Appendix I - Synthetic data generation details

Figure 7. **Examples of generated scenes from *synthetic-3D-Lanes*.**

In this appendix we provide details on the *synthetic-3D-Lanes* dataset generation. As described in Section **4.1.**, the idea was to generate a large variety of variations in the road and lane topology, topography and curvature, and to introduce natural occuring variations due to occlusions and lighting. Figure **6** shows an example of a synthetic scene generation of the static elements, and final examples of generated scenes are shown in the left and middle columns of figure **2**. Figure 7 provides additional examples exemplifying the diversity in all the generating factors, from the geometry of the surface to the lighting and objects placed in the scene. Generating a scene consists of a sequence of random selections as described in Section **4.1.**. Tables 3- 9 provide the specific parameters used to generate the dataset. Note that each table corresponds to a stage in the generation process as described in Section **4.1.** All parameters were uniformly sampled within the specified ranges. The entire world model is built relative to a 3D coordinate system such that the y-axis is roughly aligned with the driving direction, the x-axis is the lateral direction and the z-axis is in the elevation upward direction. The origin (point $(0, 0, 0)$) is placed in the middle of the scene in top view, and the main road always passes through it. In addition, whenever a secondary road exists (i.e. when splits or merges are modeled), it meets the main road at the origin.

Table 3. *Synthetic 3D-lanes* dataset parameters: **Terrain 3D.**

Parameter	**Min Value**	**Max Value**	**Unit/Type**	**Description**
#Components	1	7	discrete	Terrain is defined by a Gaussian Mixture with this number of components.
Gaussian centers	-150	+150	meters	The Gaussian center in each dimension (x and y) is chosen within this range.
Gaussian magnitude	-50	50	meters	Chosen independently for each Gaussian.
Gaussian SD	25	250	meters	SD=Standard Deviation. Chosen independently for each direction (x,y)
Gaussian orientation	0	90	degrees	

Table 4. *Synthetic 3D-lanes* dataset parameters: **Road and lane topology.**

Parameter	Values	Description
Topology type	1-4	**1. No exit - simple road** **2. Exit with single lane.** The rightmost lane of the main road splits to create and exit and also continues as rightmost lane of the main road. **3. Exit with single lane II**. The rightmost lane of the main road becomes the exit lane. The second rightmost lane of the main road splits to become rightmost and second-right lane. **4. Exit with two lanes.** The rightmost lane of the main road becomes the right exit lane. The second rightmost lane of the main road splits to the left exit lane and to the rightmost lane of the main road
Flip longitudinal	Yes/No	Flipping around the longitudinal axis transforms a right split (if exists) into a left one.
Flip lateral	Yes/No	Flipping around the lateral axis transforms a split (if exists) into a merge

Table 5. *Synthetic 3D-lanes* dataset parameters: **Lane top view geometry in defined (x,y) plane**.

Parameter	Min Value	Max Value	Unit/Type	Description
#Lanes on main road	2	4		
Lane width	3.2	4	meters	
Shoulder width	0.2	0.6		Factor of lane width
Main Road curvature	-10	10	meters	The geometry of the main road is modeled as a 4^{th} degree polynomial defined by 5 points: $\{(x^o_{-50}, -50), (x^o_{-50} + x^o_{-100}, -100), (0, 0), (x^o_{50}, 50), (x^o_{50} + x^o_{100}, 100)\}$ where each of the lateral relative offsets, $x^o_{\{-100,-50,50,100\}}$, is sampled from the given range.
Secondary road start angle	1	5	degrees	Relative to main road at exit point
Secondary road curvature	0	10	meters	Lateral offset 60m after exit. Together with the split point $(0, 0)$, and the *start angle* define a quadratic polynomial for the secondary road.
Scene boundaries			meters	Are set to encompass all roads as defined above

Table 6. *Synthetic 3D-lanes* dataset parameters: **Lane 3D**.

Parameter	Min Value	Max Value	Unit/Type	Description
Note: for the main road 3D is uniquely defined by combining the top-view geometry and the terrain elevation.				
Ramp max height	2	6	meters	Ramp height for secondary road
Ramp slope	0.5	4.5	Factor	Together with prev. param defines the ramp length as (Ramp max height$\times$Ramp slope)

Table 7. *Synthetic 3D-lanes* dataset parameters: **Terrain and Road appearance**.

Parameter	Min Value	Max Value	Unit/Type	Description
Dashed lane cycle len.	0.5	4.5	meters	Defines dash-to-dash distance
Dash length	0.3	1	Factor	fraction of cycle length
Lane marker width	0.1	0.15	meters	
Lane marker grayscale	0.2	1	Factor	Affects lane visibility. From range $[0, 1]$.
Lane marker gloss	0.5	1	Factor	Blender parameter
Road texture type	1	3	Type	Selection from possible textures
Road texture scale	10.0	30.0	Factor	Scales the texture applied to road
Road gloss	0	0.2	Factor	Blender parameter
Terrain texture type	1	2	Type	
Terrain texture scale	5.0	15.0		
Texture orientation	0	90	degrees	allows rotation of texture

Table 8. *Synthetic 3D-lanes* dataset parameters: **Objects**.

Parameter	Min Value	Max Value	Unit/Type	Description
# of cars	1	24		Positioned randomly in lanes
Car model type	1	6	Type	Model selected per car
Car scaling	0.9	1.1	Factor	Scales car model size
Car color	$[0, 0, 0]$	$[1, 1, 1]$	RGB	
Car gloss	0.3	1	Factor	Blender parameter
# of trees	40	800		Positioned randomly on terrain.

Table 9. *Synthetic 3D-lanes* dataset parameters: **Scene rendering**.

Parameter	**Min Value**	**Max Value**	**Unit/Type**	**Description**
Host car lane	1	#lanes		On main road
Host car position				Position within lane is chosen within limits such that viewing direction is towards origin
Host car offset	0	0.4	meters	Offset from lane center
Camera height	1.4	1.9	meters	
Camera pitch	0	5	degrees	Downwards
Sun position in sky	0	45	degrees	From zenith, to any xy direction
Scene exposure	1	3	Factor	Blender render exposure.