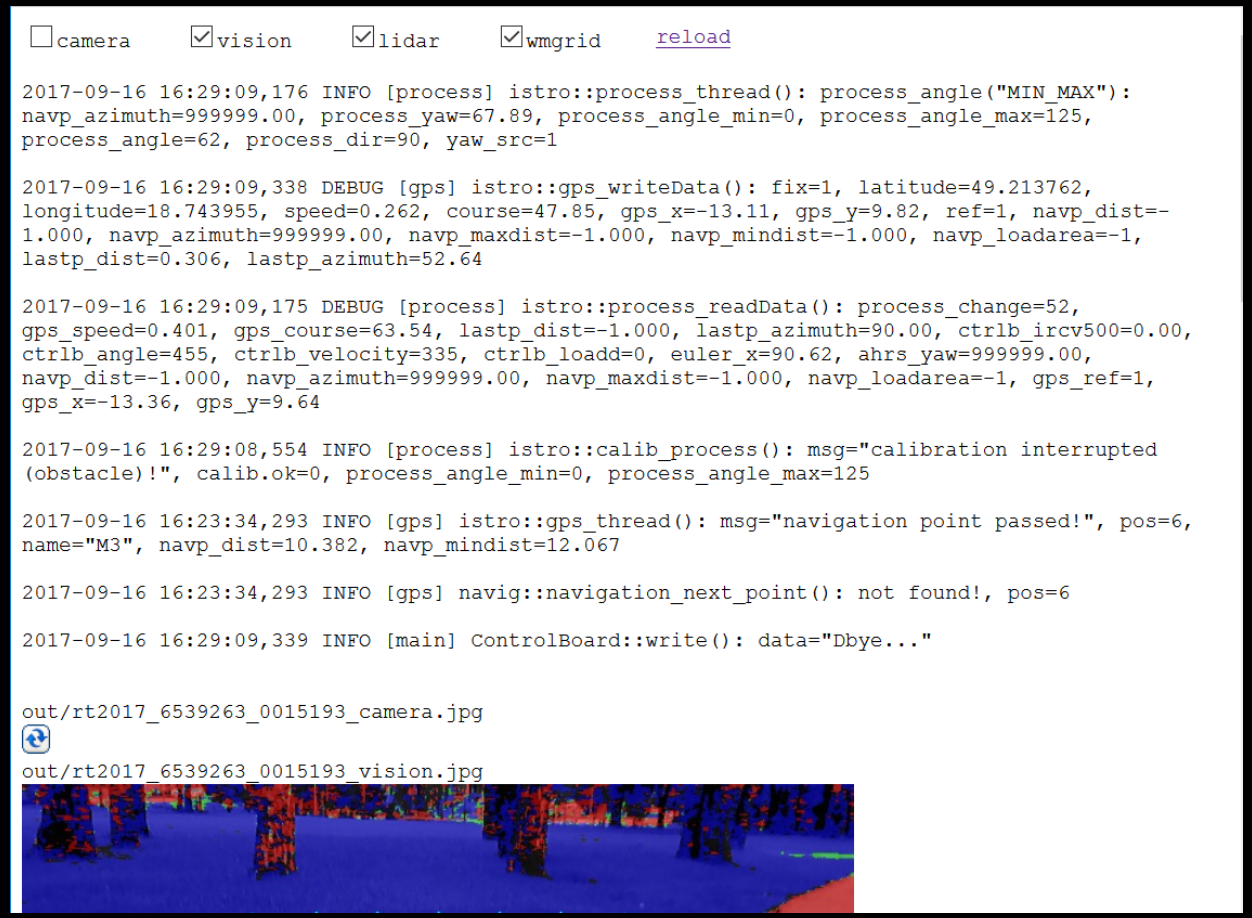
WORLD MAP – BUILDING LOCAL GRID



- Local grid map
  - to store polar information from lidar and vision
  - 1 cell: 10 x 10 cm, 1 byte pre cell, array[2000][2000]
  - always overwriting with new data - no heatmap
- Local position taken from GPS + odometry
  - wheel encoders provide speed information
- Colors used for visualization
  - Blue – grass (not-a-road) detected
  - Red – lidar obstacle
  - Green - no obstacle (light green = both sensors)



USER INTERFACE

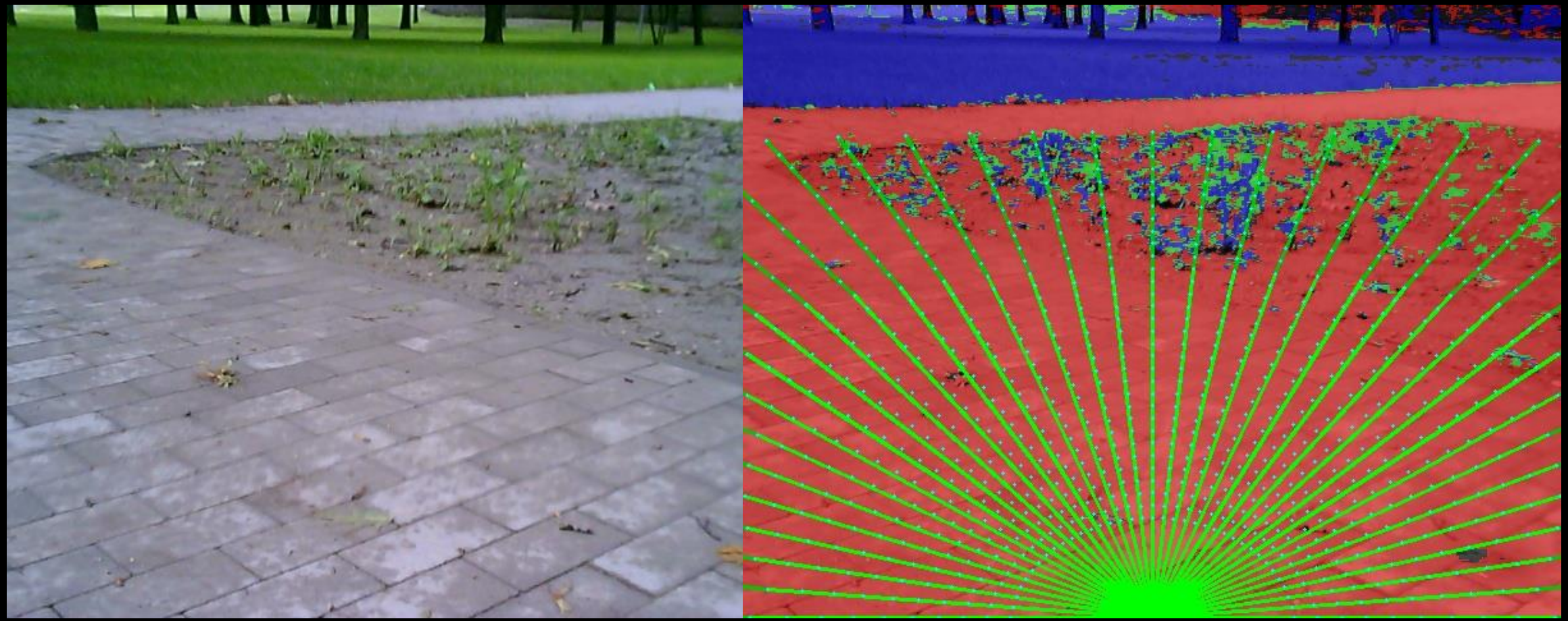


- Visualisation in web browser works on notebook/tablet/phone
- Log parser is exporting interesting data do .json file
- Web page performs Ajax JSON requests every 1 second
- Images are only downloaded on demand (checkbox)

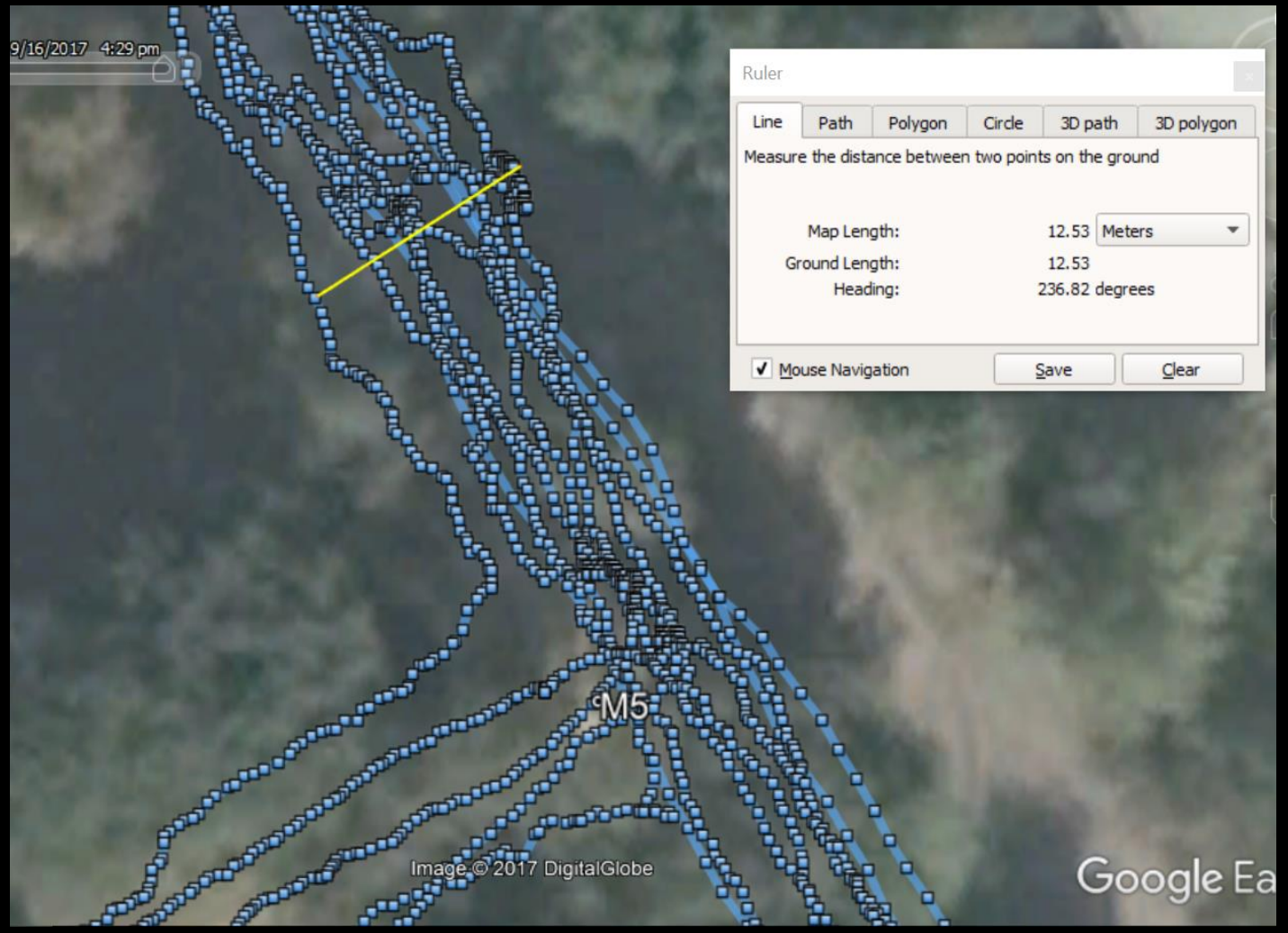
PROBLEMS

- Poor GPS performance (near service zone)
  - Incorrectly detecting pickup/dropoff points
  - impacted also compass calibration
  - => wrong calculation of navigation azimuth
- Local “traps” on roads (places for benches)
  - solution: tilt camera to look higher
- SW bug: sharp turns handled with “do nothing”
- Compass display did not work
- Robot Wifi AP failure (round2)
  - we were not able to enter GPS coordinates

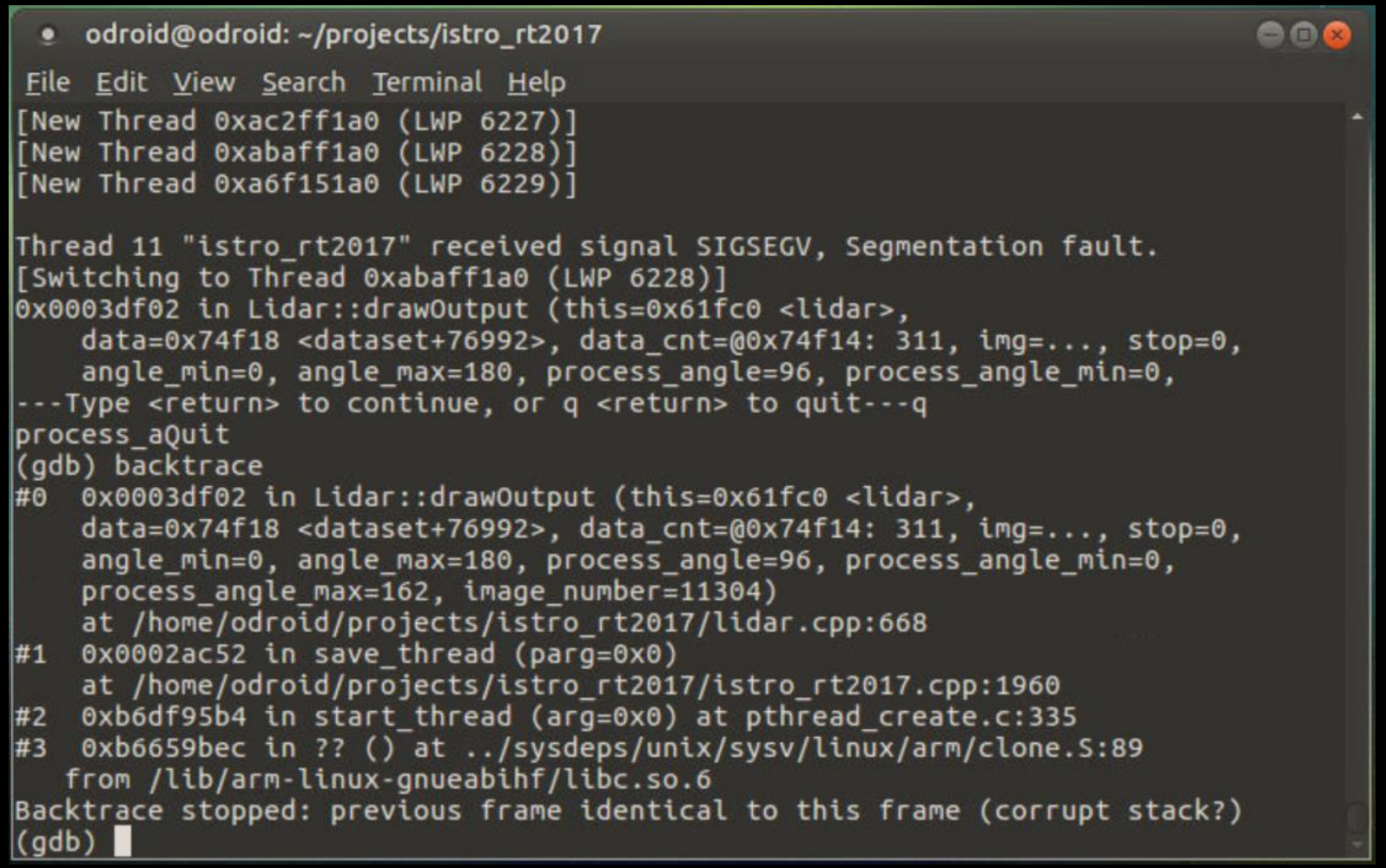
PROBLEMS – VISION FAILS DETECT ROAD

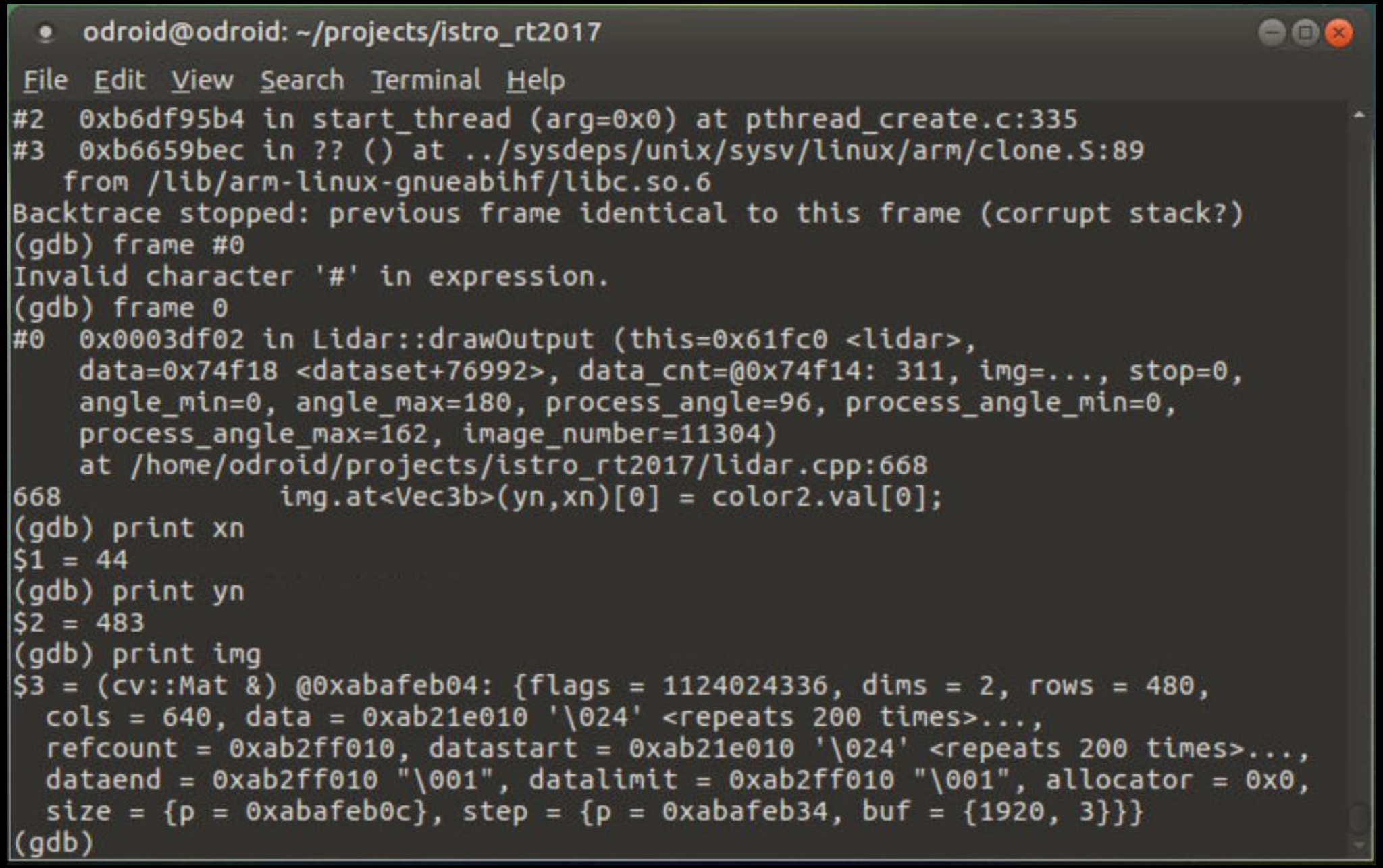


PROBLEMS – POOR GPS PERFORMANCE



PROBLEMS – SEGMENTATION FAULT




odroid@odroid: ~/projects/istro_rt2017
File Edit View Search Terminal Help
#2 0xb6df95b4 in start_thread (arg=0x0) at pthread_create.c:335
#3 0xb6659bec in ?? () at ../sysdeps/unix/sysv/linux/arm/clone.S:89
   from /lib/arm-linux-gnueabihf/libc.so.6
Backtrace stopped: previous frame identical to this frame (corrupt stack?)
(gdb) frame #0
Invalid character '#' in expression.
(gdb) frame 0
#0 0x0003df02 in Lidar::drawOutput (this=0x61fc0 <lidar>,
    data=0x74f18 <dataset+76992>, data_cnt=@0x74f14: 311, img=..., stop=0,
    angle_min=0, angle_max=180, process_angle=96, process_angle_min=0,
    process_angle_max=162, image_number=11304)
    at /home/odroid/projects/istro_rt2017/lidar.cpp:668
668   img.at<Vec3b>(yn,xn)[0] = color2.val[0];
(gdb) print xn
$1 = 44
(gdb) print yn
$2 = 483
(gdb) print img
$3 = (cv::Mat &) @0xabafeb04: {flags = 1124024336, dims = 2, rows = 480,
  cols = 640, data = 0xab21e010 '\024' <repeats 200 times>...,
  refcount = 0xab2ff010, datastart = 0xab21e010 '\024' <repeats 200 times>...,
  dataend = 0xab2ff010 "\001", datalimit = 0xab2ff010 "\001", allocator = 0x0,
  size = {p = 0xabafeb0c}, step = {p = 0xabafeb34, buf = {1920, 3}}}
(gdb)

PRACTICAL EXAMPLES

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FREE SOURCE CODES

- Sources codes are available at GitHub as public project **Istro RT:**

  https://github.com/lnx-git/istro-rt

THANK YOU