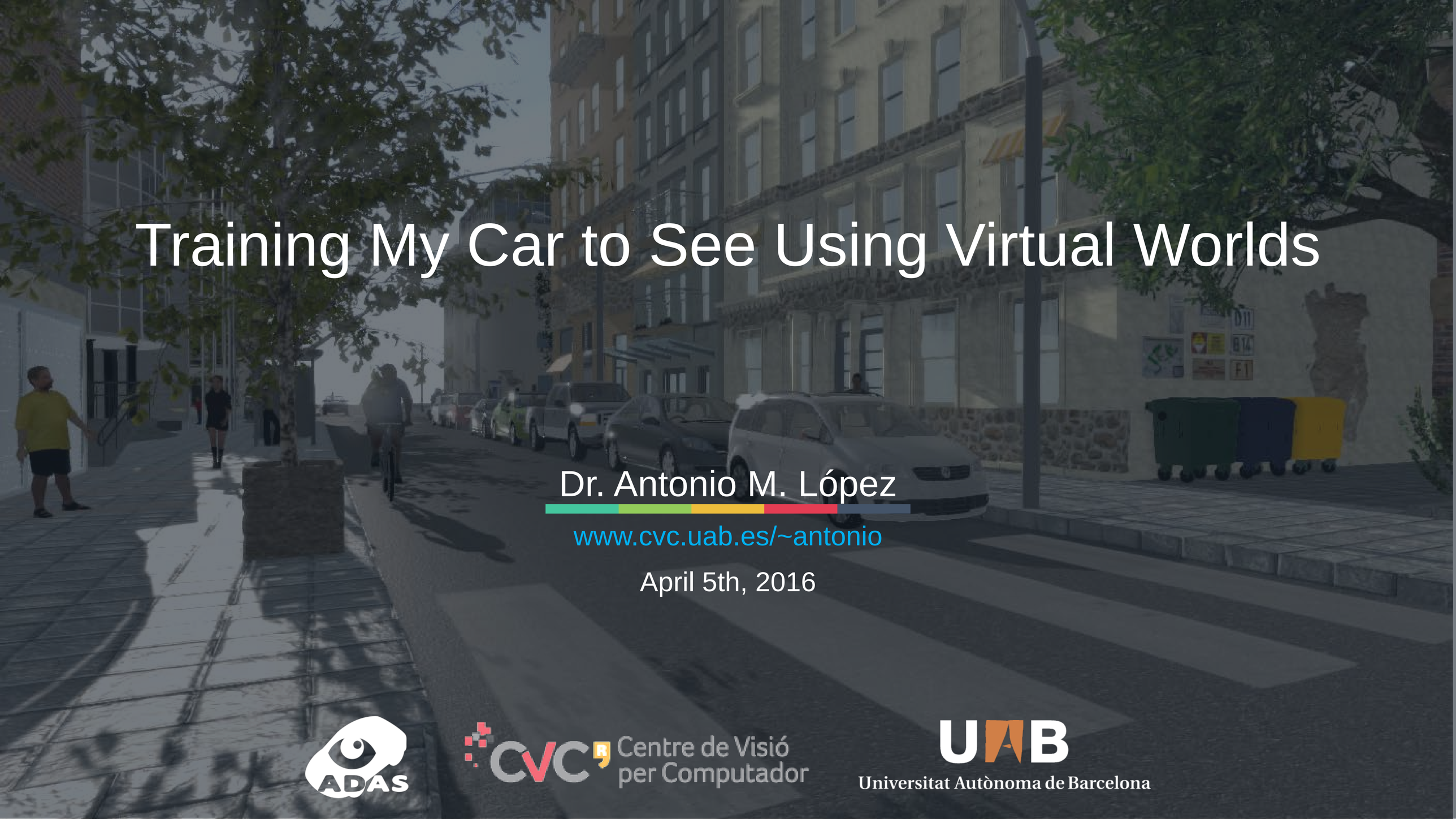


Training My Car to See Using Virtual Worlds

Dr. Antonio M. López

www.cvc.uab.es/~antonio

April 5th, 2016

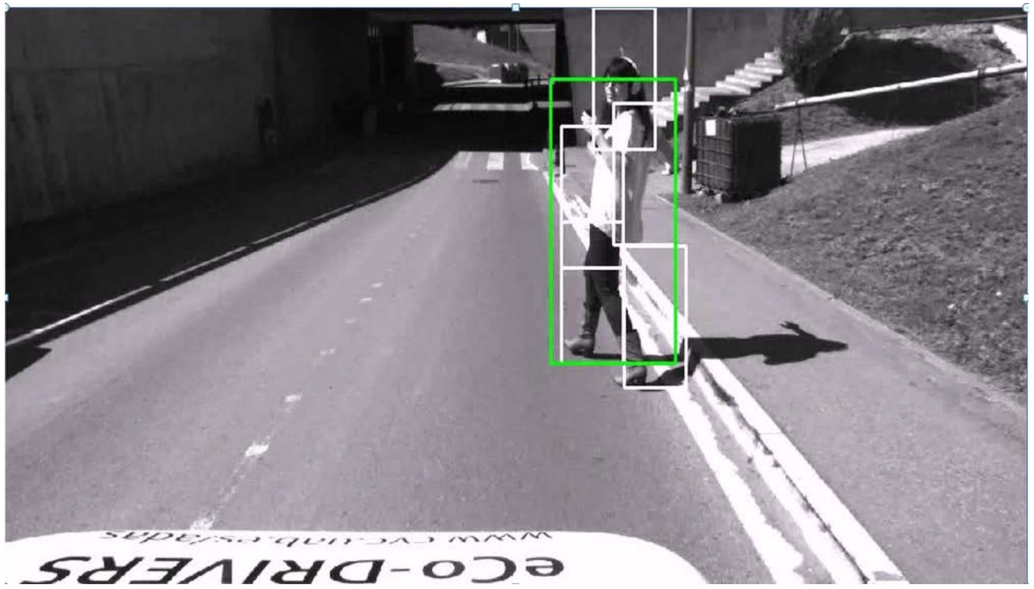
ADAS

CVC Centre de Visió per Computador

UAB Universitat Autònoma de Barcelona

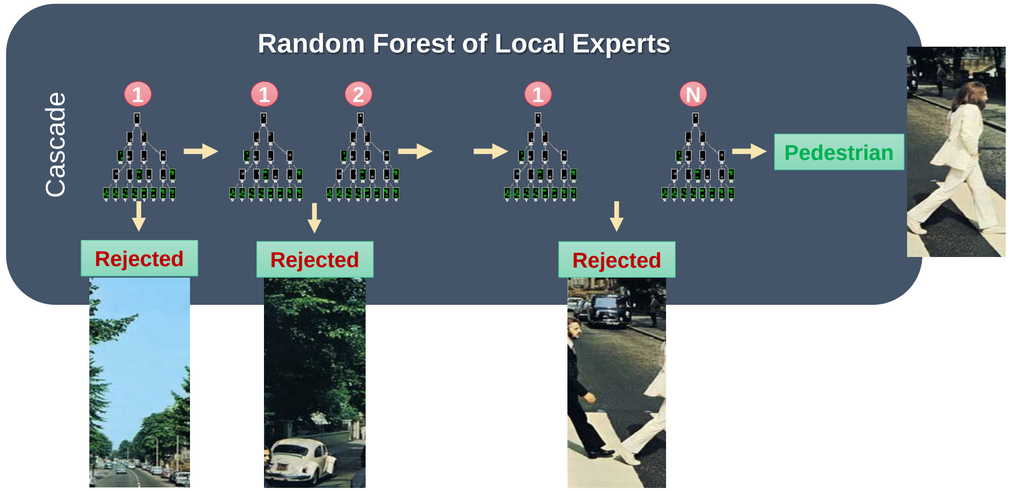
Research: Vision for ADAS & AD

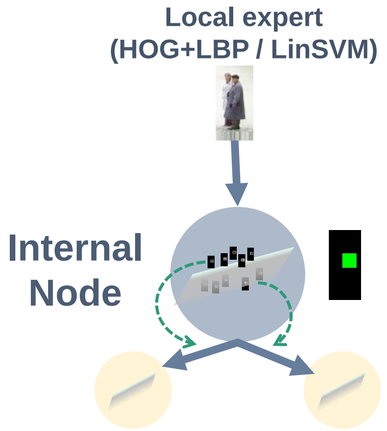
E.g. Pedestrian Detection



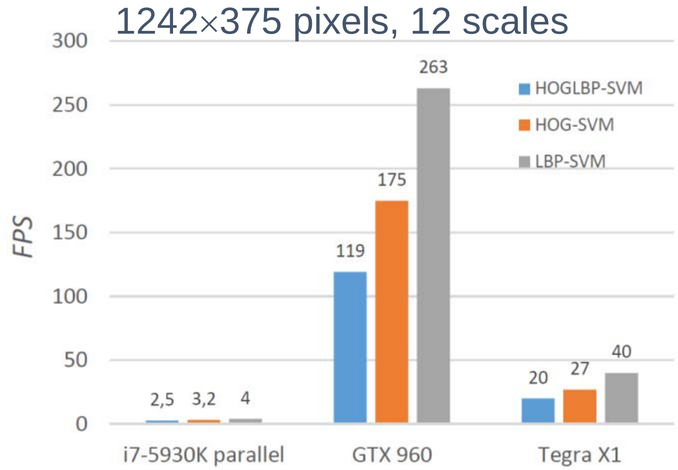
Research: Vision for ADAS & AD

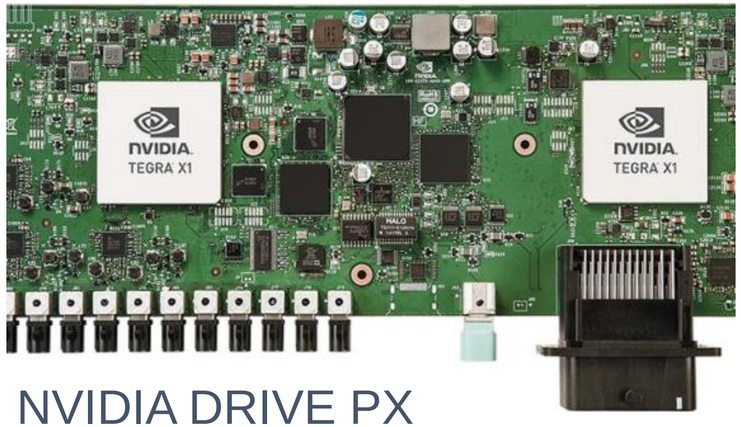
E.g. Pedestrian Detection





Best Poster at GTC'2016!!!



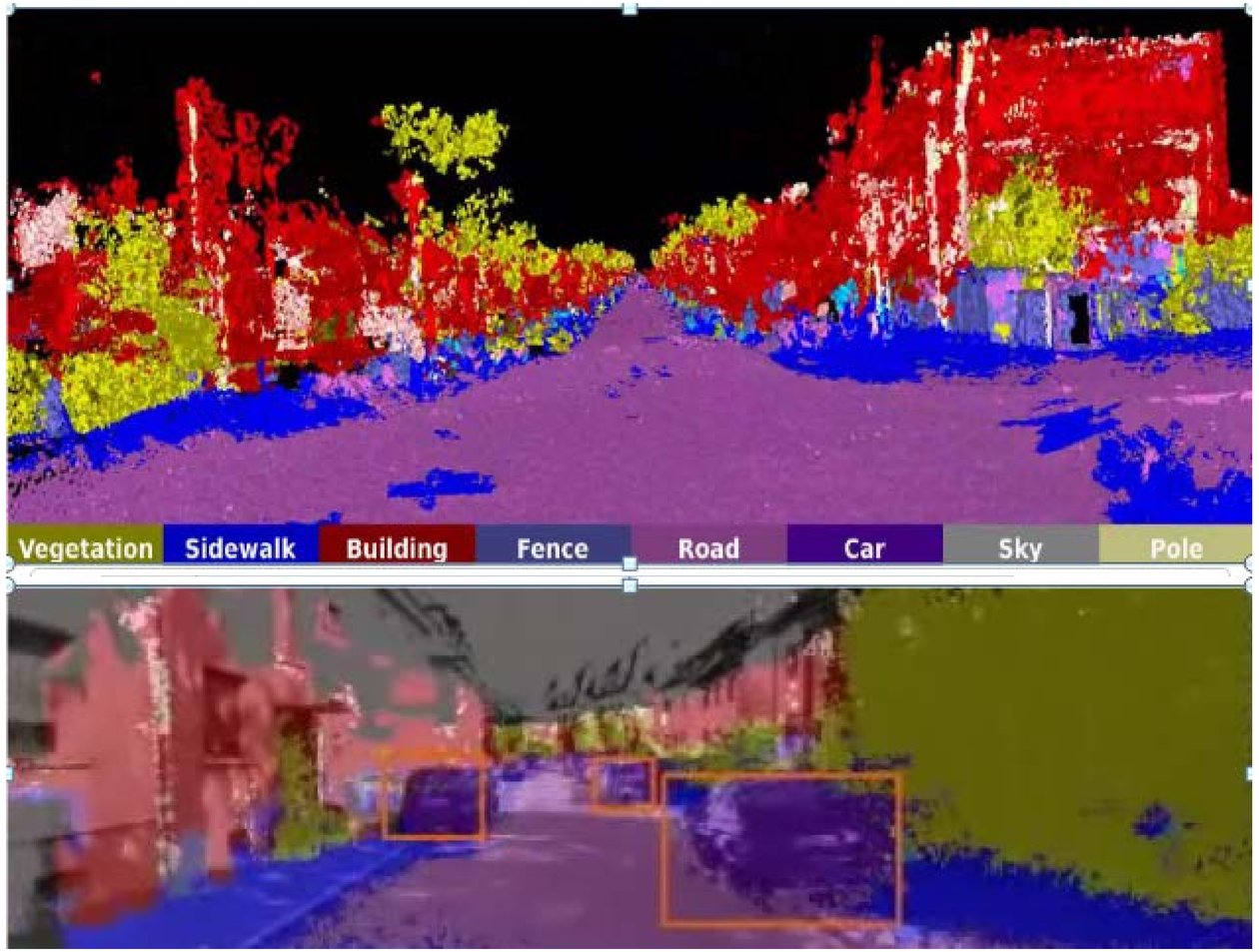


NVIDIA DRIVE PX

"GPU-based pedestrian detection for autonomous driving", GTC 2016.

Research: Vision for ADAS & AD

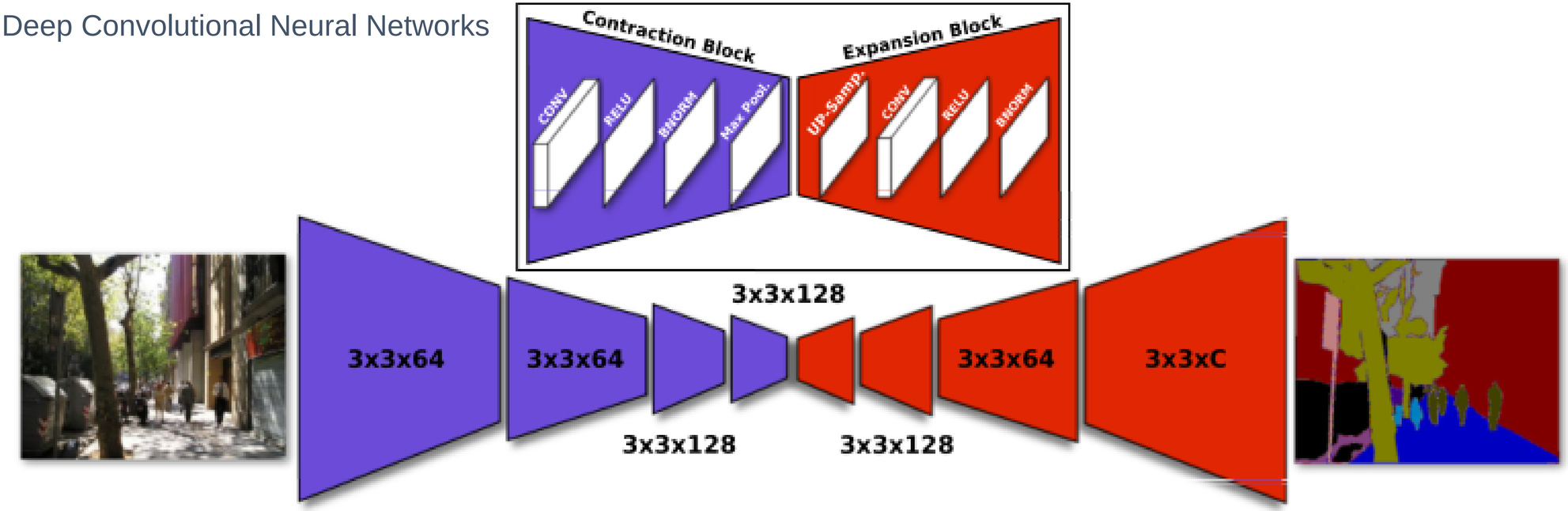
E.g. Semantic Segmentation (pixel-wise classification)



Research: Vision for ADAS & AD

E.g. Semantic Segmentation (pixel-wise classification)

Deep Convolutional Neural Networks



Research: Vision for ADAS & AD

E.g. Semantic Segmentation (pixel-wise classification)

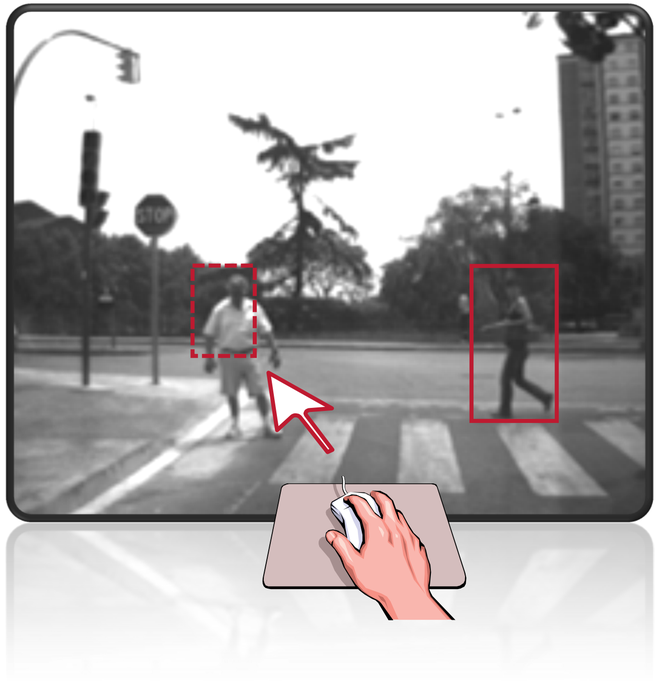
Research: Vision for ADAS & AD

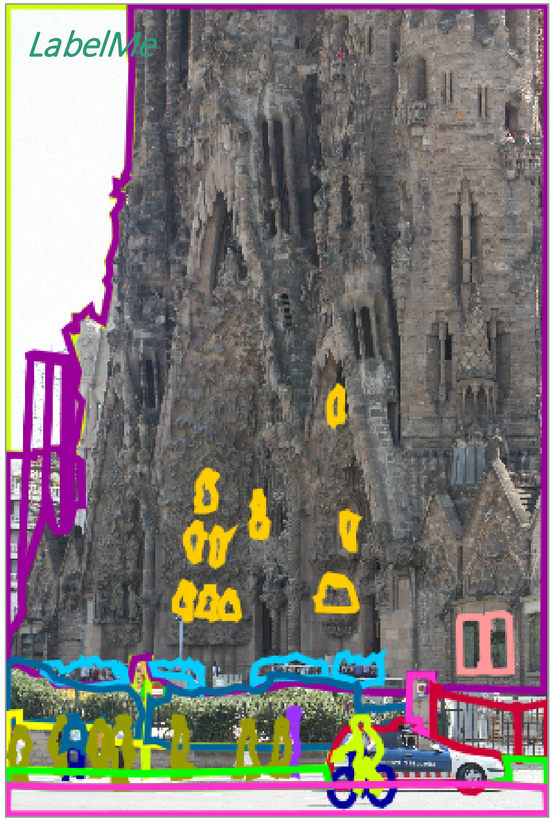
Among other tasks: object detection and
semantic segmentation, e.g., using Computer Vision.

Automated and Cooperative Driving in the City

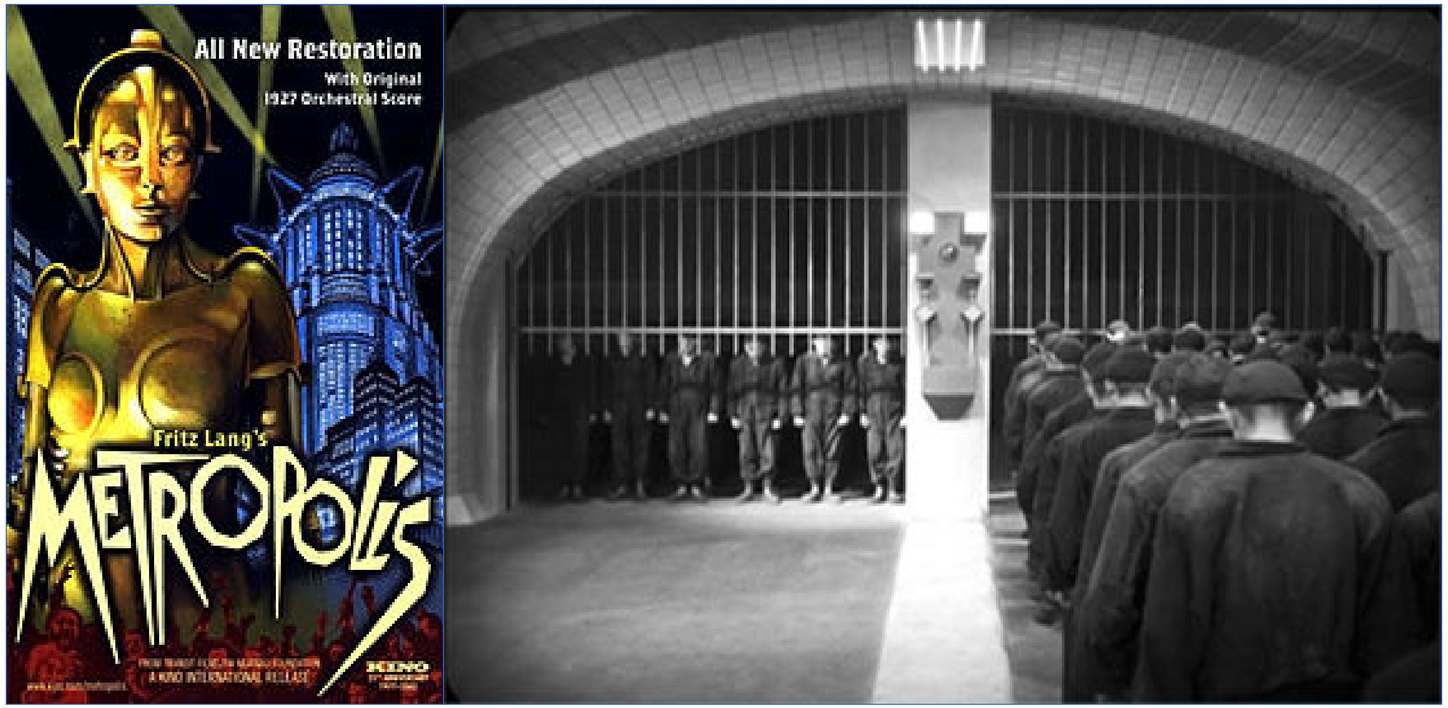
Machine Leaning Needs Annotated Data

Manual Annotation



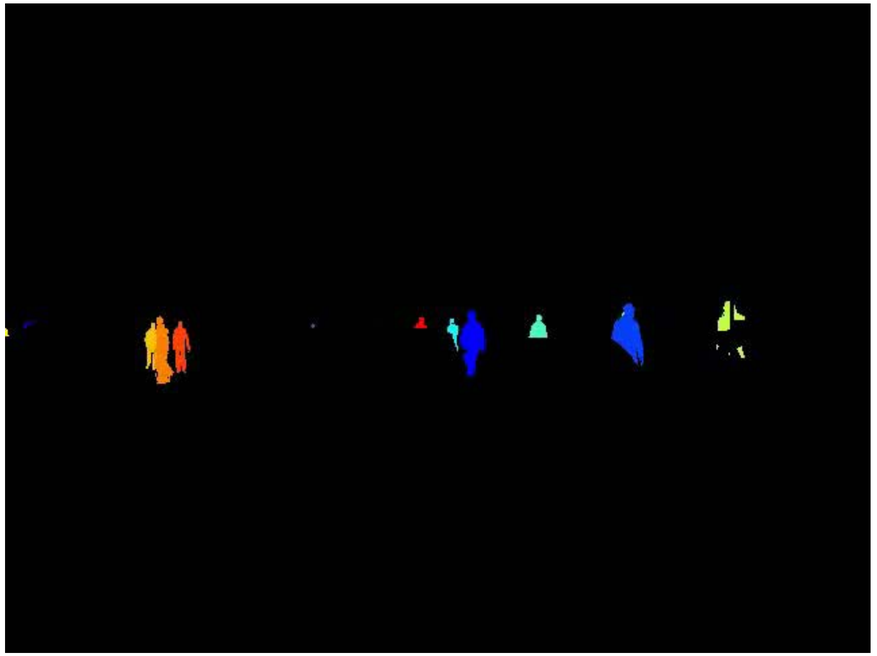


Machine Leaning Needs Annotated Data



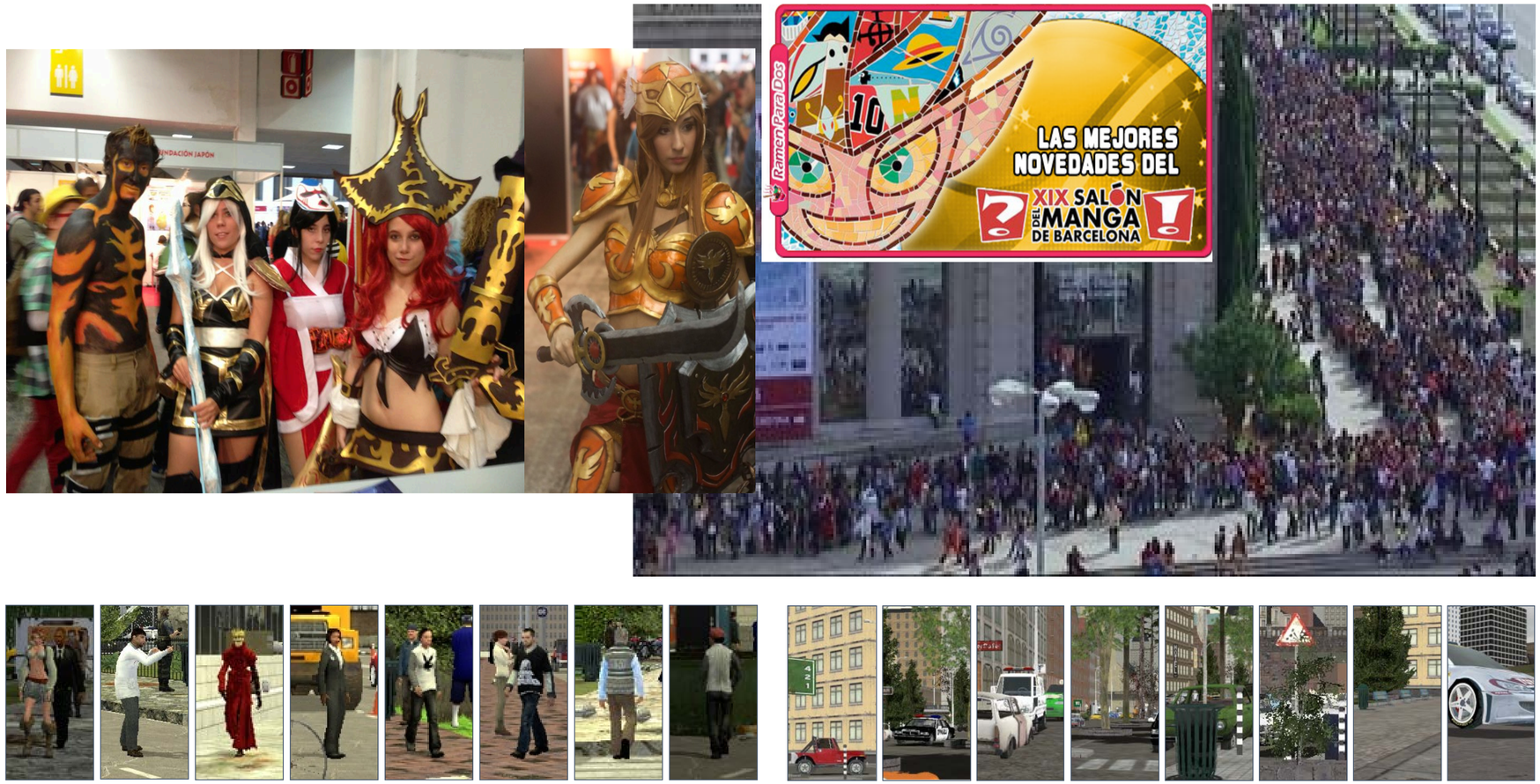
Machine Leaning Needs Annotated Data

Virtual Worlds for Automatic Annotations



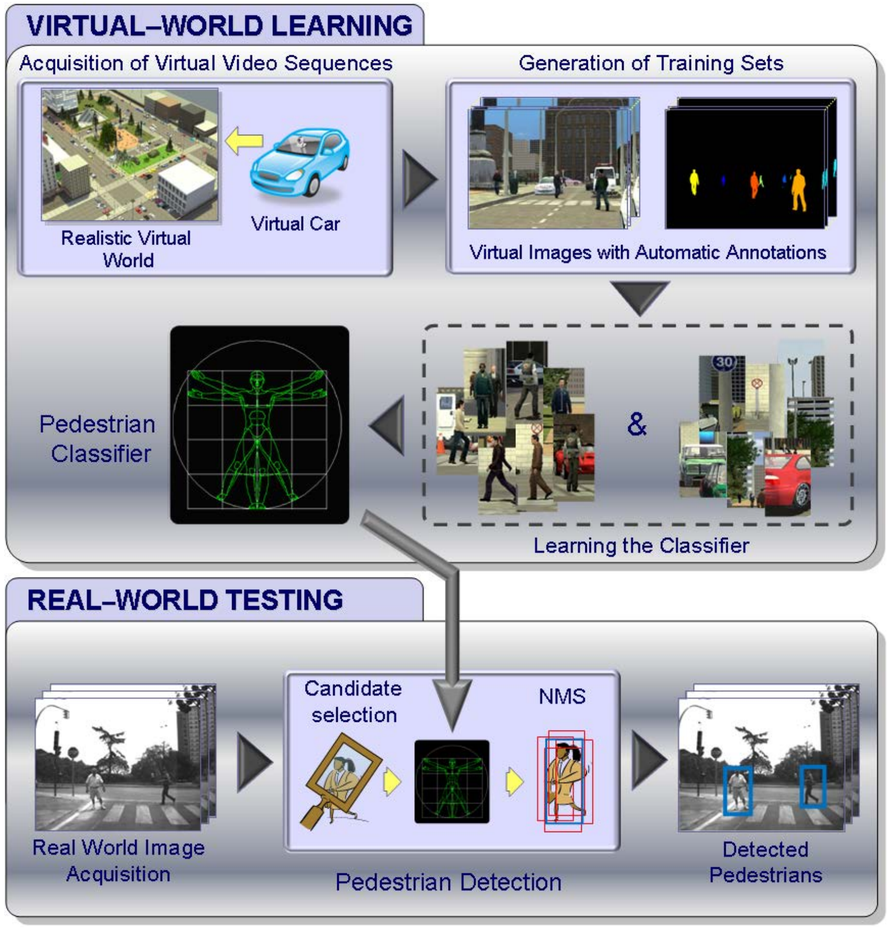
Virtual Worlds for Automatic Annotations

Virtual Worlds for Automatic Annotations



Virtual Worlds for Automatic Annotations

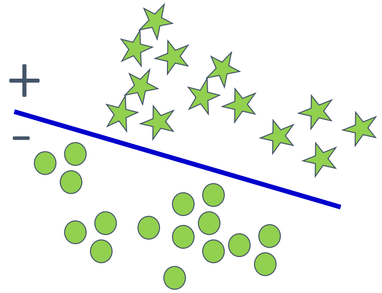
Virtual Worlds for Automatic Annotations



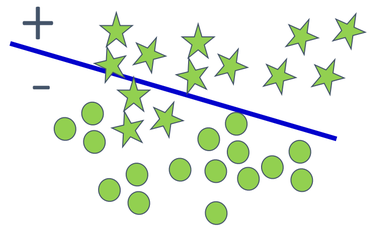
"Close the circle between modern Computer Animation and Computer Vision"

Cool World: Domain Adaptation of Virtual and Real Worlds

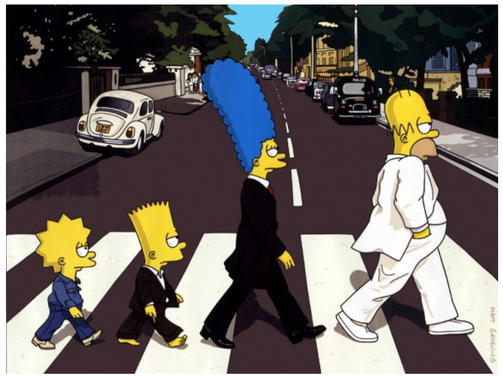
Domain shift: training and testing data follow different probability distributions



Source domain (training)



Target domain (testing)



Domain Adaptation

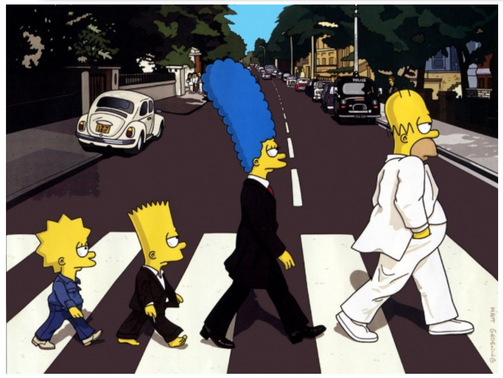
Domain adaptation: source knowledge (data or models) & target data with few or no manual annotations.

Cool World: Domain Adaptation of Virtual and Real Worlds

Domain shift: training and testing data follow different probability distributions

Source domain: Virtual world

Target domain: Real world



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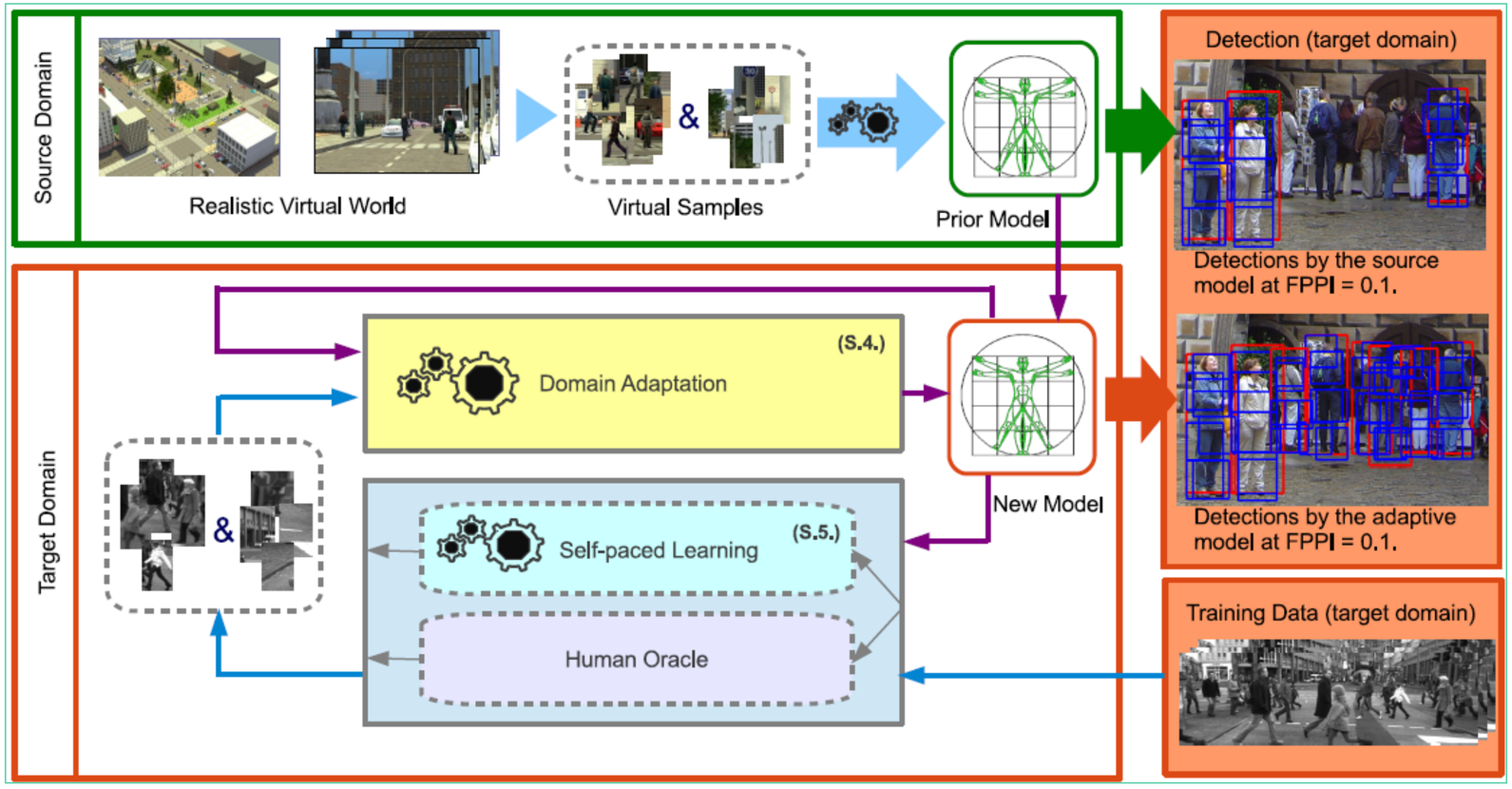
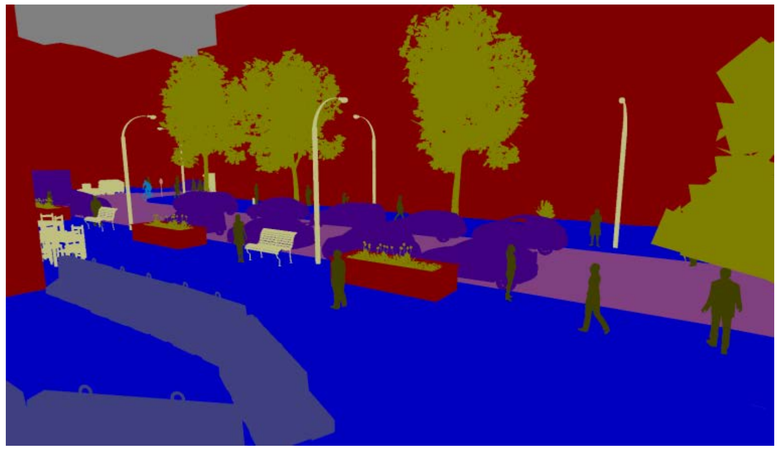
Cool World: Domain Adaptation of Virtual and Real Worlds



Virtual Worlds for Automatic Annotations

RGB

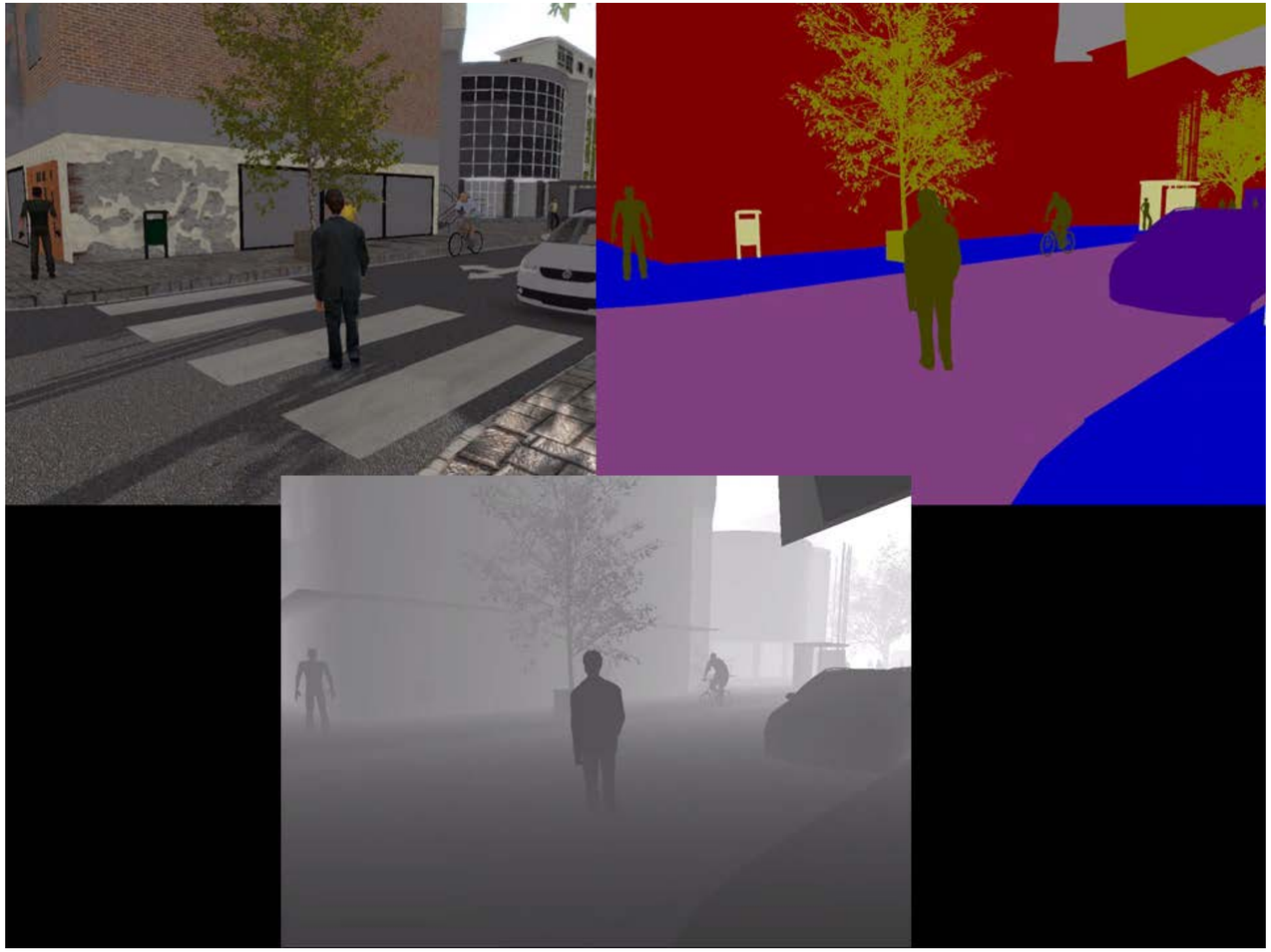


Semantic Segmentation

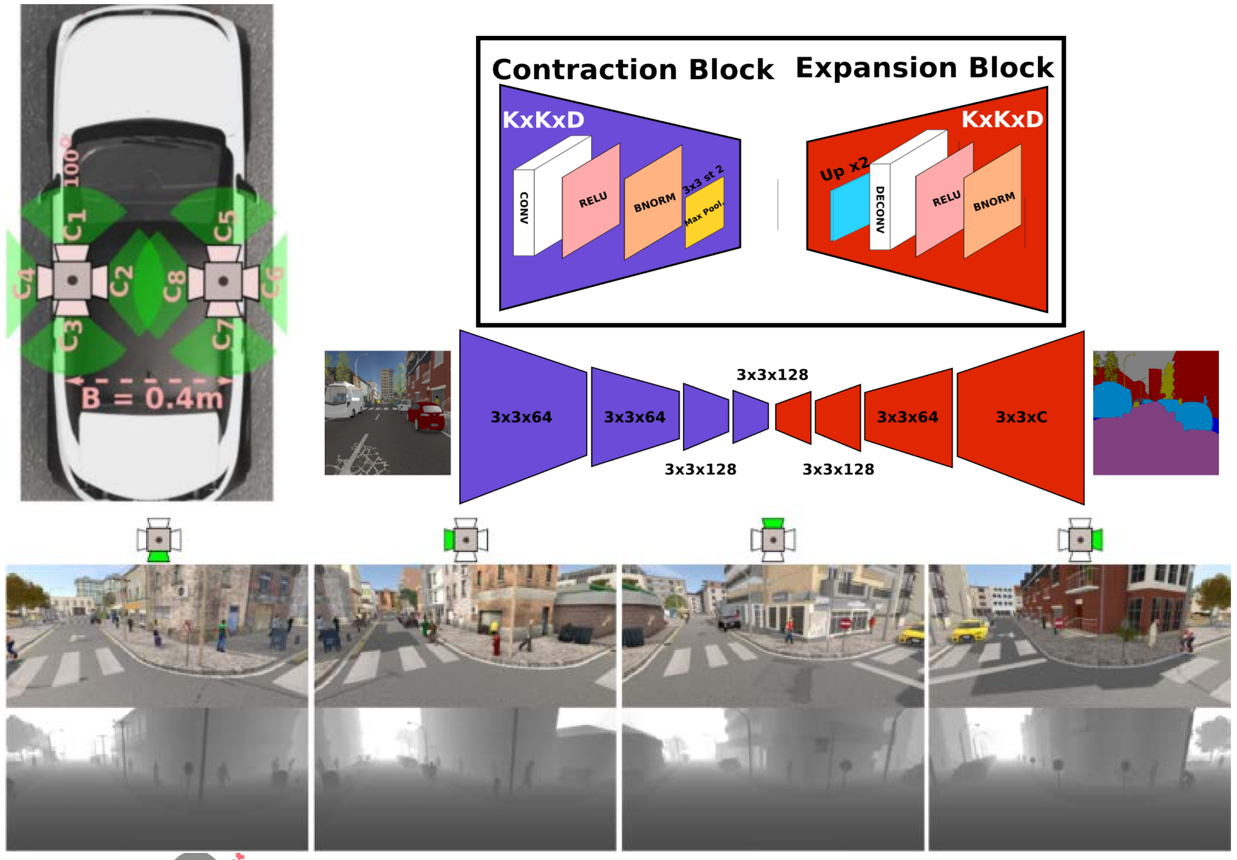
Depth Map

Powered By unity

Virtual Worlds for Automatic Annotations



SYNTHIA: Synthetic Imagery with Annotations



Dataset	# Frames (A)	# Training (T)	# Validation (V)
CamVid [5, 6]	701	300	401
KITTI [11, 19, 29]	547	200	347
Urban LabelMe [31, 1]	942	200	742
CBCL StreetScenes [4, 1]	3547	200	3347
SYNTHIA-Rand	13,400	13,400	0

SYNTHIA: Synthetic Imagery with Annotations

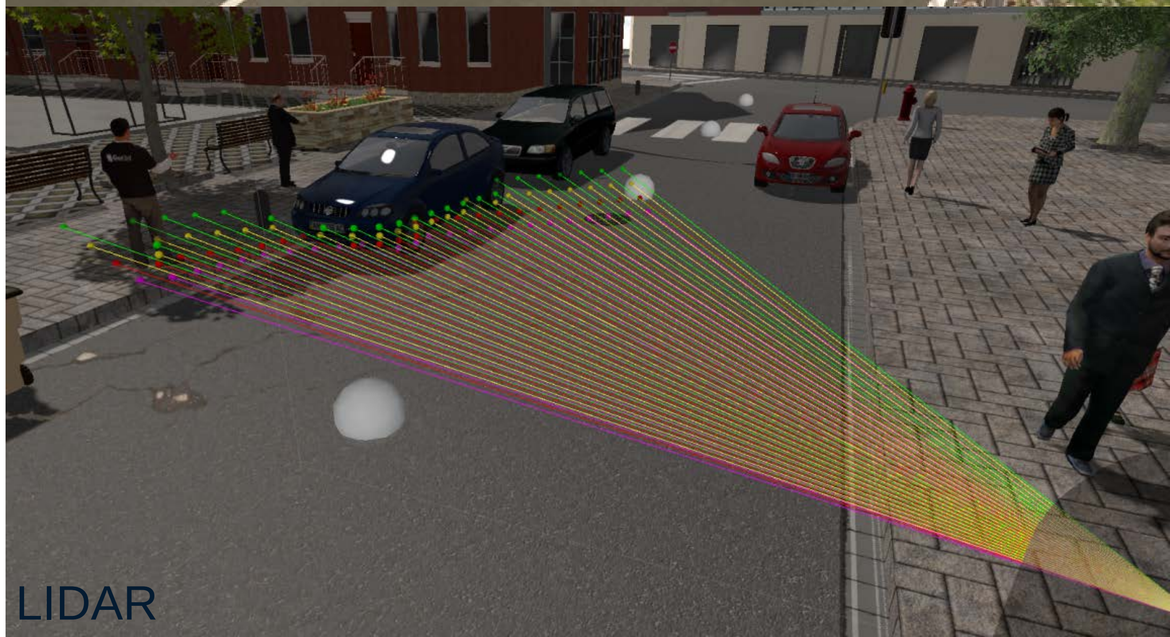
Training	Validation	sky	building	road	sidewalk	fence	vegetation	pole	car	sign	pedestrian	cyclist	per-class	global
Camvid (T)	CamVid (V)	99	65	95	52	7	79	5	80	3	26	6	46.3	81.9
Camvid (T) + *SYNTHIA-Rand* (A)	CamVid (V)	98	**90**	91	**63**	5	**83**	**9**	**94**	0	**58**	**31**	56.5 (**10.2**)	90.7 (**8.8**)
KITTI (T)	KITTI (V)	79	83	87	73	0	85	0	69	0	10	0	44.2	80.5
KITTI (T) + *SYNTHIA-Rand* (A)	KITTI (V)	**89**	**86**	**90**	58	0	72	0	**76**	0	**66**	**29**	51.6 (**7.4**)	80.8 (**0.3**)
U-LabelMe (T)	U-LabelMe (V)	72	80	75	45	0	62	2	53	0	14	2	36.4	62.4
U-LabelMe (T) + *SYNTHIA-Rand* (A)	U-LabelMe (V)	69	77	**93**	33	0	62	**11**	**77**	**1**	**67**	**24**	46.7 (**10.3**)	72.1 (**9.7**)
CBCL (T)	CBCL (V)	62	77	86	41	0	74	5	63	0	7	0	37.9	73.9
CBCL (T) + *SYNTHIA-Rand* (A)	CBCL (V)	**72**	**82**	**90**	39	0	58	**26**	**70**	**5**	**52**	**39**	48.4 (**10.5**)	75.2 (**1.3**)

Virtual Worlds for Automatic Annotations

city pub

CLEARANCE 13'-9"
93
90
Quincy
Worcester
CLEARANCE 13'-9"
93
90
Quincy
Worcester

city pub



LIDAR

spring

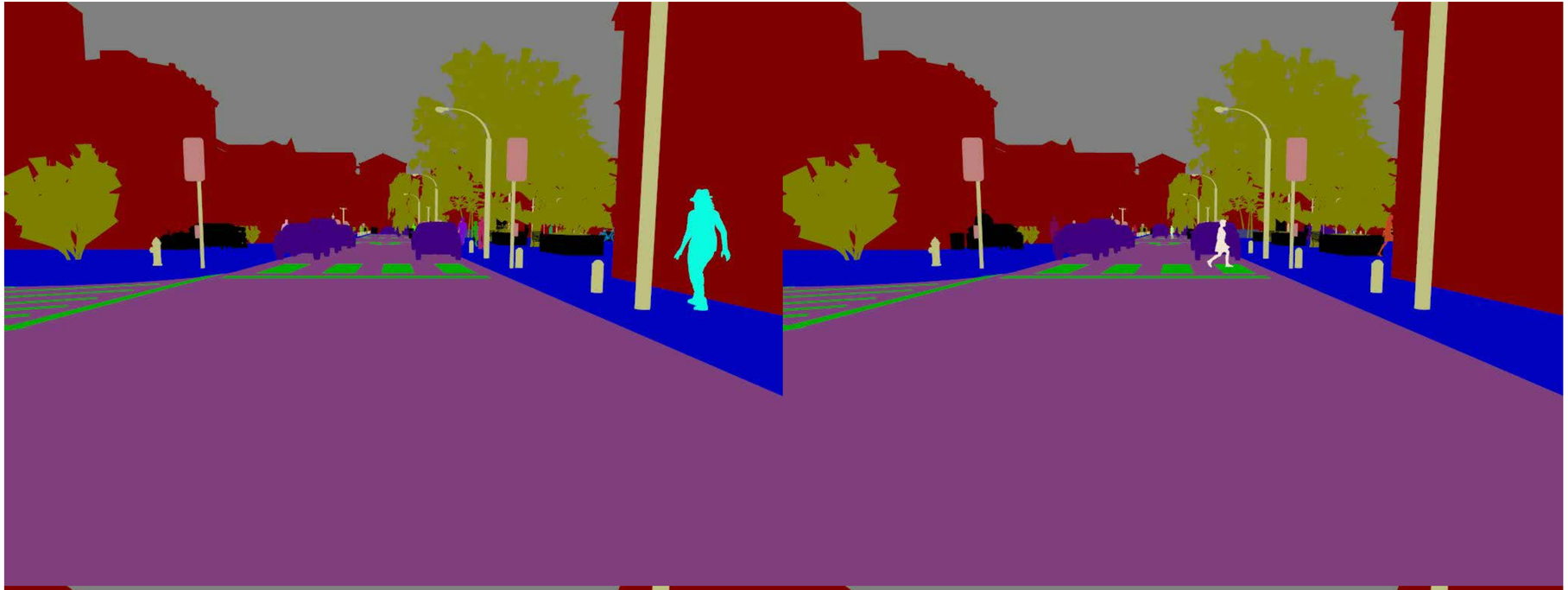
summer

fall

winter

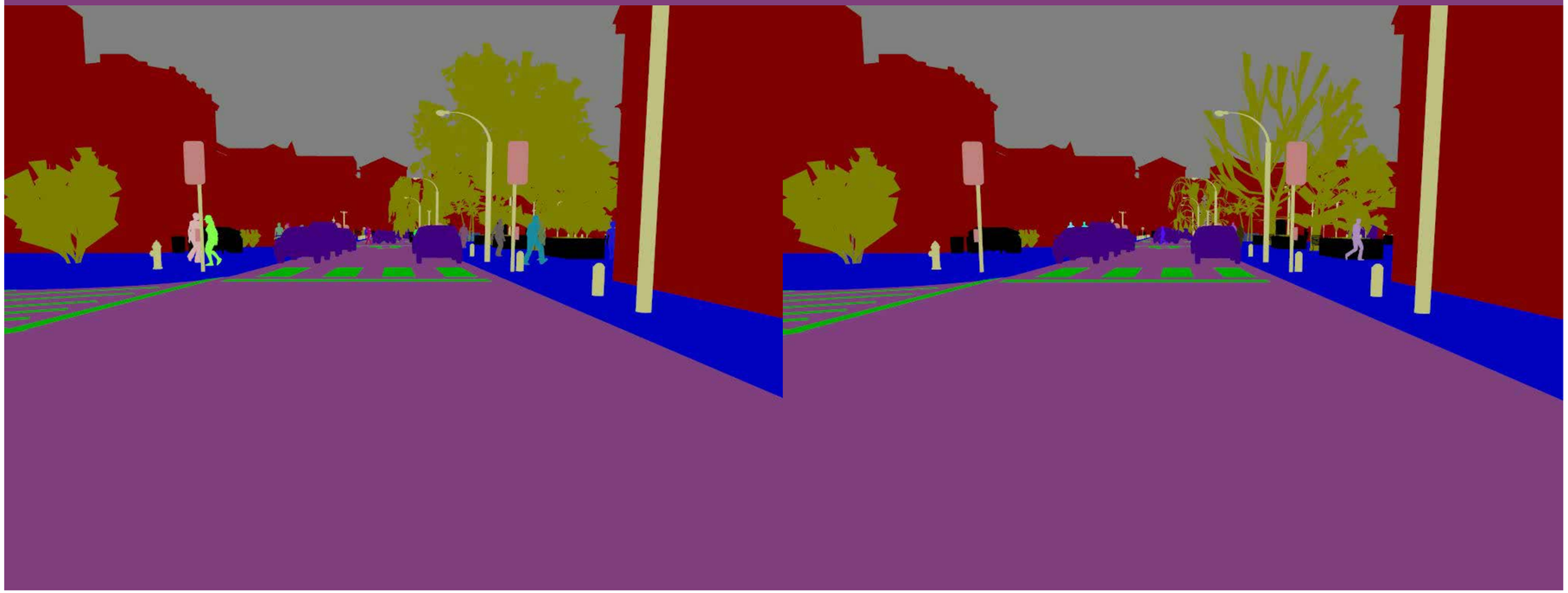
spring

summer



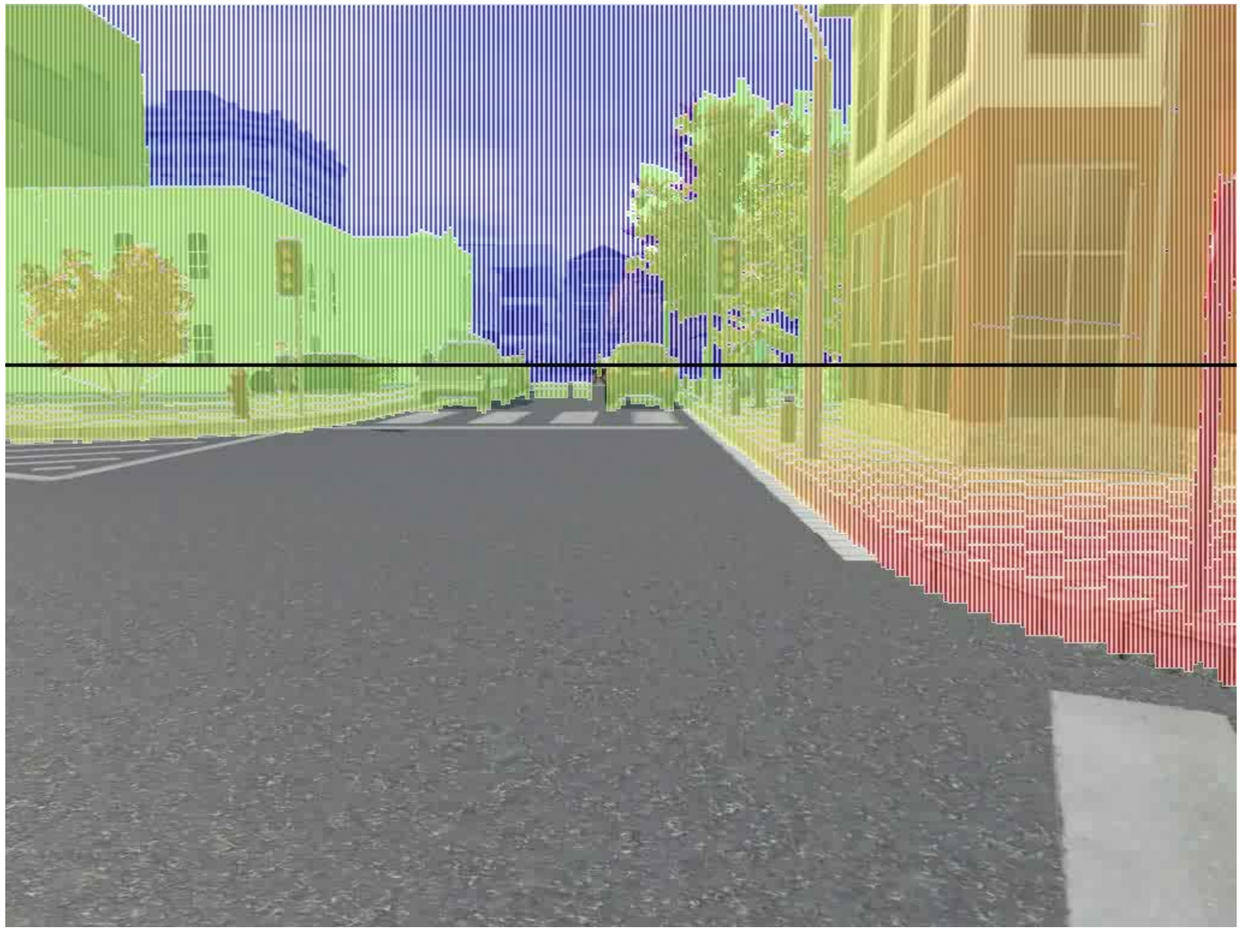
fall

winter

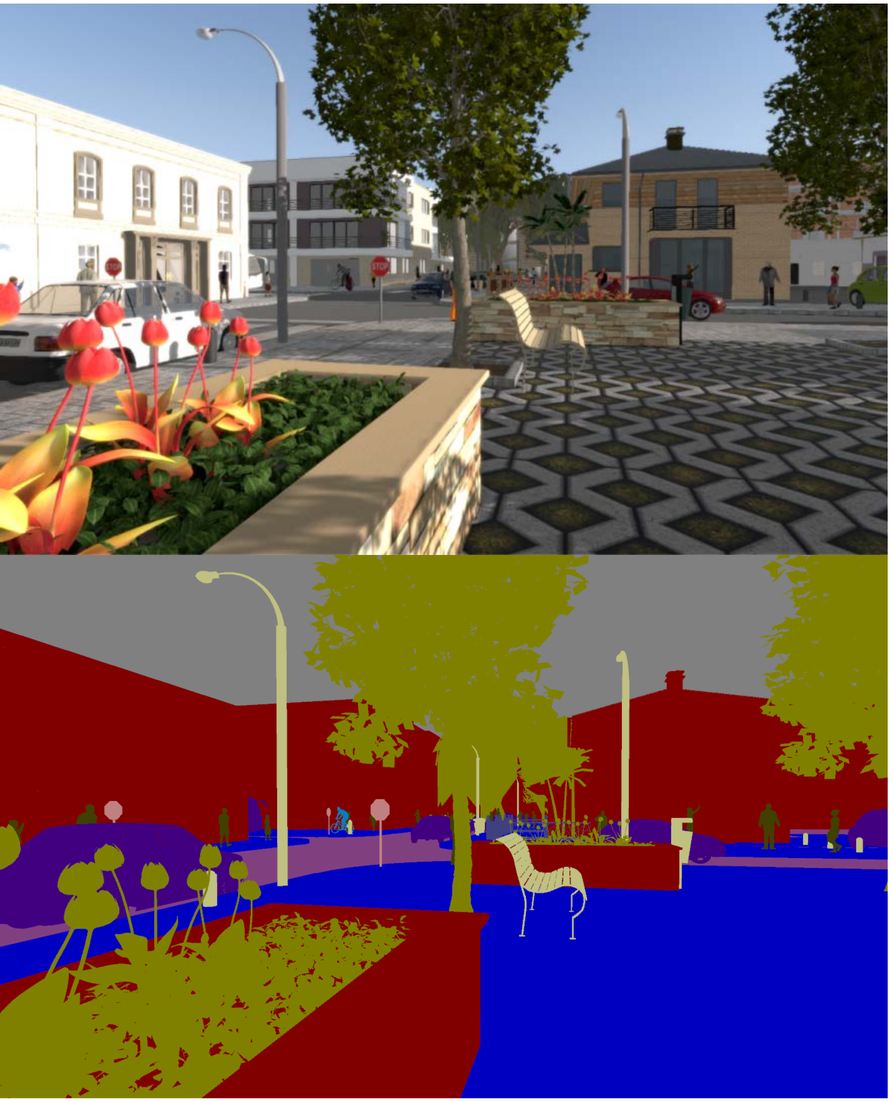


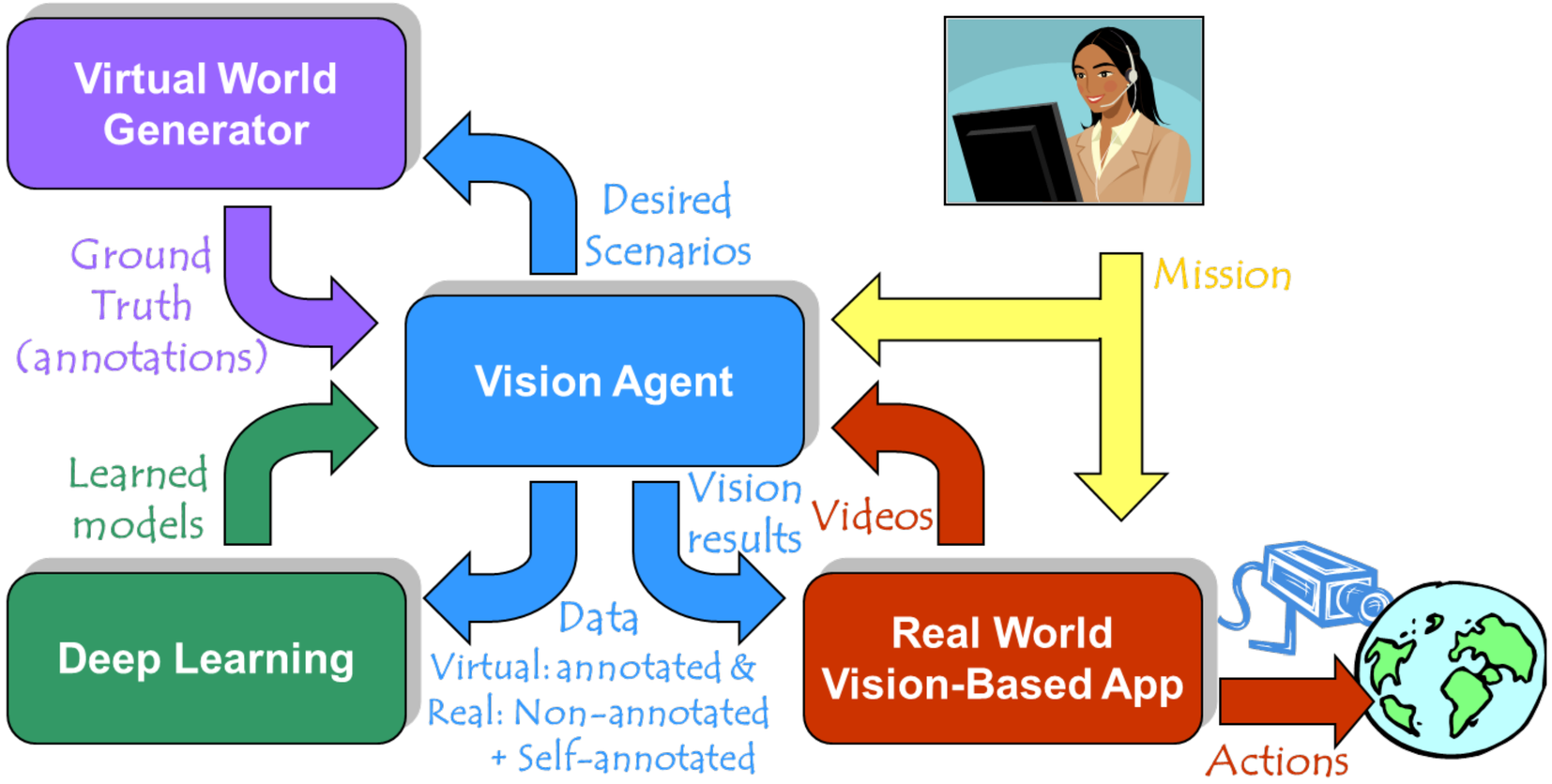
Virtual Worlds for Simulation

Virtual Worlds for Debugging



Conclusion




Virtual World Generator
Desired Scenarios
Ground Truth (annotations)
Vision Agent
Mission
Learned models
Vision results
Videos
Deep Learning
Data
Virtual: annotated & Real: Non-annotated + Self-annotated
Real World Vision-Based App
Actions

Many Thanks!!!

Dr. Antonio M. López, Principal Investigator UAB & CVC ADAS Group

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- Spanish MEC TRA2014-57088-C2-1-R.
- Generalitat Catalunya: 2014-SGR-1506.

Of course, many thanks also to:

NVIDIA