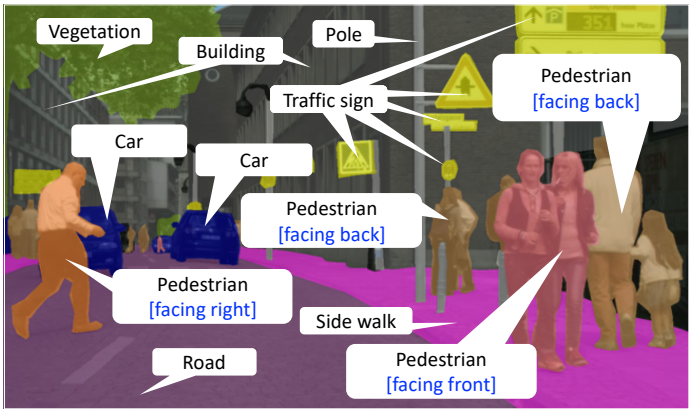
CityWalks



More semantic → Better understanding → Improved performance

Semantic segmentation nowadays becomes an interesting topic to many researchers and practitioners in the fields of machine learning and computer vision. There are numerous challenges that are publicly available; one of them is the Cityscapes which is very popular in the semantic segmentation task intended for autonomous driving applications. However, the Cityscapes provides the annotations to only learn the name of objects. Meanwhile, for traffic scene understanding purposes, additional information describing a particular object such as its attributes is important to enrich the semantic information and may help improve the segmentation performance.

We construct the CityWalks, which is an extension of the Cityscapes dataset, by re-annotating the original ground truth with additional labels corresponding to four pedestrian's body orientations. It is constructed to challenge the attribute-aware semantic segmentation task aimed at understanding the pedestrians' walks. Information regarding pedestrian's moving orientation is meaningful and important for driving assistant and possible risk avoidance.

The re-annotation process is applied to the original Cityscapes' ground truth provided in training and validation sets, containing 2,975 and 500 images, respectively. The ground truth re-annotation was conducted manually and very carefully by appointed annotators with considering details in pixel-level using a conventional image editor. By extending the class *person* into four classes representing pedestrian's orientation classes (*back*, *right*, *front*, and *left*) and preserving the original class of *person*, the CityWalks provides trainable 23 classes encoded in 'trainId'.

Figure 1. Guidance in the re-annotation process with pedestrian's body orientations

Figure 2. Examples comparing the ground truths from the original Cityscapes and the CityWalks

Table 1. Labels and colors provided by the CityWalks for the 23 trainable classes

Name	TrainId	CityWalks color				Cityscapes color			
		R	G	B	#	R	G	B	#
'road'	0	128	64	128		244	35	232	
'sidewalk'	1	244	35	232		70	70	70	
'building'	2	70	70	70		102	102	156	
'wall'	3	102	102	156		190	153	153	
'fence'	4	190	153	153		153	153	153	
'pole'	5	153	153	153		250	170	30	
'traffic light'	6	250	170	30		220	220	0	
'traffic sign'	7	220	220	0		107	142	35	
'vegetation'	8	107	142	35		152	251	152	
'terrain'	9	152	251	152		70	130	180	
'sky'	10	70	130	180					
'person/pedestrian (unknown)'	11	255	0	0		220	20	60	
'rider'	12	0	250	0		255	0	0	
'car'	13	0	0	42		0	0	42	
'truck'	14	0	0	170		0	0	170	
'bus'	15	0	60	100		0	60	100	
'train'	16	0	80	100		0	80	100	
'motorcycle'	17	0	0	230		0	0	230	
'bicycle'	18	119	11	32		119	11	32	
'pedestrian (back)'	19	171	121	66		--	--	--	--

'pedestrian (right)'	20	237	125	49		--	--	--	--
'pedestrian (front)'	21	220	100	110		--	--	--	--
'pedestrian (left)'	22	118	214	255		--	--	--	--
'ignored'	255	0	0	0		0	0	0	

Table 2. Statistic of the CityWalks

	Training set	Validation set
#image	2,975	500
#image with *person*	2,345	402
#image with four orientation attributes	2,083	371
%image with *person* in the dataset	78.82 %	80.40 %
%image with attributes in the dataset	70.02 %	74.20 %
%*person* pixels in the dataset	1.08 %	1.15 %
%attribute pixels in the dataset	1.03 %	1.09 %

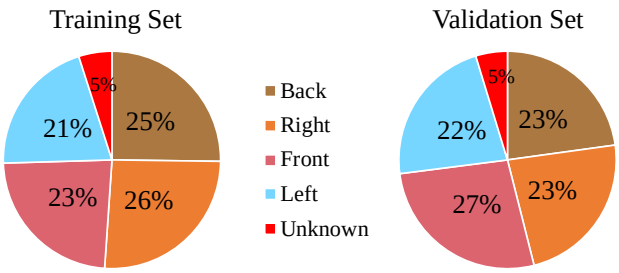


Figure 3. Distributions of pedestrian orientations annotated in the CityWalks

We finally publish the CityWalks dataset as the third party contributor to the basis Cityscapes dataset. It will be available at https://www.cityscapes-dataset.com/downloads/.

The downloaded package will include:

1. Annotated ground truth
    a. gtFine_color: train, val
    b. gtFine_labelid: train, val
    c. gtFine_trainid: train, val
2. Supplementary scripts and files that support the CityWalks

Our published paper related to the construction of the CityWalk is:

1. M. D. Sulistiyo, Y. Kawanishi, D. Deguchi, T. Hirayama, I. Ide, J. Y. Zheng, and H. Murase, *"Attribute-Aware Loss Function for Accurate Semantic Segmentation Considering the Pedestrian Orientations"*, IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences, Vol. E103-A, No. 1, pp. 231–242, January 2020

Other publications related to the Attribute-aware Semantic Segmentation are:

1. M. D. Sulistiyo, Y. Kawanishi, D. Deguchi, I. Ide, T. Hirayama, and H. Murase, *"ColAtt-Net: In Reducing the Ambiguity of Pedestrian Orientations on Attribute-aware Semantic Segmentation Task"*, IEEJ Transactions on Electrical and Electronic Engineering (TEEE C), In press.
2. M. D. Sulistiyo, Y. Kawanishi, D. Deguchi, I. Ide, T. Hirayama, and H. Murase, *"Performance Boost of Attribute-aware Semantic Segmentation via Data Augmentation for Driver Assistance"*, Proc. 8th International Conference on Information and Communication Technology, pp. 293–298, June 2020
3. M. D. Sulistiyo, Y. Kawanishi, D. Deguchi, T. Hirayama, I. Ide, J. Y. Zheng, and H. Murase, *"Attribute-aware Semantic Segmentation of Road Scenes for Understanding Pedestrian Orientations"*, Proc. 21st International Conference on Intelligent Transportation Systems, pp. 2698–2703, November 2018