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GOOSE Dataset Labeling Policy

Class Definitions and Examples for the Labeling Process

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1 Class Definitions

Table 1.1 shows all the labels which are divided into groups. Specific labels for different classes are then defined on the following pages. Examples for images and point clouds are shown for different labels.

Table 1.1: Class Definitions

Group	Class Labels
Animal	animal
Construction	bridge, building, container, debris, fence, guard_rail, tunnel, wall, wire
Human	person, rider
Object	barrel, obstacle, pipe, pole, rock, street_light,
Road	bikeway, curb, pedestrian_crossing, rail_track, road_marking, sidewalk
Sign	barrier_tape, misc_sign, traffic_cone, traffic_light, traffic_sign, road_block, boom_barrier
Sky	sky
Terrain	asphalt, cobble, gravel, soil, snow
Vegetation	bush, crops, forest, hedge, high_grass, leaves, low_grass, moss, scenery_vegetation, tree_crown, tree_root, tree_trunk
Vehicle	bicycle, bus, car, caravan, heavy_machinery, kick_scooter, military_vehicle, motorcycle, on_rails, trailer, truck
Void	ego_vehicle, outlier, undefined
Water	water

Semantic Segmentation

All images have to be labeled pixel-wise; the same holds for 3D point clouds.

Instances-Wise Labeling

Classes that are marked red have to be labeled instance-wise with an **instance_id**. *Example:* For an image with multiple cars one has to use **car 0**, **car 1**, **car 2** etc. In the case of labeling a sequence where the same object can be found in consecutive frames one should use the same **instance_id** for the object. *Example:* **car 0** should have the same **instance_id** in frame 0 and frame 1. In addition, the same **instance_id** should be used for the same object if it is visible in frames of multiple sensors. *Example:* Instance-label **car 0** is used across the frames of all sensors (LiDAR, camera1, camera2 and so on).

Alphabetically ordered class labels: A – Mi

Class Label	ID	RGB	Color	Page
animal	33	rgb(0,0,53)		65
asphalt	23	rgb(255,47,128)		45
barrel	60	rgb(208,208,0)		105
barrier_tape	48	rgb(190,196,89)		89
bicycle	13	rgb(0,77,67)		26
bikeway	7	rgb(163,0,89)		17
boom_barrier	25	rgb(52,54,45)		48
bridge	43	rgb(160,121,191)		82
building	38	rgb(1,51,73)		72
bus	15	rgb(153,125,135)		30
bush	17	rgb(128,150,147)		35
car	12	rgb(183,151,98)		24
caravan	36	rgb(48,0,24)		69
cobble	3	rgb(255,52,255)		10
container	58	rgb(255,138,154)		101
crops	30	rgb(0,134,237)		57
curb	22	rgb(74,59,83)		44
debris	29	rgb(136,111,76)		55
ego_vehicle	8	rgb(255,219,229)		18
fence	41	rgb(255,181,0)		78
forest	16	rgb(90,0,7)		32
gravel	24	rgb(97,97,90)		46
guard_rail	42	rgb(194,255,237)		81
heavy_machinery	57	rgb(250,208,159)		100
hedge	59	rgb(209,87,160)		103
high_grass	51	rgb(238,195,255)		92
kick_scooter	49	rgb(111,0,98)		90
leaves	5	rgb(0,137,65)		14

Alphabetically ordered class labels: Mo – U

Class Label	ID	RGB	Color	Page
low_grass	50	rgb(12,189,102)		91
military_vehicle	63	rgb(64, 64, 64)		108
misc_sign	47	rgb(0,30,9)		88
moss	18	rgb(180,168,189)		38
motorcycle	20	rgb(79,198,1)		41
obstacle	4	rgb(255,74,70)		12
on_rails	35	rgb(161,194,153)		68
outlier	56	rgb(120,141,102)		99
pedestrian_crossing	9	rgb(122,73,0)		20
person	14	rgb(143,176,255)		29
pipe	61	rgb(221,0,0)		106
pole	45	rgb(192,185,178)		85
rail_track	26	rgb(107,121,0)		49
rider	32	rgb(221,239,255)		63
road_block	10	rgb(0,0,166)		21
road_marking	11	rgb(99,255,172)		22
rock	40	rgb(55,33,1)		77
scenery_vegetation	52	rgb(69,109,117)		93
sidewalk	21	rgb(59,93,255)		42
sky	53	rgb(183,123,104)		95
snow	2	rgb(209,87,160)		8
soil	31	rgb(209,97,0)		59
street_light	6	rgb(0,111,166)		16
traffic_cone	1	rgb(255,255,0)		7
traffic_light	19	rgb(27,68,0)		40
traffic_sign	46	rgb(194,255,153)		87
trailer	37	rgb(10,166,216)		71

Alphabetically ordered class labels: Wa – Wi

Class Label	ID	RGB	Color	Page
tree_crown	27	rgb(0,194,160)		50
tree_root	62	rgb(196,164,132)		107
tree_trunk	28	rgb(255,170,146)		53
truck	34	rgb(123,79,75)		67
tunnel	44	rgb(204,7,68)		83
undefined	0	rgb(0,0,0)		5
wall	39	rgb(0,132,111)		74
water	54	rgb(122,135,161)		96
wire	55	rgb(255,140,0)		97

ID#0: undefined **rgb(0,0,0)** ■

*All unlabeled pixels are defined with the label **undefined**.*

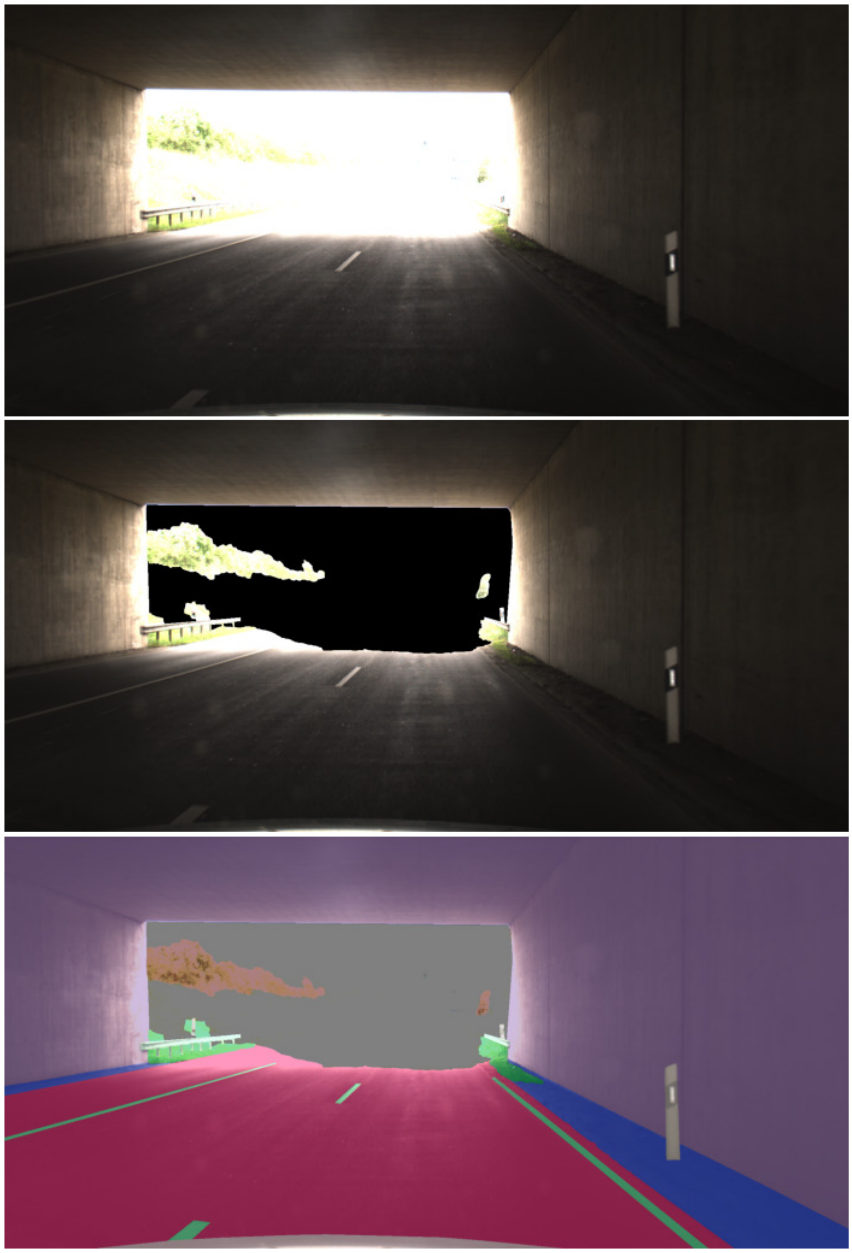


Figure 0.1:
Annotation examples of undefined (■) for an overexposed area of the camera image.

Figure 0.2:
Annotation examples of undefined (■) for an overexposed area of the camera image.

ID#1: traffic_cone rgb(255,255,0)

Traffic cones, also called pylons, witches' hats, road cones, highway cones, safety cones, channelizing devices, or construction cones, are usually cone-shaped markers that are placed on roads or footpaths to temporarily redirect traffic in a safe manner.

Figure 1: Annotation examples of traffic cone ( ).

ID#2: snow rgb(209,87,160)

Snow that covers surfaces and objects in the winter should be annotated as snow (■). We want to avoid labeling too many small patches as snow since this could obscure the underlying object or surface. Therefore, only clearly visible snow patches of 150 px^2 in area should be annotated as snow.

Figure 2.1: Annotation examples of snow (■).

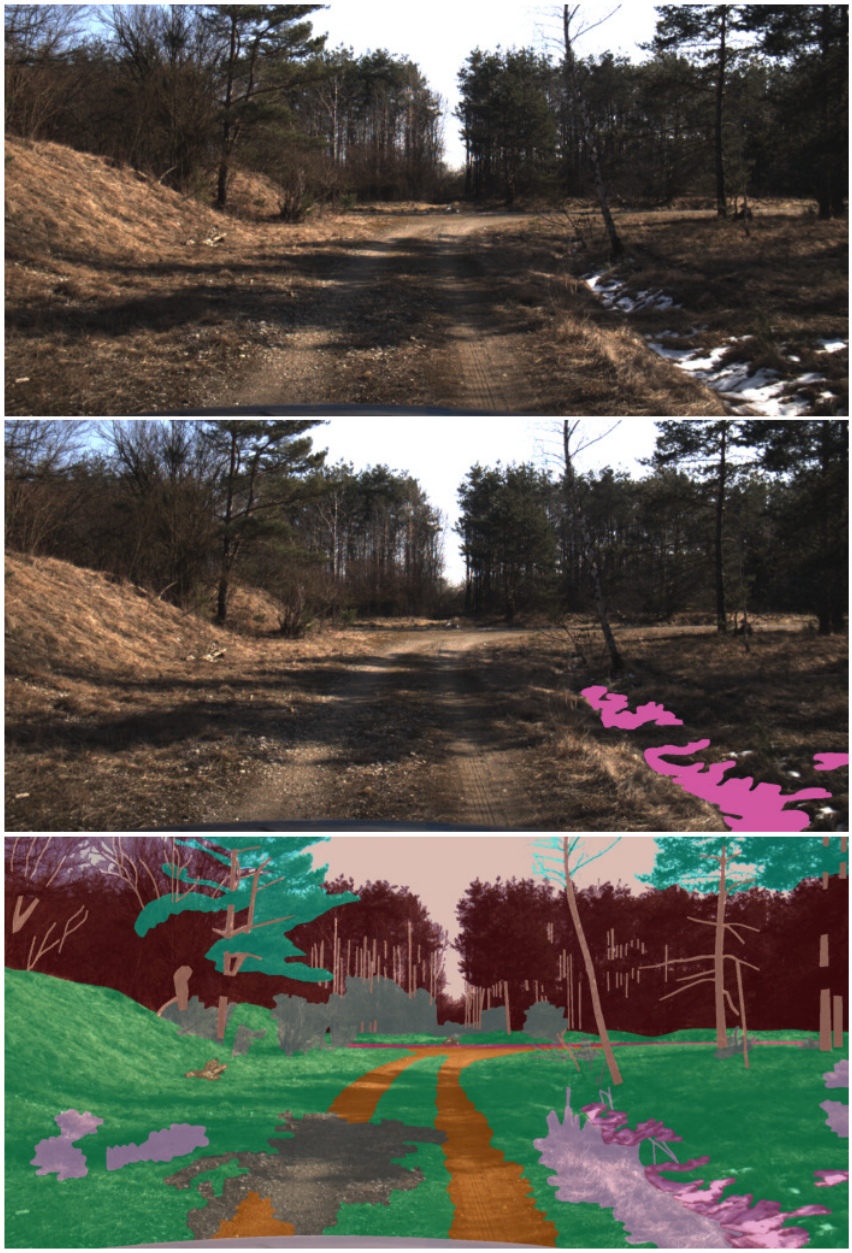


Figure 2.2: Annotation examples of snow (■).

ID#3: cobble rgb(255,52,255)

A drivable surface that consists of cobble/cobblestone.

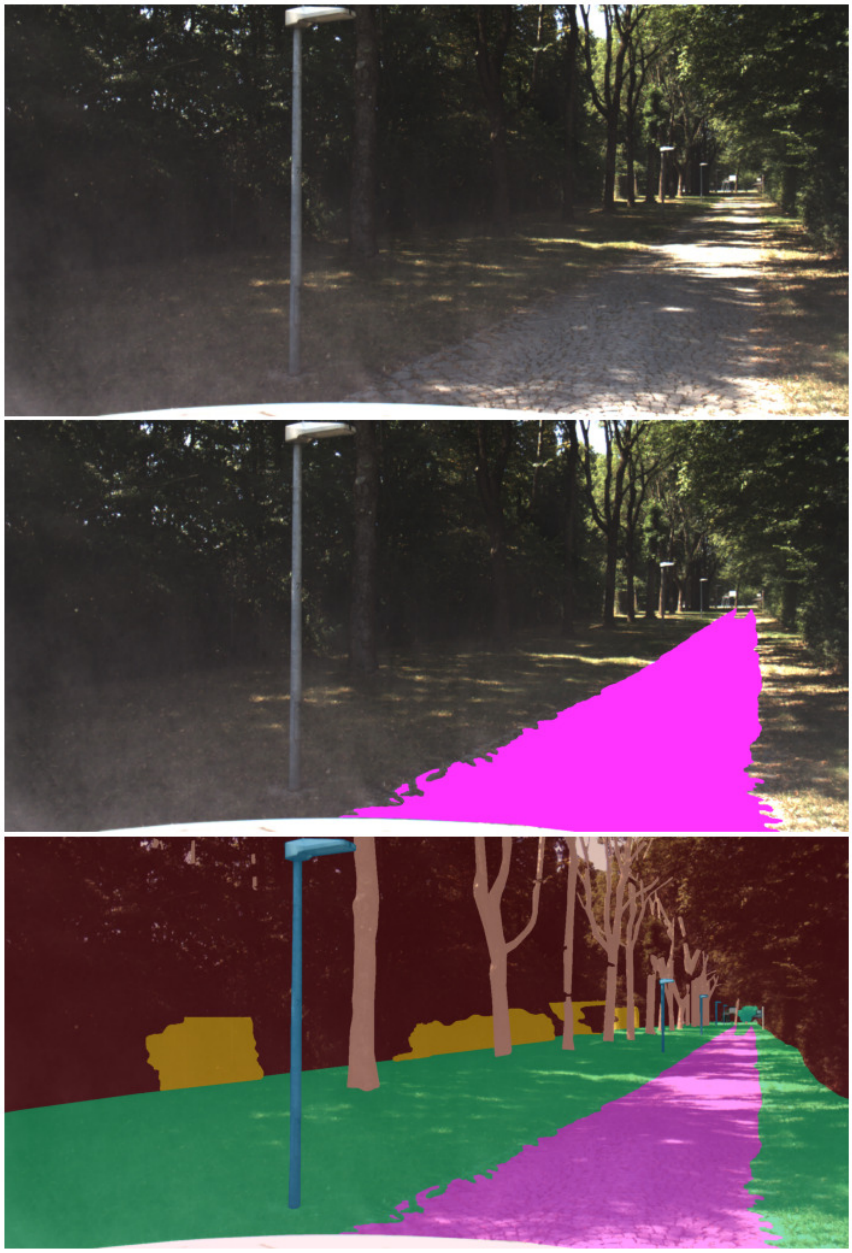


Figure 3.1: Annotation examples of cobble ( ).

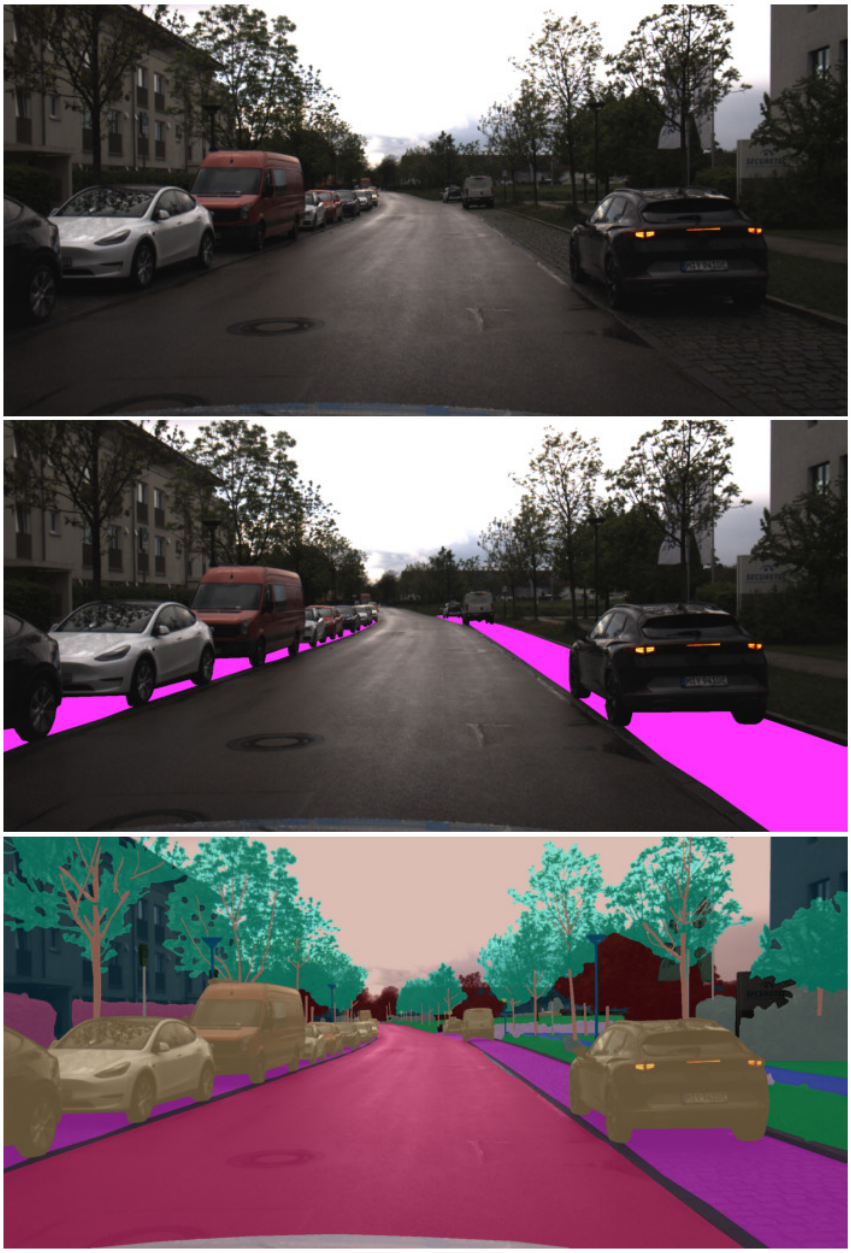


Figure 3.2: Annotation examples of cobble (■).

ID#4: obstacle rgb(255,74,70)

Man-made objects and structures that are typically non-drivable. Examples are canisters, trash bins, parts on a construction site etc.

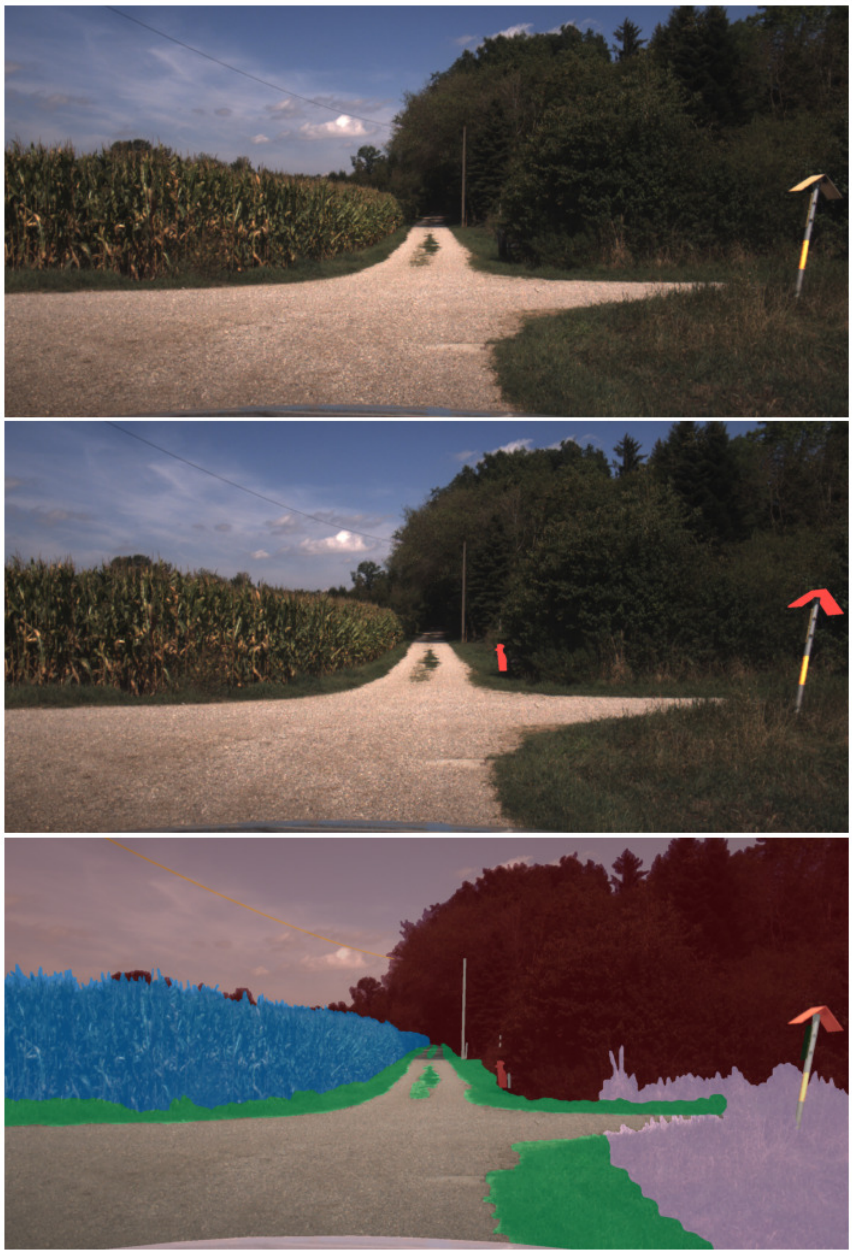


Figure 4.1: Annotation examples of small obstacles (■).

Figure 4.2: Annotation examples of larger obstacles (■).

ID#5: leaves rgb(0,137,65)

Fallen leaves that are sometimes located on flat surfaces such as on trails or roads. This label should be used if the underlying surface isn't clearly recognizable. Patches with an area of at least 400 px^2 should be annotated as leaves.

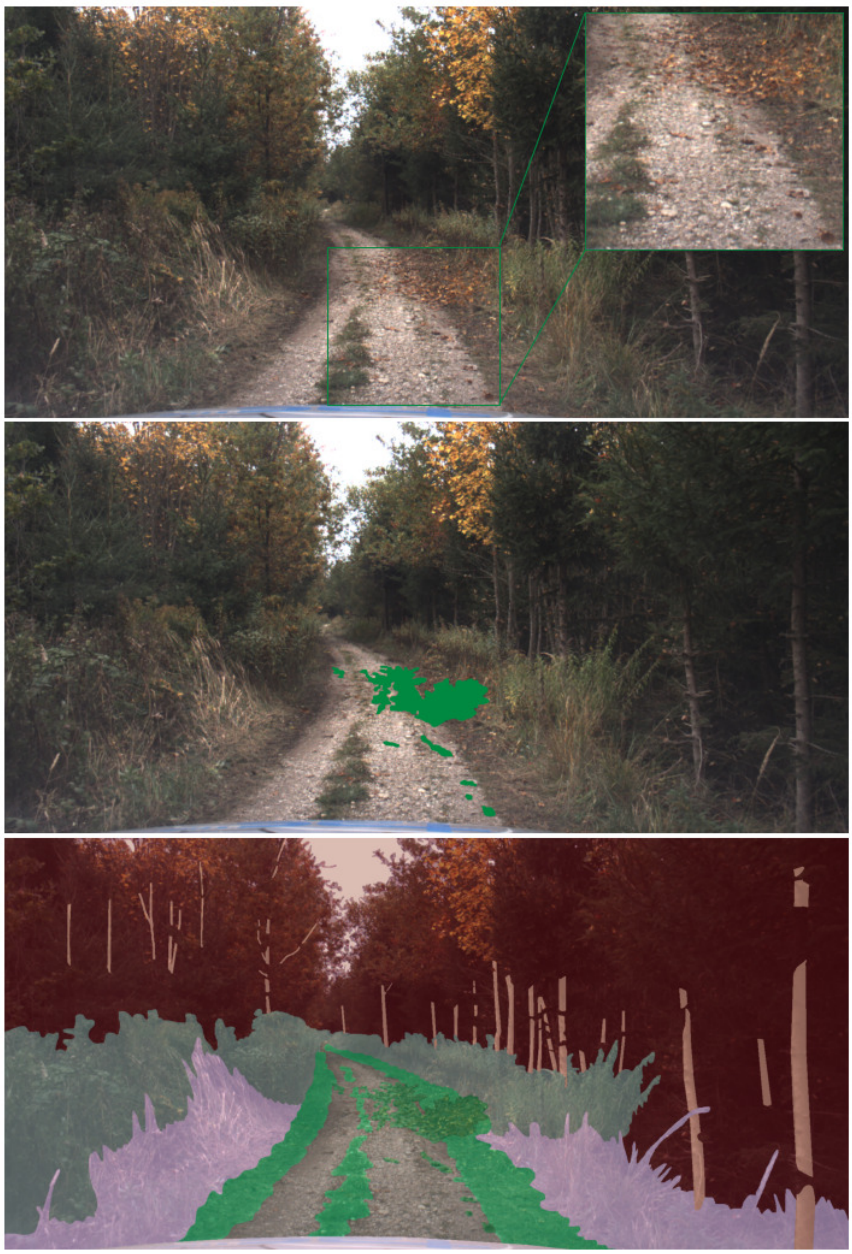


Figure 5.1: Annotation examples of leaves (■).

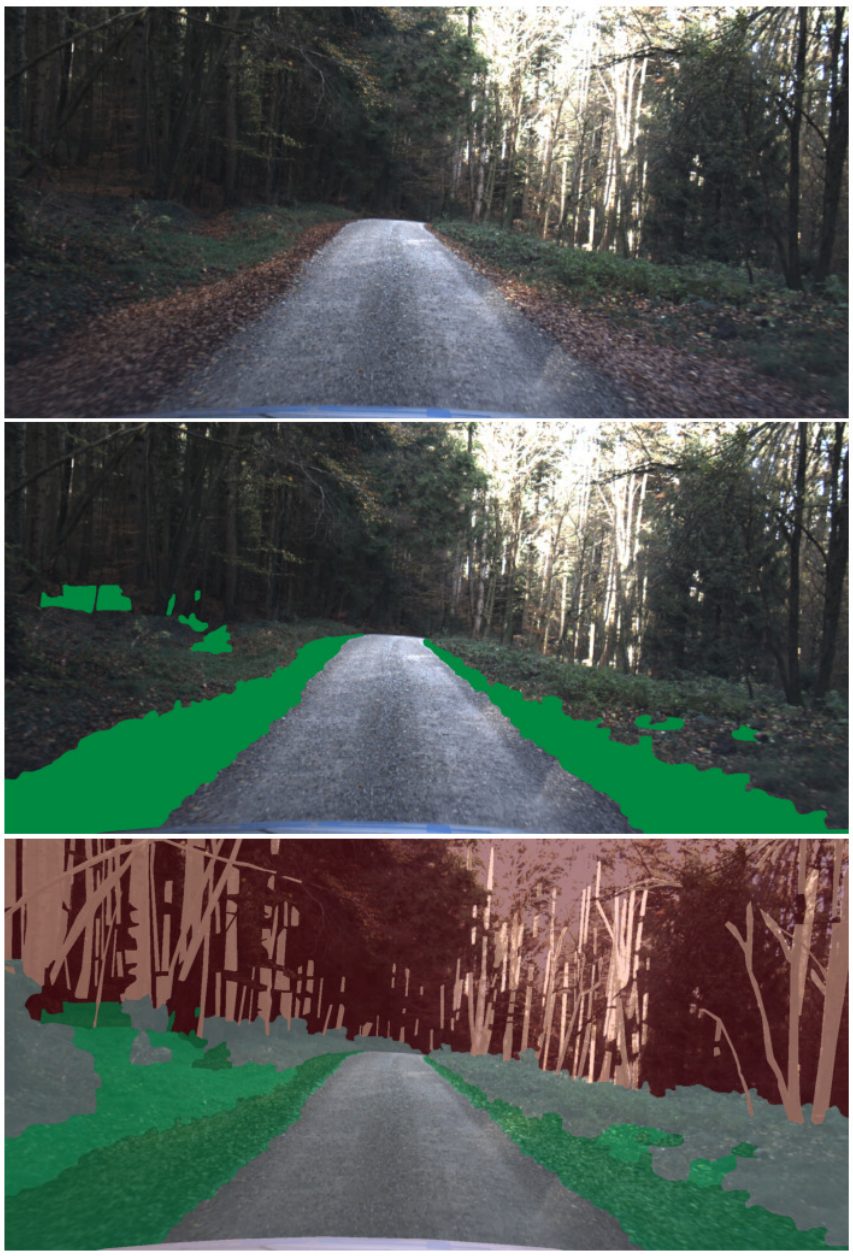


Figure 5.2: Annotation examples of leaves (■).

ID#6: street_light rgb(0,111,166)

A street light, light pole, lamppost, street lamp, light standard or lamp standard is a raised source of light on the edge of a road or path.

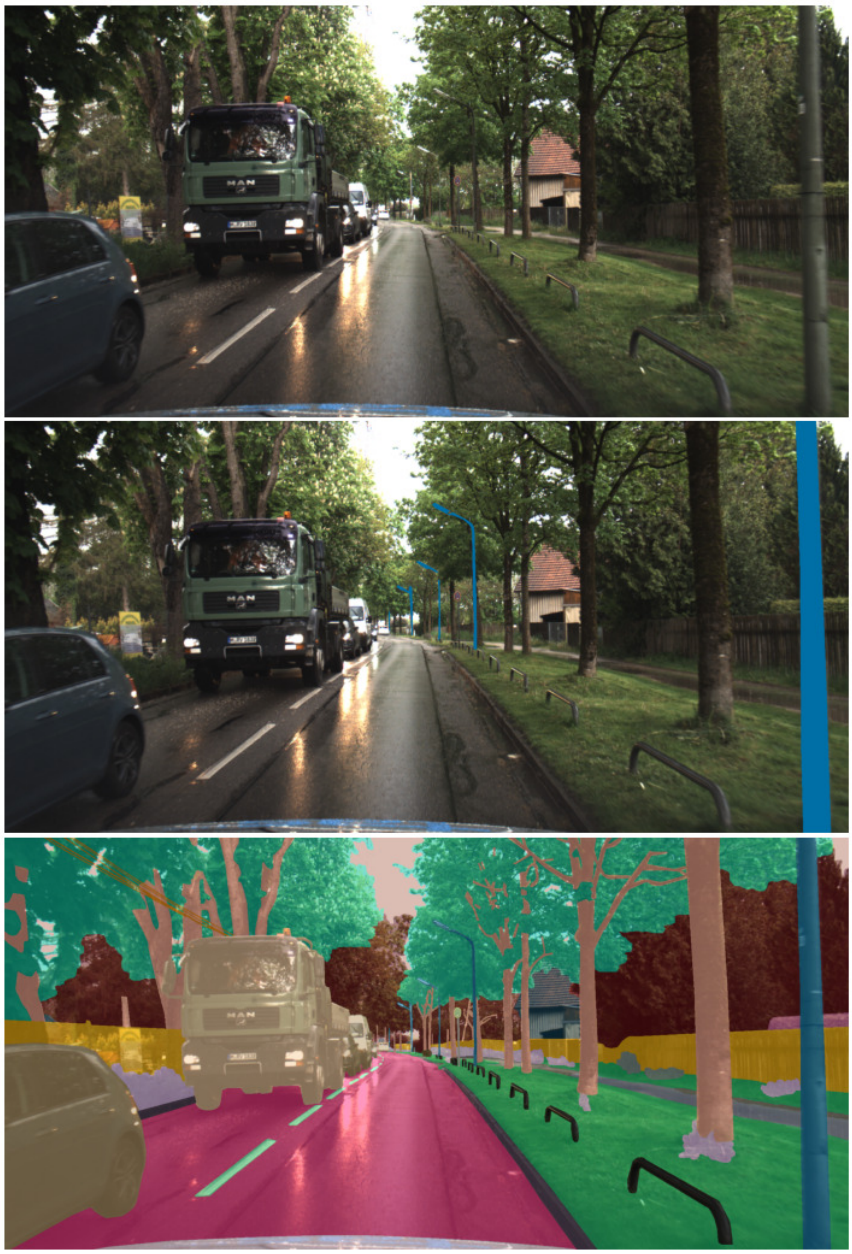


Figure 6: Annotation examples of a street light ( ).

ID#7: bikeway **rgb(163,0,89)**

A bikeway is a lane, route, way or path which in some manner is specifically designed and /or designated for bicycle travel. Only annotate bikeways that are clearly distinguished by the (red) paint. Otherwise when they are shared with motor traffic they are annotated as part of the road or when they are shared with pedestrians they are label as part of the sidewalk.
3D Point Cloud: *The LiDAR intensity (return strength of the laser beam) can be used to differentiate between the road surface and the road markings in the 3D case (compare road_marking example in Figure* **??***).*

Figure 7: Annotation examples of a bikeway (■).

ID#8: ego_vehicle rgb(255,219,229)

Visible parts of the ego vehicle: hood, windshield wiper, etc.

Figure 8.1: Example of the vehicle's hood as ego vehicle ( ).

Figure 8.2: Example of the windshield wiper as ego vehicle ( ).

ID#9: pedestrian_crossing rgb(122,73,0)

A pedestrian crossing or crosswalk is a place designated for pedestrians to cross a road, street or avenue. Only the (white) markings are annotated when the stripes are interrupted. he space in between the stripes is labeled as the surface material, e.g., asphalt or cobble, when the stripes are interrupted.
3D Point Cloud: *The LiDAR intensity (return strength of the laser beam) can be used to differentiate between the road surface and the road markings in the 3D case (compare Figure* **??** *of the road_marking example).*

Figure 9: Example of a pedestrian crossing (■).

ID#10: road_block rgb(0,0,166)

A barrier or barricade on a road, especially one set up by the authorities to stop and examine traffic.

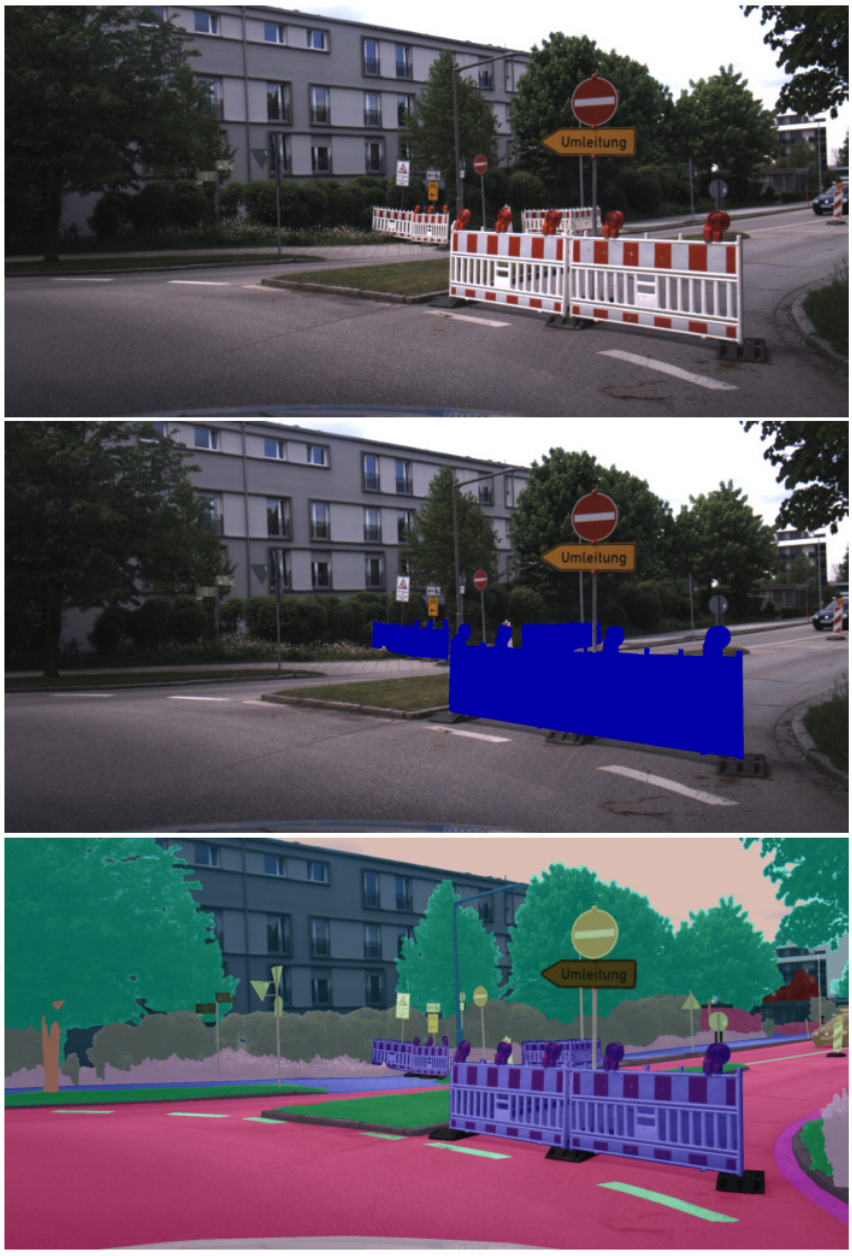


Figure 10:
Annotation examples with an annotation of road_block (■). Notice that the sign should be annotated separately as traffic_sign (■).

ID#11: road_marking rgb(99,255,172)

Road surface marking is any kind of device or material that is used on a road surface in order to convey official information.
Road markings for explicitly marked bikeways should be annotated as bikeway.
3D Point Cloud: *The LiDAR intensity (return strength of the laser beam) can be used to differentiate between the road surface and the road markings in the 3D case, as seen in Figure 11.2.*

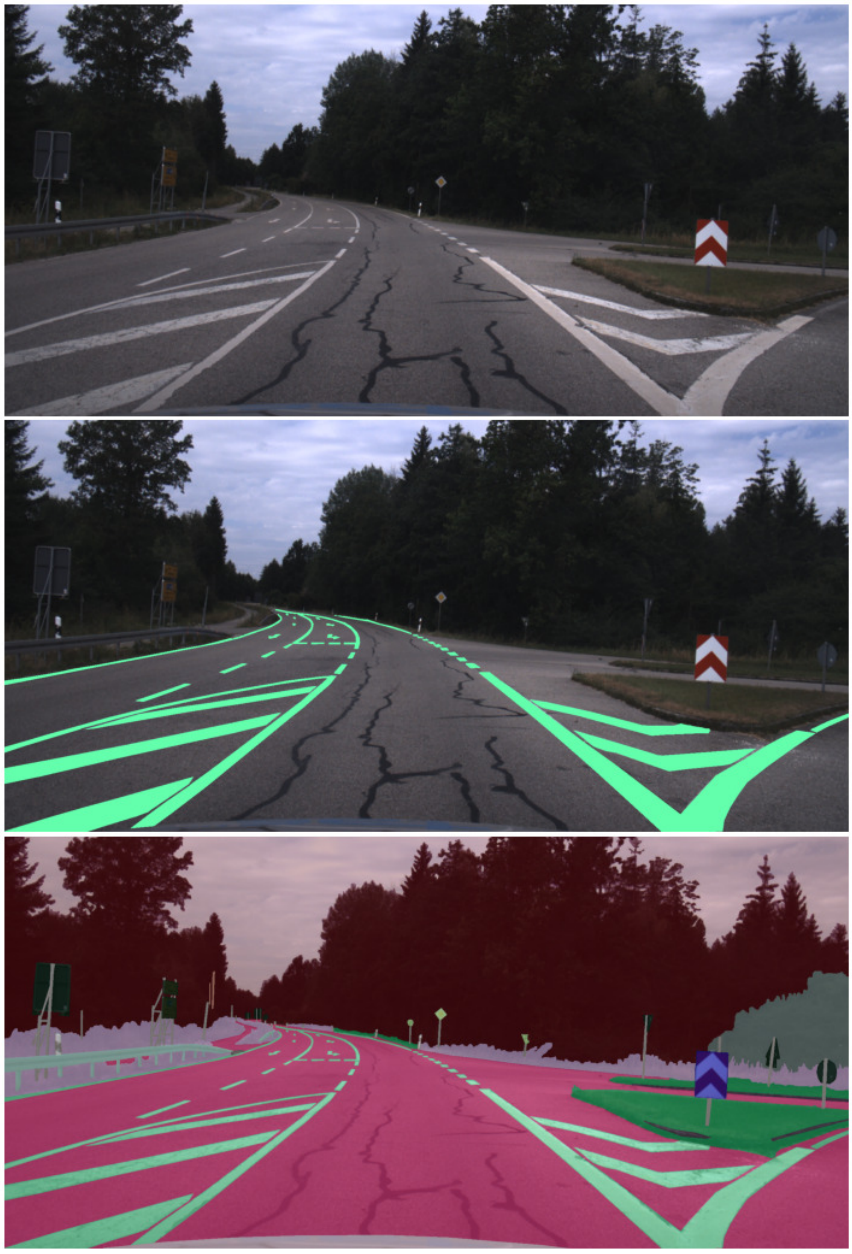


Figure 11.1: Example or road markings ( ).

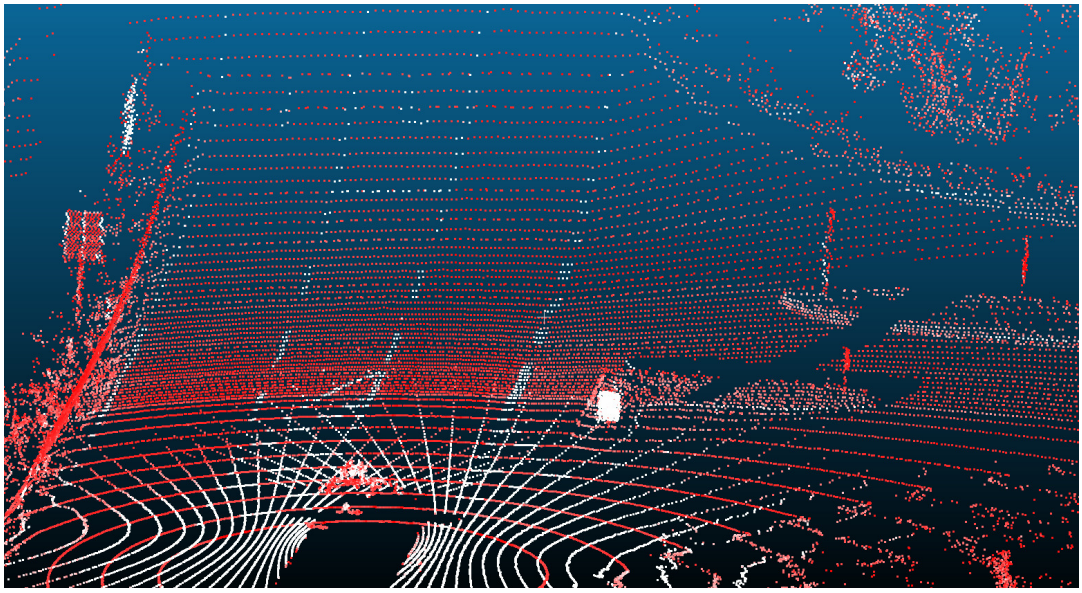


Figure 11.2:
The white paint of the road marking can be separated from the road surface in 3D when looking at the intensity values of the LiDAR point cloud.

ID#12: car **rgb(183,151,98)**

Car, jeep, SUV, van with continuous body shape, no other trailers [1]. A roof construction (e.g. sensors, bike rack, antenna), are also labeled as car.

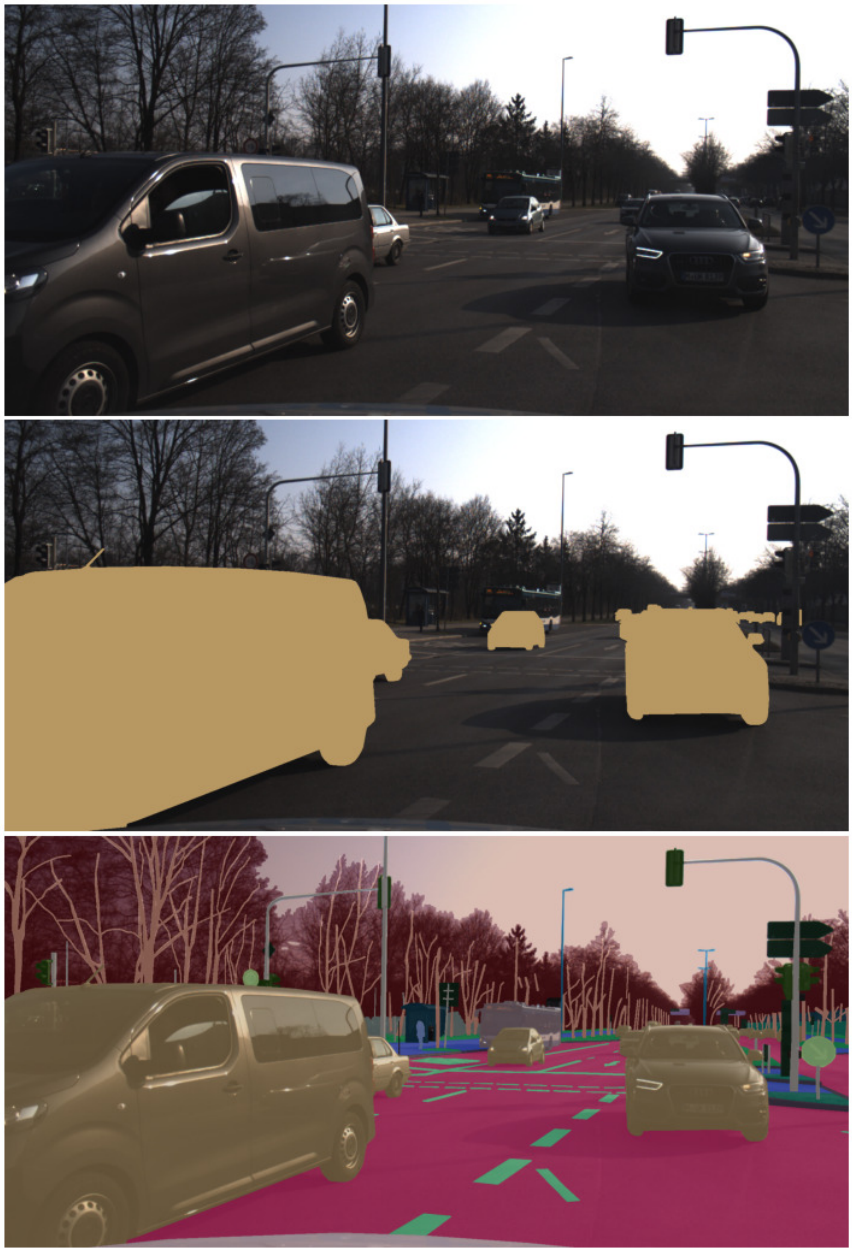


Figure 12.1: Annotation examples of a car ( ).

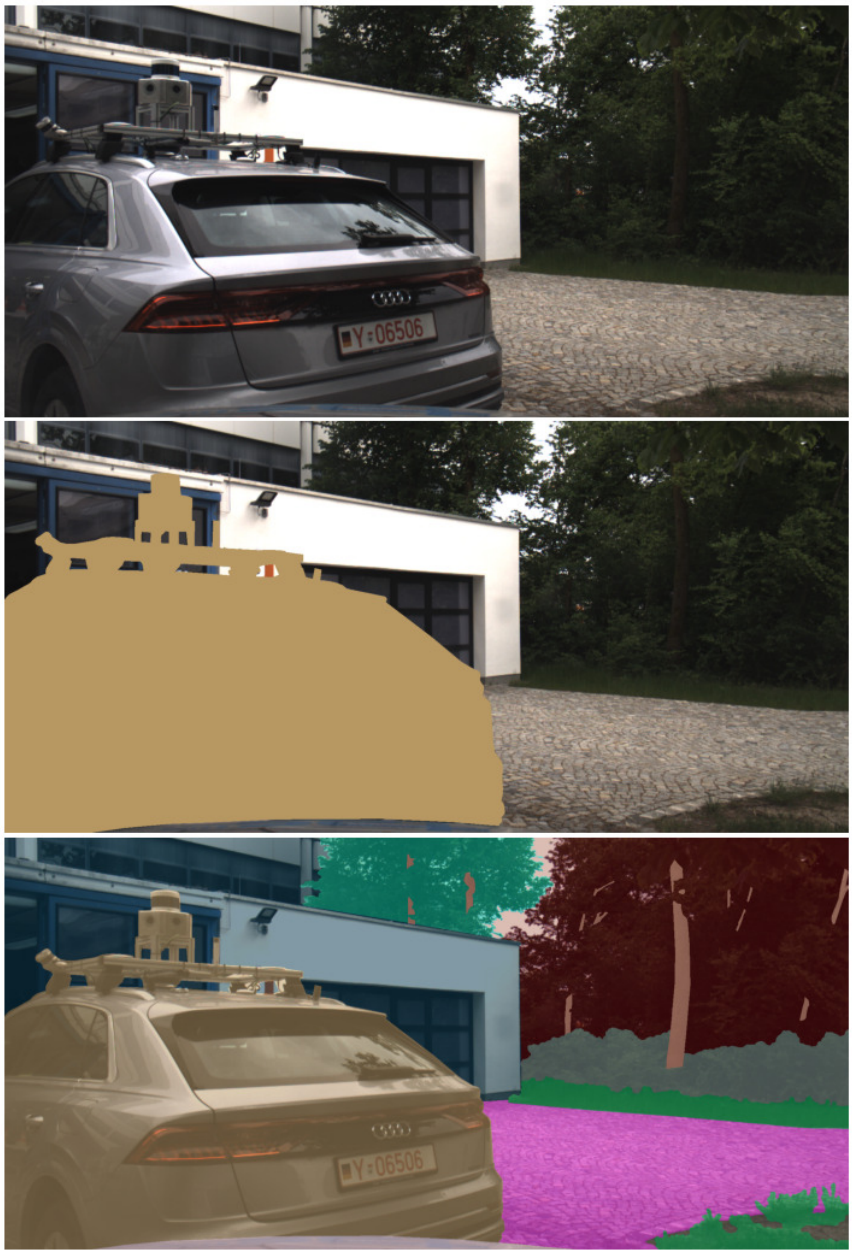


Figure 12.2:
A roof construction as well as cameras, LiDAR sensors and antennas are also labeled as part of the car (■).

ID#13: bicycle rgb(0,77,67)

Bicycle without the cyclist. The rider is annotated separately [1].

Figure 13.1: Example of a bicycle (■).

Figure 13.2: Example of a bicycle (■).

Figure 13.3:
Example of a bicycle (■) where the rider (■) is annotated as a separate class.

ID#14: person **rgb(143,176,255)**

If the human would walk, the label is person, otherwise not. Examples are people walking, standing or sitting on the ground, on a bench, on a chair. This class also includes toddlers, someone pushing a bicycle or standing next to it with both legs on the same side of the bicycle. This class includes anything that is carried by the person. e.g. backpack, but not items touching the ground, e.g. trolleys [1].
In cases of crowds and when multiple persons are far away (each person covers an area smaller than 100 px^2) the requirement of annotating each person as an individual instance is lifted. People that overlap in the image can then be annotated as a single instance.

Figure 14: Example of a person ( ).

ID#15: bus rgb(153,125,135)

Bus for 15+ persons, public transport or long distance transport (similar to [1]).

Figure 15.1: Example of a bus (■).

Figure 15.2: Example of a bus (■).

ID#16: forest rgb(90,0,7)

For the following cases we annotate vegetation as forest:

- *Multiple trees or bushes, that are part of a forest, thicket or strip of woods at some distance ($> 100\,m$).*
- *At closer distances ($< 100\,m$) use forest when individual trees cannot be distinguished. If separable use tree_trunk and tree_crown.*
- *Smaller branches and foliage that can be grazed by the ego vehicle at very close distance ($< 3\,m$) should be labeled as tree_crown.*

Notice that the 100 m distance threshold is not an exact measure, but rather an estimate at what distance individual trees or bushes of a forest cannot be separately annotated. In our scenes this tends to be at a distance of 100 m from the ego vehicle.

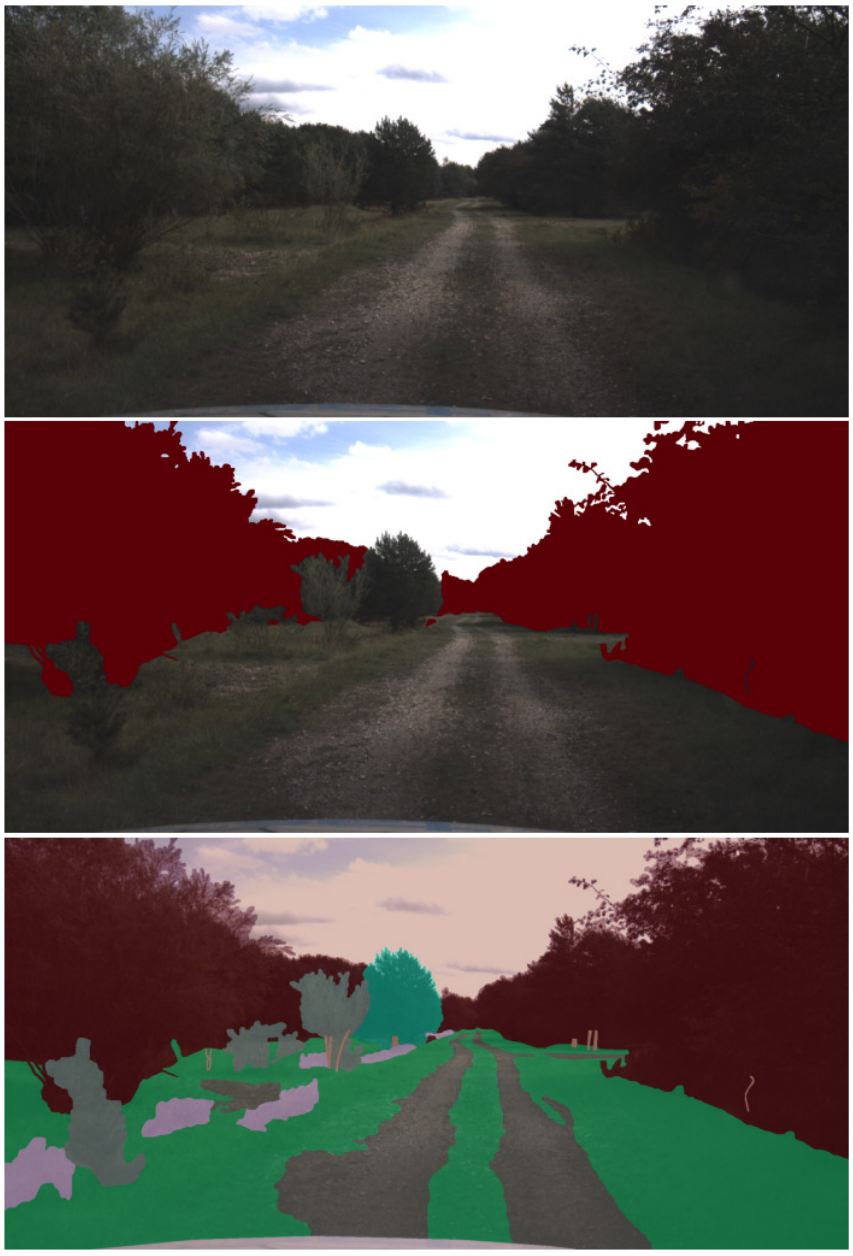


Figure 16.1:
Annotation examples of forest (■). Here the forest is at least 100 m away from the ego vehicle. All the visible vertical vegetation at that distance is labeled as forest.

Figure 16.2:
Annotation examples of forest (■). Here in the foreground we have individual trees, which are annotated with tree_trunk (■) and tree_crown (■). The background consists of indistinguishable vertical vegetation and is therefore annotated as forest.

ID#17: bush rgb(128,150,147)

A bush has several main stems growing from the ground level rather than from one trunk. Bushes should have a structure that would allow the ego vehicle to graze them. Several things have to be considered when labeling a bush:

- *If the foliage is clearly separable from one larger trunk, then annotate as tree_crown ( ) with an accompanying tree_trunk ( ).*
- *If a group of bushes form a line and function as a barrier, then annotate the line of bushes as hedge.*
- *If the bushes are at a greater distance ($>$ 100 m) and cannot be separated from the other vegetation, then annotate as forest ( ). At a close to medium distance (0 m – 100 m) annotate as bush.*

A bush can be touched by a vehicle/car without causing noticeable damage to the car.

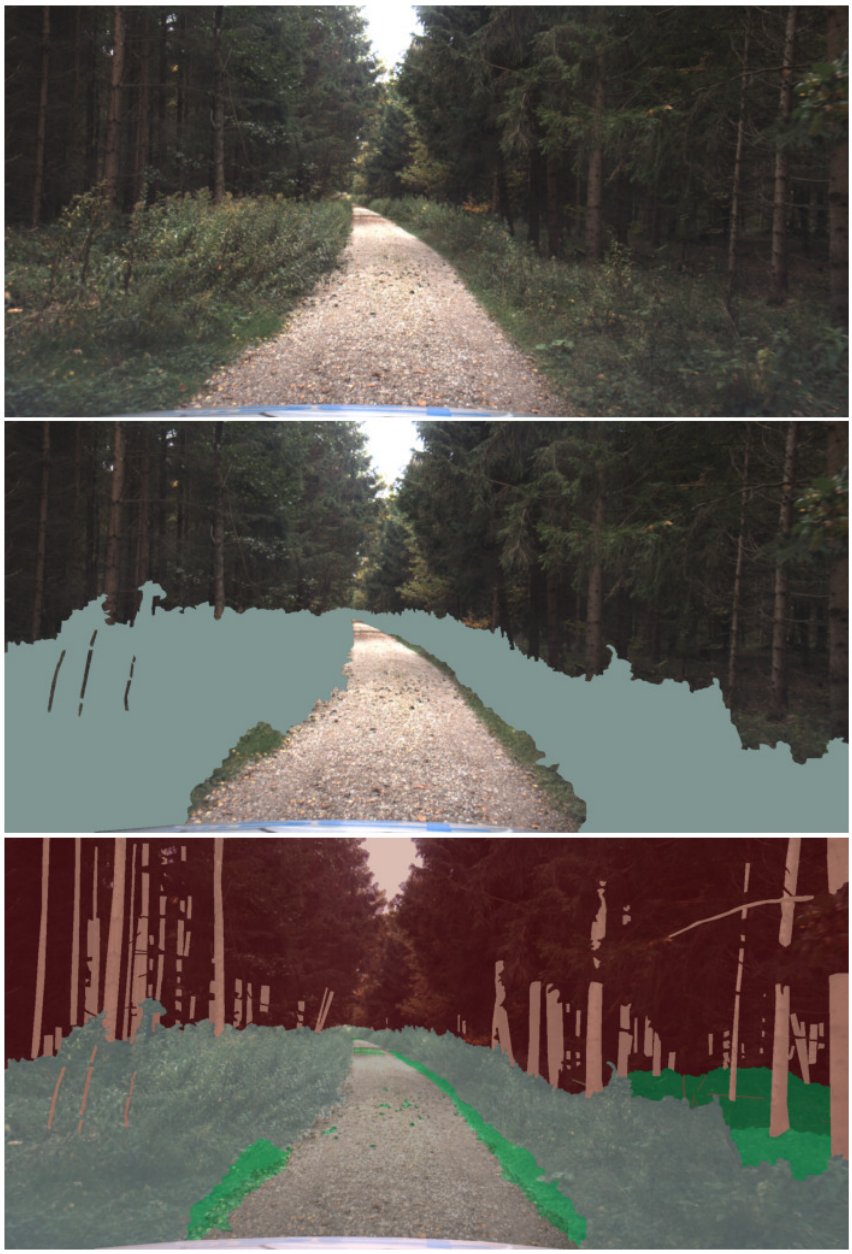


Figure 17.1: Example of a bush (■).

Figure 17.2:
Example of a individual bush (■). Bushes are often semitransparent, and visible obstacles within a bush like a pole (■) should be annotated. If the bush form a line and aren't distinguishable from each other, we annotate them as hedge (■).

ID#18: moss rgb(180, 168, 189)

This label also includes moss that grows on tree trunks or rocks. Only clearly visible moss patches of 150 px^2 in area should be annotated as moss.

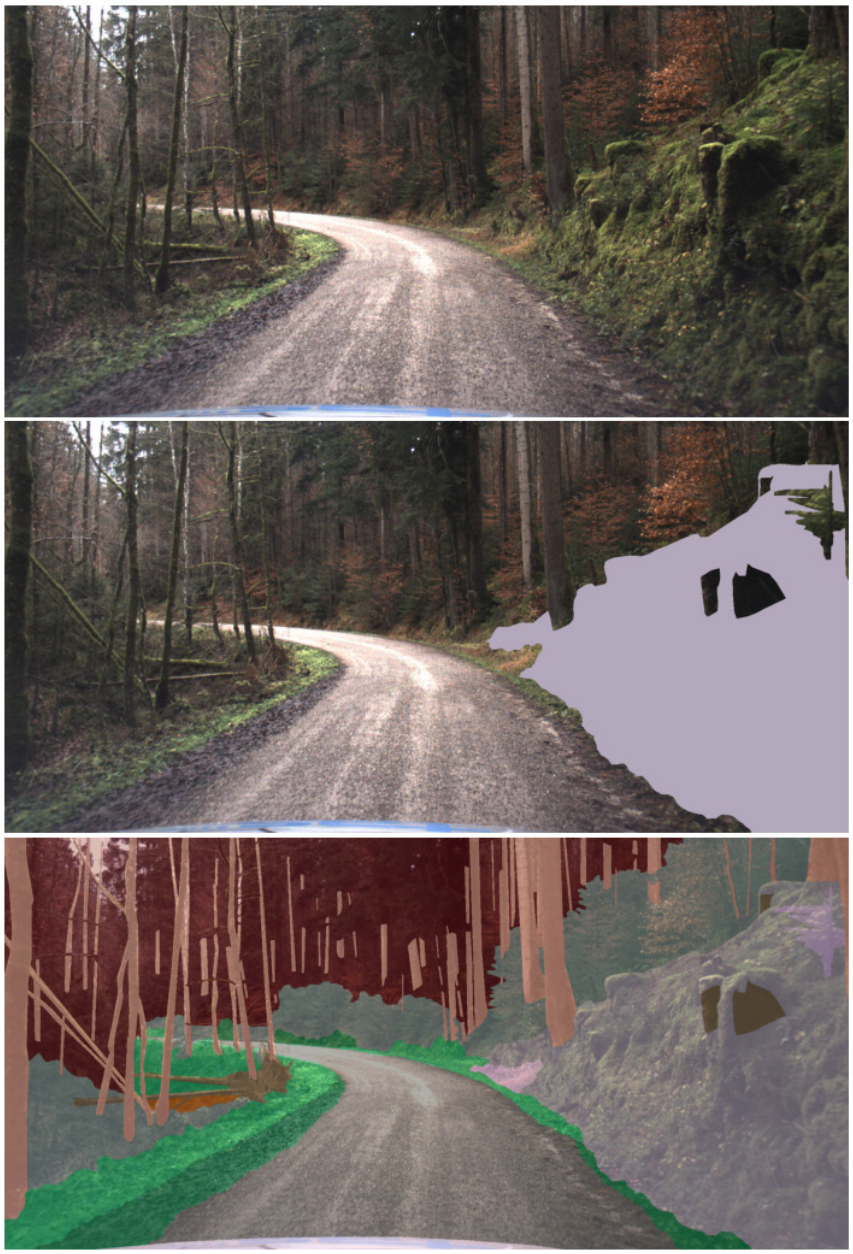


Figure 18.1: Example of annotated moss ( ).

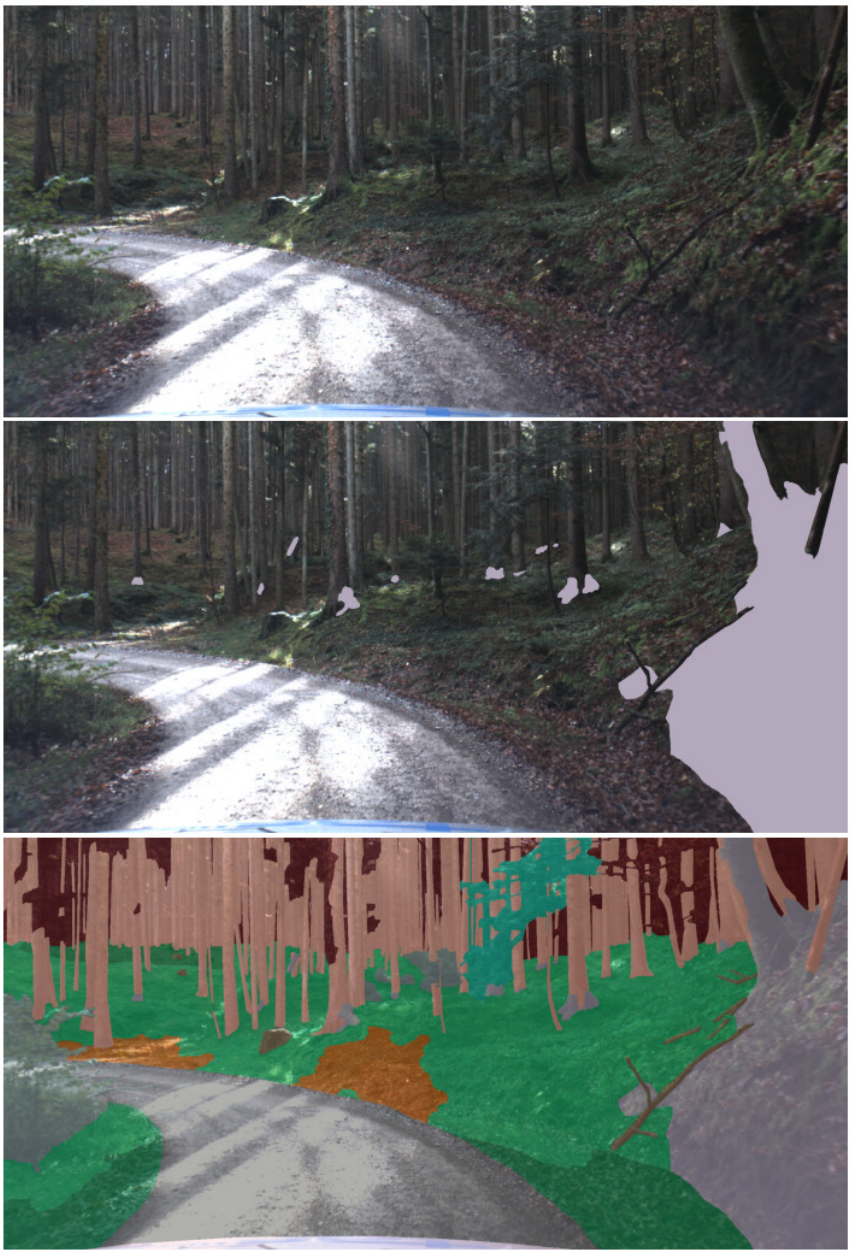


Figure 18.2: Example of annotated moss (■).

ID#19: traffic_light rgb(27,68,0)

The traffic light box without its poles [1].

Figure 19:
Example of a traffic_light (■). Notice that the pole is annotated separately. We also annotate the traffic lights not directed towards the ego vehicle.

ID#20: motorcycle rgb(79,198,1)

Motorbike, moped, scooter without the driver. The driver is annotated separately as rider [1].

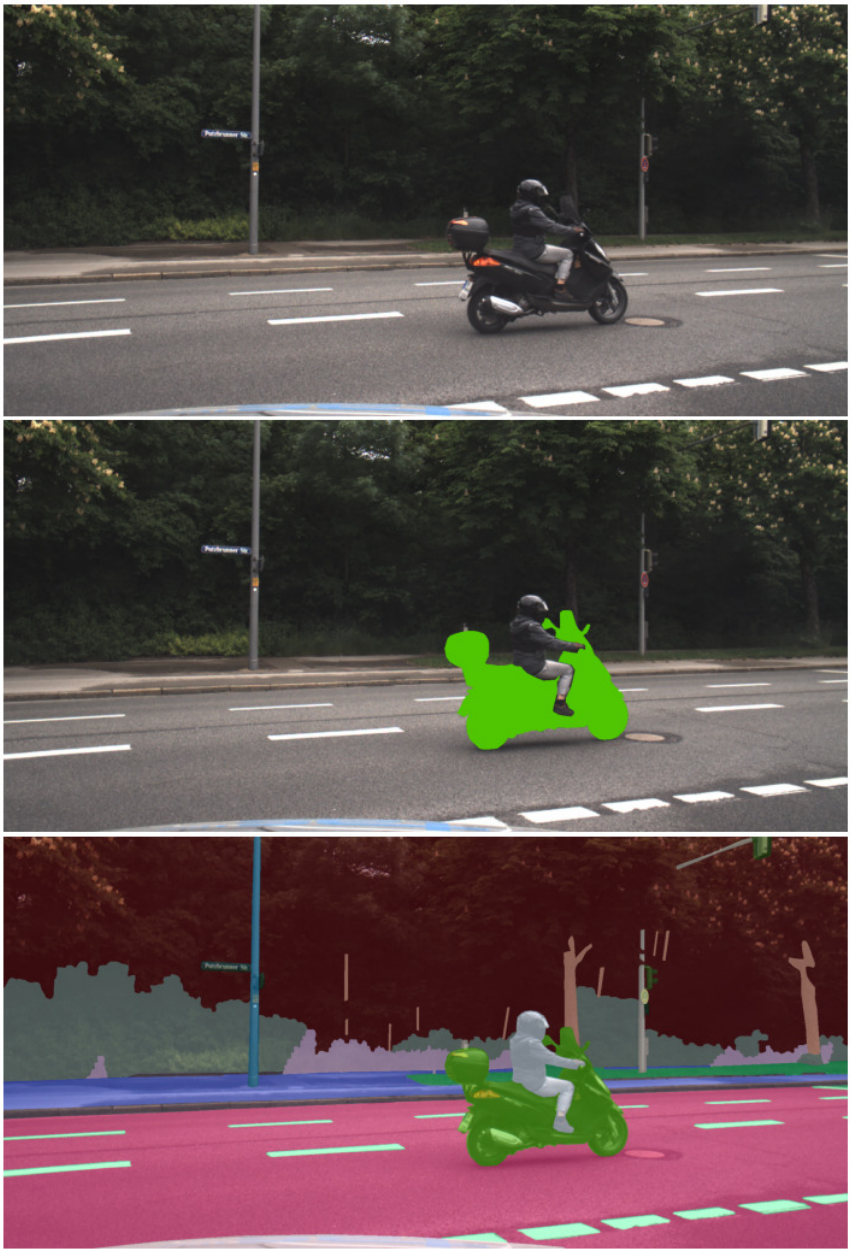


Figure 20:
Annotation examples of a scooter that is annotated as motorcycle ( ) [1]. The driver of the motorcycle is annotated as rider ( ).

ID#21: sidewalk rgb(59,93,255)

Part of ground designated for pedestrians or cyclists. Delimited from the road by some obstacle, e.g. curbs or poles (might be small), not only by markings. Often elevated compared to the road. Often located at the sides of a road. This label includes a traffic islands (the walkable part), or pedestrian zones (where usually cars are not allowed to drive during day-time) [1]. This class label excludes curb.

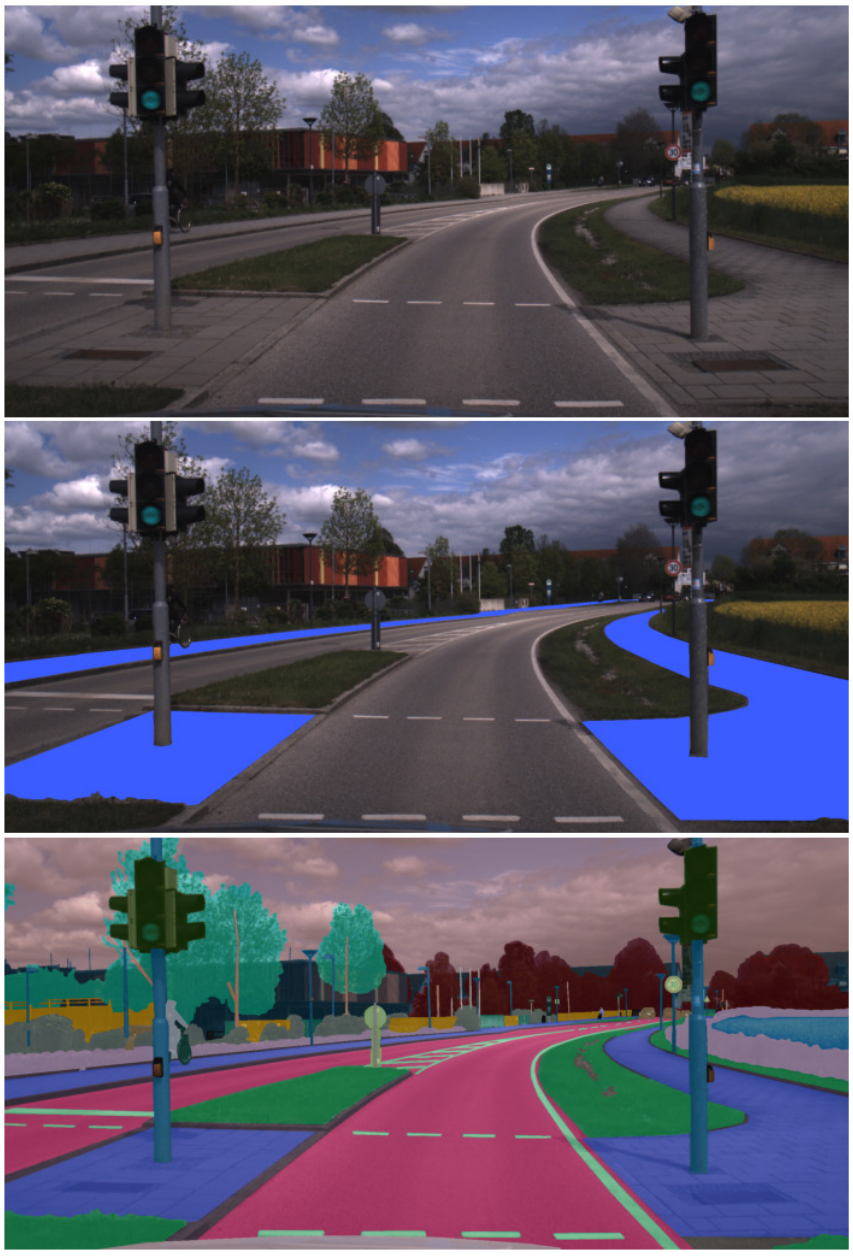


Figure 21.1:
Example of a sidewalk (■). Here the sidewalk is separated from the asphalt road (■) by a curb (■) and a patch of grass (■). The annotation includes the walkable part of a traffic island.

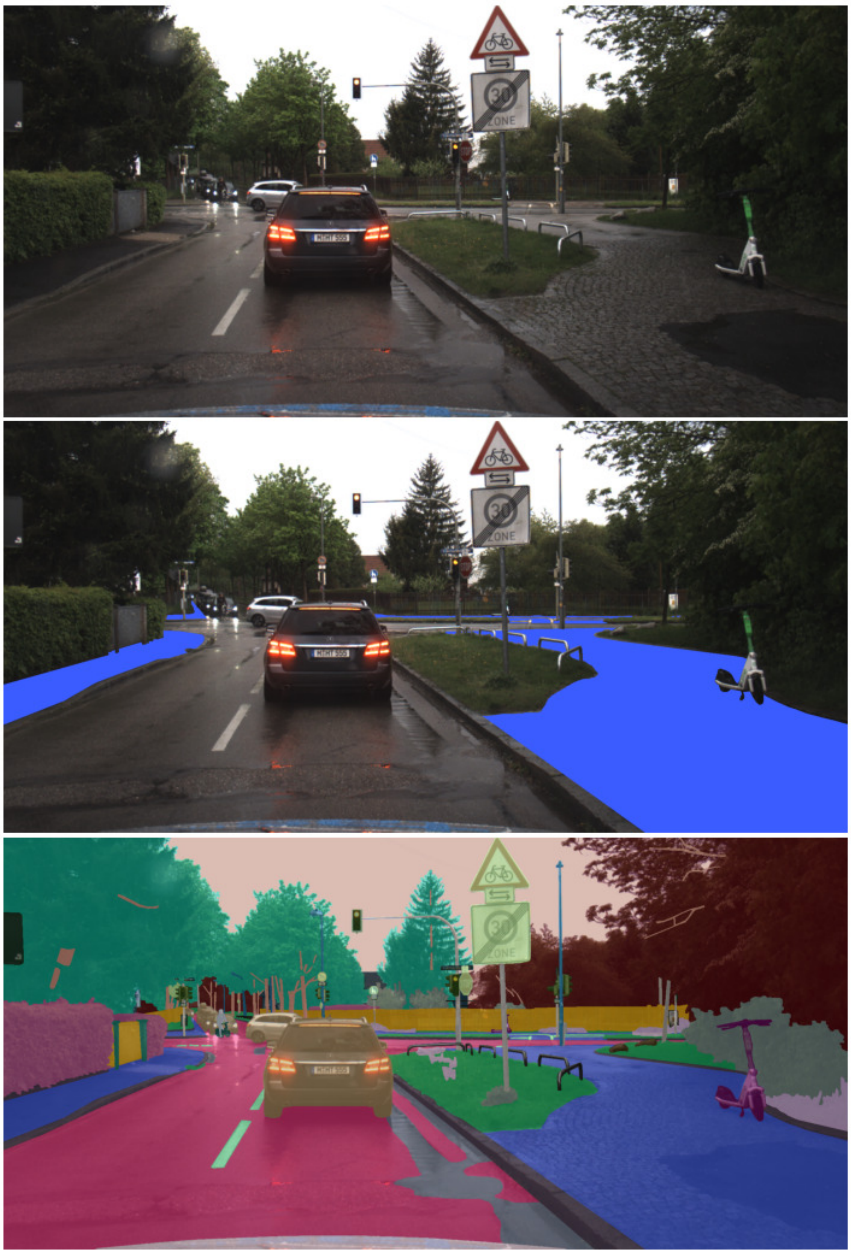


Figure 21.2:
Example of a sidewalk (■). Here the sidewalk is separated from the asphalt road (■) by a curb (■) and a patch of grass (■).

ID#22: curb rgb(74,59,83)

A curb, or kerb, is the edge where a raised sidewalk or road median/central reservation meets a street or other roadway.

Figure 22: Example of a curb (■).

ID#23: asphalt **rgb(255, 47,128)**

Drivable surfaces that are made of asphalt: e.g. asphalt roads. This also includes concrete surfaces. Road markings do often appear in white or yellow color and are annotated separately with the label road_marking ( ).

Figure 23: Example of annotated asphalt ( ).

ID#24: gravel rgb(97,97,90)

Drivable surfaces that are made of gravel (small stones): e.g. gravel roads.

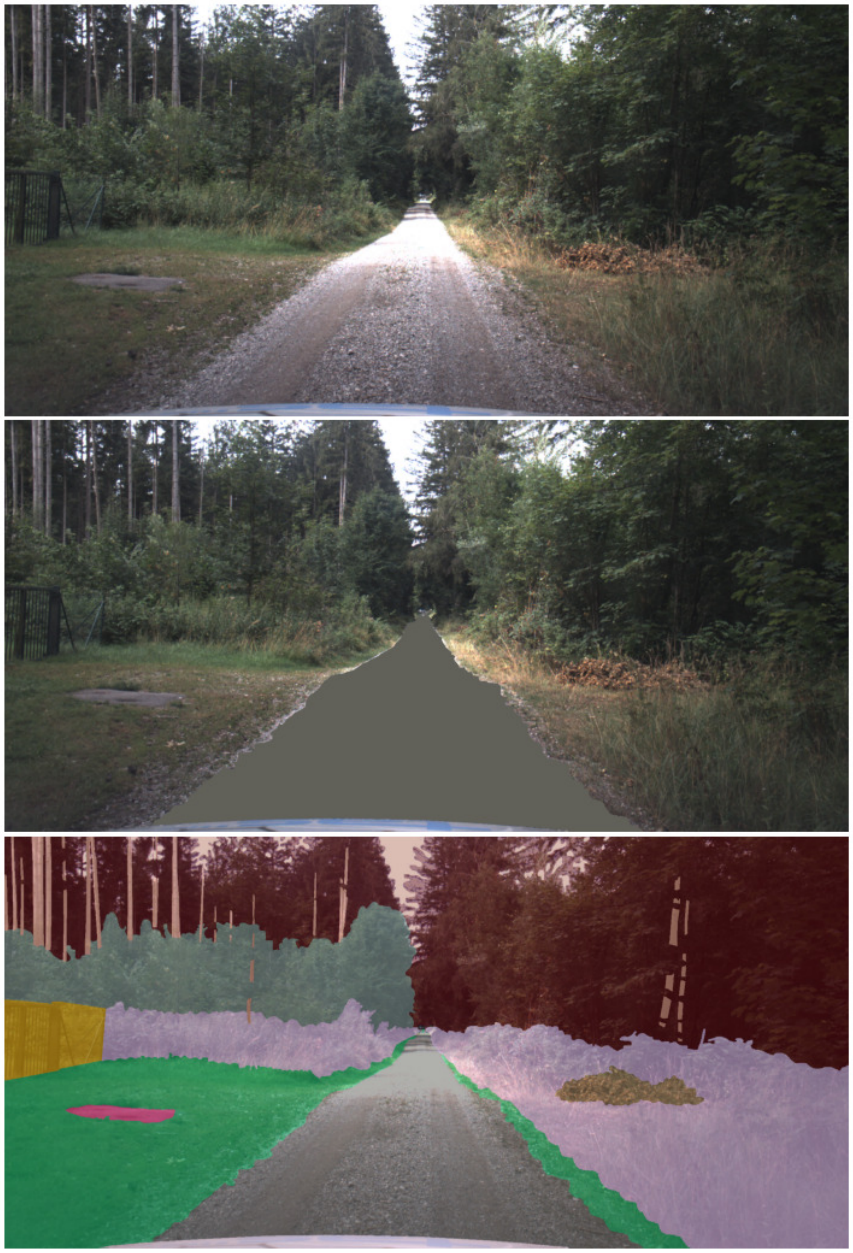


Figure 24.1: Annotation examples of gravel (■).

Figure 24.2:
Annotation examples of gravel (■). Notice that the grass patches in the middle of the gravel road are annotated separately as low_grass (■).

ID#25: boom_barrier rgb(52,54,45)

A boom barrier helps stopping of intruding vehicles. It is commonly used for parking spaces, camps as well as for civilian uses. This class excludes the vertical part which commonly operates the barrier mechanically; it is labeled as an obstacle. Therefore, only the moving part is labeled boom_barrier.

Figure 25: Examples of a boom barrier (■).

ID#26: rail_track rgb(107,121,0)

All kind of rail tracks, e.g. subway, tram and train rail tracks.
The tracks are annotated, as well as the railway ties when they differ from the underlying surface.
If there are no railway ties, then the area between the rail tracks is annotated as the underlying surface.

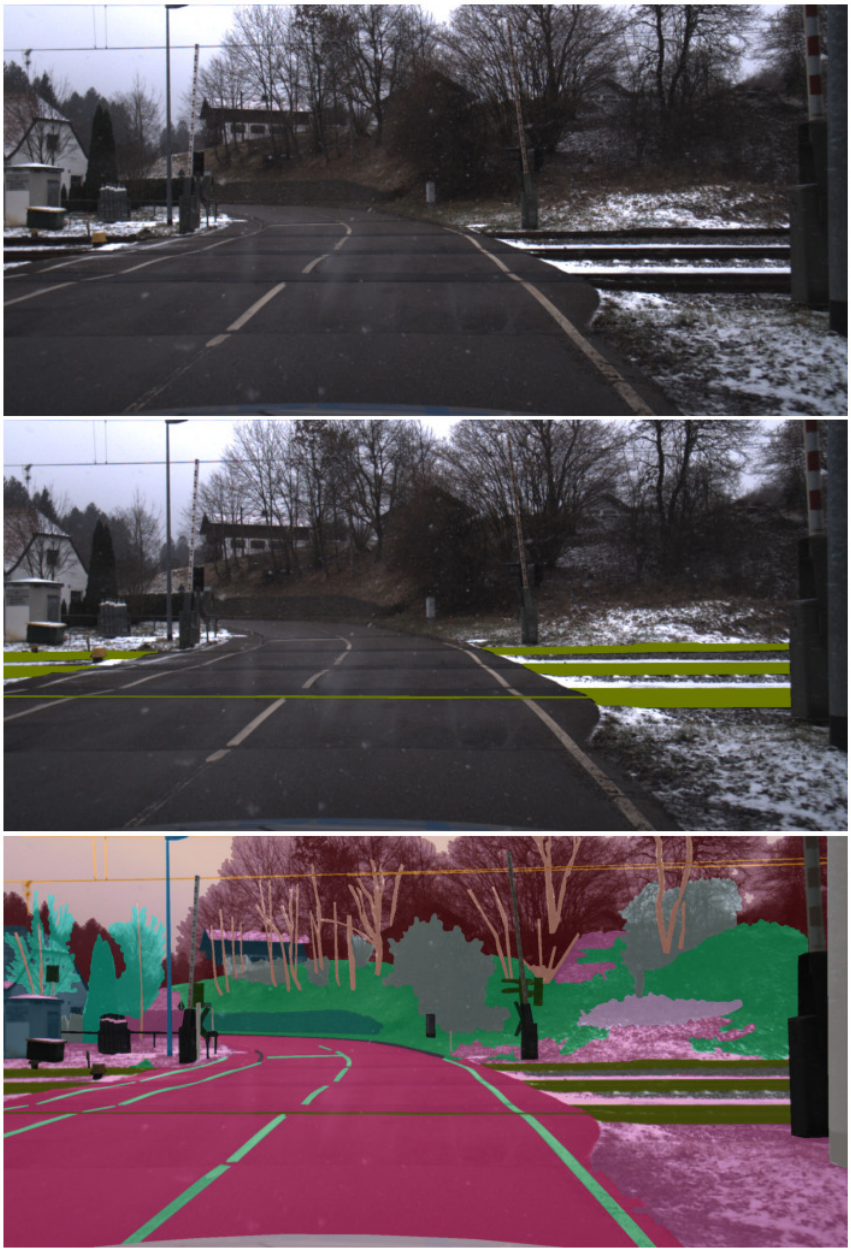


Figure 26: Example of a rail track (■).

ID#27: tree_crown rgb(0,194,160)

The crown of a plant refers to the total of an individual plant's above ground parts, leaves, but excluding the tree trunk. The following has to considered when labeling trees:

- *Labeling the crown of a tree as tree_crown requires that the tree_trunk ( ) is also annotated in the image and that the individual tree can be distinguished from the surrounding vegetation; an individual tree can either be physically located apart from the surrounding vegetation or they are separable due to color differences (see XIII in the illustration). In cases where the vegetation cannot be separated, annotate the vegetation as forest ( ).*
- *Smaller branches and foliage that can be grazed by the ego vehicle at very close distances (< 3 meter) is labeled as tree_crown ( ). In these cases we do **not** require the tree_trunk ( ) to be visible in the image (see XII in the illustration).*

Figure 27.1: Example of a tree crown (■).

Figure 27.2: Example of a tree crown (■).

ID#28: tree_trunk rgb(255,170,146)

The trunk is the stem and main wooden axis of a tree. Tree trunks are labeled, even if tree crowns are not clearly distinguishable. Overall, there are two scenarios where we label tree trunks:

- *Trees on an open field are visible and can be separated into single instances. Here we separate the tree into its tree_trunk ( ) and tree_crown ( ). Figure 28.1 shows tree trunks annotated based on this scenario.*
- *When close to a forest we annotate the tree trunks that are highly visible within the forest vegetation, since these are considered as dangerous obstacles. Here we only annotate the tree_trunk ( ) and the surrounding vegetation is annotated as forest ( ). Figure 28.2 shows tree trunks annotated based on this scenario.*

Figure 28:
Annotation examples of a tree trunk (■). Here we annotate tree trunk without any tree crowns (■) on the left side of the image, since they are not visible and separable there. The annotated area behind the tree trunks (■) is labeled as forest (■). On the right side of the image this is possible, where the tree crown (■) is also annotated.

ID#29: debris rgb(136,111,76)

Debris is rubble, wreckage, ruins, litter and discarded garbage/refuse/trash/brushwood, as well as tree logs, scattered remains of something destroyed or discarded.

Figure 29.1: Example of brushwood annotated as debris (■).

Figure 29.2: Example of discarded tree logs annotated as debris (■).

ID#30: crops rgb(0,134,237)

Agricultural fields that are planted with crops such as corn or wheat.

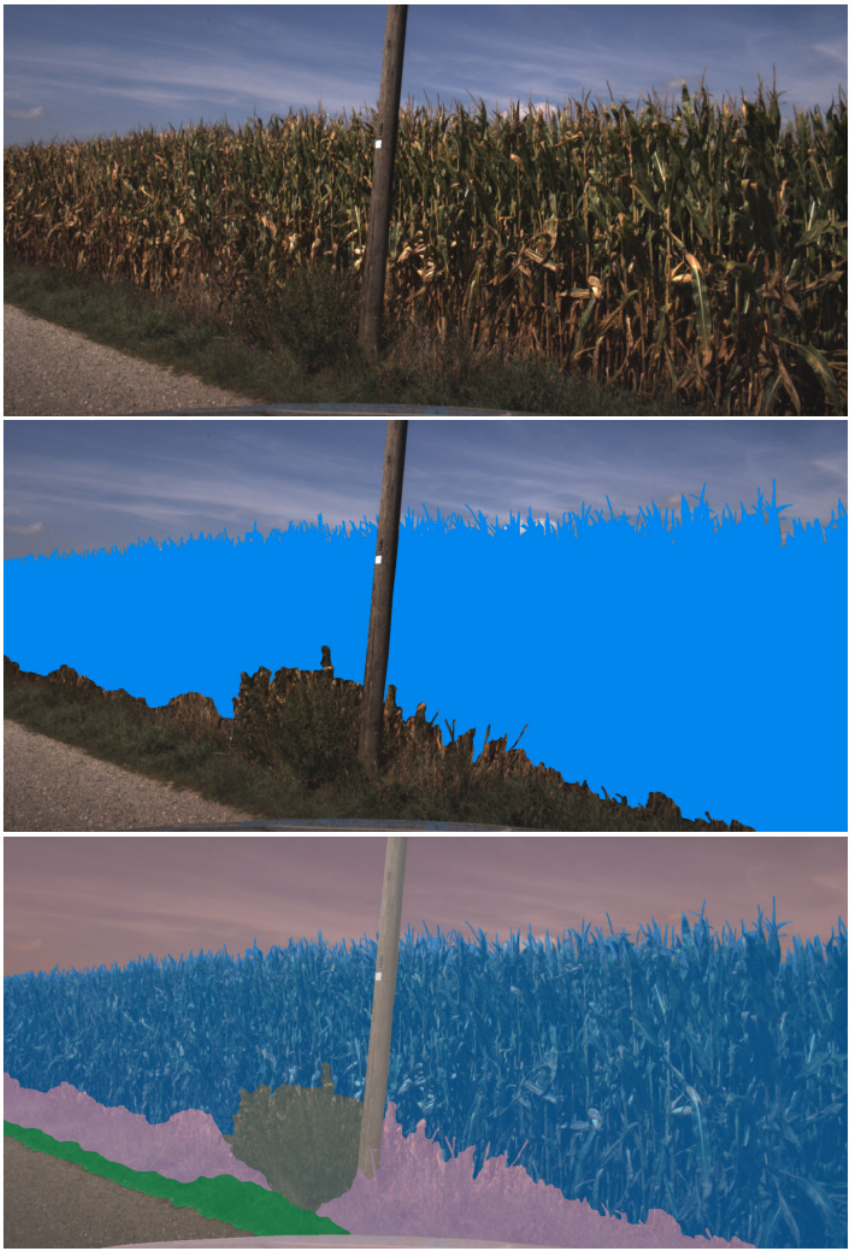


Figure 30.1: Example of a corn field annotated as crops (■).

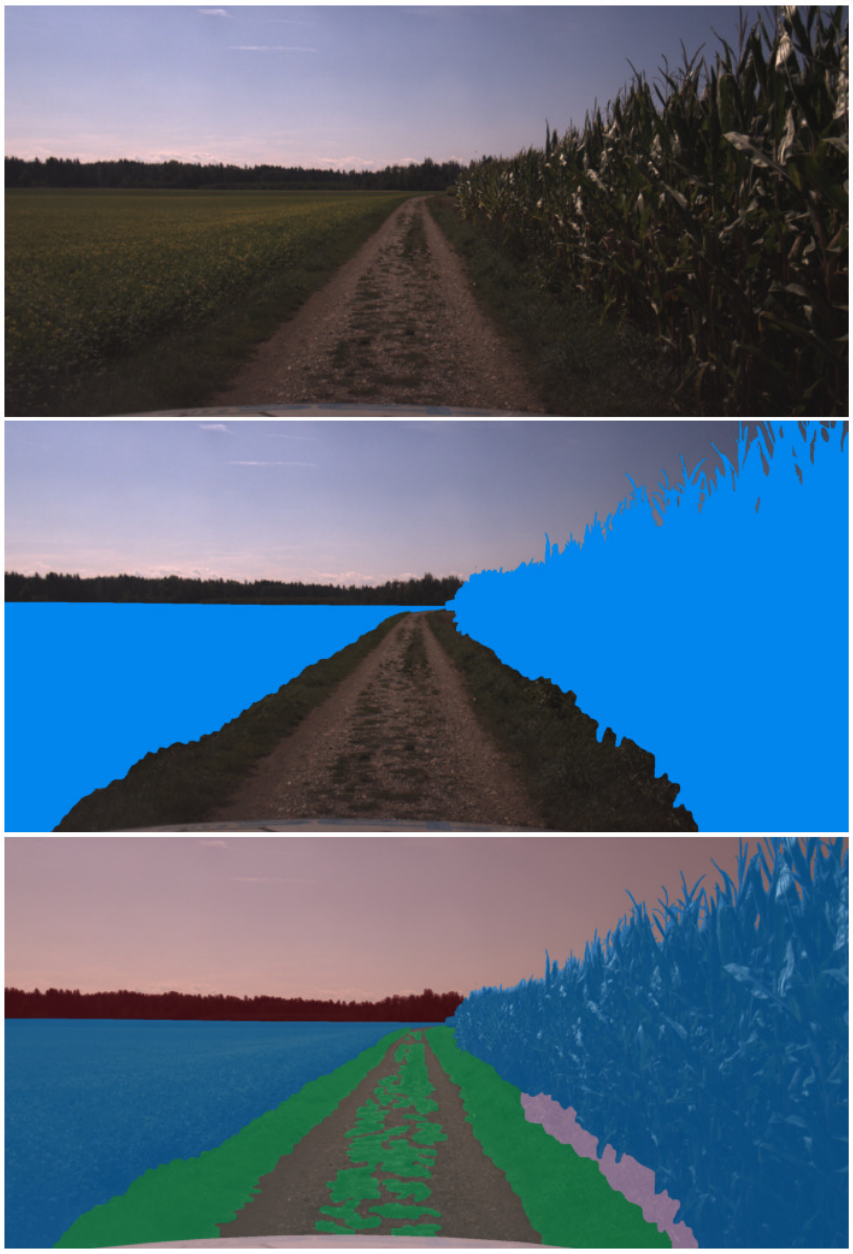


Figure 30.2:
Example of a corn field annotated as crops (■) on the right and the still growing canola field on the left also annotated as crops (■).

ID#31: soil **rgb(209,97,0)**

Surfaces that are made of soil or sand: e.g. dirt roads or dirt patches. Sand is a granular material composed of finely divided rock. It is defined by size, being 1 mm - 2 mm. Sand is sometimes found on the roadside. Soil is often brown colored, composed of small mineral particles and found on agricultural fields.

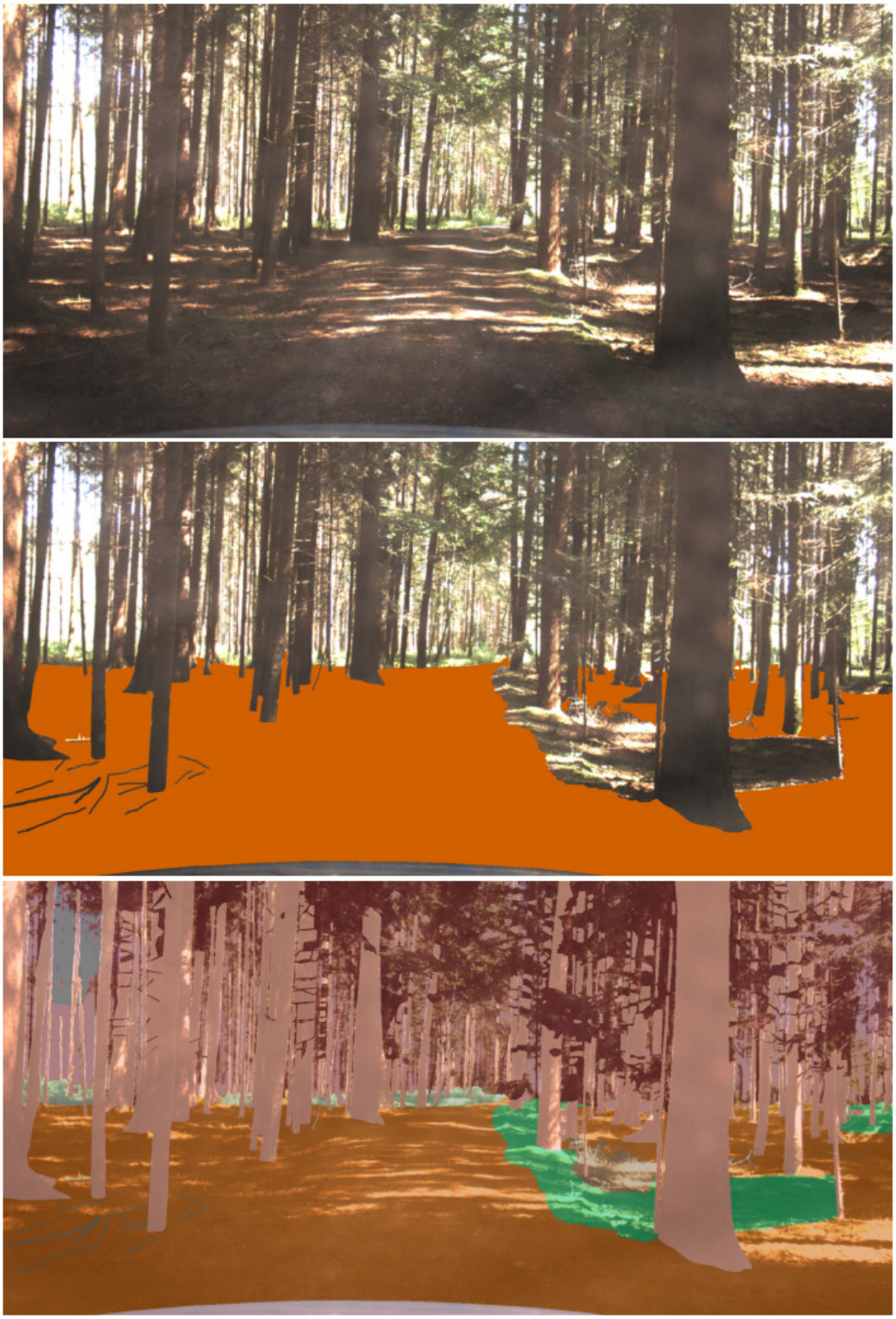


Figure 31.1: Example of the forest ground annotated as soil (■).

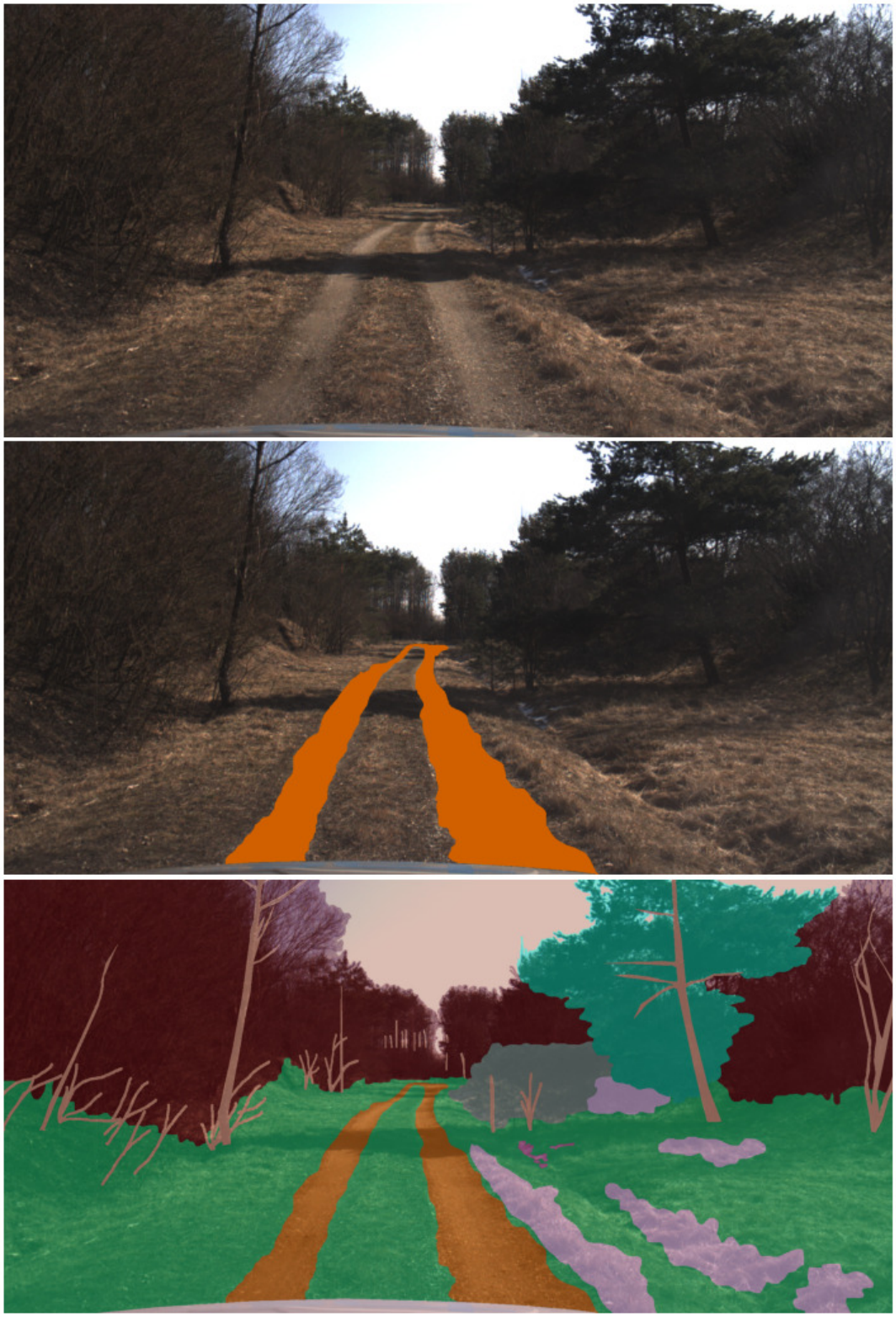


Figure 31.2:
Example of a field path annotated as soil (■) with grass (■) splitting the tracks of the path.

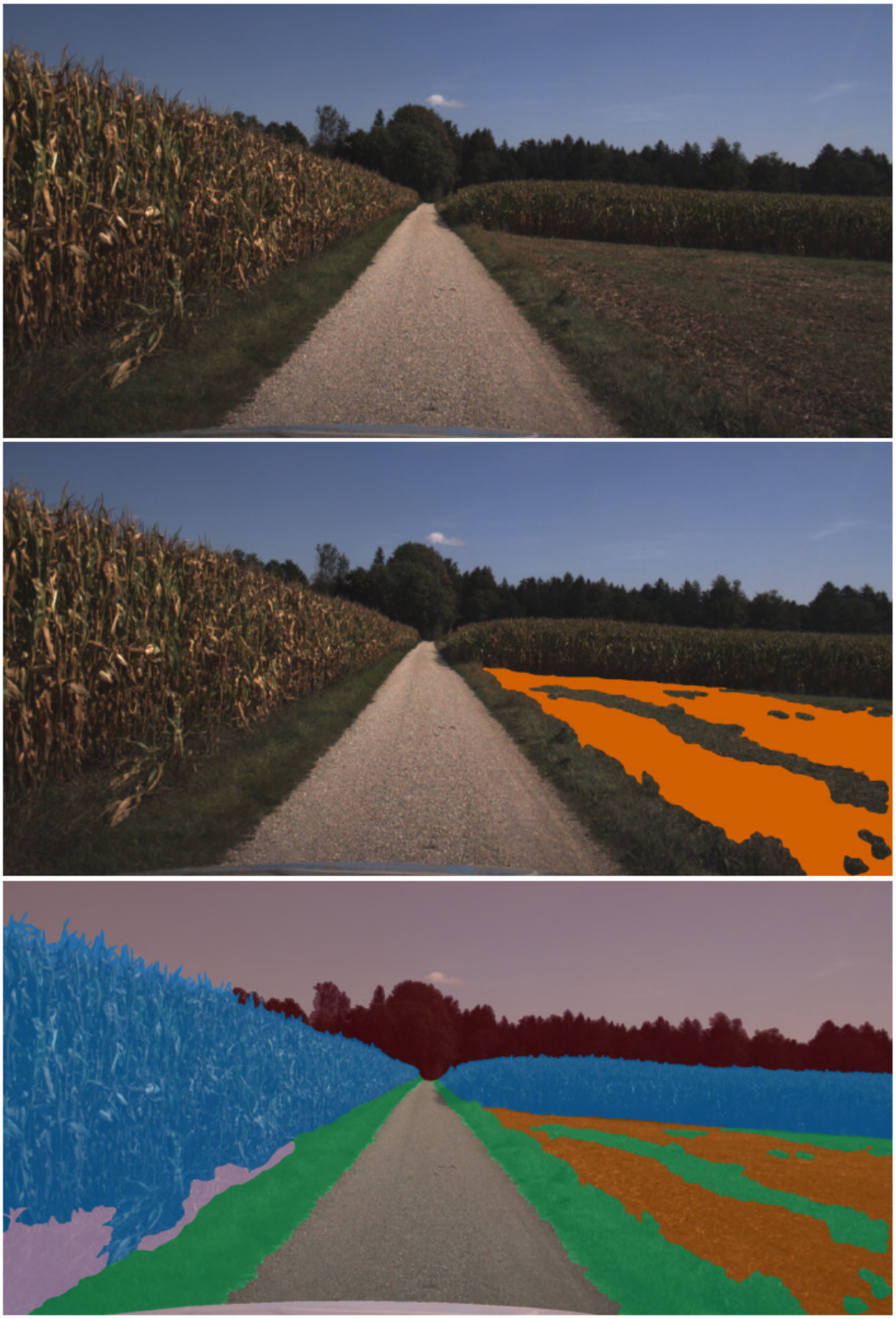


Figure 31.3: Example of dry patches in the field being annotated as soil (■).

ID#32: rider rgb(221,239,255)

A human that would use some device to move a distance of 1m. Includes, riders/drivers of bicycle, motorbike, scooter, skateboards, horses, roller-blades, wheelchairs, road cleaning cars, cars without roof. We do not label riders visible in car windows, only riders out in the open [1].

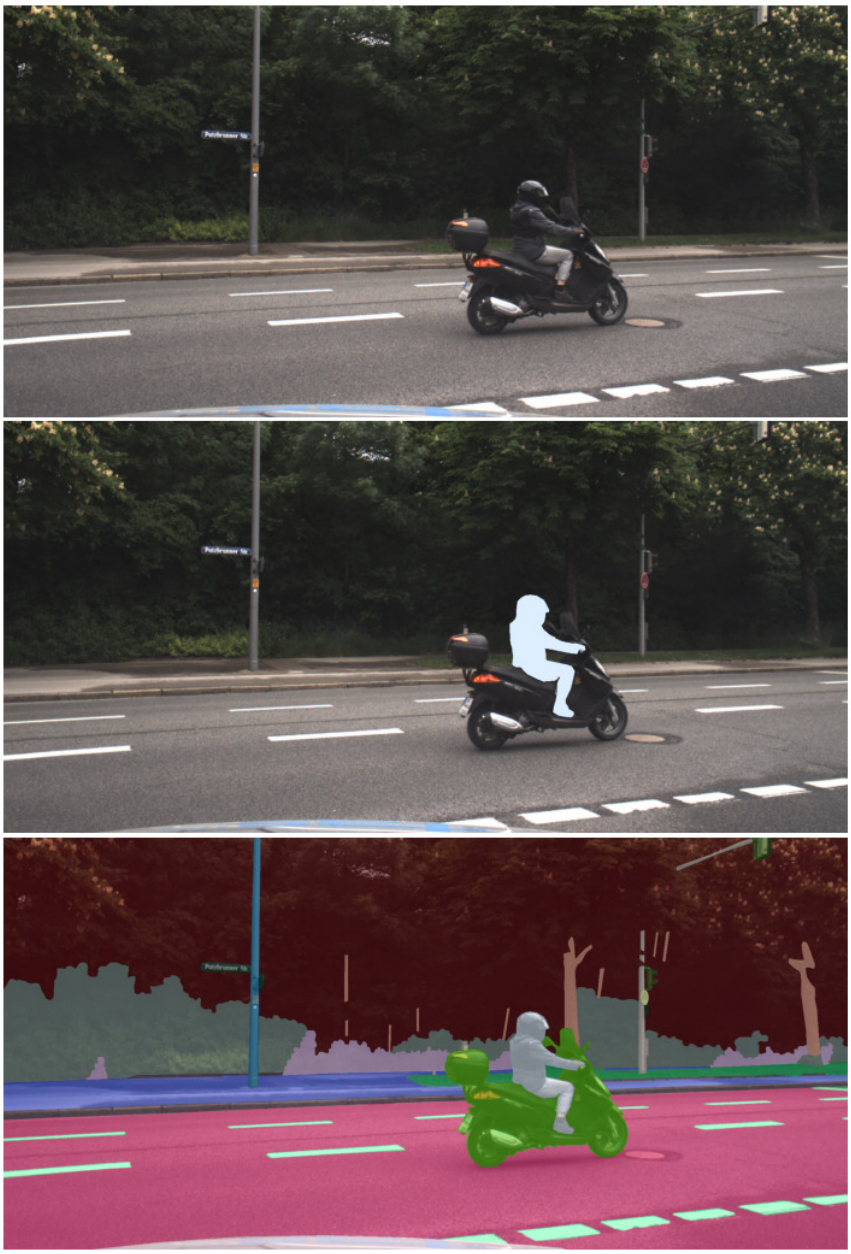


Figure 32.1: Examples of a rider on a scooter ( ) [1].

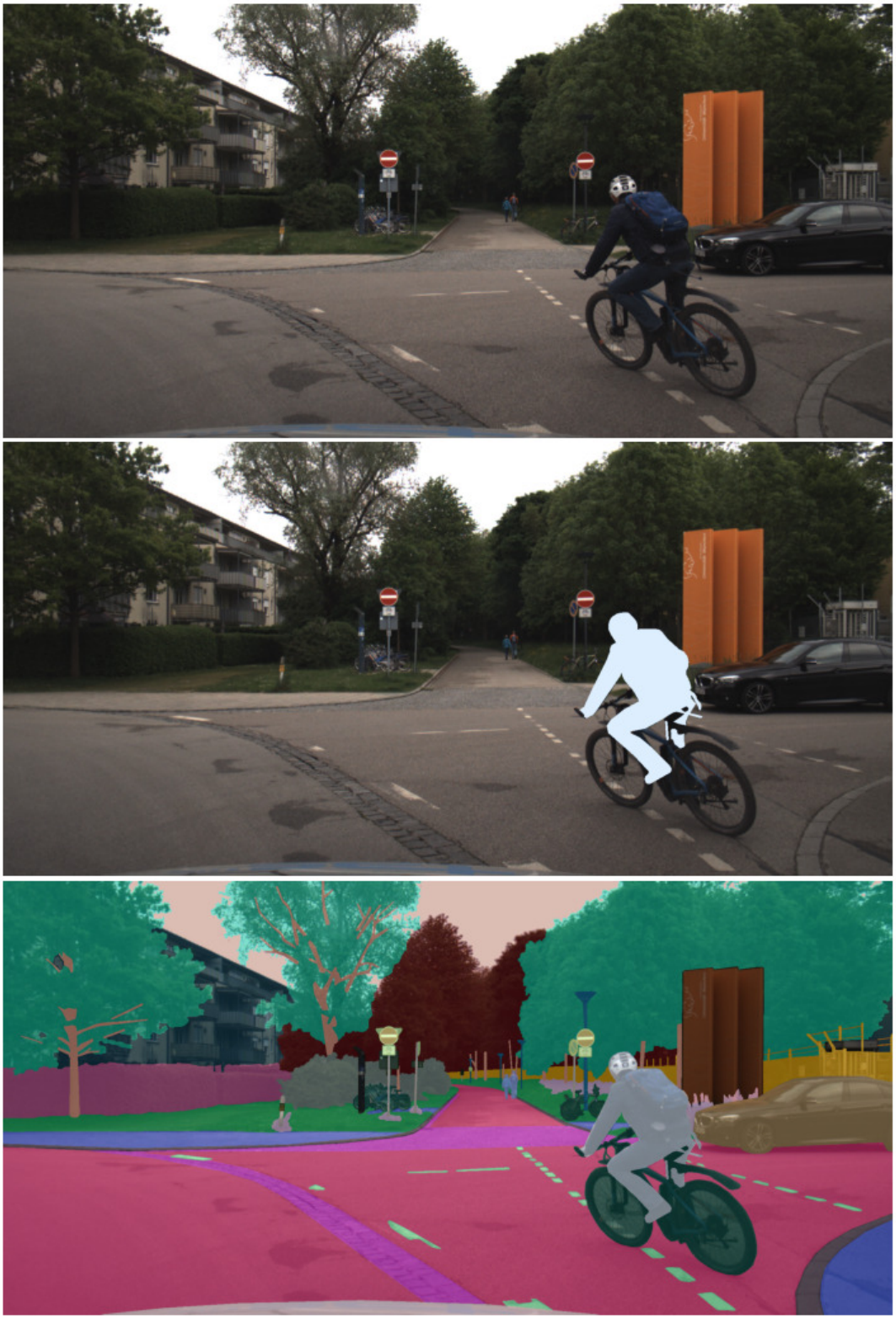


Figure 32.2: Examples of a rider on a bicycle ( ) [1].

ID#33 animal rgb(0,0,53)

All kinds of animals: cats, dogs, cows, etc.

Figure 33.1: Example of a horse annotated as animal (■) [1].

Figure 33.2: Example of dogs annotated as animal (■) [1].

ID#34: truck **rgb(123,79,75)**

Truck and box truck. Including their trailers. Back part / loading area is physically separated from driving compartment [1].

Figure 34: Example of a truck (■).

ID#35: on_rails rgb(161,194,153)

Vehicle on rails, e.g. tram, train [1].

Figure 35: Example of a train ( ).

ID#36: caravan rgb(48,0,24)

Like truck, but back is primarily for living/sleeping; including caravan trailers [1].

Figure 36.1: Example of a caravan (■).

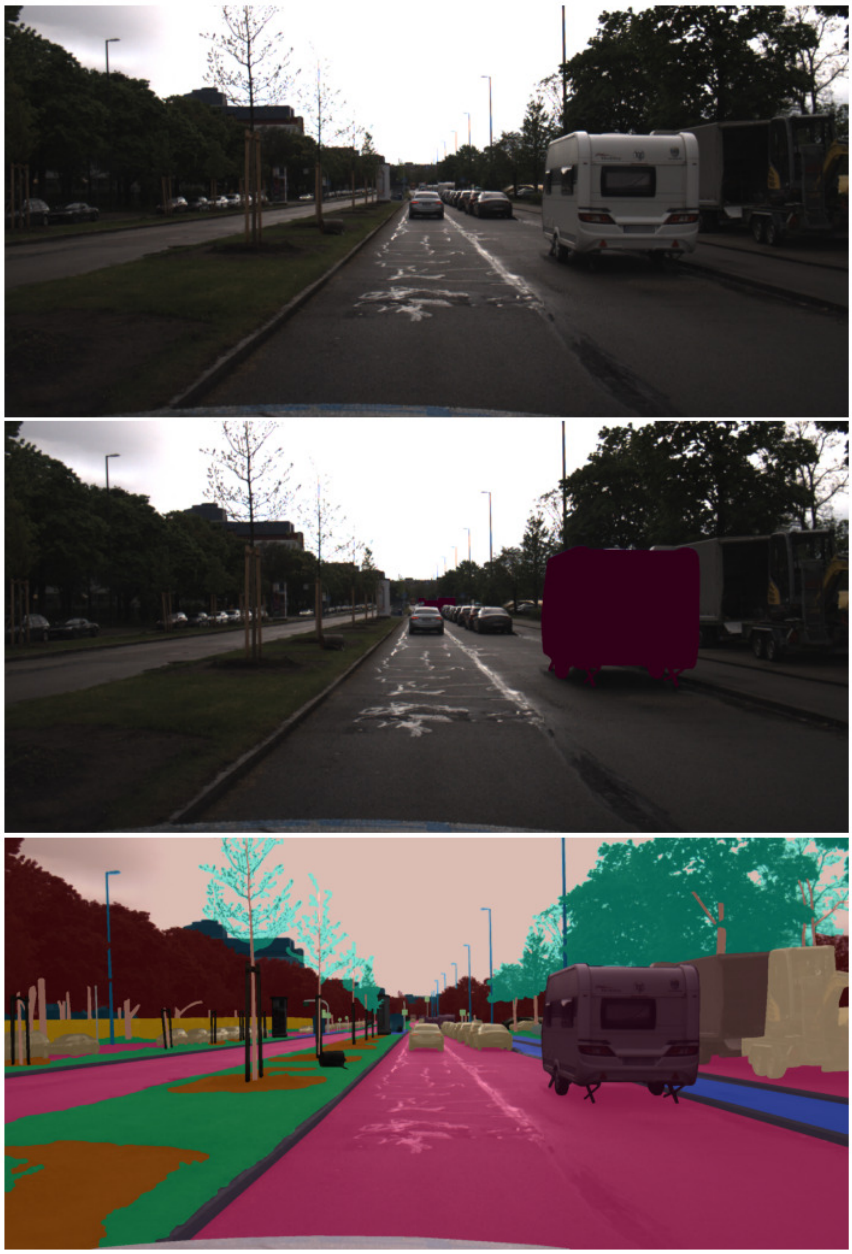


Figure 36.2: Example of a caravan trailer (■).

ID#37: trailer **rgb(10,166,216)**

Trailers typically pulled by cars. Note that this label contains bicycle or horse trailers [1]. Truck trailers are labeled as truck. Caravan trailers as caravan.

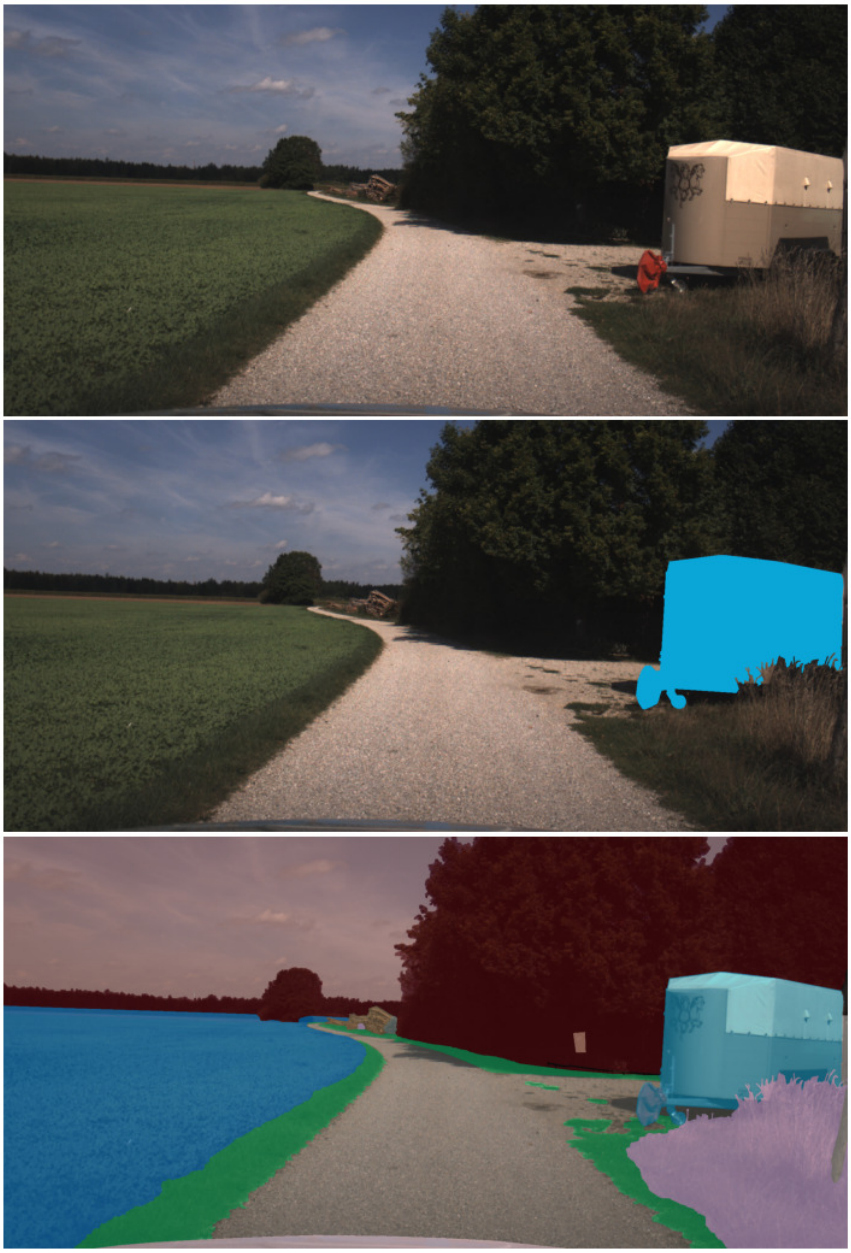


Figure 37: Example of a trailer ( ).

ID#38: building rgb(1,51,73)

Building, skyscraper, house, bus stop building, garage, tent, car port. If a building has a glass wall that you can see through, the wall is still building. Includes scaffolding attached to buildings [1]. This label includes transmission towers and construction cranes that commonly consist of steel and it includes holes.

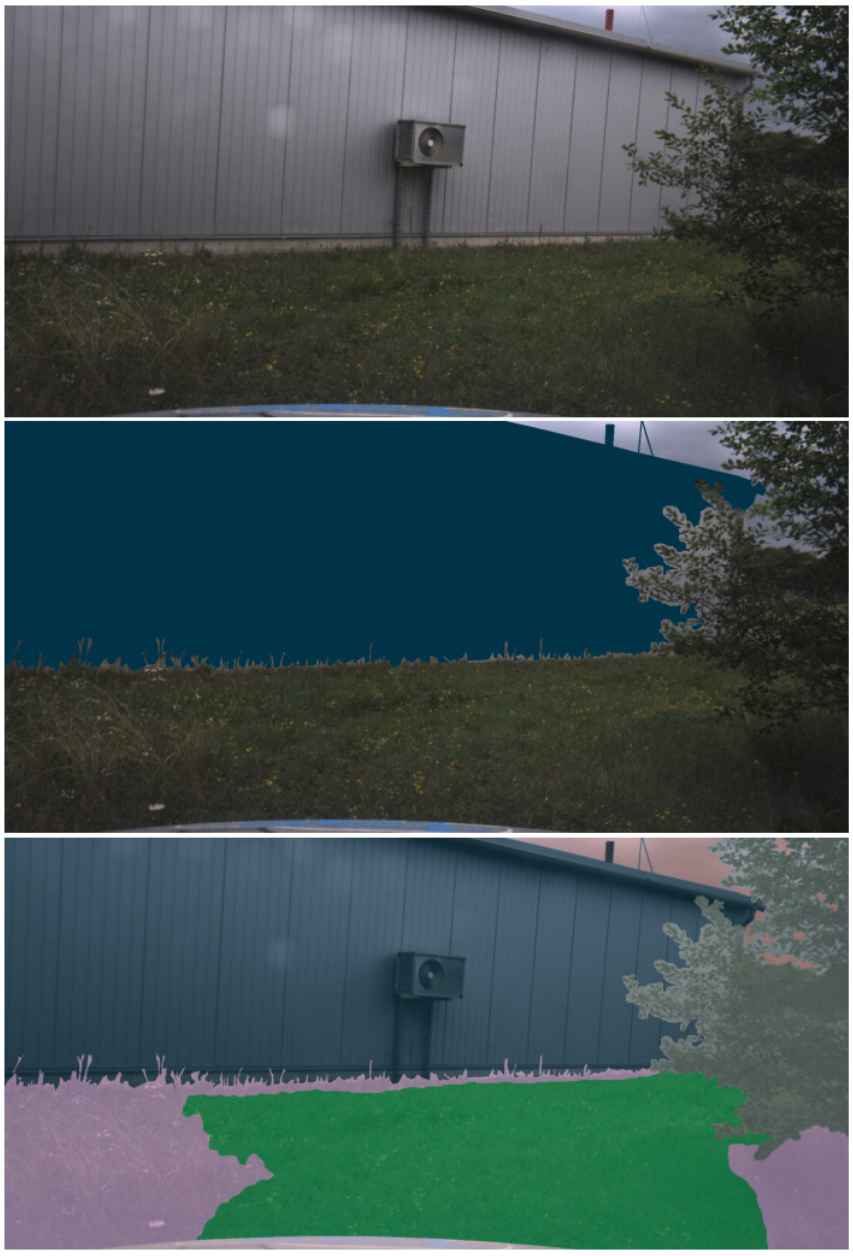


Figure 38.1: Example of a building (■).

Figure 38.2: Example of a transmission tower annotated as building (■).

ID#39: wall rgb(0,132,111)

Individual standing wall. Not part of a building [1].
At tunnels (■), the walls at the tunnel entrance are labeled as walls.

Figure 39.1: Example of a wall (■).

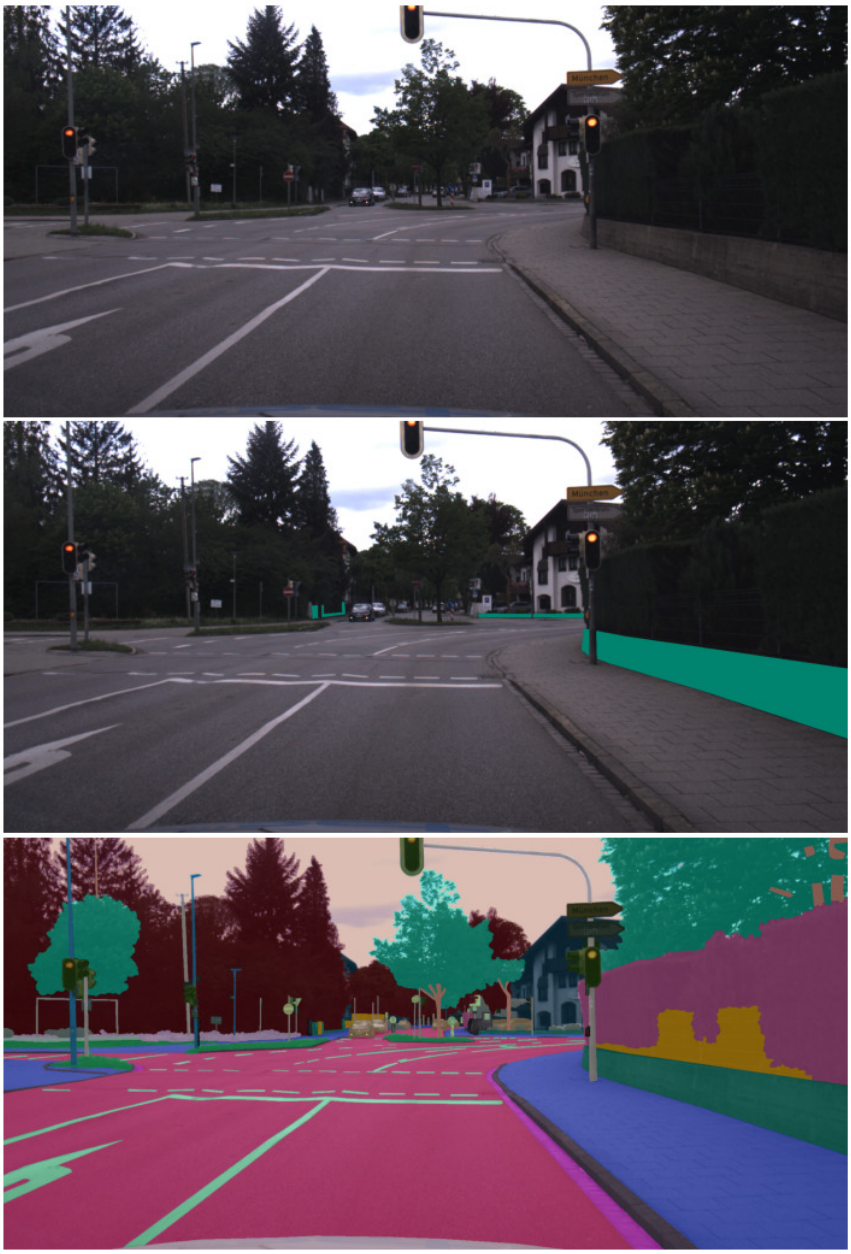


Figure 39.2: Example of a wall (■).

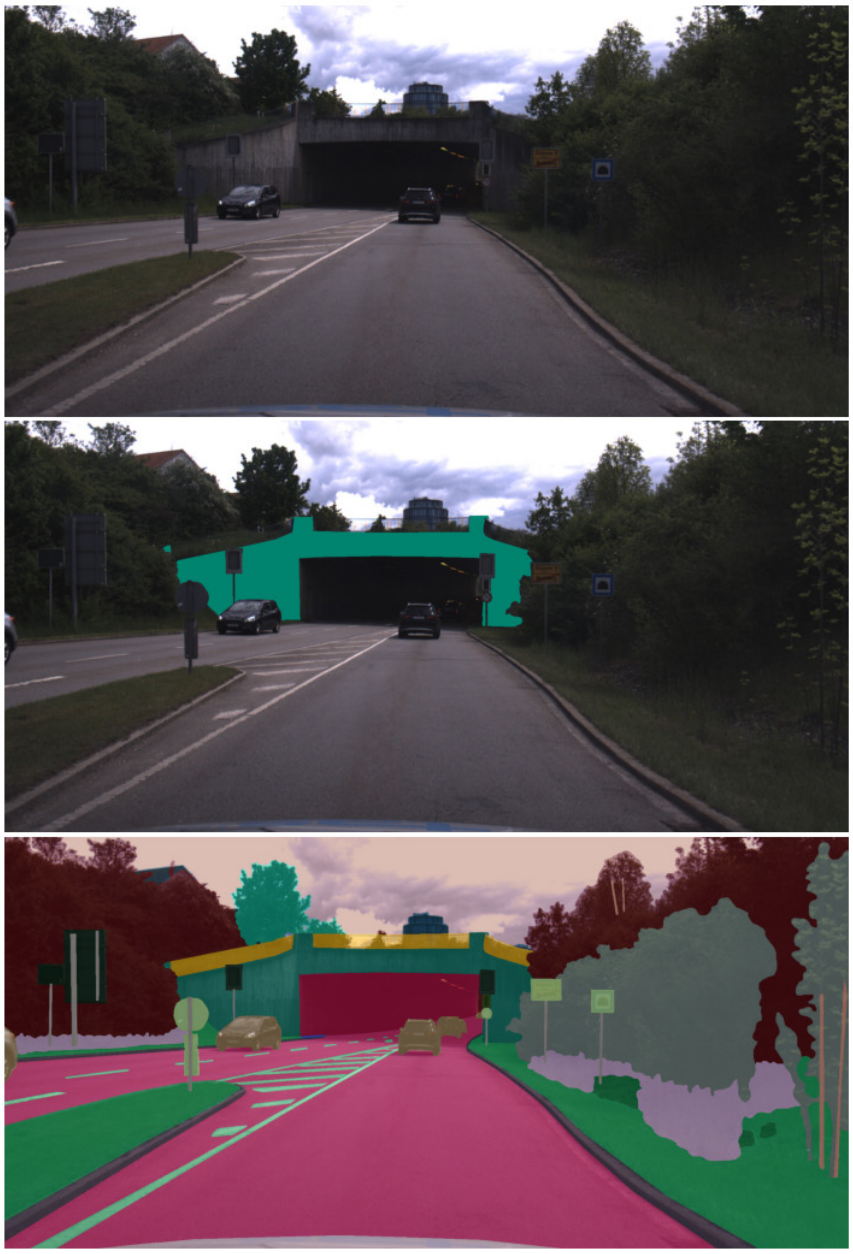


Figure 39.3:
Example of a tunnel where the wall around the entrance to the tunnel (■) is annotated as wall (■).

ID#40: rock

rgb(55,33,1)

Rocks or stones that are clearly recognized as such.
The moss (■) on a rock is annotated separately.

Figure 40: Example of a rock (■).

ID#41: fence rgb(255,181,0)

A fence is labeled as a surface including any transparent holes that are smaller than 750 px^2 in size. For patches that are larger than 750 px^2 the visible objects behind the fence are labeled.
*For the **3D point cloud segmentation**, all points behind a fence are annotated as is and not as part of the fence class.*

Figure 41.1: Example of an annotated fence (■).

Figure 41.2:
Example of an annotated fence (■). Even though the building and tree behind the fence is clearly visible, the patches between the links of the fence are too small to warrant annotating the objects behind the fence.

Figure 41.3:
Example of an annotated fence (■). Here the parts of the fence are not clearly visible between the beams. The patches are large enough to warrant annotating the visible parts between the beams of the fence.

ID#42: guard_rail **rgb(194,255,237)**

All types of guard rails/crash barriers [1]. Guard rails are a boundary feature and may be a means to prevent or deter access to dangerous or off-limits areas while allowing light and visibility in a greater way than a fence. Common shapes are flat, rounded edge, and tubular in horizontal railings.

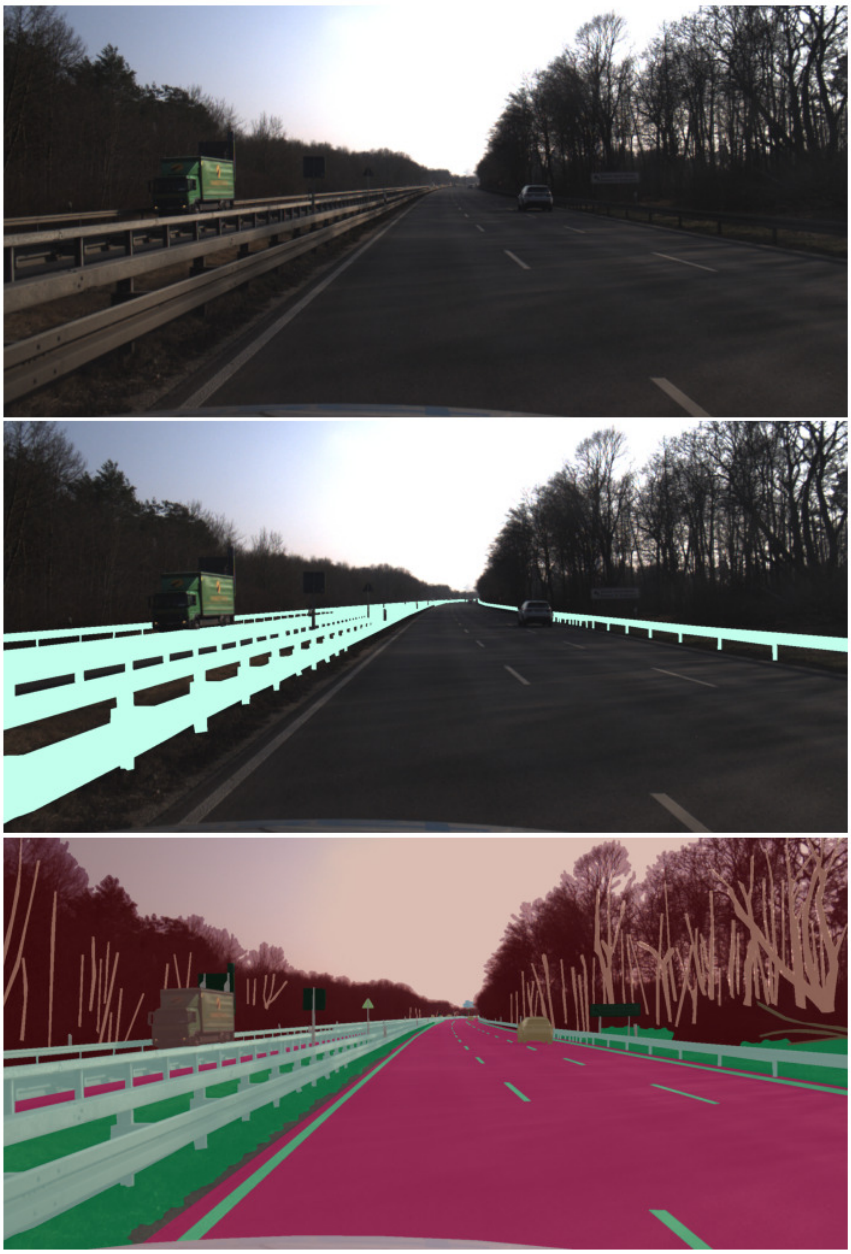


Figure 42: Example of a guard rail ( ).

ID#43: bridge rgb(160,121,191)

Only the bridge. Fences, people or vehicles on top are labeled separately [1]. This label is not used if the robot is driving on the bridge.

Figure 43: Example of a bridge ( ).

ID#44: tunnel rgb(204,7,68)

Tunnel wall and 'the dark'. No vehicles [1]. The outside wall leading into the tunnel is labeled as wall (■).

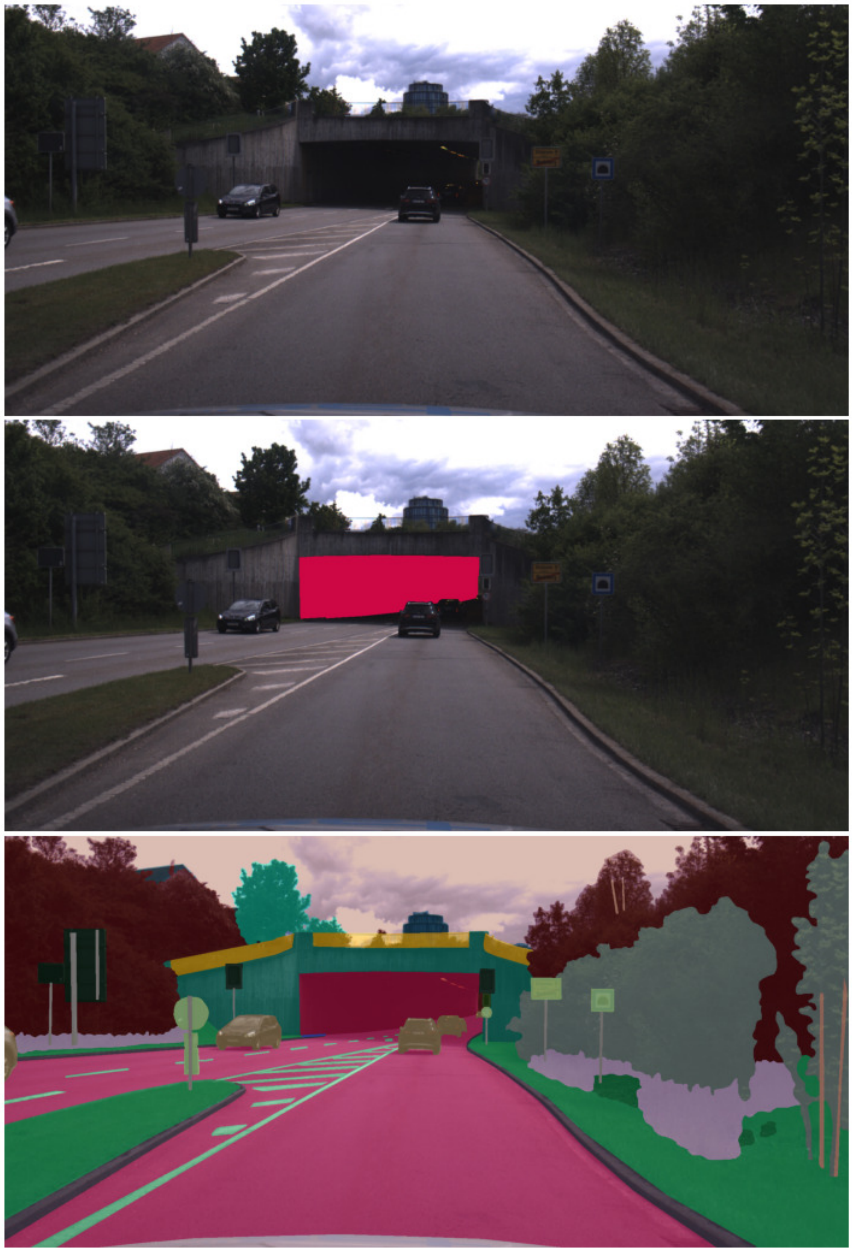


Figure 44.1: Example of approaching a tunnel (■).

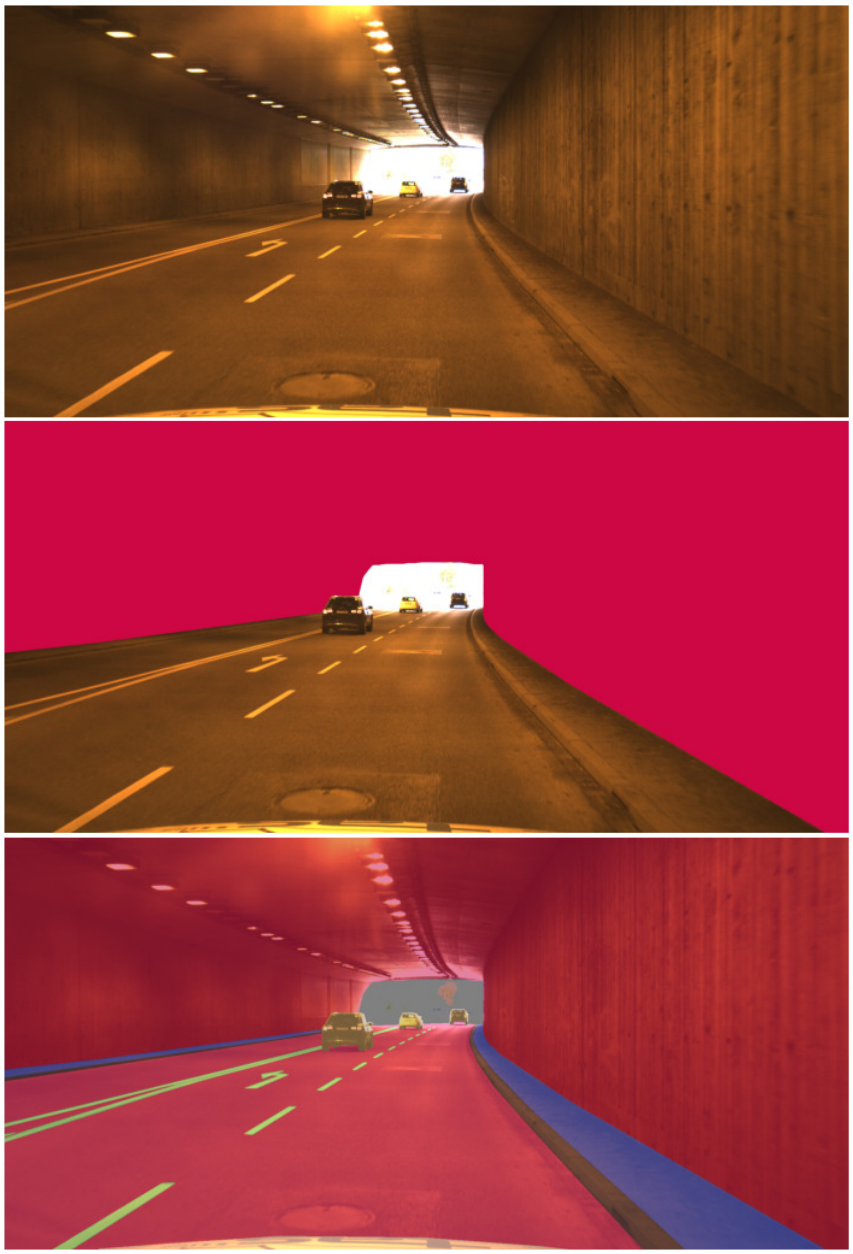


Figure 44.2: Example inside a tunnel (■).

ID#45: pole rgb(192,185,178)

Small mainly vertically oriented pole. E.g. sign pole or traffic light poles. If the pole has a horizontal part (often for traffic light poles) this part is also considered part of the pole. If there are things mounted at the pole that are neither a traffic_light nor traffic_sign and that have a diameter (in pixels) of at most twice the diameter of the pole, then these things might also be labeled pole. [1] Construction beams or transmission towers that consist of one pole instead of several steal/iron masts are labeled as pole.

Figure 44.1: Example of shorter and taller poles ( ).

Figure 44.2:
Example of annotated poles by the traffic lights (■) and the difference to street lights (■).

ID#46: traffic_sign rgb(194,255,153)

Sign installed from the state/city authority, usually for information of the driver/cyclist/pedestrian in an everyday traffic scene, e.g. traffic-signs, parking signs, direction signs - without their poles. Also annotate it as traffic sign even if only the backside is visible. No ads/commercial signs.
Note that commercial signs attached to buildings become building [1]. Pole and traffic_sign are not labeled together. The class misc_sign is used for ads and commercial signs that are not attached to buildings.
An overview for traffic signs that occur in Germany and have to be annotated can be found at: https://www.adac.de/verkehr/recht/verkehrszeichen/.

Figure 46: Example of a traffic and direction signs ( ).

ID#47: misc_sign rgb(0,30,9)

Signs that are not installed from the state/city authority and do not provide information for the driver/cyclist/pedestrian in an everyday traffic scene. Examples are ads or commercial signs. Note that commercial signs attached to buildings become building (■), attached to poles or standing on their own become misc_sign.

Figure 47: Example of a commercial sign annotated as miscellaneous sign (■).

ID#48: barrier_tape **rgb(190,196,89)**

Barrier or barricade tape is brightly colored tape (often incorporating a two-tone pattern of alternating yellow-black or red-white stripes or the words "Caution" or "Danger" in prominent lettering) that is used to warn or catch the attention of passersby of an area or situation containing a possible hazard.

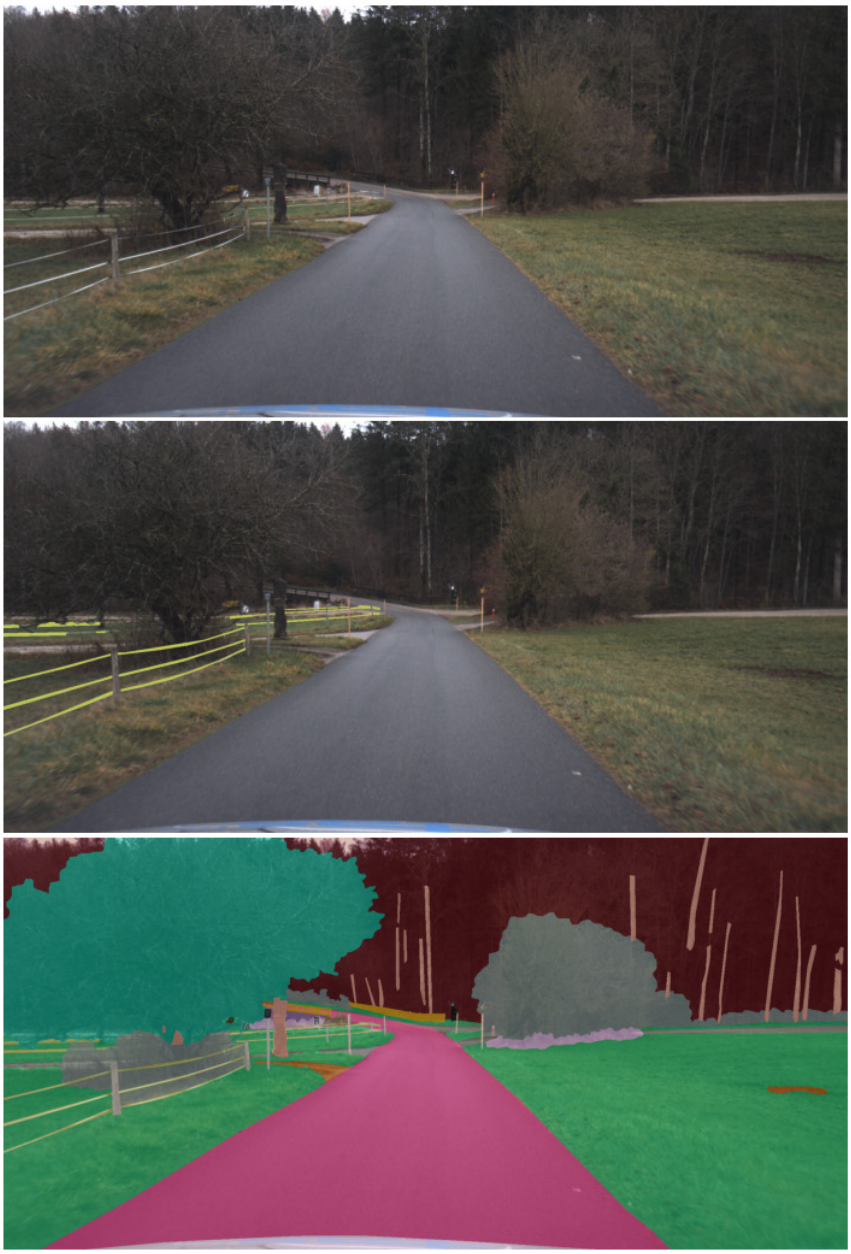


Figure 48: Example of barrier tape ( ).

ID#49: kick_scooter rgb(111,0,98)

A light vehicle consisting of a footboard mounted on two wheels and a long steering handle. It can be propelled by resting one foot on the footboard and pushing the other against the ground; it can also be powered by an electric engine. This instance does not include the driver (that's a rider, see above).

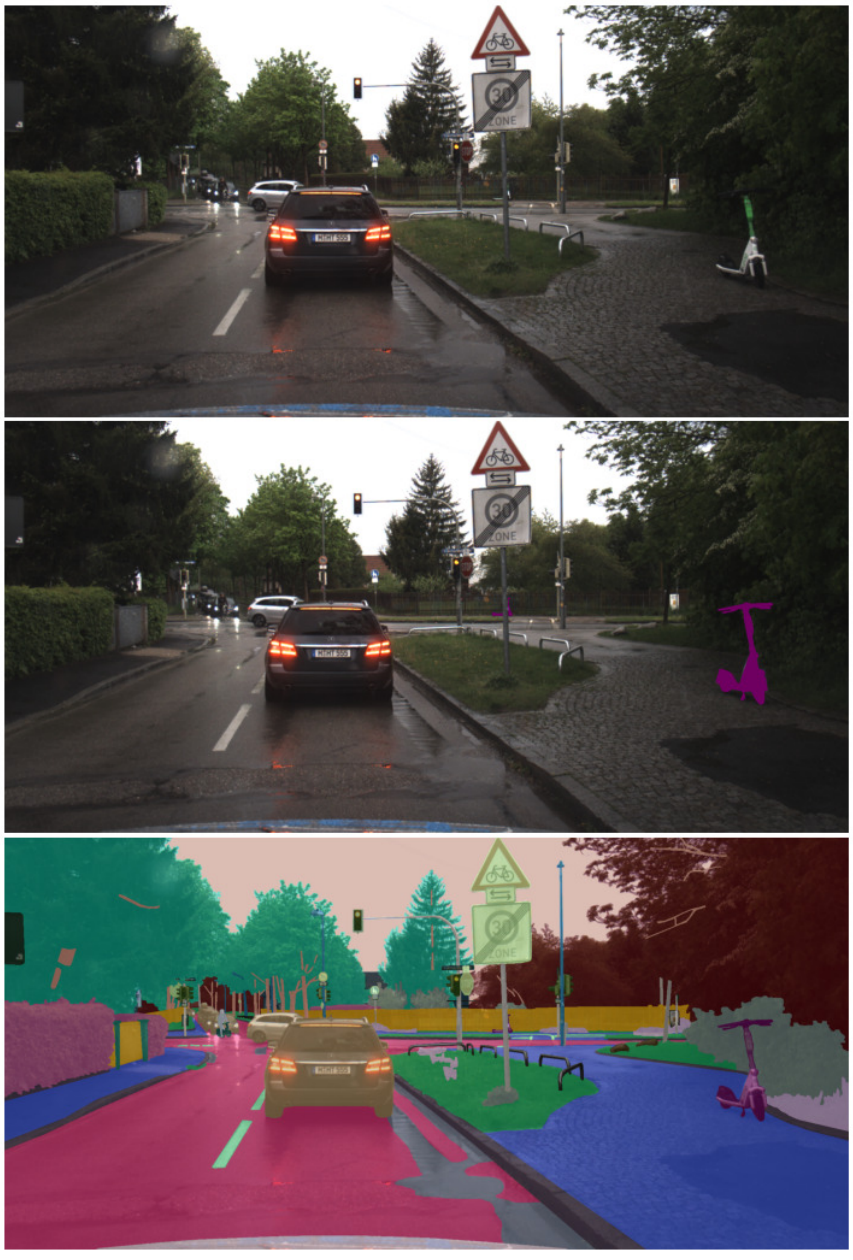


Figure 49: Example of a kick scooter (■).

ID#50: low_grass rgb(12,189,102)

Grass with a height smaller than 20 cm.

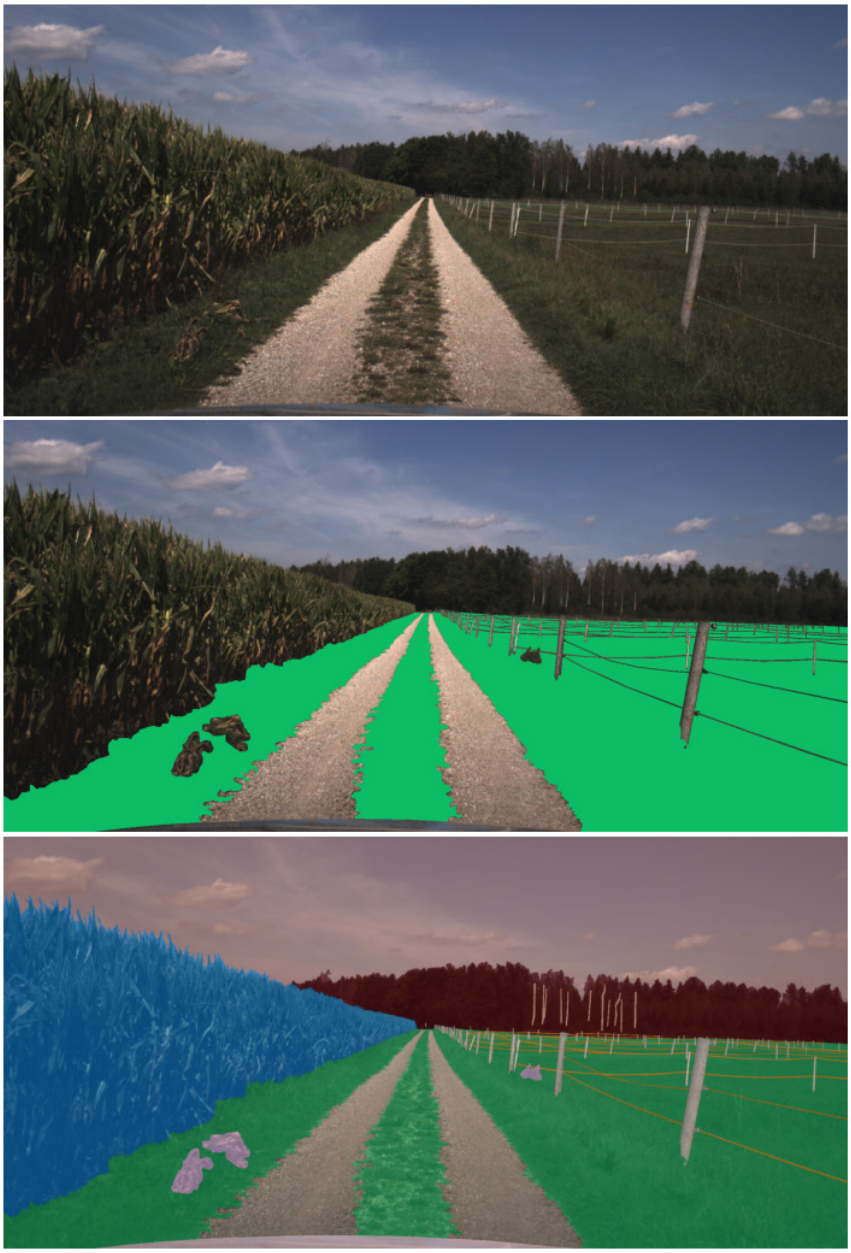


Figure 50: Example of a low grass (■).

ID#51: high_grass rgb(238,195,255)

Grass with a height bigger than 20 cm.

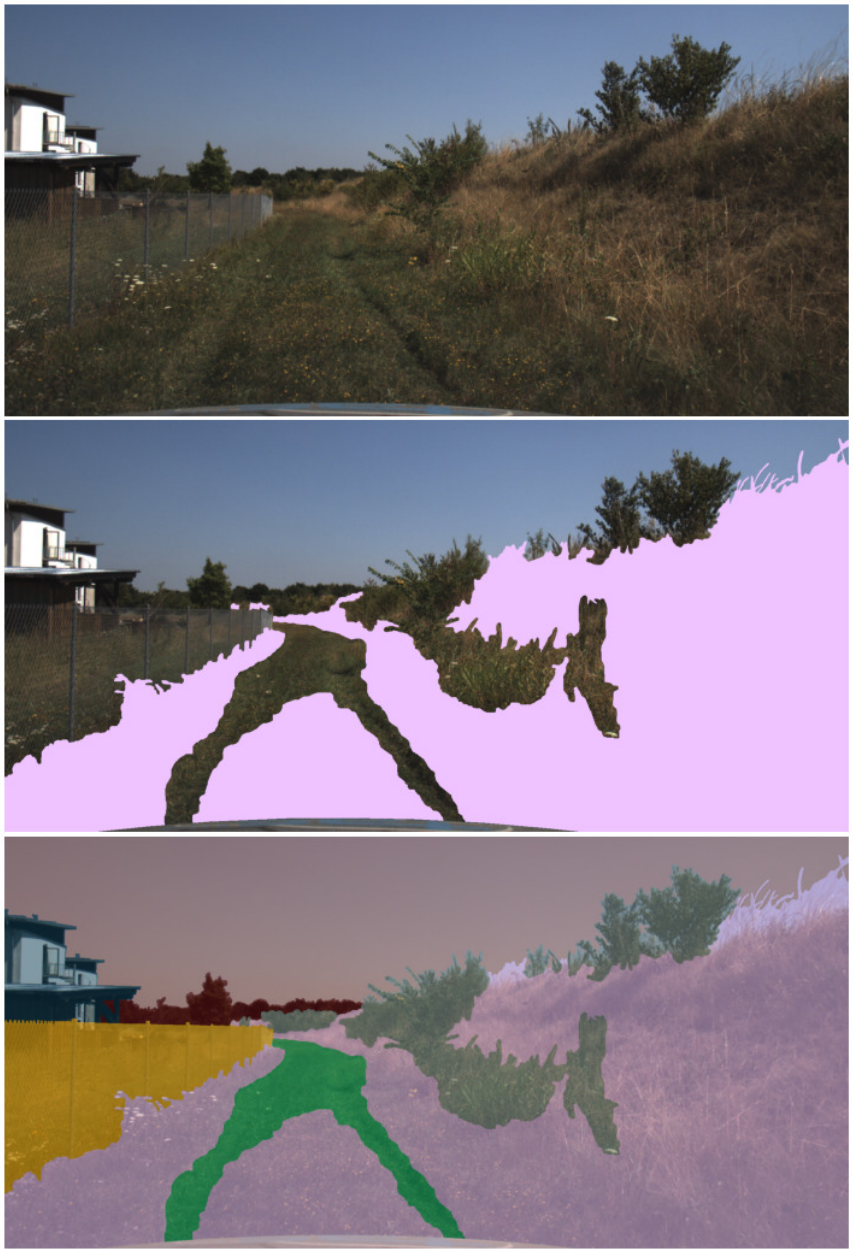


Figure 51: Example of a high grass ( ) in comparison to low grass ( ) and bush ( ).

ID#52: scenery_vegetation rgb(69,109,117)

Vegetation in the far distance (>300 m) that makes up the scenery. At this distance the vegetation cannot be well separated into fields and forested areas. Hills are also annotated as scenery_vegetation (see I in the illustration).
The buildings (■) are still annotated separately, even in the far distance.
***3D Point Cloud:** Points cannot be annotated as scenery_vegetation.*

Figure 52.1:
Example of the hills in the far distance being annotated as scenery vegetation (■).

Figure 52.2:
Example of the hills in the far distance being annotated as scenery vegetation (■).

ID#53: sky rgb(183,123,104)

Open sky, without leaves of tree [1].

Figure 53: Example of the annotated sky (■).

ID#54: water rgb(122,135,161)

Examples can be a puddle on a road, a pond, a river or a stream.

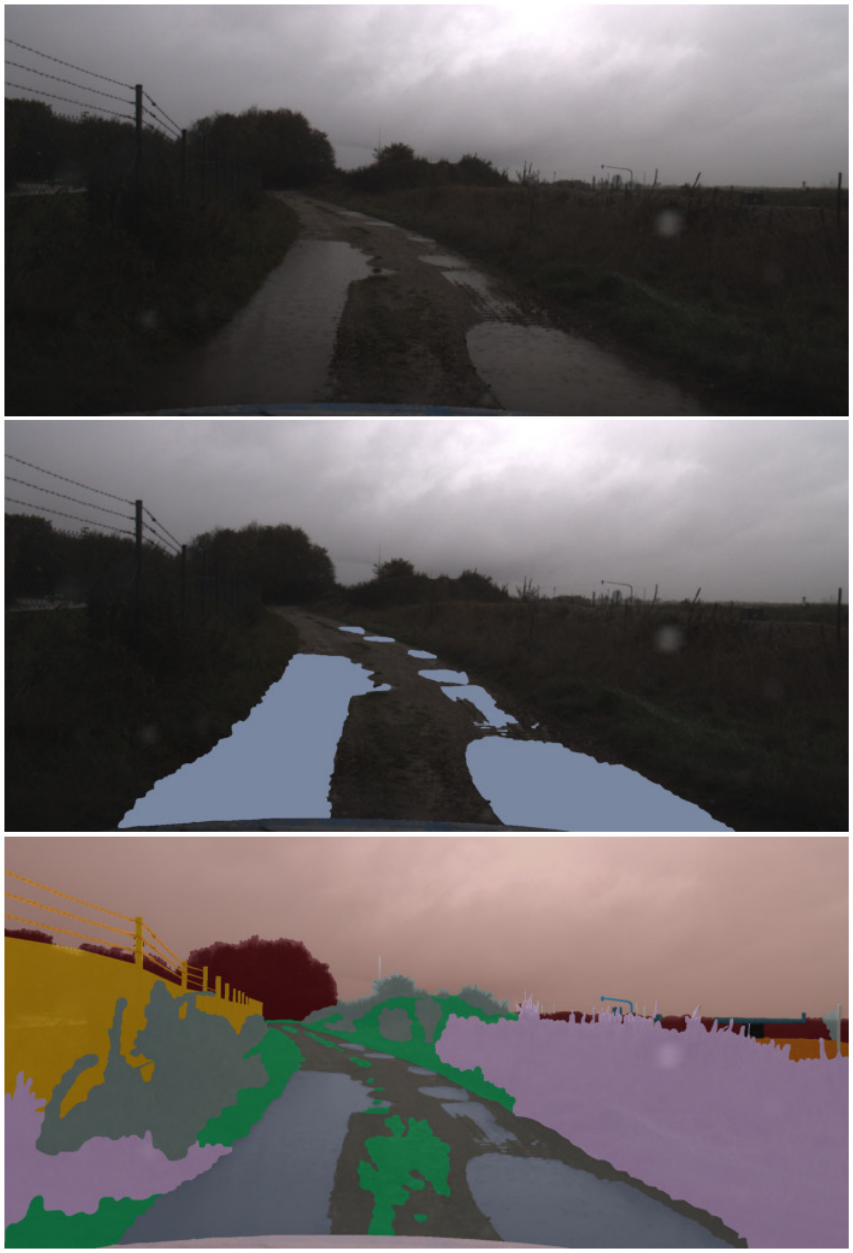


Figure 54:
Example of puddles along path annotated as water (■). Here we annotated a puddle along the road, but rivers and larger bodies of water are also annotated with this label. Water can reflect the lasers of a the LiDAR sensor, sometimes leading to detection of points under (or above) the ground plane that the ego vehicle is traveling on. These are considered as errors in the measurement and should be labeled as outlier.

ID#55: wire rgb(255,140,0)

Thin wires that connect individual poles, but do not resemble a fixed fence (e.g. pasture fence). Only the wires are labeled as such. The visible regions between the wires are annotated as usual.
The class is also applied for visible wires between electric/telephone poles.
If it is a tape with red and white markings, then annotate as barrier_tape.

Figure 55.1:
Example of wire (■). Notice that only the small image regions, where the wire between the poles (■) is visible are annotated.

Figure 55.2: Example of wires along a transmission tower (■).

ID#56: outlier **rgb(120,141,102)**

Erroneous measurements for 3D-LiDAR sensors: e.g., points that are detected in the water (puddle) and are falsely located meters under the drivable surface. False measurements can also appear above the drivable surface. These are detectable as sparse points without any neighboring surface.

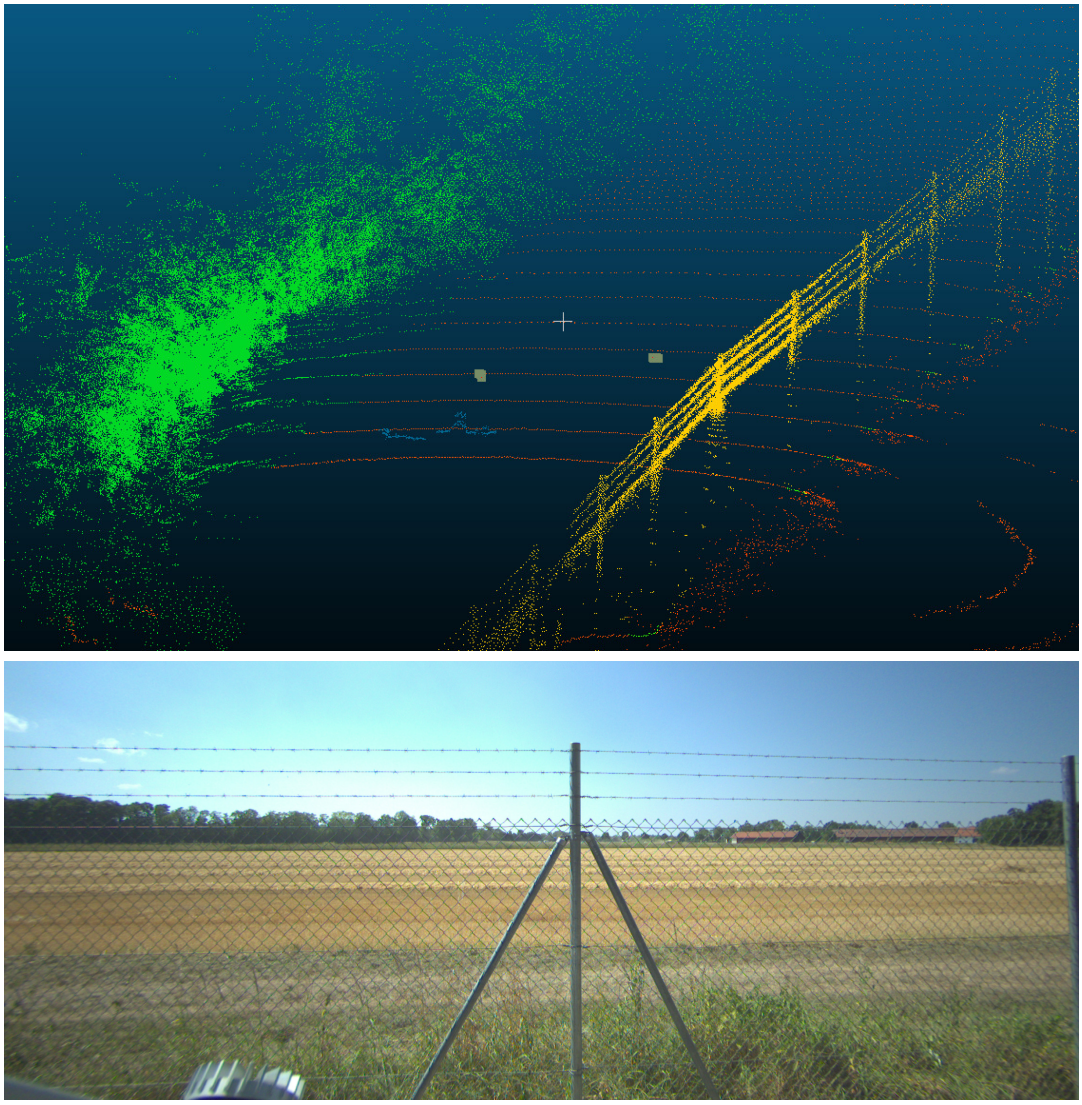


Figure 56:
Point cloud example of outlier points close to the ego vehicle (■) The outlier points are magnified int the point cloud view. The surround camera facing to the right does not show any obstacles between the ego vehicle and the fence.

ID#57: heavy_machinery rgb(250,208,159)

Heavy equipment refers to heavy-duty vehicles, specially designed for executing construction or agricultural tasks, most frequently ones involving earthwork operations. They are also known as heavy machines and examples are cranes and excavators.

Figure 57: Example of a tractor annotated as heavy machinery ( ).

ID#58: container rgb(255,138,154)

Shipping containers, construction site trailer, etc. A shipping container is a container with strength suitable to withstand shipment, storage, and handling.
Larger trash bins (more than a single household) are annotated as container, anything smaller is annotated as an obstacle.

Figure 58.1: Example of a large trash bin annotated as container ( ).

Figure 58.2: Example of container (■).

ID#59: hedge rgb(209, 87, 160)

A hedge is a line of closely grown shrubs. The hedge can be wild or trimmed. A bush ( ) resembles a single shrub that can clearly be separated from the surrounding vegetation, while the hedge is a line of shrub. The hedge should have a minimum length of about 5 m to be annotated as such, otherwise it is still considered a bush (see III and XI in the illustration). A hedge can be touched by a vehicle/car without causing noticeable damage to the car.

Figure 59.1:
Annotation example of wild hedges ( ). The hedge ( ) class starts over the high_grass ( ) at the point, where the visible vegetation resembles a vertical structure and is not drivable for the vehicle.
This is not annotated as a forest ( ), since no tree trunks or larger branches are visible in the hedge. Also a forest is typically taller (> 3 m) than a hedge.

Figure 59.2:
Annotation example of a hedge (■) in an urban environment. In these scenes the hedges tend to be trimmed and flat compared to wild hedges.

ID#60: barrel rgb(208, 208, 0)

Detecting individual barrels is relevant for different decontamination scenarios. Barrels are cylindrical containers of any material type. A barrel isn't larger than a regular person and each barrel has its own instance ID. Anything larger should be classified as a container. Many barrels stacked on a truck should be labeled as part of the truck.

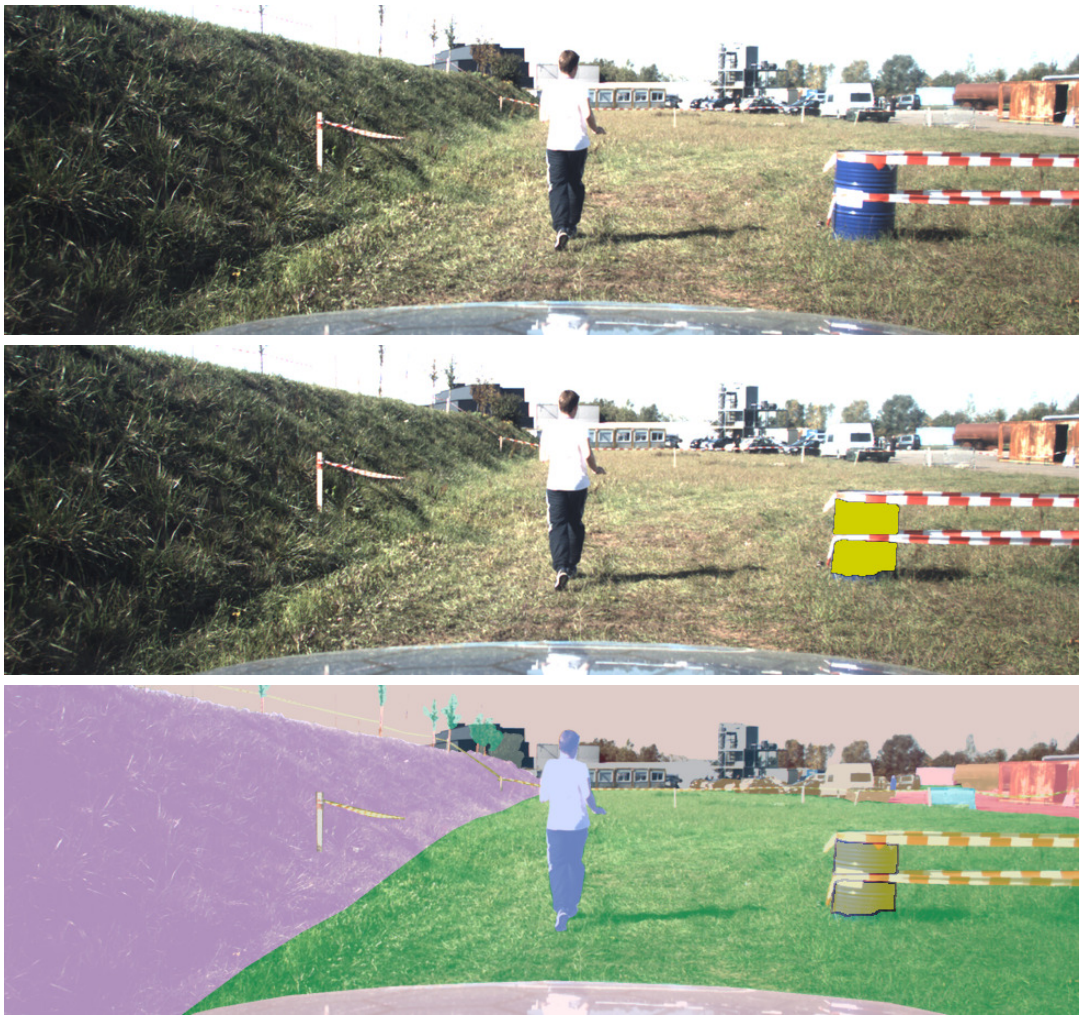


Figure 60: Annotation examples of a barrel ( ).

ID#61: pipe rgb(221, 0, 0)

A pipe can appear both above and below ground. Pipes are long cylindrical structure out of metal or plastic. Electrical wiring along poles and fences are labeled as wire. We also include larger pipes such as in pipelines into this semantic class.

Figure 61: Annotation example of a pipe (■).

ID#62: tree_root rgb(196, 164, 132)

A tree root has to be clearly visible and rise out of the surface material to be labeled as such. A tree root can be visible below ground level in excavated pits or above ground close to a tree_trunk.

Figure 62: Annotation example of a tree root ( ).

ID#63: military_vehicle rgb(64, 64, 64)

A military vehicle consists of any vehicle that can be clearly distinguished from pedestrian or construction vehicles due to its camouflage coating. This holds both for land-based military transport and combat vehicles.
Pedestrian vehicles with military license plates are excluded from this class.

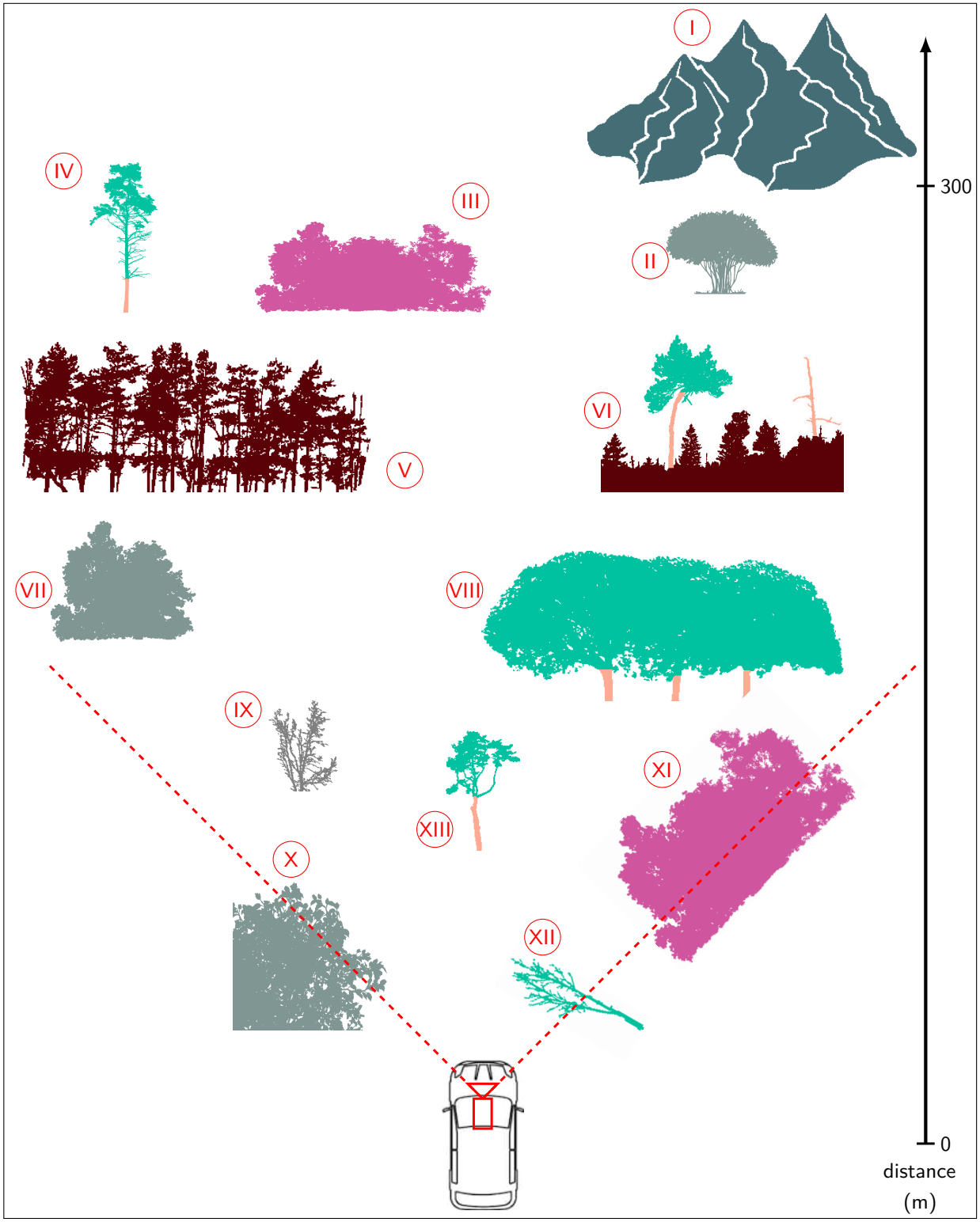


Figure 62:
Illustration for non-drivable vegetation: bush – hedge – forest – scenery_vegetation – tree_trunk – tree_crown.

Legend for illustration:

I: scenery_vegetation (■)
Vegetation in the far distance (>300 m) that makes up the scenery. At this distance the vegetation cannot be well separated into fields and forested areas. Hills are also annotated as scenery_vegetation.
3D Point Cloud: *Points cannot be annotated as scenery_vegetation.*

II: bush (■)
A bush has several main stems growing from the ground level rather than from one trunk. It resembles a single shrub that can clearly be separated from the surrounding vegetation. Bushes can also be annotated in the distance if clearly visible.
Bushes have a structure that would allow the ego vehicle to graze them.

III: hedge (■)
A hedge is a line of closely grown shrubs. This hedge is wild and has the minimum length of about 5 m. Hedges can also be annotated in the distance if clearly visible. A hedge can be touched by a vehicle/car without causing noticeable damage to the car.

IV: tree_crown (■) and tree_trunk (■)
Trees on an open field that are clearly visible can be separated into single instances (instead of as a forest). Here we separate the tree into its tree trunk and tree crown. We annotate tree crown when tree limbs branch off from the main stem, or when the foliage begins. Single trees can also be annotated in the distance if clearly visible.

V: forest (■)
Multiple trees or bushes, that are part of a forest, thicket or strip of woods at some distance. The individual trees and bushes cannot be clearly separated. Forests tend to appear at a distance of at least 100 m in our scenes.
Notice that the 100 m distance threshold is not an exact measure, but rather an estimate at what distance individual trees or bushes of a forest cannot be separately annotated.

VI: tree_crown (■), tree_trunk (■) and forest (■)
Multiple trees or bushes, that are part of a forest, thicket or strip of woods at some distance. We label individual trees in cases where they clearly rise above the forest. Their tree crown has to be clearly separated from the forest to be labeled as such. Tree trunks without a tree crown are also annotated as such when they clearly rise above the forest; branches are also annotated as tree trunk in such cases.

VII: bush (■)
This example for a bush resembles a single shrub that can clearly be separated from the surrounding vegetation. The foliage of the bush does not grow from a single visible stem, but covers the whole visible area of the bush. This bush appears at a medium distance, where most vegetation is still clearly distinguishable.
Bushes have a structure that would allow the ego vehicle to graze them.

VIII: tree_crown (■) and tree_trunk (■)
A group of trees where the tree trunks can be clearly separated (as individual instances) from the background, while the tree crowns of the tree trunks cannot be clearly separated (annotated as one single class). This can often occur when driving along an avenue lined by trees. This type of vegetation often appears at a middle distance. If the tree crown is mixed with different vegetation in the background and cannot be visually separated, then annotate as forest.

IX: bush (■)
A bush has several main stems growing from the ground level rather than from one trunk. It resembles a single shrub that can clearly be separated from the surrounding vegetation. The thin stems of the bush are also annotated as such.
These bushes tend do appear at a close to a middle distance in our scenes.
Bushes have a structure that would allow the ego vehicle to graze them.

X: bush (■) – partly visible at a close distance
Shrub at a close distance that is only partly visible in the input image. This is annotated as a bush if it appears to be a single bush compared to line of bushes resembling a hedge. We expect the bush to have a structure that would allow the ego vehicle to slightly graze them.

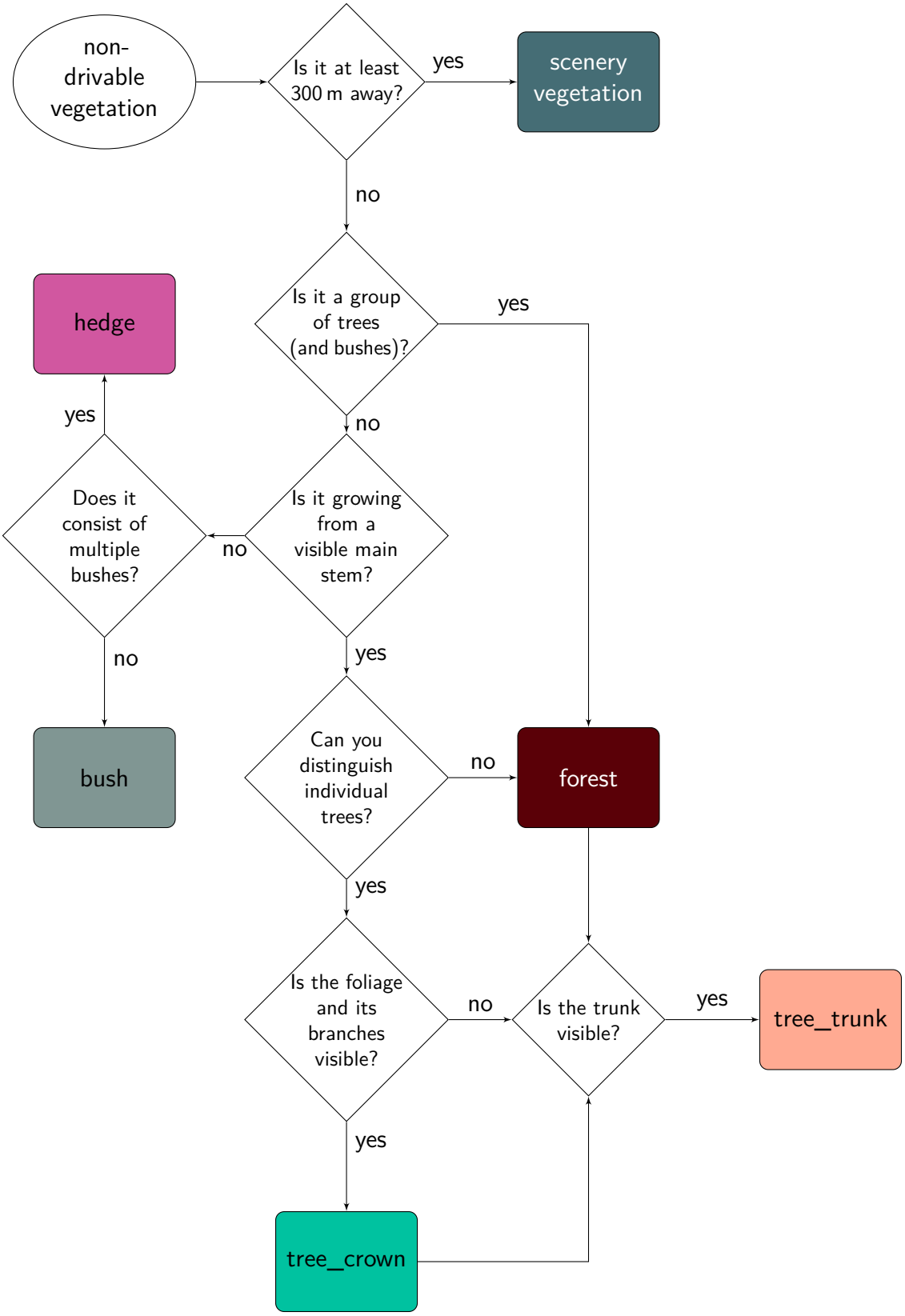
XI: hedge (■) – partly visible at a close distance
A line of shrubs at a close distance that is only partly visible in the input image is annotated as a hedge. The line of hedges should have a length of at least 5 m to be clearly distinguishable from a single bush.
In cases where the car is driving along a path in the woods, where individual tree trunks can be separated from the surrounding vegetation at close range, then annotate as forest and tree_trunk.

XII: tree_crown (■) – partly visible at a close distance
A branch of a tree crown that horizontally appears in the scene at a very close distance to the ego vehicle is annotated as a tree_crown. The expectation is that the branch greatly obscures the view of the camera but is passable for the ego vehicle.

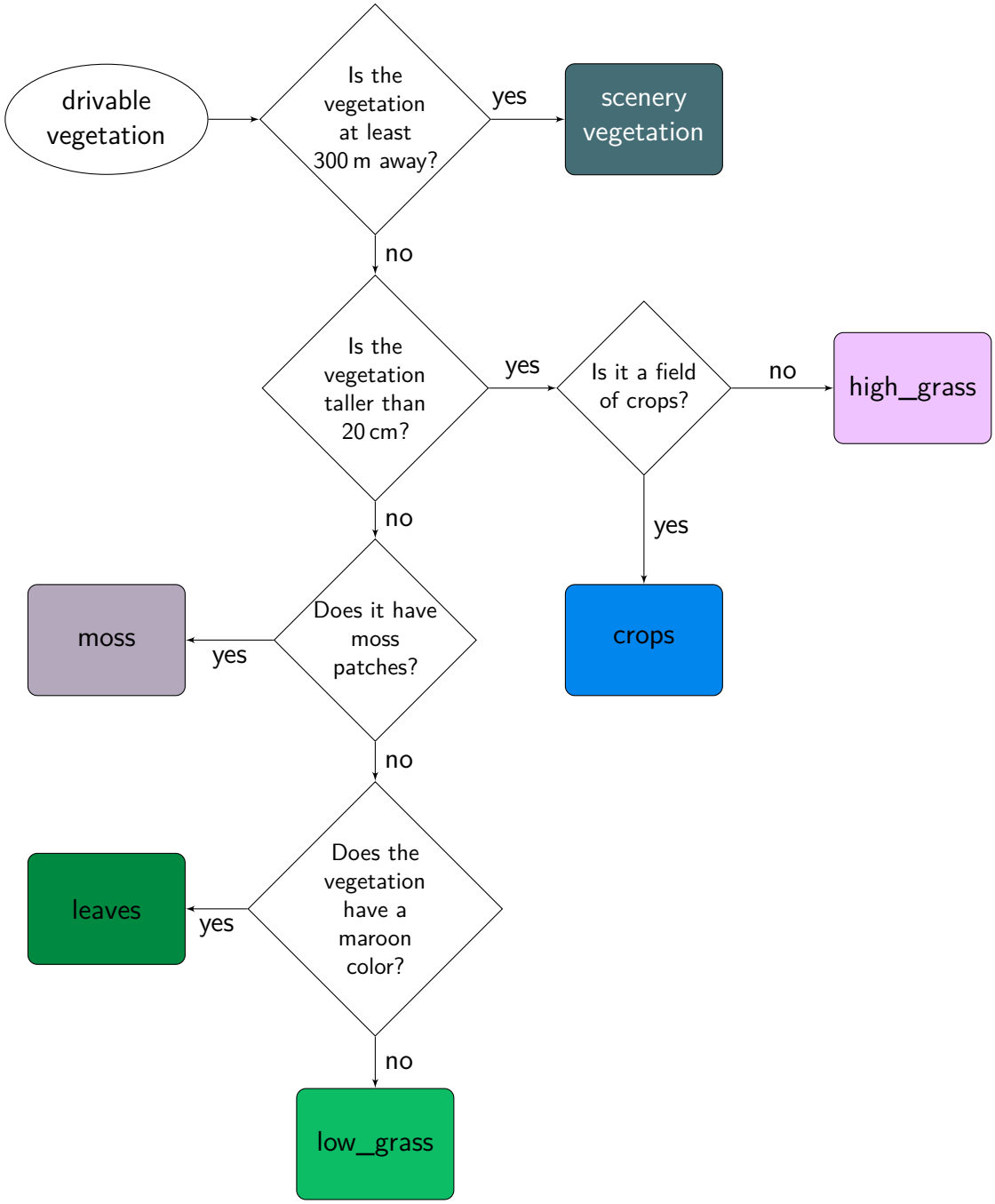
XIII: tree_crown (■) and tree_trunk (■)

Trees on an open field that are clearly visible can be separated into single instances (instead of as a forest). Here we separate the tree into its tree trunk and tree crown. We annotate as tree crown when tree limbs branch off from the main stem. Single trees like here usually appear at a middle distance, where they are clearly distinguishable from the surrounding vegetation.

2.1 Signal flow diagram for non-drivable vegetation: bush – hedge – forest – scenery_vegetation – tree_trunk – tree_crown



2.2 Signal flow diagram for drivable vegetation: leaves – moss – low_grass – high_grass – crops



Bibliography

[1] "The Cityscapes Dataset," 2018. [Online]. Available: https://www.cityscapes-dataset.com/dataset-overview/#class-definitions