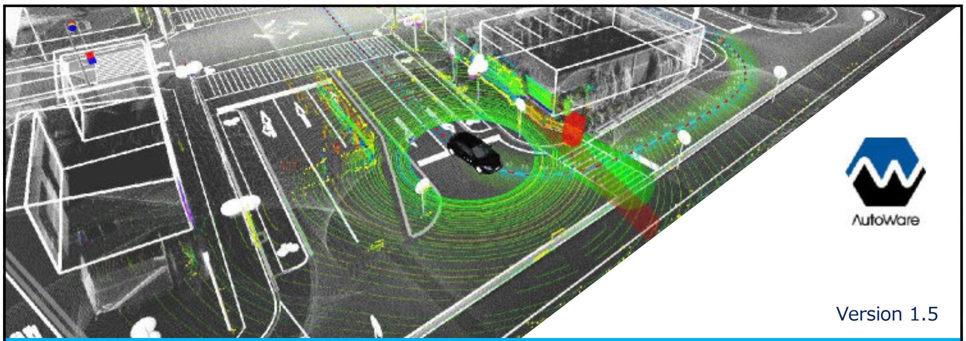


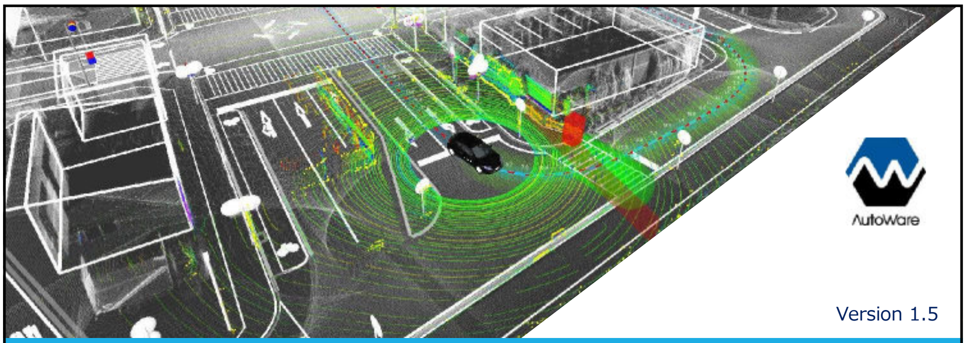
Version 1.5

Autoware in depth

Day 2
Autoware Hands-on Experience

Tier IV
Intelligent Vehicle

Table of Contents



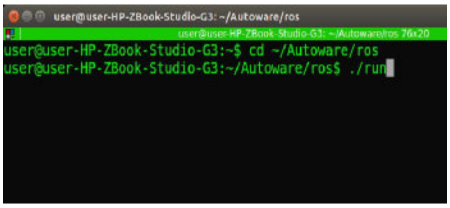
Version 1.5

Autoware Hands-on Experience

Chapter 1 : Basic operations of Autoware

Launching Autoware

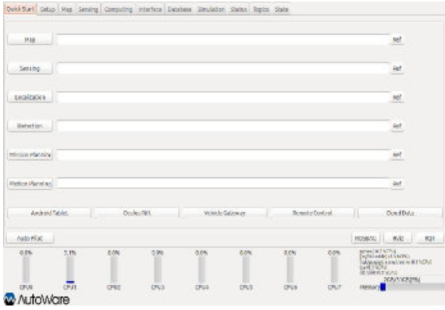
1. Open a terminal by pressing **Ctrl + Alt + T**
2. Execute “run” in a terminal using the following commands
   $ **cd ~/Autoware/ros**
   $ **./run**
3. Enter **sudo** password



Autoware GUI: **run time manager**

Autoware UI consists of **three** main parts

- Tabs
- Contents
- Status of the Machine and ROS tools

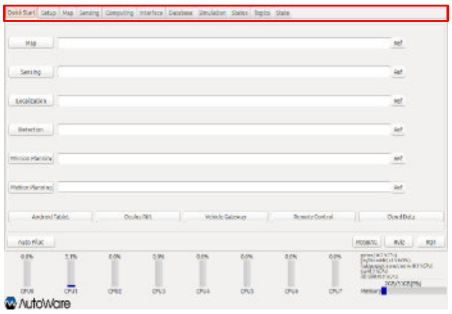


5

Autoware: Tabs

Autoware UI consists of **three** main parts

- <u>Tabs</u>
- Contents
- Status of the Machine and ROS tools

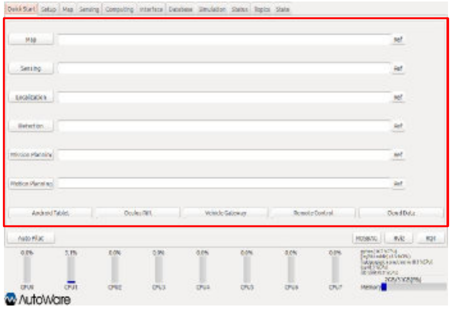


6

Autoware: Contents

Autoware UI consists of **three** main parts

- Tabs
- Contents
- Status of the Machine and ROS tools

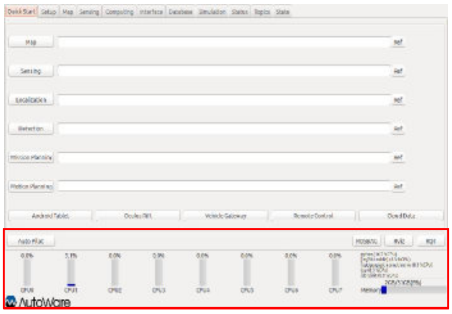


7

Autoware: Status of the Machine and ROS tools

Autoware UI consists of **three** main parts

- Tabs
- Contents
- Status of the Machine and ROS tools



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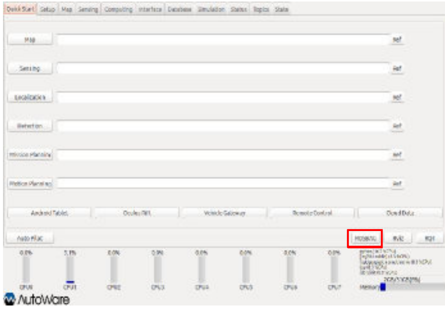
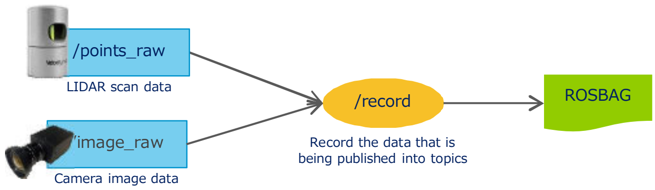
ROSBAG

- In ROS, log data of sensors and etc., can be saved into a single file called ROSBAG (or BAG) file
- The ROSBAG file format is very efficient for both recording and playback, as all the data is stored with timestamp





Tier IV

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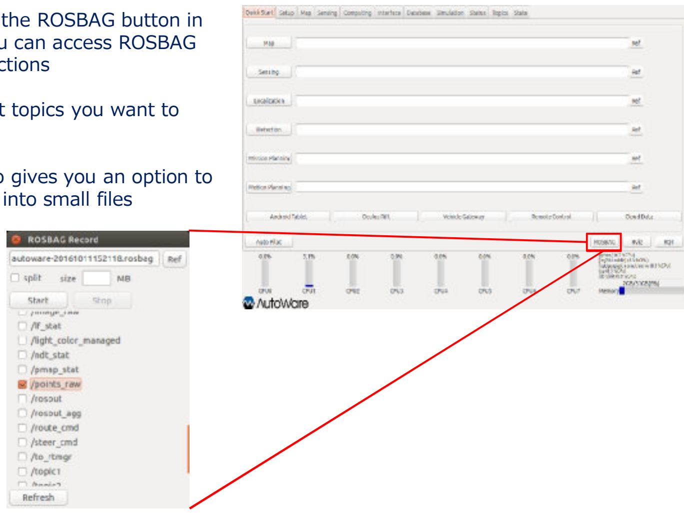
ROSBAG

- By clicking at the ROSBAG button in Autoware, you can access ROSBAG recording functions
- You can select topics you want to record
- Autoware also gives you an option to split ROSBAG into small files



Tier IV

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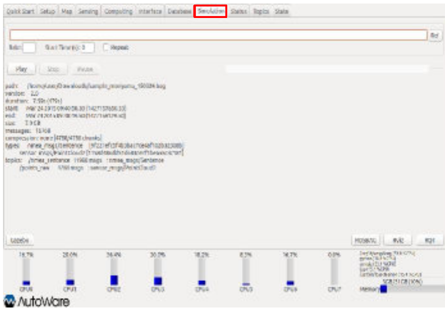
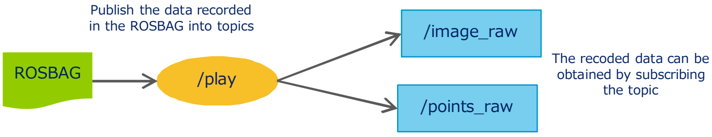
Simulation

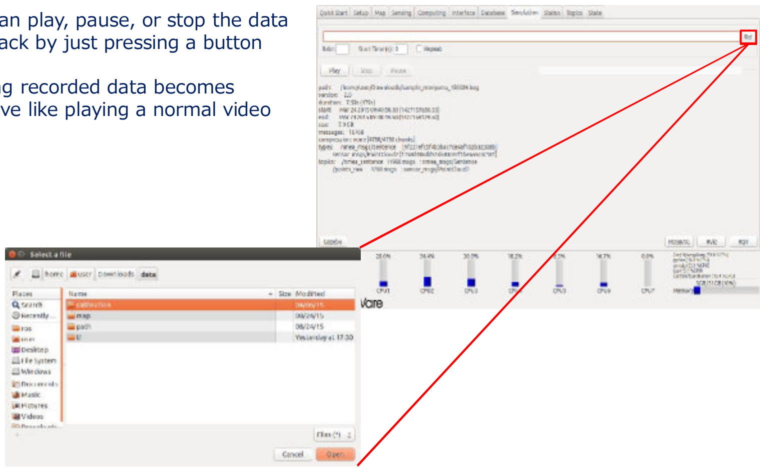
- In the simulation tab, you can find a ROSBAG playback function which lets you replay the recorded data easily
- With this simulation tool, developing a new algorithm becomes less time consuming





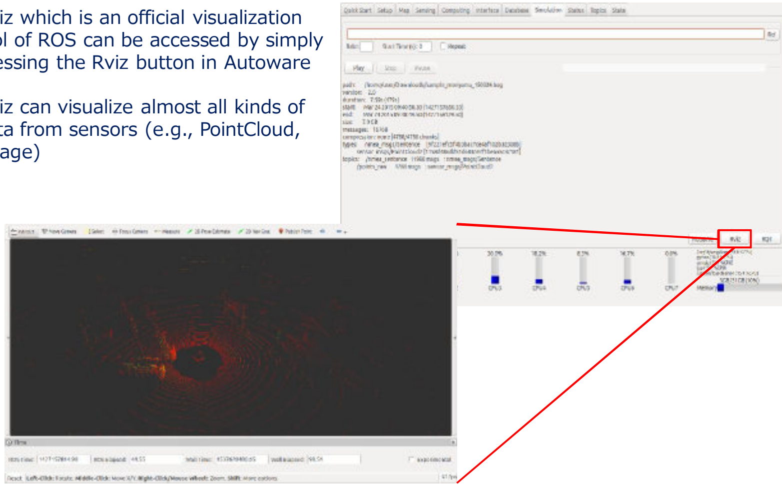
Simulation

- You can play, pause, or stop the data playback by just pressing a button
- Playing recorded data becomes intuitive like playing a normal video



RViz

- RViz which is an official visualization tool of ROS can be accessed by simply pressing the Rviz button in Autoware
- RViz can visualize almost all kinds of data from sensors (e.g., PointCloud, Image)



Tier IV

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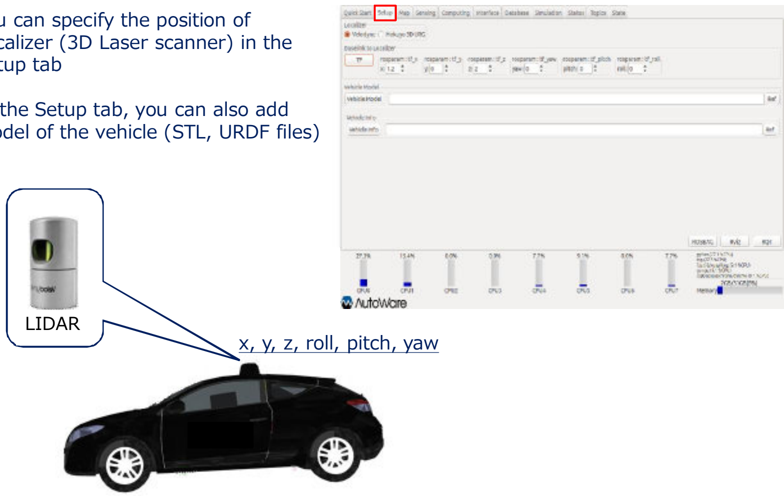
Setup

- You can specify the position of Localizer (3D Laser scanner) in the Setup tab
- In the Setup tab, you can also add model of the vehicle (STL, URDF files)



Tier IV

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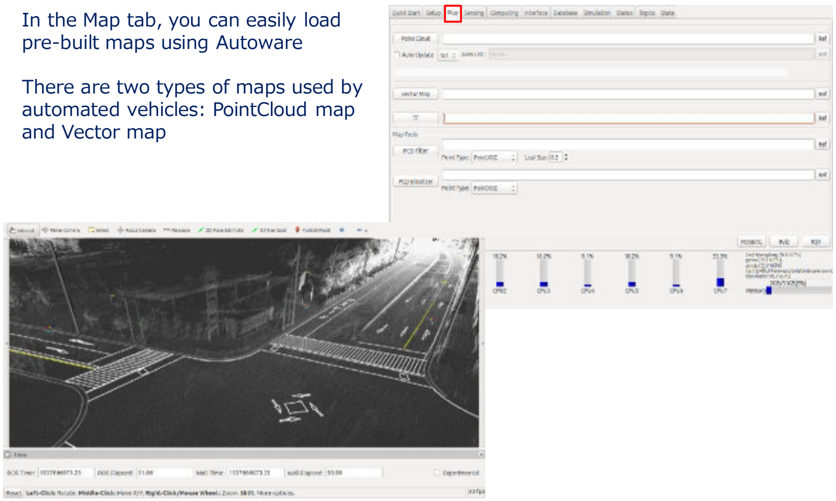
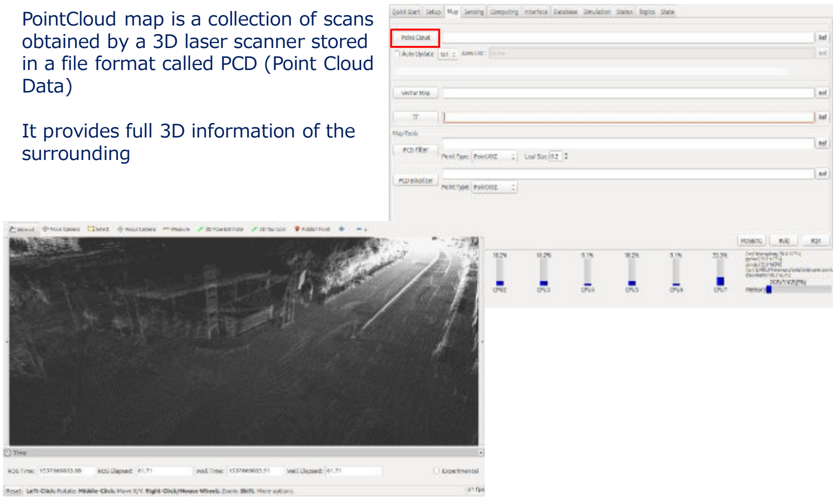
Map

- In the Map tab, you can easily load pre-built maps using Autoware
- There are two types of maps used by automated vehicles: PointCloud map and Vector map



Map: PointCloud Map

- PointCloud map is a collection of scans obtained by a 3D laser scanner stored in a file format called PCD (Point Cloud Data)
- It provides full 3D information of the surrounding



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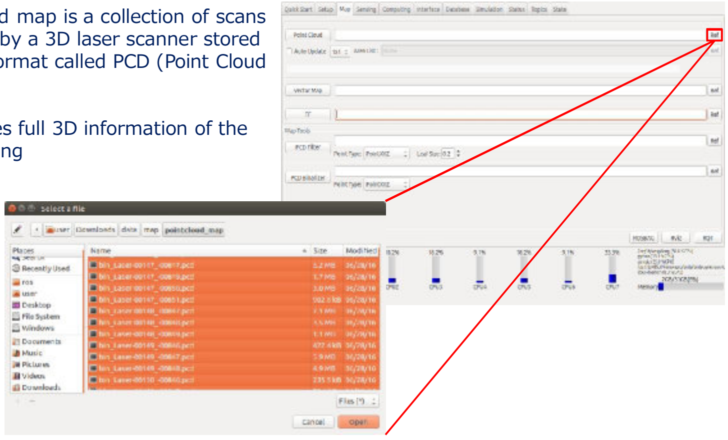

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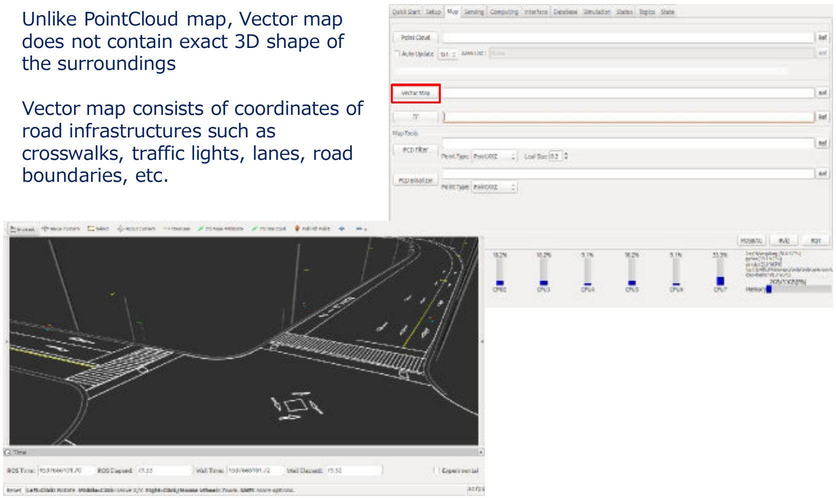
Map: Vector Map

- Unlike PointCloud map, Vector map does not contain exact 3D shape of the surroundings
- Vector map consists of coordinates of road infrastructures such as crosswalks, traffic lights, lanes, road boundaries, etc.



TierIV

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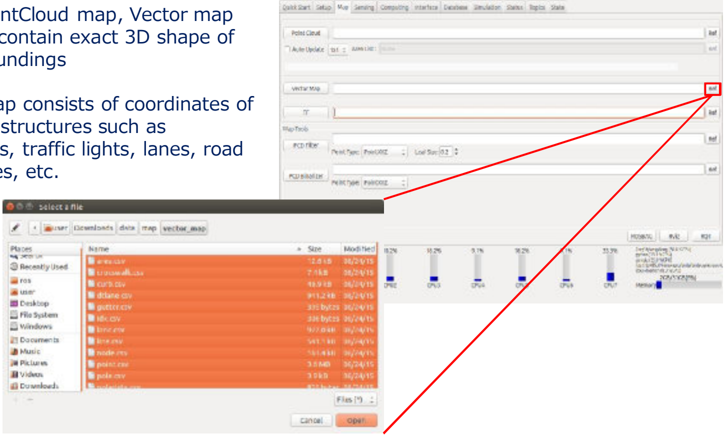
Map: Vector Map

- Unlike PointCloud map, Vector map does not contain exact 3D shape of the surroundings
- Vector map consists of coordinates of road infrastructures such as crosswalks, traffic lights, lanes, road boundaries, etc.



TierIV

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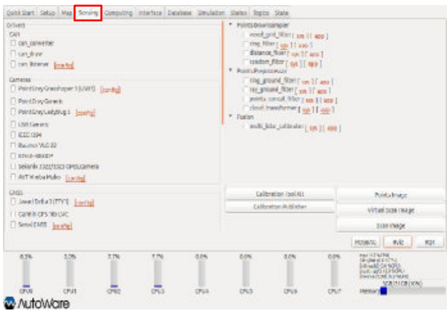
Sensing

- In the Sensing tab, there is a collection of tools for sensing process such as sensors drivers and Calibration toolkit



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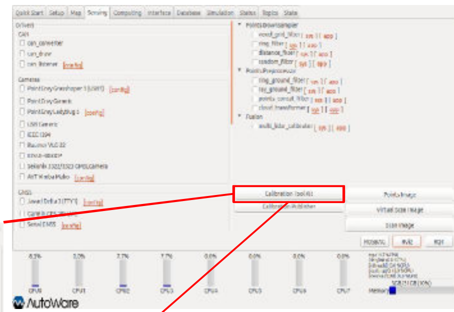
Sensing: Drivers

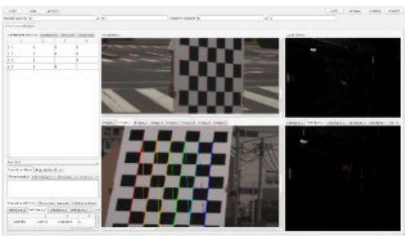
- In Autoware, drivers of many sensors are included e.g., Cameras, LiDARs, GNSS, and IMU
- By simply checking the box in front of the sensor name, the data from such sensor is ready to be visualized or recorded

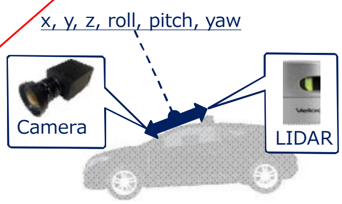
Tier IV

Sensing: Other tools

- In the Sensing tab, you can also find Calibration toolkit
- Calibration toolkit makes it easy and simple to find a relative position between Camera and LiDAR necessary for sensor fusion



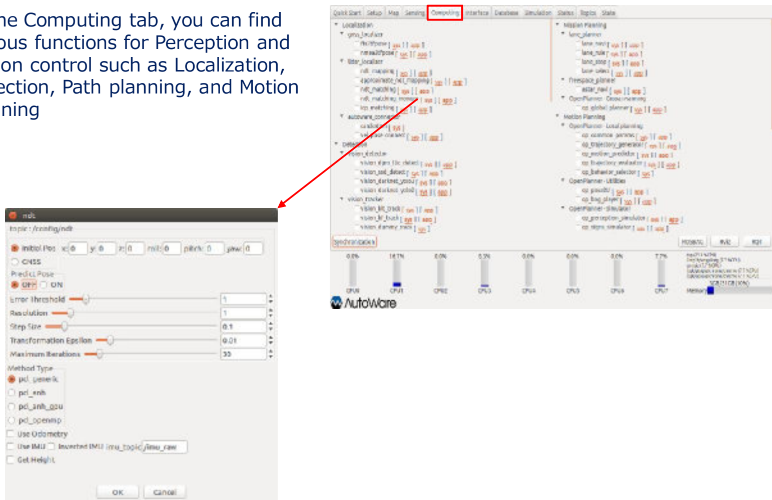




Tier IV

Computing

- In the Computing tab, you can find various functions for Perception and Motion control such as Localization, Detection, Path planning, and Motion planning



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Computing: Localization

- Autoware offers both GNSS-based Localization and LiDAR-based localization

Tier IV

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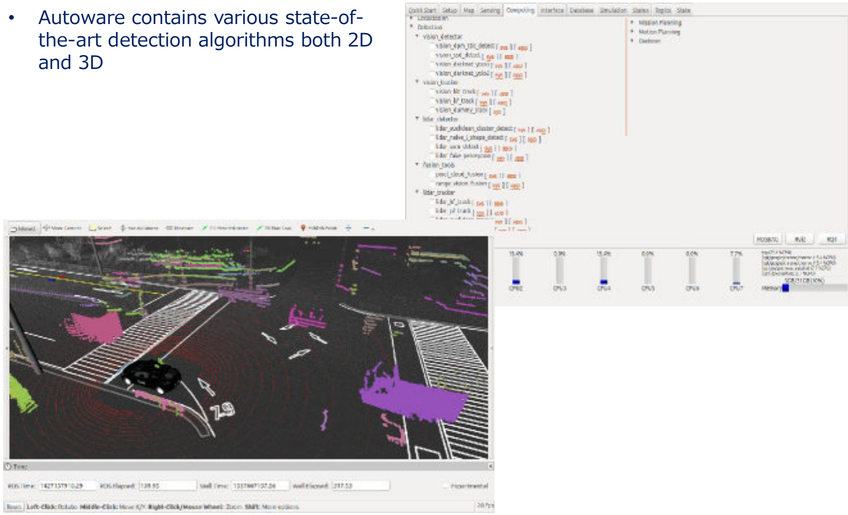
Computing: Detection

- Autoware contains various state-of-the-art detection algorithms both 2D and 3D



Tier IV

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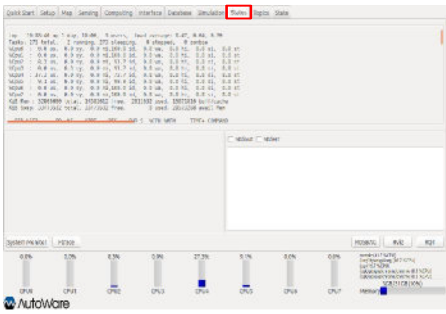
Status

- In the Status tab, you can find information of CPU status, memory status, and running processes



Tier IV

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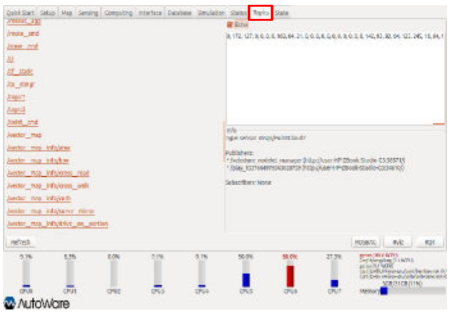
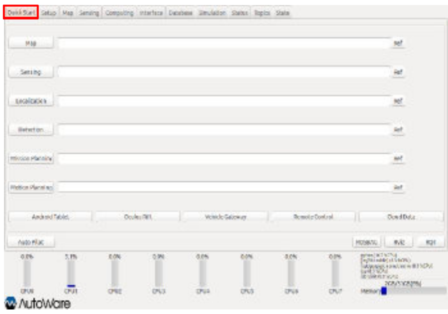
Topics

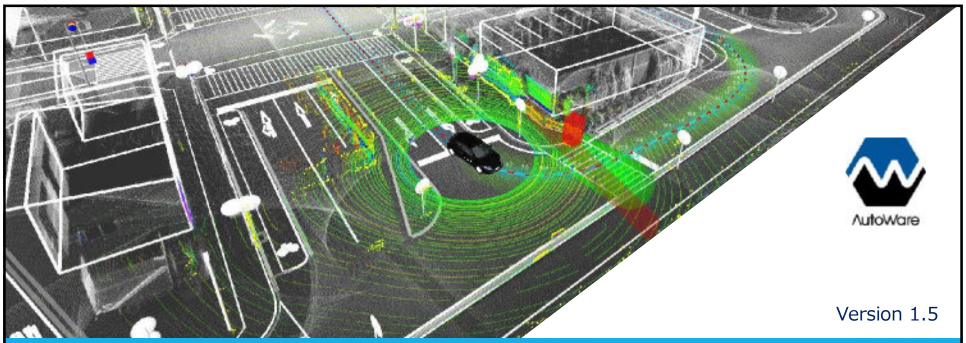
- All current ROS topics are listed in the Topics tab
- You can also show the messages in each topic by checking the Echo box



Quick Start

- All the introduced functions can also be launched in the Quick Start tab
- Once know which functions to use, you can prepare ROS launch scripts and get your vehicle ready in seconds by using the Quick Start tab





Version 1.5

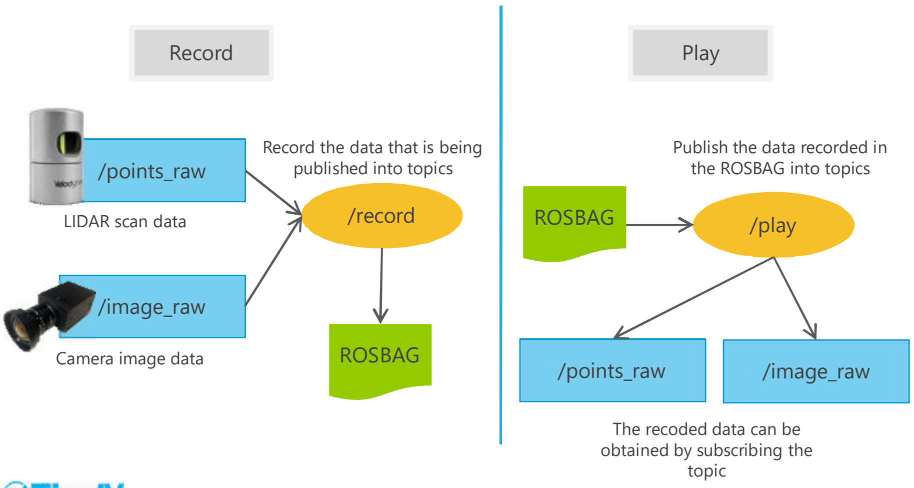
Autoware Hands-on Experience

Chapter 2 : Data Recording/Playing and Sensor Calibration

1. Data Recording/Playing

Data Recording/Playing – Overview

- In ROS, log data of sensor and etc., can be saved into a file format called ROSBAG
- Playing ROSBAG replays recorded sensor information, it can be used for simulation
- Autoware provides ROSBAG recording/playing functions in GUI



Data Recording/Playing

Rosbag: important commands

- rosbag record : write the selected topics into a log file
  - Recording specific topics
    - **$ rosbag record -O <filename.bag> <topic1> <topic2> ...**
  - Recording all topics
    - **$ rosbag record -a -O <filename.bag>**
- rosbag info : gets the list of topics and their type
  - **$ rosbag info <filename.bag>**

```
path:        for-calib-c0-traffic-c1-object.bag
version:     2.0
duration:    5:22s (322s)
start:       Sep 12 2016 11:24:28.05 (1473647068.05)
end:         Sep 12 2016 11:29:50.85 (1473647390.85)
size:        30.2 GB
messages:    8747
compression: none [6540/6540 chunks]
types:       sensor_msgs/Image          [060021388200f6f0f447d0fcd9c64743]
             velodyne_msgs/VelodyneScan [50804fc9533a0e579e6322c04ae70566]
topics:      /camera0/image_raw   3296 msgs   : sensor_msgs/Image
             /camera1/image_raw   3244 msgs   : sensor_msgs/Image
             /velodyne_packets    2207 msgs   : velodyne_msgs/VelodyneScan
```


Data Recording/Playing

- rosbag play : read (play) a bag file
  - reads the data and publishes the topics
    - **$ rosbag play <filename1.bag> <filename2.bag> ...**
  - clock: gets the clock source from the log file
    - $ **rosbag play --clock <filename.bag>**

    Remember to set the /use_sim_time ROS parameter ***before hand***

    $ rosparam set use_sim_time true
  - Play from the specified starting time
    - $ **rosbag play -s <seconds> <filename.bag>**
  - How to pause
    - Space key
  - Play just once
    - s key

Data Recording/Playing

- rosbag filter : keep the specified topics and re-write the file
  - **$ rosbag filter <before.bag> <after.bag> "topic == '/topic_name'"**

- rosbag reindex : fix a broken/incomplete bag file, fix the indexing
  - **$ rosbag reindex <filename.bag>**
    - The original bag file is renamed (for copy) as filename.orig.bag and the recoverd file will have the original name
  -

Data Recording – Steps (1/2)

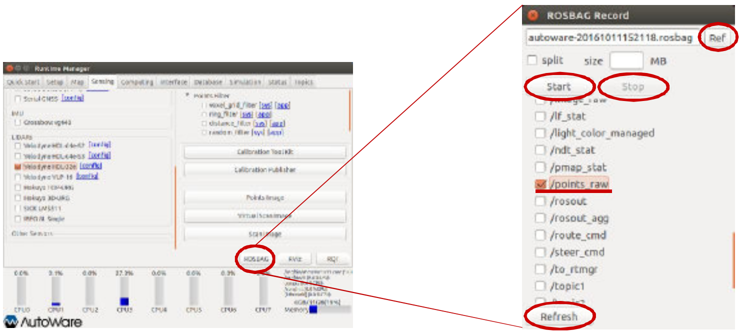
- Publish topics to be recorded

1. Launch Autoware
   A) Execute "run" on a terminal as follows (alternatively, click on the "run" script on a file manager) :
   $ cd ~/Autoware/ros/
   $ ./run

2. Launch ROS nodes by checking (☑) the boxes, this will publish ROS topics that can be recorded
   - i.e. [Velodyne HDL-32e]: this node publishes Velodyne data to /points_raw topic

Data Recording – Steps (2/2)

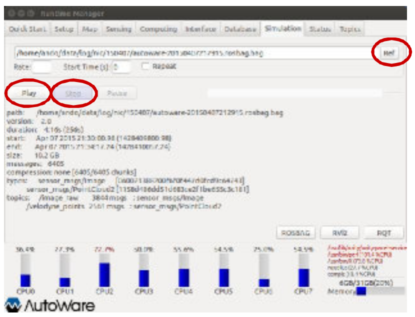
- ROSBAG recording
  - A) Display a dialog by clicking [ROSBAG] button
  - B) Click [Ref] button, and then specify the filename of the ROSBAG to be saved
  - C) Click [Refresh] button
  - D) Check (☑) the boxes of ROS topics to be recorded
  - E) Click [Start] button to start recording the selected topic
  - F) Click [Stop] button to end the recording

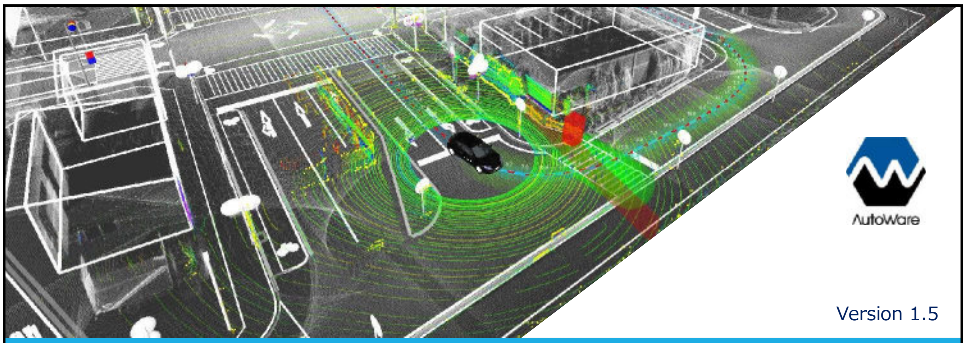


Data Playing – Step

- ROSBAG playing

1. Playing a bag file in [Simulation] tab
   - A) Open [Simulation] tab
   - B) Click [Ref] button, and then specify the bag file to play
   - C) Click [Play] button to play back the contents of the bag file
     - ➢ The ROS parameter [/use_sim_time] is set to [true] automatically
   - D) Click [Pause] button to pause/resume the playback
   - E) Click [Stop] button to stop the playback
     - ➢ The ROS parameter [/use_sim_time] is set to [false] automatically





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Autoware Hands-on Experience

Chapter 1 : Data Recording/Playing and Sensor Calibration

2. Sensor Calibration

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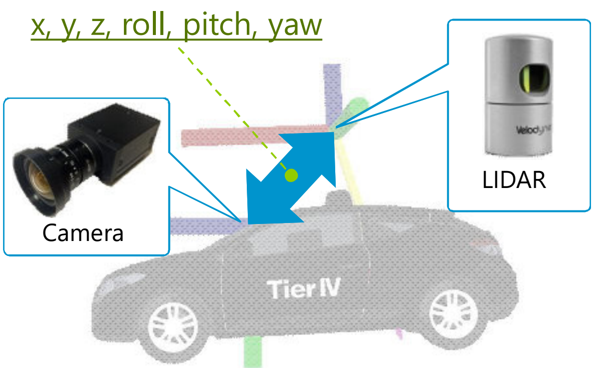
Sensor Calibration – Overview

- Calculate relative position relation (i.e., x, y ,z, roll, pitch, yaw) of the LIDAR and the camera mounted on vehicle
- Both of the LIDAR data and the camera data can be fused by utilizing the relative position between them
  - The LIDAR scan data is projected on the camera image
- A checkerboard is used to calibrate both sensors



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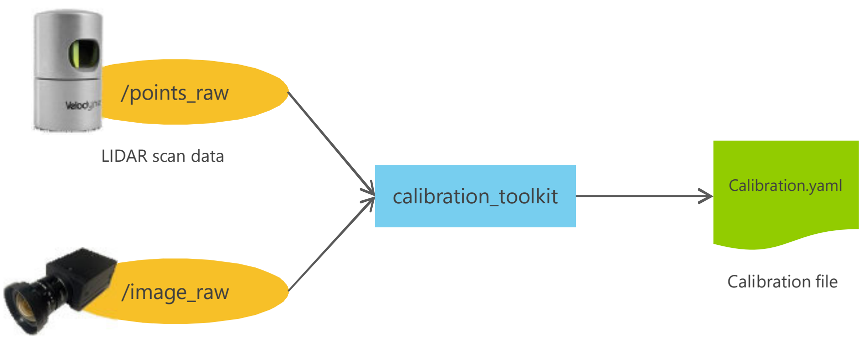
Sensor Calibration – Structure



Sensor Calibration – Steps (1/4)

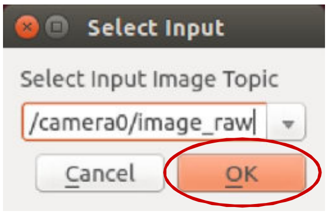
- Launch tools
  - In this slide, a calibration file is generated by using a ROSBAG that contains "/points_raw" and "/image_raw"

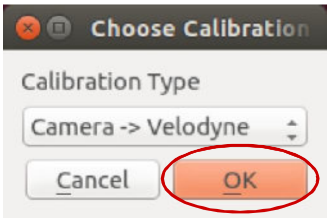
1. Play/Stop ROSBAG
   A) Click [Play] button in [Simulation] tab, and then click [Pause] button
      - If the ROSBAG includes "/velodyne_packets" instead of "/points_raw", launch Velodyne Driver following the steps described in p.18

2. Launch Calibration Toolkit
   A) Click [Calibration Toolkit] in [Sensing] tab

Sensor Calibration – Steps (2/4)

- Data source selection

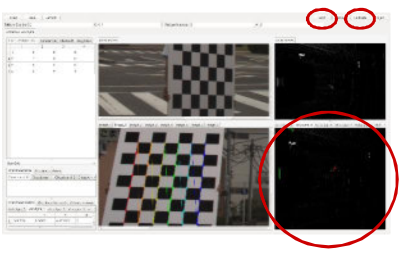




3. Select data source for calibration
   A) Select a camera topic for calibration
      - Here, select "/camera0/image_raw"
   B) Select calibration type
      - Since this example uses the relative position between the camera and the Velodyne, select [Camera->Velodyne]

Sensor Calibration – Steps (3/4)

- Run data grab and calibration

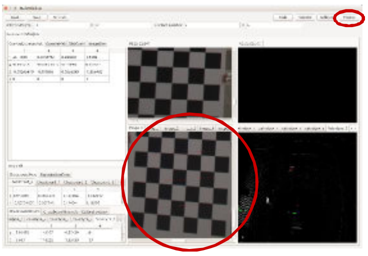


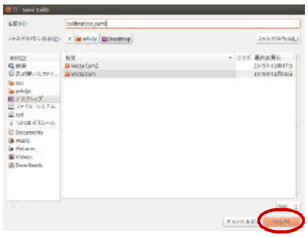
Move: ↑,↓,→,←,PgUp,PgDn
Rotate: a,d,w,s,q,e
Point size: o(decrease), p(increase)
Change background color: b

4. Press Grab to capture data from both sensors
   A) Confirm that a camera image (upper-left) and LIDAR (upper-right) data are displayed, then click [Grab] button
5. Select grabbed data points that are projected on the checkerboard
   A) Click LIDAR scan projected on the checkerboard from the right-bottom window
      - Conduct this step as many times as the number of grabbed frames.
6. Calibration
   A) Click [Calibrate]
   B) Confirm that the parameters of calibration are updated on the table shown in the left window

Sensor Calibration – Steps (4/4)

- Run data grab and calibration



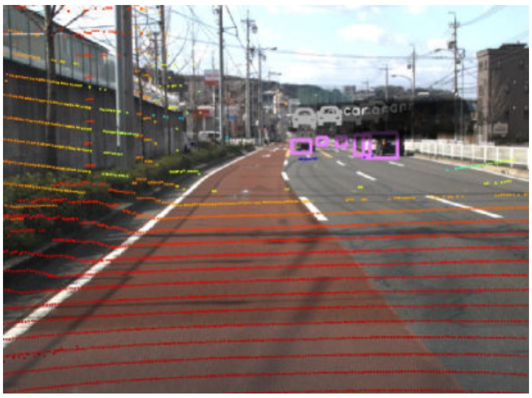


7. Pointcloud projection
   - A) Click on the "Project" button
   - B) Confirm that the points selected with grab are projected onto the image
8. Save file
   - A) Click [Save] button
   - B) Select the file name, the directory, and then click the [Save] button

Camera-LiDAR Fusion

Sensor fusion comes at a cost: we need **sensor calibration**:
1. Camera Intrinsic Calibration (image rectification)
2. Lidar-Camera Extrinsic Calibration

We need to be able to **correlate lidar data and image data**

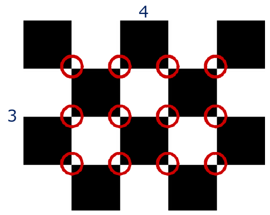


Camera Extrinsic Calibration

This tool is not yet available in GUI, must launch from terminal.
- cd ~/Autoware/ros/
- source devel/setup.bash
- rosrun autoware_camera_lidar_calibrator cameracalibrator.py --square 0.1 --size MxN image:=/image_raw

There are several parameters based on your setup:
- --square is the size of chessboard square in meters
- --size is chessboard size, as in number of inner square corners
- image:= image topic (needs to be published)
- --detection cv2 or matlab, matlab is more reliable but cv2 is open-source.

If launched correctly, the GUI should pop-up with image being displayed.



--size 4x3

Tier IV

Camera Intrinsics Calibration

Intrinsics camera calibration GUI

Tier IV

Camera Extrinsics – Launch Calibration

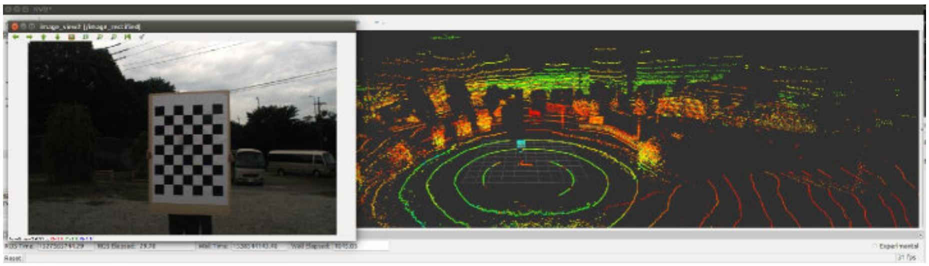
Launching the extrinsic calibration node is also through command line:

- roslaunch autoware_camera_lidar_calibrator camera_lidar_calibration.launch intrinsics_file:=camera_intrinsic_calibration.yaml image_src:=/image

Some parameters to specify:

- instrinsic_file: the output of the intrinsic calibration
- image_src: the image topic name

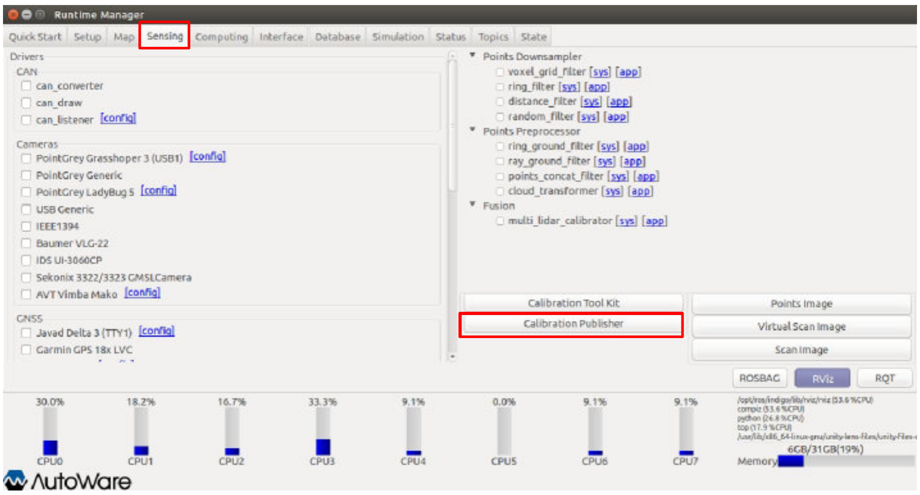
Then you can set up Rviz to see the image and pointcloud side by side.



TierIV

Step 1 – Load in Calibration File

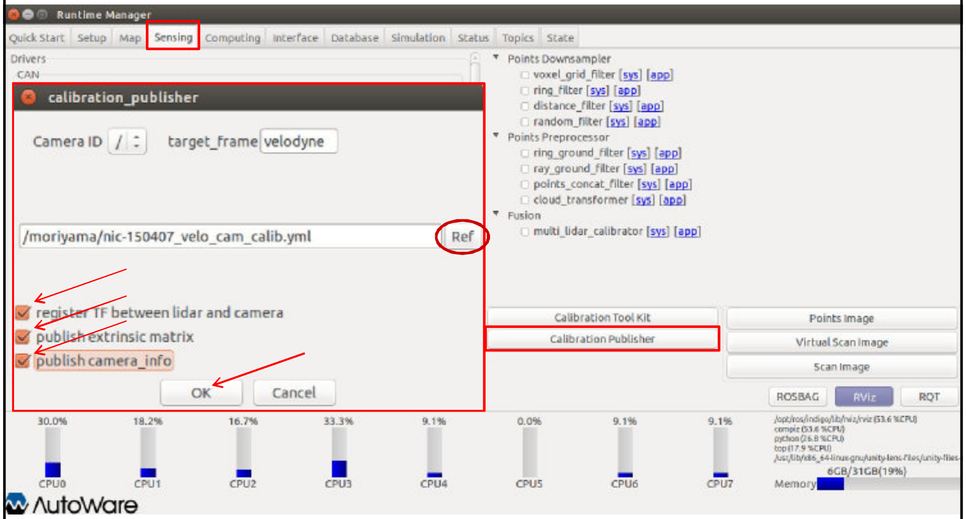
Go to the Sensing tab and click on the Calibration Publisher



TierIV

Step 1 – Load in Calibration File

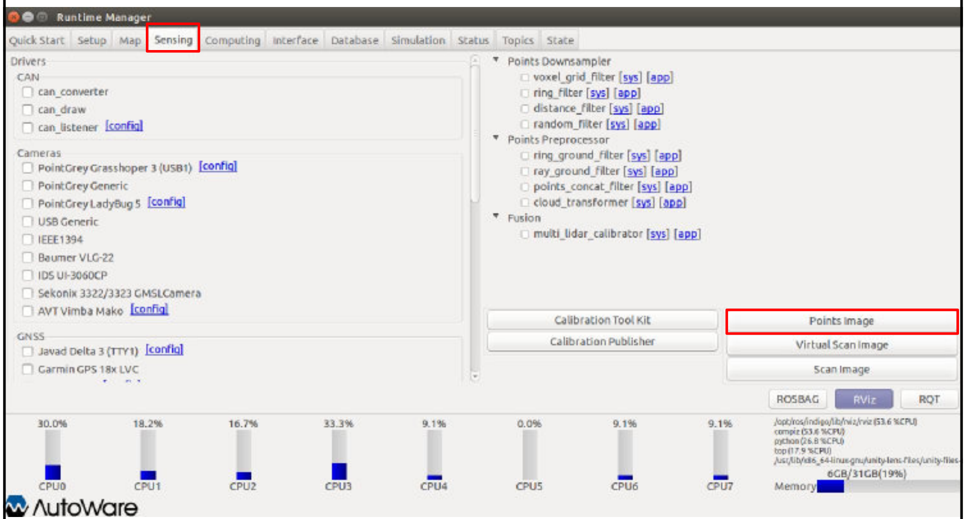
Load in the calibration file, click all checkboxes and click OK



TierIV

Step 2 – Create the points_image

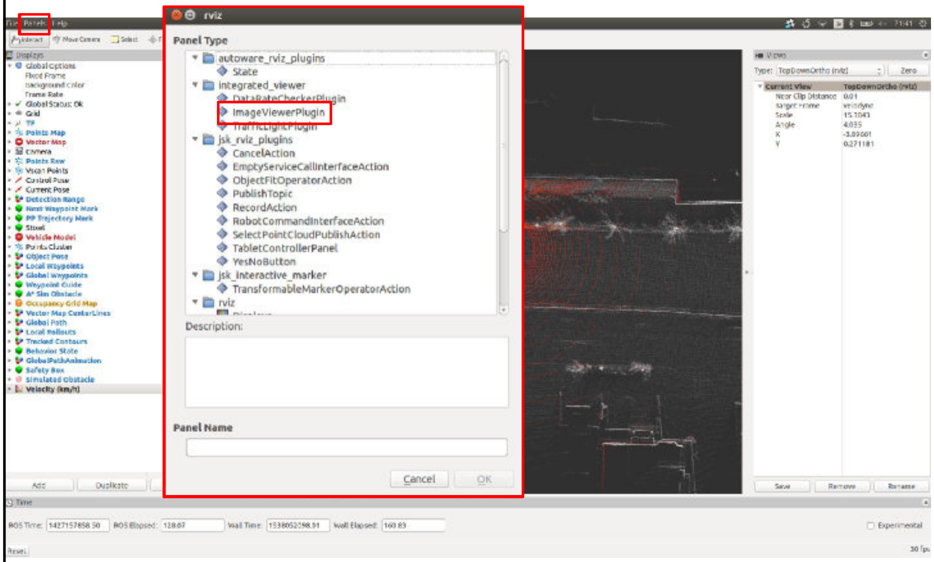
Click the Points Image button and OK



TierIV

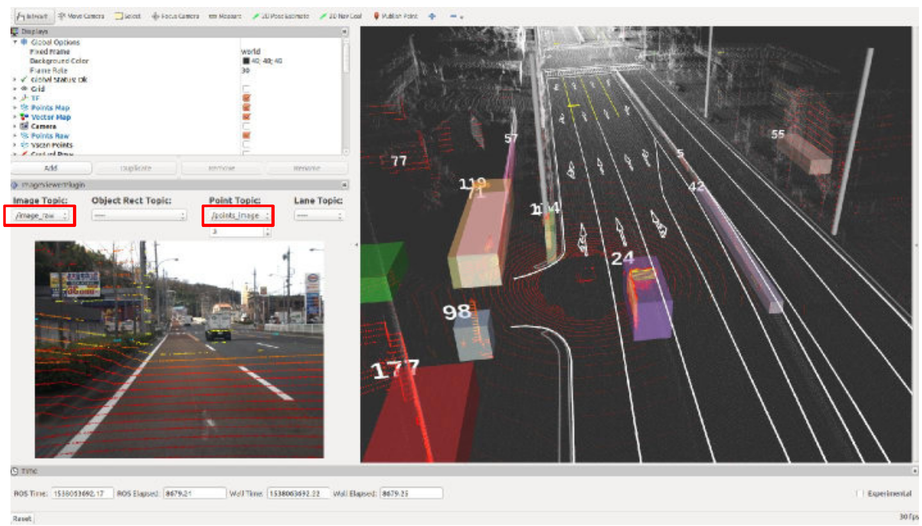
Step 3 – Visualize LiDAR points in Camera image

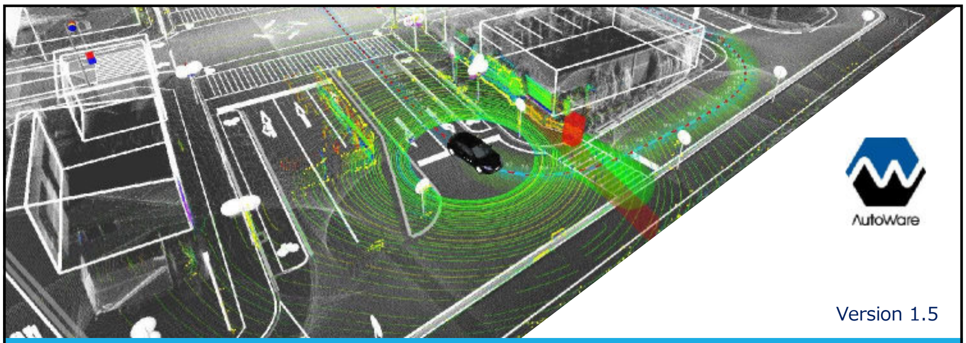
On RVIZ taskbar click Panels -> Add New Panel -> ImageViewerPlugin



Step 3 – Visualize LiDAR points in Camera image

Set the image topic to **/image_raw** and point topic to **/points_image**





Version 1.5

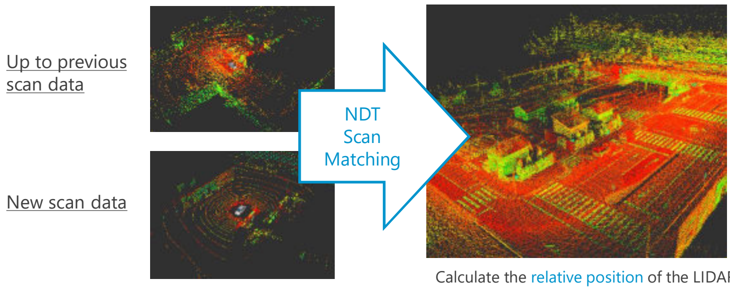
Autoware Hands-on Experience

Chapter 3：3D Map Generation and Localization

1. 3D Map Generation

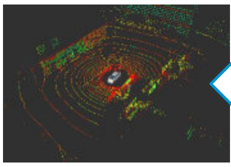
3D Map Generation – Overview

- Generate 3D map from LIDAR scan data
- Localize the vehicle position with the help of NDT scan matching, and then add the scan data to the initial 3D map
  - The larger the map data, the longer the calculation time required for localization. The 3D map is generated by recording and then playing LIDAR points on the initial 3D map
- 3D map is down-sampled with the help of Voxel Grid filter. Finally, the down sampled map is stored in a PCD file.
- If the size of map is large, the error in the 3D map may also be large.

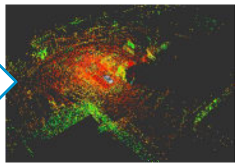


Calculate the relative position of the LIDAR from matching result of both scan data, and then add the new scan data to the 3D map

3D Map Generation – Structure



NDT
Scan Matching



x,y,z,ring,intensity

/points_raw → /ndt_mapping → /ndt_map → PCD

/ndt_mapping → /current_pose

cloud nodelet → /points_raw

/velodyne_packets → cloud nodelet

/velodyne_packets

Velodyne raw data

/current_pose

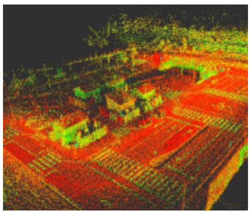
Localization

/ndt_map

Generated 3D map

PCD

Down-sampling by VoxelGrid Filter



Tier IV

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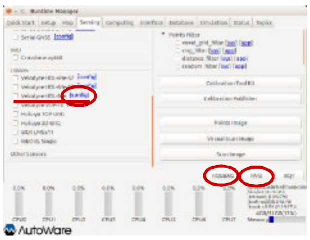
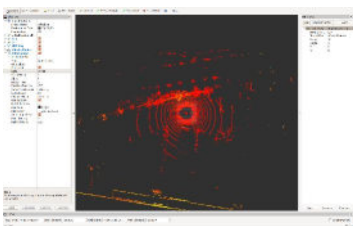
3D Map Generation - Steps (1/5)

- ROSBAG validation



1. Record LIDAR scan data into a ROSBAG
   A) Launch Velodyne HDL-32e driver (a ROS node)
      - Click [config] on [Velodyne HDL-32e] in [Sensing] tab, and specify the following file: Autoware/ros/src/sensing/drivers/lidar/packages/velodyne/velodyne_pointcloud/params/32db.yaml
      - Check (☑) the box of [Velodyne HDL-32e]



   B) Confirm the ROSBAG data on RViz by clicking [Rviz] button
      - Click [File] - [Open Config], and then open the following file: Autoware/ros/src/.config/rviz/ndt_mapping.rviz
      - Change [Fixed Frame] on [Global Options] in RViz to [velodyne]
      - Confirm that [Points Raw] is being displayed

Tier IV

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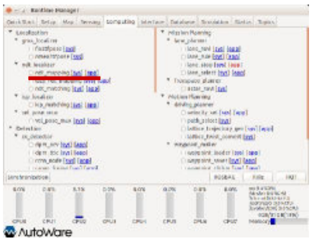
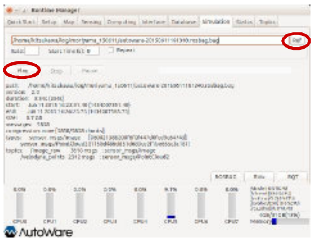
3D Map Generation - Steps (2/5)

- 3D map generation

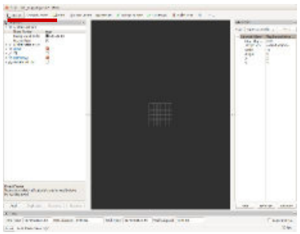


2. 3D map generation while playing LIDAR points
   A) Launch the map generation node [ndt_mapping]
      - Launch [ndt_mapping] by checking (☑) the box in [Computing] tab

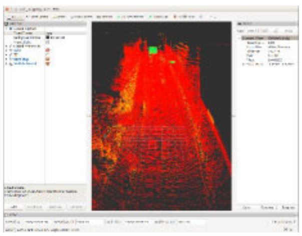


   B) ROSBAG playback
      - Click [Ref] on [Simulation] tab, and specify the ROSBAG recorded scan data
      - Click [Play] to playback

3D Map Generation - Steps (3/5)



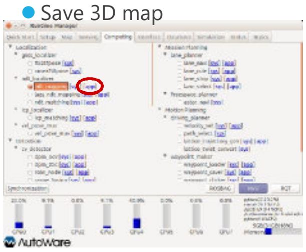
C) Change [Fixed Frame] on [Global Options] in RViz to [map]



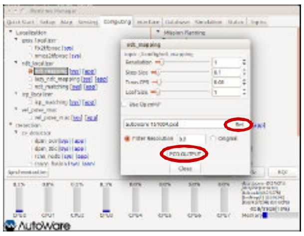
D) With the help of RViz confirm that the 3D map is being generated

3D Map Generation - Steps (4/5)

- Save 3D map



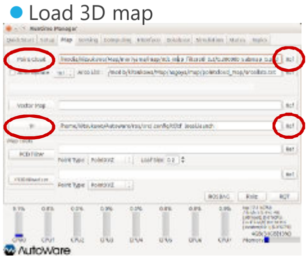
3. Save 3D map in a PCD file after generating the 3D map
   A) Open [Config] window by clicking [app] on [ndt_mapping] in [Computing] tab



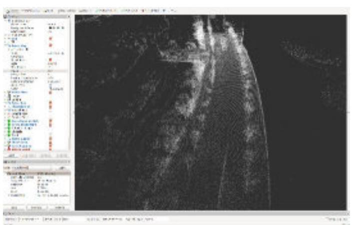
   B) Click [Ref], specify the directory and the filename to save the map into a PCD file
   C) Specify sampling parameter [Filter Resolution] (default: 0.2) for 3D map, and click [PCD OUTPUT] button to start saving
   D) Confirm the file exists in the specified directory

3D Map Generation - Steps (5/5)

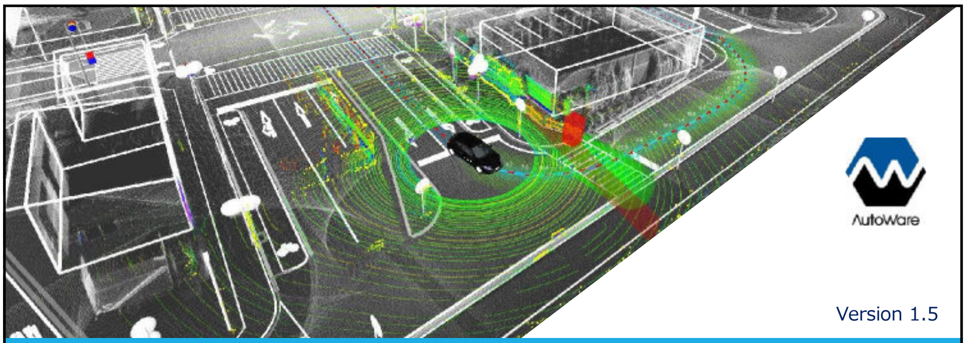
- Load 3D map



1. Load generated 3D map
   A) Click on “Map” tab, then on ref button. Select your PCD map file. Then press “Point Cloud” button.
2. Load the map TF
   A) Click on “Map” tab, then on ref button. Select your tf launch file and press “TF” button.
      - Example (default): ~/Autoware/ros/src/.config/tf/tf_local.launch



3. Use RVIZ to confirm your map
   A) Start RVIZ
   B) From the File -> Open config menu, select: Autoware/ros/src/.config/rviz/default.rviz
   C) The map will be displayed



Version 1.5

Autoware Hands-on Experience

Chapter 3：3D Map generation and Localization

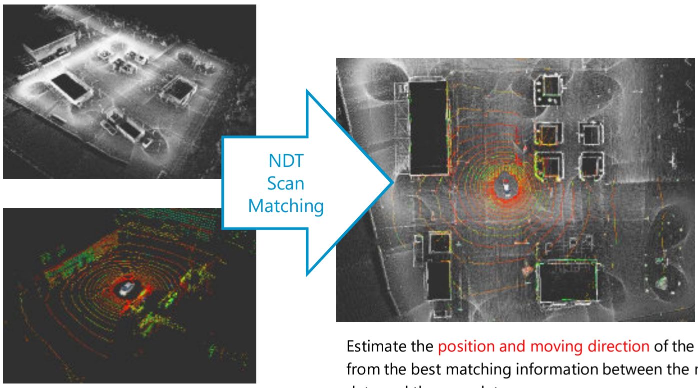
2. Localization

Localization – Overview

- Calculate self-position (the position and the direction in the map) by scan matching with LIDAR scan data and a 3D map
- Specify the initial localization position either using the RViz button [2D Pose Estimate], GNSS data or known map coordinate values
- Voxel Grid filter node is required by localization node

Map data

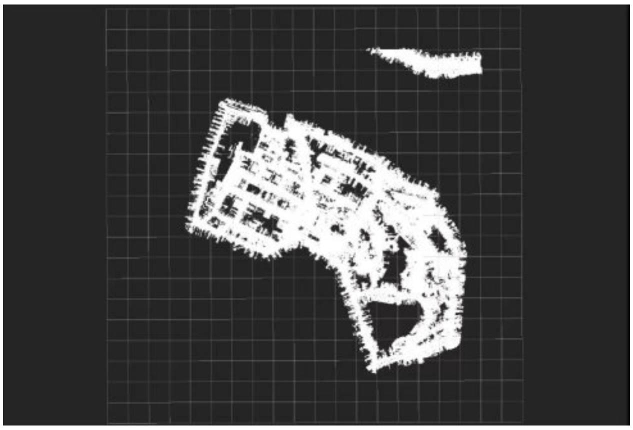
Scan data



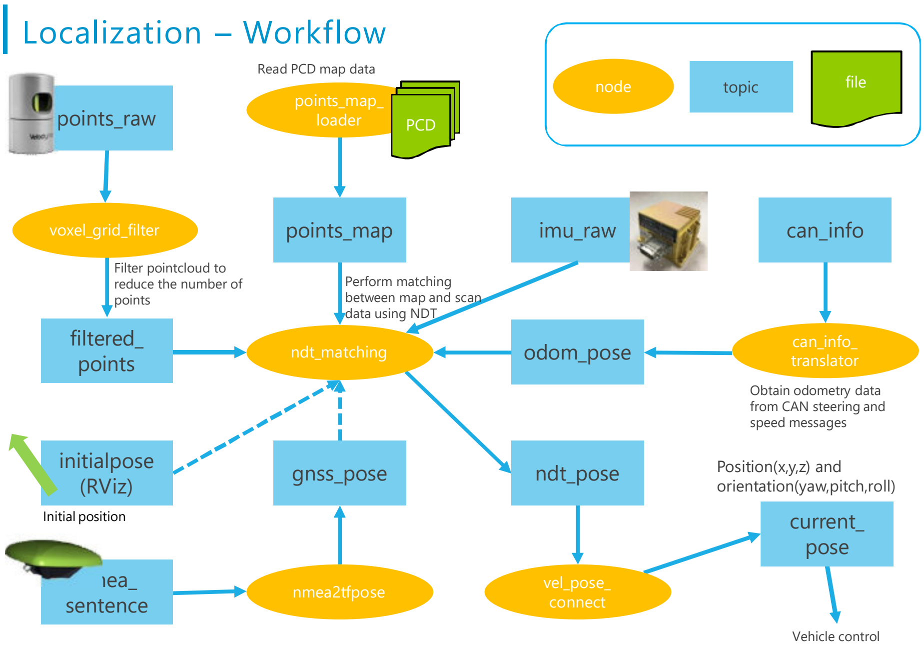
Estimate the position and moving direction of the vehicle from the best matching information between the map data and the scan data

Localization – Overview

- Calculate self-position (the position and the direction in the map) by scan matching with LIDAR scan data and a 3D map
- Specify the initial localization position either using the RViz button [2D Pose Estimate], GNSS data or known map coordinate values
- Voxel Grid filter node is required by localization node

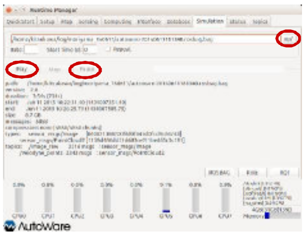


Localization – Workflow

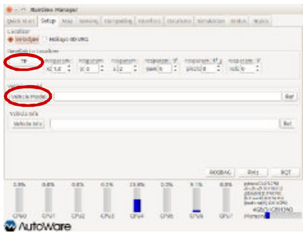


Localization – Steps (1/5)

- Specifying simulation time, TF, and vehicle model



1. Turning Simulation Time "ON"
   A) Select a ROSBAG file in [Simulation] tab for localization. Click [Play], and then click [Pause].
      - This operation automatically sets use_sim_time of ROS Param to "ON"



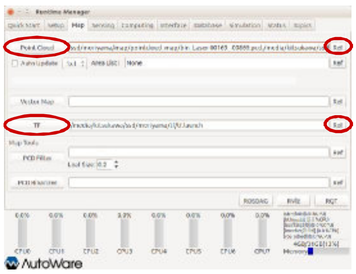
2. TF set and vehicle model loading
   A) Select [Velodyne] on [Localizer] in [Setup] tab
   B) Specify the relative position between the vehicle control position and the Velodyne on [Baselink to Localizer] as follows:

      Specify x:1.2, y:0, z:2.0, yaw:0, pitch:0, roll:0, and then click [TF]

   C) Click [Vehicle Model]
      - If no file is specified, default model is loaded

Localization – Steps (2/5)

- Map data loading



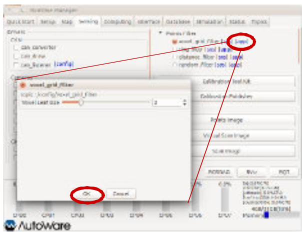
3. Point cloud map loading
   A) Click [Ref] of [Point Cloud] in [Map] tab, specify the PCD file generated by map generation
   B) Click [Point Cloud] button

4. Specify the TF representing the position of the map data
   A) Click [Ref] on [TF] in [Map] tab and specify "tf_local.launch"
   B) Click [TF] button
      - This operation publishes TF between world frame and map frame

Localization – Steps (3/5)

- Map data Loading

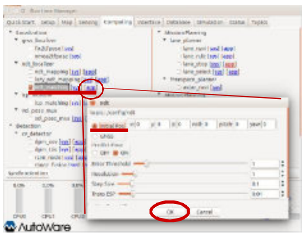
5. Down-sampling scan data
   - A) Launch [voxel_grid_filter] in [Sensing] tab by checking (☑) the box



   - B) Click [app], specify [Voxel Leaf Size] (default: 2.0) in the shown window, and then click [OK]

Localization – Steps (4/5)

- Localization



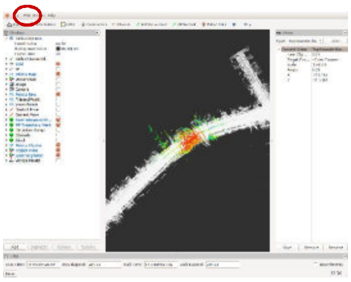
6. Localization
   - A) Launch [ndt_matching in [Computing] tab by checking ☑ the box
   - B) Click [app], and specify [Initial Pos] (e.g., all 0) in the displayed window

     Or, select GNSS to use global positioning if your rosbag or driver has NMEA sentences
   - C) Click [OK]
     - Initial localization position can be specified on [2D Pose Estimate] in [Rviz]

7. ROSBAG playback
   - A) Click [Play] button in [Simulation] tab

Localization – Steps (5/5)

- Localization



8. Displaying the result on RViz
   A) Launch Rviz, and then specify "Autoware/ros/src/.config/rviz/default.rviz" in [File]->[Open Config]
   B) Confirm that the map and the scan data are overlapped

Localization – Coordinate transformation

- Localization

world
Is the starting coordinates system

↓ TF in the Map tab

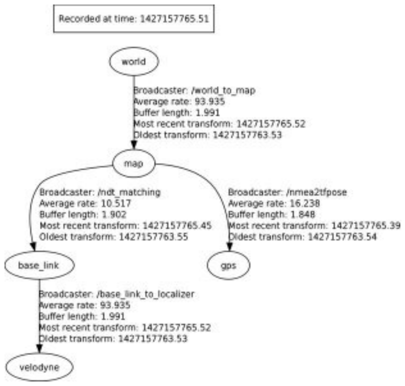
map
Map coordinates (origin: rectangular plane in world system)

↓ ndt_matching

base_link
Car coordinate system (origin: the center of the rear axle)

↓ TF in the Setup tab

velodyne
Velodyne coordinates (origin: the position of velodyne on car)



TF Tree obtained from RQT

Parameters configuration

Parameters related to mapping and localization and their performance

1. Scan downsampling (localization)
   - ✓ VoxelGrid Filter
   - ✓ Ring Filter
   - ✓ Distance Filter
   - ✓ Random Filter
2. NDT parameters (localization, mapping)
   - ✓ Resolution
   - ✓ Step Size
   - ✓ Transformation Epsilon
   - ✓ Maximum Iterations
3. Selection of points (mapping)
   - ✓ Minimum Scan Range
   - ✓ Minimum Add Scan Shift
4. Map post-processing (mapping)
   - ✓ Leaf Size

Parameters configuration: scan downsampling

Downsampling methods

- VoxelGrid Filter
  - Approximation to center of mass of voxel
- Ring Filter
  - Filter scan rings + VoxelGrid Filter
- Distance Filter
  - Sampling using weights proportional to distance squared
- Random Filter
  - Sampling based on fixed intervals

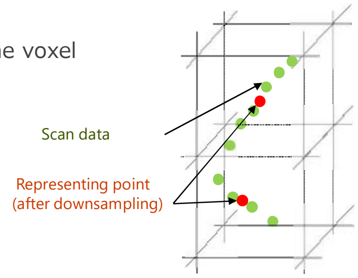
Reasons for downsampling

- ✓ Reducing the number of points, accelerates the matching calculation
- ✓ Mitigates the effect of obstacles not existing in the map (like cars, people)

Parameters configuration: scan downsampling

VoxelGrid Filter

✓Use the centroid to represent all points on the voxel
✓Can change the voxel size
✓The number of points after downsampling is relative to the scanning space
✓Mitigates the effect of unknown objects



Distance Filter

✓Weights proportional to square of distance
<u>prefers far points、reduces number of close points</u>
(In a LiDAR the points at close range have higher density)
✓Is possible to define the number of points

Random Filter

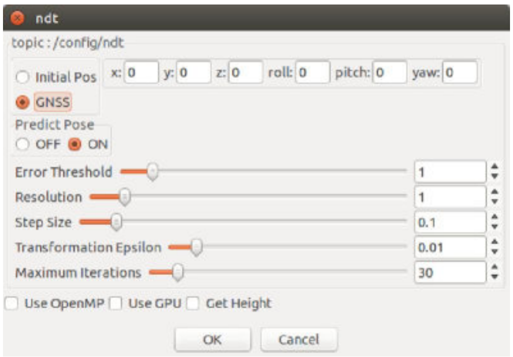
✓Sampling based on fixed interval
(Neighboring points become dense)

Parameters configuration: scan downsampling

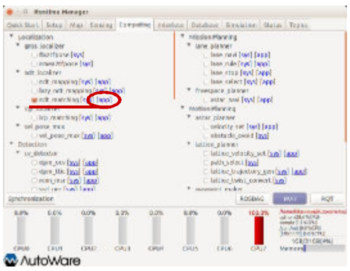
1. Play some rosbag including velodyne data
~/log/drive/moriyama/20150324.bag
2. Start RVIZ
(Set the Fixed Frame to velodyne, add the /filtered_points topic)
3. On the Sensing tab go to Points Downsampler
4. For every app on this node, configure the parameters
5. Verify how each downsampling affect the scan data

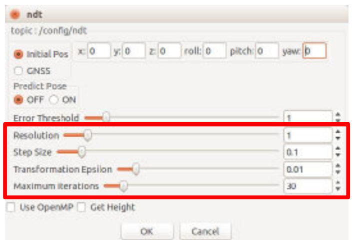
Parameters configuration: NDT

- Resolution : NDT cell size of map data （default: 1.0）
- Step Size : Step width for the Newton method iteration（default : 0.1）
- Transformation Epsilon : convergence condition for iteration （default : 0.01）
- Maximum Iterations : Maximum number of iterations（default : 30）



Parameters configuration: NDT





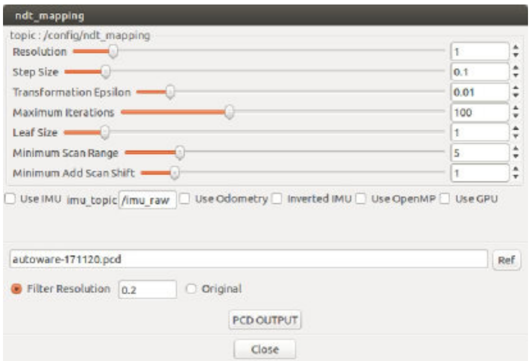
1. Start ndt_matching
2. Click on the app button of ndt_matching to show the configuration dialog
3. Modify the parameters
4. Verify the effects of each parameter change

Parameters configuration: selection of points

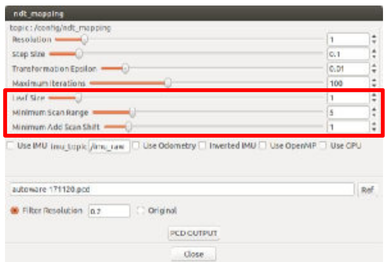
Parameters to control how points are selected for mapping

1. Minimum Scan Range – Controls the scope of points to add points to the map
   (Points below this threshold are not added to the map) (defaut : 5.0)

2. Minimum Add Scan Shift – Controls the amount of displacement to add points to the map
   (from the position where the previous scan was added, if the new position is over Minimum Add Scan Shift meters add the scan to the map) (default : 1.0)



Parameters configuration: selection of points



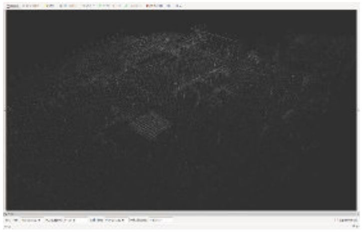
1. Start ndt_mapping
2. Click on the app button of ndt_mapping to show the Config dialog
3. Change each parameters
4. Verify how the generated maps are affected

Parameters configuration: map post-processing

On the Map tab, select the PCD Filter, the map file can be downsampled

Without downsampling : approx. 16million points

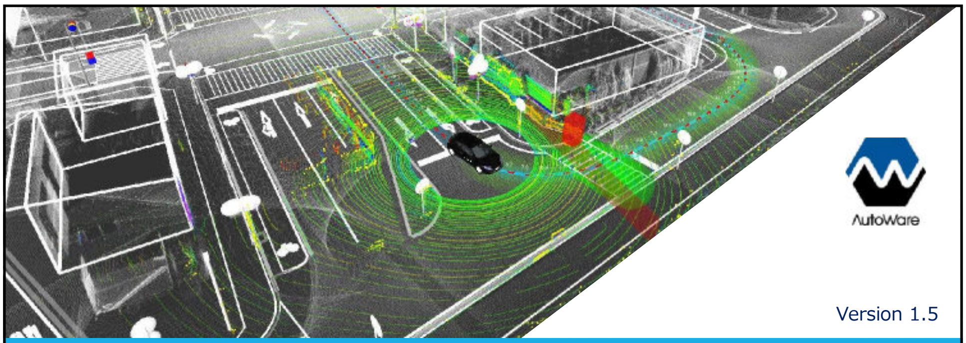
After using VoxelGrid Filter with 0.2m : approx. 2.6 million points



After using VoxelGrid Filter with 1m : approx. 200000 points

Parameters configuration: map post-processing

1. On the Map tab, go to PCD Filter and click on Ref, select the PCD file for downsampling (can select multiple files)
2. On Point Type, select the correct type of PCD
3. On Leaf Size, select the size for the VoxelGrid Filter
4. Click on PCD Filter
5. Verify that the downsampled PCD files are on the sample folder as the initial map



Autoware Hands-on Experience

Chapter 3 : 3D Map generation and Localization

3. Vector Maps (VectorMapper and Vector Map Builder)

Tier IV

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VectorMapper

- It is a web tool to create vector maps (ADAS maps)
- After adding the PCD map, the following items can be created
  - Pedestrian crossings (zebra lines)
  - Road center lines
  - Traffic lights and signs
  - Stop lines
  - Drivable areas
- The output (vector map) can be read on the Map tab
- *Needs a Tier4 account!!*

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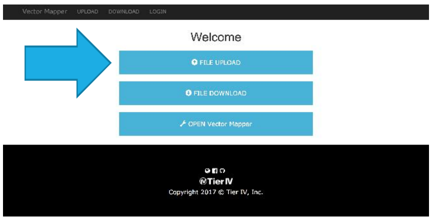
VectorMapper usage: uploading PCD map file

1. Access the MapTools (https://maptools.tier4.jp)

2. On Vector Mapper -> Try it, access the Vector Mapper

3. Upload the pointcloud
   1. Click on FILE UPLOAD
   2. On Add files... select the PCD file
   3. Click on Start upload



VectorMapper usage: connecting

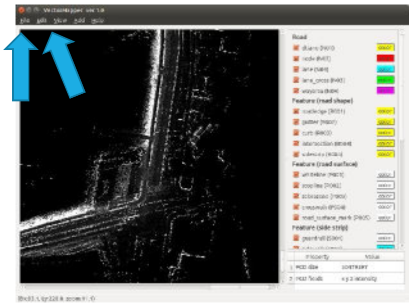
4. Click on OPEN Vector Mapper

5. On the upper right, click on Connect

VectorMapper usage: reading PCD

6. On the upper left, select File -> Open PCD dir... (for multiple files), or select Open PCD file... (for a single file), and select your PCDs files previously uploaded

7. Verify the pointcloud is shown
   If not showing, on Edit -> Preferences, configure PCD display

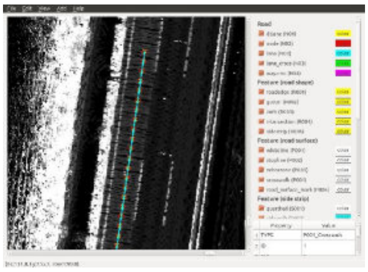


VectorMapper usage: adding road center lines

8. Click on Add -> Lane

9. Click on the start and end points, to generate the road center lines
   - By default points are generated 1m apart
   - With Edit -> Preference -> Max Lane length you can change the distance

10. Press enter and verify



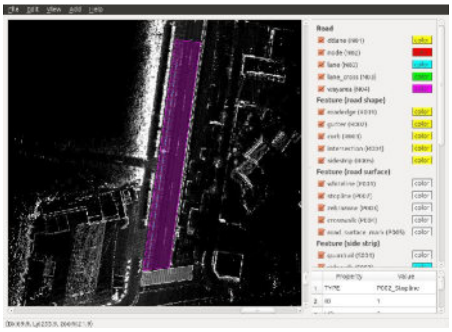
After pressing enter, points appear in red, line in green

VectorMapper usage: adding drivable areas

8. Click Add -> Wayarea

9. Click to define the drivable area

10. Press enter and verify

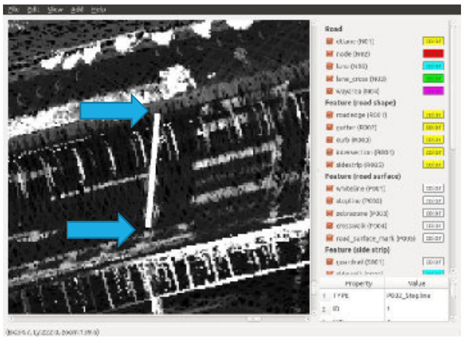


The selected drivable area appears in purple

VectorMapper usage: adding stop lines

8. Click on Add -> Stopline

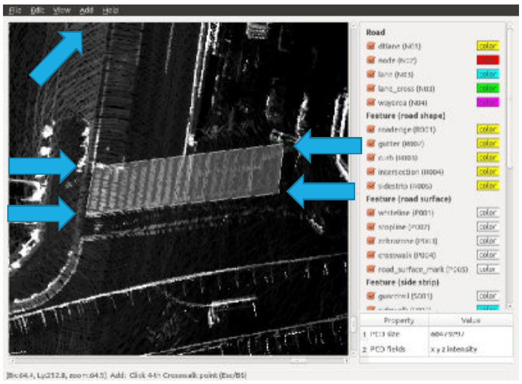
9. Click on the start and end points of the stop line



VectorMapper usage: adding pedestrian crossing

8. Click on Add -> Crosswalk

9. Select in order the four corners of the pedestrian crossing

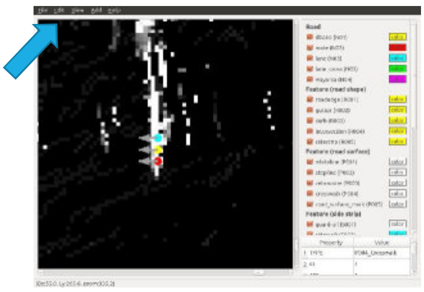


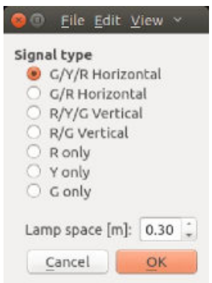
VectorMapper usage: adding traffic lights

8. Click on Add -> Signaldata

9. Click on the coordinates for the traffic light, then click on the end point according to the orientation of the light

10. Select the type of traffic light and the separation (space) between lamps, then click OK

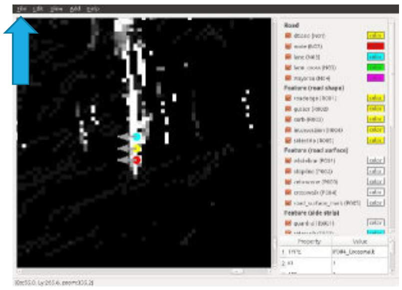


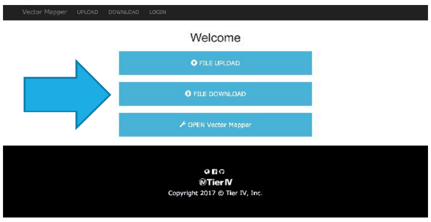


VectorMapper usage: saving the map

8. On File -> Save ADAS dir... we can save the generated vector map

9. Close the VectorMapper, then on FILE DOWNLOAD you can get the generated CSV files





Vector Map Builder

- Another (newest) web based tool for vector map (ADASMap) creation
- Importing pointcloud map (PCD), the following elements can be created
  - Road
    Node, Lane, Wayarea(drivable area), center lines(do be implemented)
  - Road shape
    Curb, Road border, Gutter, Intersection
  - Road surface
    White lines, Stop lines, Zebra zones, Pedestrian crossing, Road markings
  - Road side
    Guard rails, Sidewalk
  - Structures
    Poles, Utility pole, Signs, Traffic light, Street lights, Curve mirror, Walls, Fences, Railway crossing zone
- The output data can be read on Autoware Map tab
- *Needs a TierIV premium account*!

Vector Map Builder

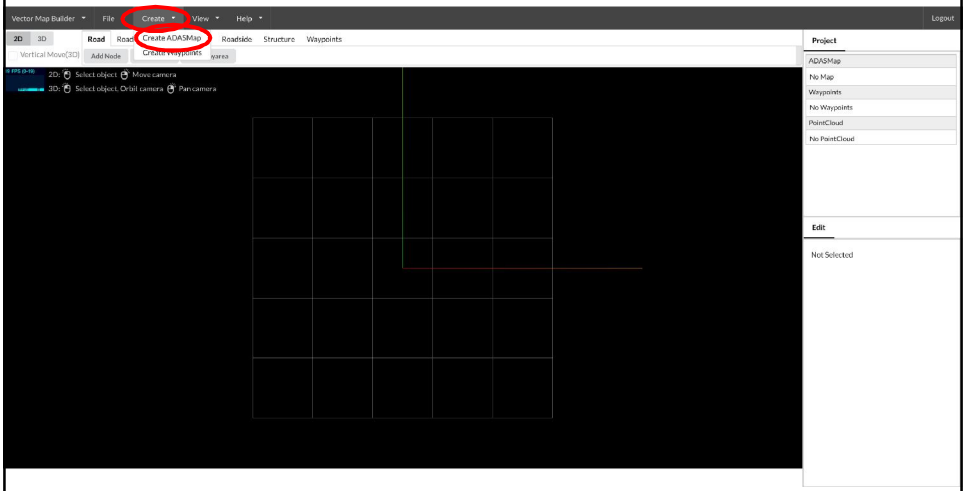
Accessing Vector Map Builder

1. Access TierIV MapTools (https://tools.tier4.jp)

2. Click on [VectorMapBuilder] and then click on [Try it]
(will open https://tools.tier4.jp/vector_map_builder/)

New vector map creation

On the upper header [Create] menu, select [Create ADASMap]



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New vector map creation

Enter the map name on the [ADASMap Name] field and the reference number*, and then click [Create]

* Reference number of planar rectangular coordinates system [平面直角座標系の系番号] only applies to Japan

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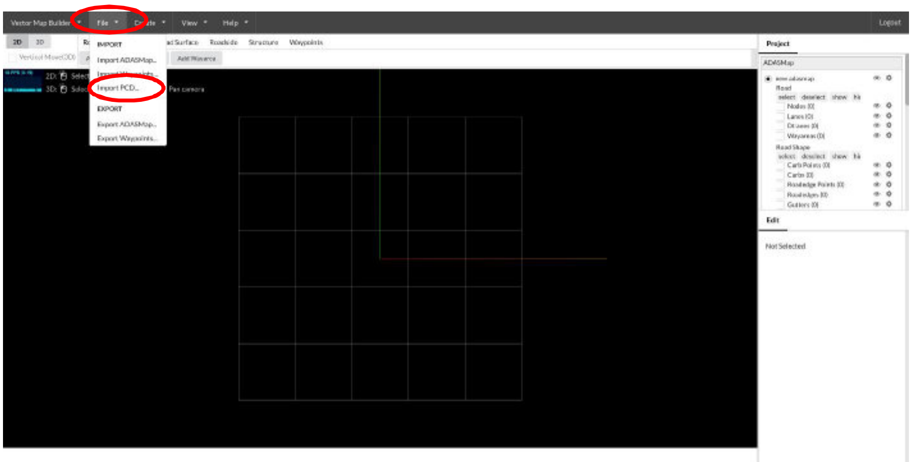
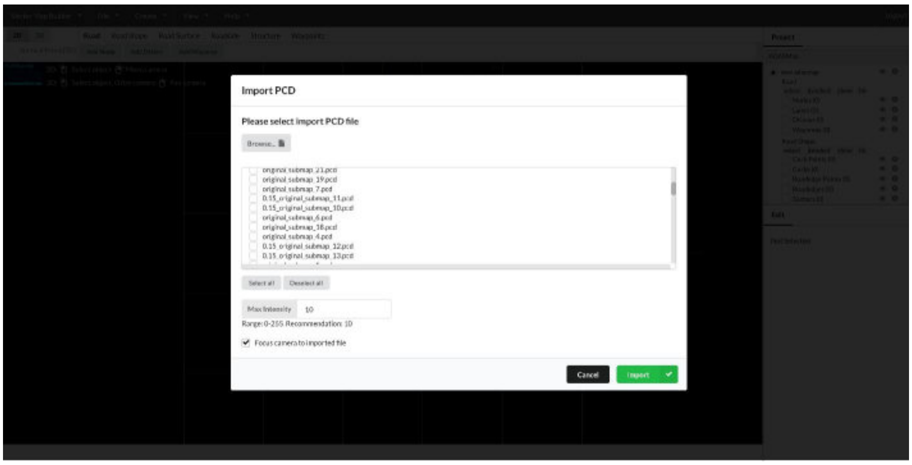
Import pointcloud map PCD file

Load the PCD file(s) using [File] → [Import PCD]

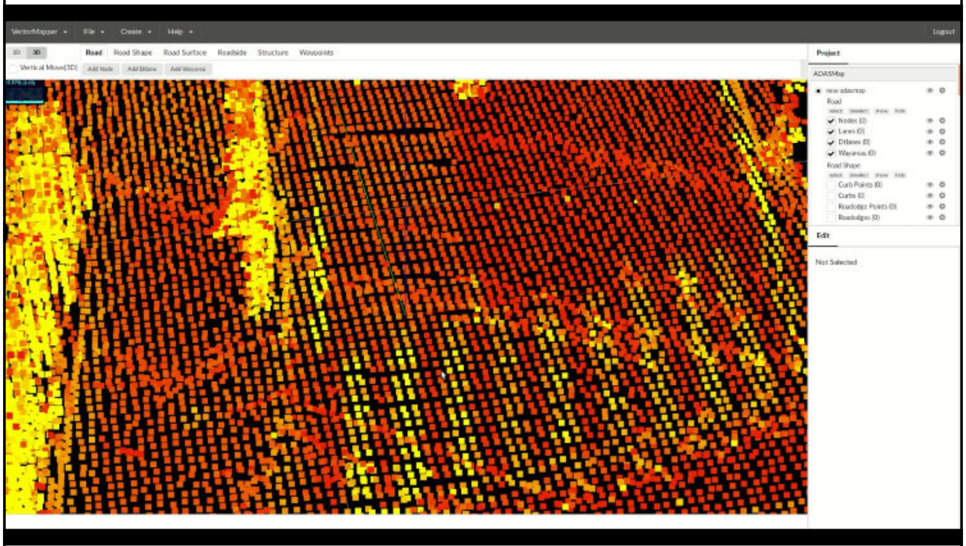


Import pointcloud map PCD file

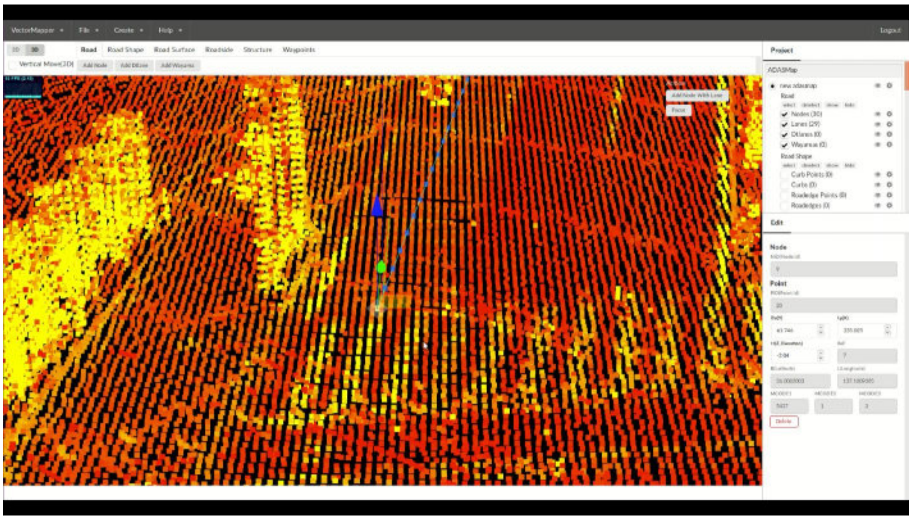
Select the PCD file(s) and then click on [Import]



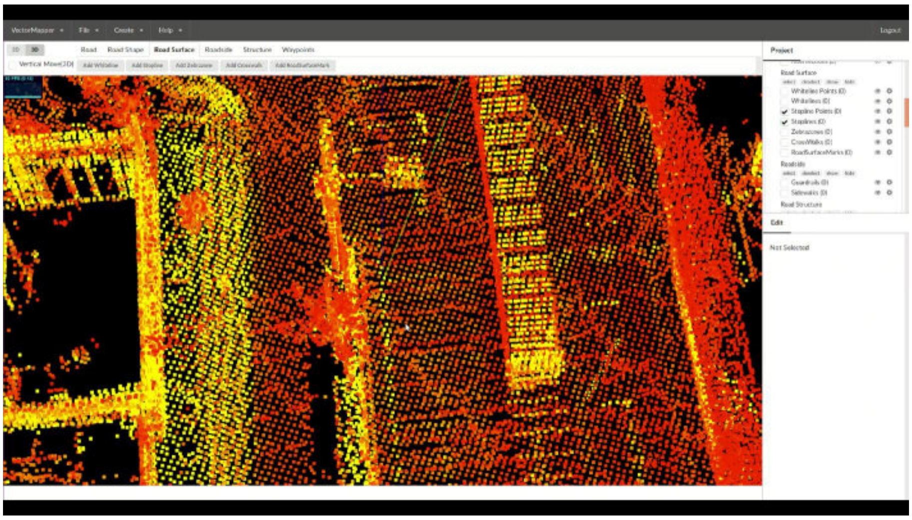
Creating Nodes/Lanes



Creating Wayareas (drivable surface)



Creating Stop lines



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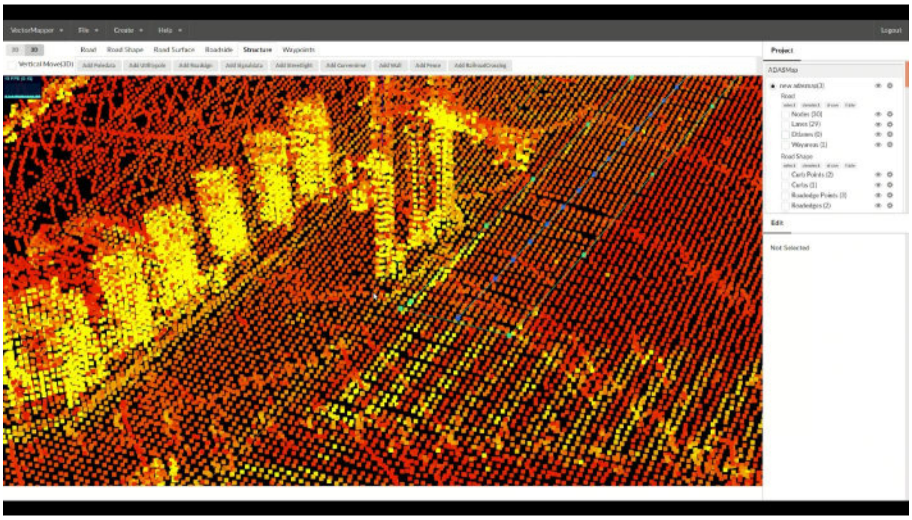
Adding traffic lights



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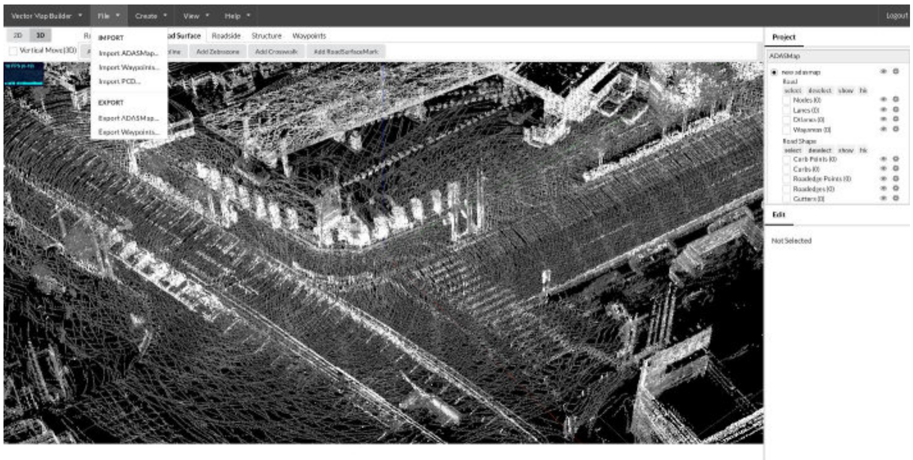
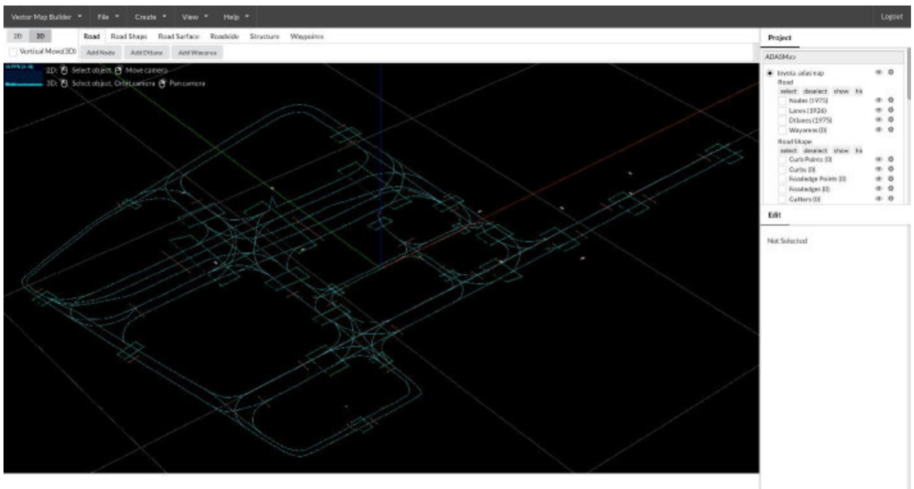
Download the ADASMap

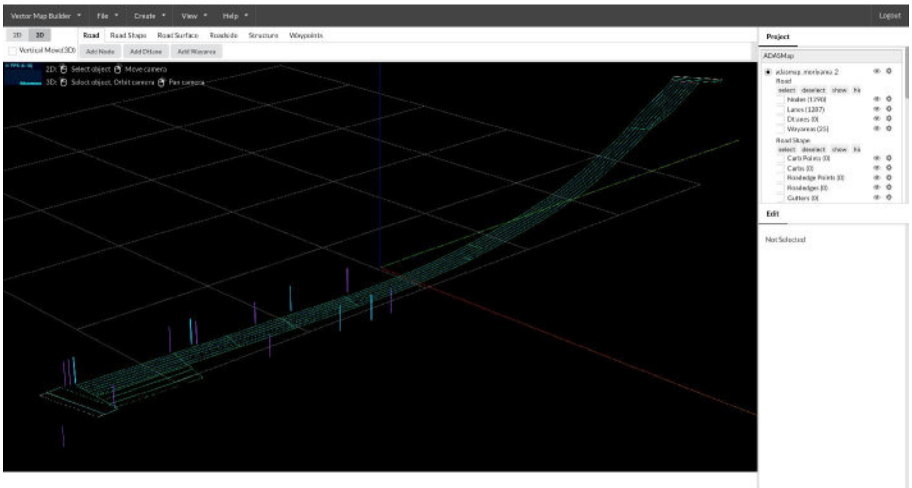
On [File] → [Export ADASMap…] → [Download], you can download the ZIP file



Examples of vector maps created



Examples of vector maps created



Tier IV

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