

Street Scene: A new dataset and evaluation protocol for video anomaly detection

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1. More Detection Result Visualizations

We show more examples of our detection results using our flow-based algorithm with $T = 4$ frames in Figures 1 through 9. In each of the frames shown, the red tinted pixels are detected as anomalous by our algorithm. The blue rectangles show the ground truth annotations in each frame.

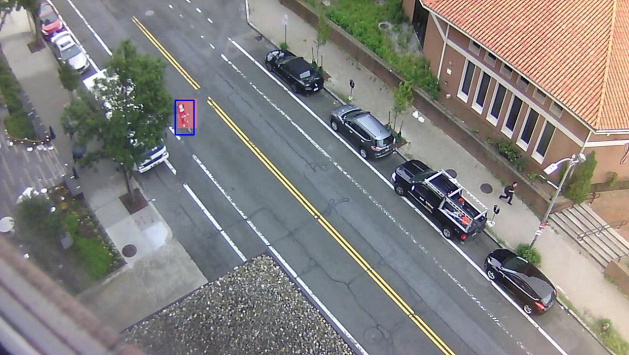


Figure 1: Detection result for flow-based method showing correctly detected biker outside of the bike lane.

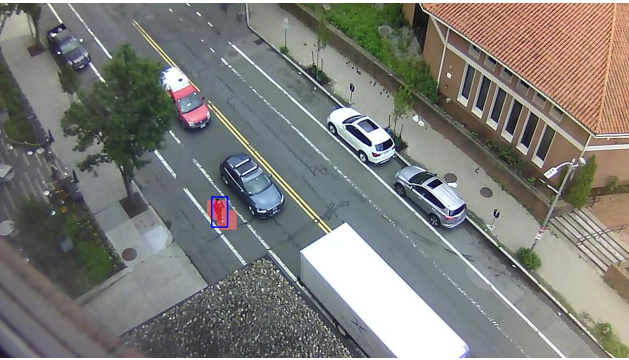


Figure 2: Detection result for flow-based method showing correctly detected skateboarder in a bike lane.

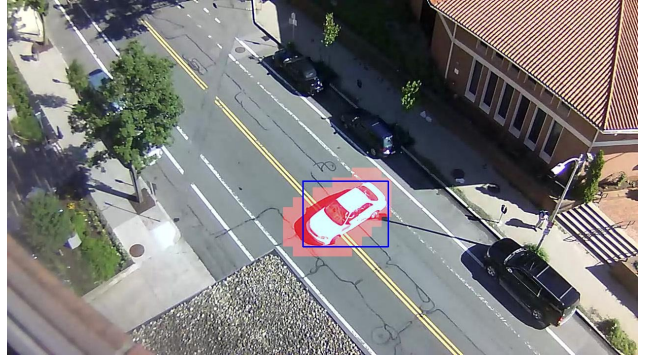


Figure 3: Detection result for flow-based method showing correctly detected car u-turn.

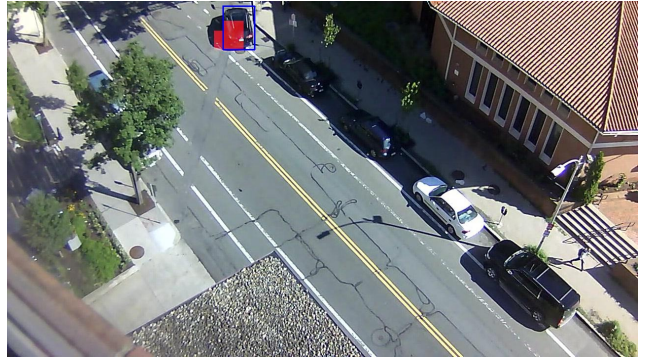


Figure 4: Detection result for flow-based method showing correctly detected illegal parking.

2. Results of baseline algorithms on UCSD Ped1 and Ped2

The baseline video anomaly detection method described in the paper is not the focus of this paper and is not claimed to be superior to the current state of the art on existing datasets. The purpose is to provide reasonable baseline results on Street Scene for future work to compare against since the available implementations of previous algorithms do not perform well on Street Scene. However, readers may be interested in how our exemplar-based algorithm per-

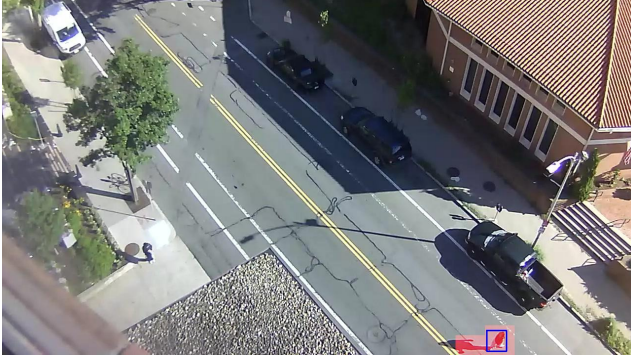


Figure 5: Detection result for flow-based method showing correctly detected jaywalker.

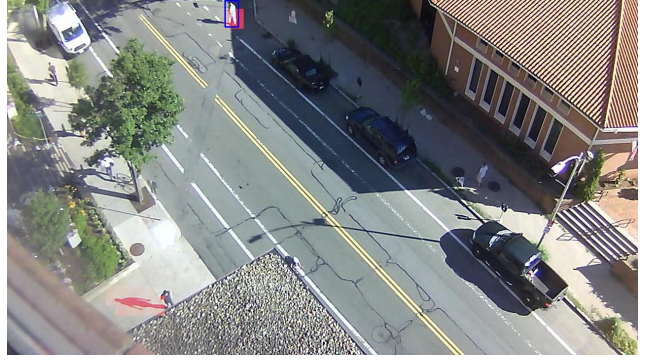


Figure 8: Detection result for flow-based method showing correctly detected jaywalker as well as a false positive.



Figure 6: Detection result for flow-based method showing correctly detected biker outside of the bike lane.

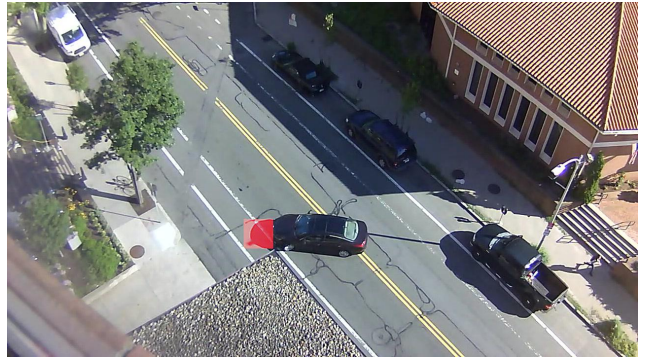


Figure 9: Detection result for flow-based method showing a false positive caused by a shadow of a car.

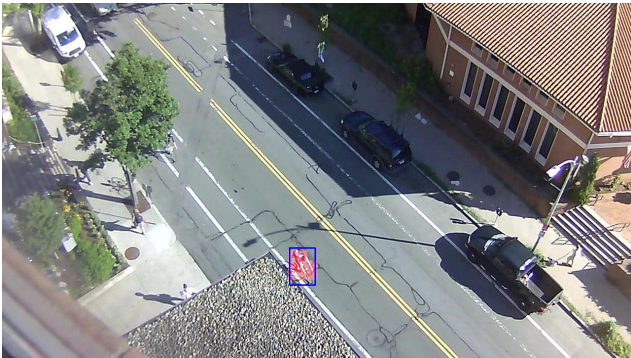


Figure 7: Detection result for flow-based method showing correctly detected biker outside of the bike lane.

forms on existing datasets. Table 1 shows results for our foreground baseline algorithm on UCSD Ped1 and Ped2 datasets using the traditional frame-level and pixel-level criteria. We also show results from other recent papers for comparison. Our results are comparable to many recent results especially using the pixel-level criterion.

3. Detailed List of Anomalies in Street Scene

Tables 2 and 3 list every annotated anomaly in the Street Scene dataset for all 35 testing videos. This list will be included with the dataset when it is publicly released (along with the ground truth bounding boxes for all frames). The lists give a good sense of what is contained in the data set. It is purely for informative purposes. The anomaly types are not used in the evaluation criteria.

References

- [1] B. Antic and B. Ommer. Video parsing for abnormality detection. In *IEEE International Conference on Computer Vision (ICCV)*, pages 2415–2422. IEEE, Nov. 2011. 3
- [2] B. Antic and B. Ommer. Spatio-temporal Video Parsing for Abnormality Detection. *arXiv preprint arXiv:1502.06235*, 2015. 3
- [3] M. Hasan, J. Choi, J. Neumann, A. Roy-Chowdhury, and L. Davis. Learning temporal regularity in video sequences. In *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2016. 3
- [4] W. Li, V. Mahadevan, and N. Vasconcelos. Anomaly detection and localization in crowded scenes. *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, 2014. 3

Method	Ped1 Frame-level		Ped1 Pixel-level		Ped2 Frame-level		Ped2 Pixel-level	
	AUC	EER	AUC	EER	AUC	EER	AUC	EER
Dictionary method [5]	91.8%	15%	63.8%	43%	-	-	-	-
Autoencoder [3]	81.0%	27.9%	-	-	90.0%	21.7%	-	-
AMDN [7]	92.1%	16%	67.2%	40.1%	90.8%	17%	-	-
MDT [4]	81.8%	25%	44.1%	58.0%	85.0%	25%	44.0%	-
Video parsing [1]	91.0%	18%	83.6%	23%	92.0%	14%	-	-
ST Video parsing [2]	93.9%	12.9%	84.2%	20.5%	94.6%	10.6%	81.1%	11.2
Plug and play CNN [6]	95.7%	8%	64.5%	-%	88.4%	18%	-	-
Our FG Baseline	77.3%	25.9%	69.3%	39.4%	88.3%	18.9%	83.9%	23.5%

Table 1: Traditional frame-level and pixel-level results on UCSD Ped1 and Ped2.

Test video	Anomaly Index	Anomaly Type	Test video	Anomaly Index	Anomaly Type	Test video	Anomaly Index	Anomaly Type
Test001	1	Jaywalk	Test009	1	Biker outside lane	Test015	4	Biker outside lane
	2	Worker in bushes		2	Biker outside lane		5	Jaywalk
Test002	1	Person opening trunk	Test010	3	Biker on sidewalk		6	Biker outside lane
	2	Loitering		1	Car u-turn		7	Biker outside lane
	3	Loitering		2	Car Illegally parked		8	Biker outside lane
	4	Loitering		3	Jaywalk		9	Biker outside lane
	5	Jaywalk		4	Biker outside lane	Test016	1	Jaywalk
	6	Jaywalk		5	Jaywalk		2	Biker outside lane
	7	Jaywalk		6	Jaywalk		3	Biker outside lane
Test003	1	Jaywalk	Test011	1	Loitering	Test017	1	Dog
	2	Jaywalk		2	Car u-turn		2	Loitering
	3	Jaywalk		3	Biker outside lane		3	Loitering
Test004	1	Car u-turn		4	Biker outside lane		4	Jaywalk
	2	Jaywalk		5	Biker outside lane		5	Jaywalk
	3	Car outside lane		6	Jaywalk		6	Jaywalk
	4	Jaywalk		7	Car illegally parked		7	Pedestrian reverses direction
	5	Jaywalk		8	Jaywalk		8	Loitering
Test005	1	Loitering		9	Biker outside lane		9	Jaywalk
	2	Dog		10	Jaywalk		10	Loitering
	3	Loitering	Test012	1	Loitering		11	Dog
	4	Loitering		2	Loitering		12	Loitering
	5	Jaywalk		3	Car u-turn		13	Biker outside lane
	6	Loitering		4	Biker outside lane	Test018	1	Biker outside lane
	7	Loitering		5	Loitering		2	Biker outside lane
	8	Jaywalk		6	Dog		3	Biker outside lane
	9	Jaywalk	Test013	1	Dog		4	Pedestrian reverses direction
	10	Loitering		2	Loitering		5	Loitering
	11	Loitering		3	Biker on sidewalk		6	Biker outside lane
	12	Loitering		4	Dog		7	Biker outside lane
	13	Loitering		5	Loitering		8	Loitering
	14	Jaywalk		6	Dog		9	Metermaid ticketing car
Test006	1	Person sitting on bench		7	Loitering		10	Pedestrian reverses direction
	2	Person opening trunk		8	Loitering		11	Loitering
	3	Jaywalk		9	Dog		12	Biker on sidewalk
Test007	1	Jaywalk		10	Loitering	Test019	1	Person exits car on street
	2	Skateboarder in bike lane		11	Person opening trunk	Test020	1	Jaywalk
	3	Skateboarder in bike lane	Test014	1	Jaywalk		2	Jaywalk
	4	Biker on sidewalk		1	Car turning from parking space		3	Jaywalk
Test008	1	Jaywalk	Test015	1	Biker outside lane	Test021	1	Jaywalk
	2	Jaywalk		2	Biker outside lane		2	Biker outside lane

Table 2: List of anomalies labeled in each testing video

[5] C. Lu, J. Shi, and J. Jia. Abnormal event detection at 150 fps in matlab. In *IEEE International Conference on Computer Vision (ICCV)*, 2013. 3

[6] M. Ravanbakhsh, M. Nabi, H. Mousavi, E. Sangineto, and N. Sebe. Plug-and-play cnn for crowd motion analysis: An

application in abnormal event detection. In *IEEE Winter Conference on Applications of Computer Vision (WACV)*, 2018. 3

[7] D. Xu, E. Ricci, Y. Yan, J. Song, and N. Sebe. Learning deep representations of appearance and motion for anomalous event

Test video	Anomaly Index	Anomaly Type	Test video	Anomaly Index	Anomaly Type	Test video	Anomaly Index	Anomaly Type
Test021	3	Dog	Test025	4	Biker outside lane	Test029	11	Car outside lane
	4	Biker outside lane		5	Biker outside lane	Test030	1	Car outside lane
	5	Biker outside lane		6	Biker outside lane		2	Pedestrian reverses direction
	6	Jaywalk		7	Biker on sidewalk		3	Car outside lane
	7	Loitering		8	Jaywalk	Test031	1	Person sitting on bench
Test022	1	Loitering	Test026	1	Biker outside lane		2	Biker outside lane
	2	Dog		2	Biker outside lane		3	Pedestrian reverses direction
	3	Loitering		3	Car outside lane		4	Jaywalk
	4	Loitering		4	Car outside lane		5	Motorcycle drives onto sidewalk
Test023	1	Dog		5	Loitering	Test032	1	Worker in bushes
	2	Biker outside lane		6	Biker on sidewalk		2	Worker in bushes
	3	Car u-turn	Test027	1	Jaywalk		3	Pedestrian reverses direction
	4	Biker on sidewalk		2	Jaywalk		4	Jaywalk
	5	Jaywalk		3	Jaywalk	Test033	1	Worker in bushes
	6	Biker outside lane		4	Jaywalk		2	Jaywalk
	7	Biker outside lane	Test028	1	Jaywalk		3	Jaywalk
	8	Biker outside lane		2	Biker outside lane	Test034	1	Worker in bushes
	9	Biker outside lane		3	Car outside lane		2	Jaywalk
	10	Biker outside lane	Test029	1	Illegal parking		3	Jaywalk
Test024	1	Jaywalk		2	Jaywalk		4	Worker in bushes
	2	Jaywalk		3	Jaywalk		5	Worker in bushes
	3	Jaywalk		4	Car illegally parked		6	Worker in bushes
	4	Jaywalk		5	Car outside lane	Test035	1	Jaywalk
	5	Jaywalk		6	Car outside lane		2	Jaywalk
	5	Biker outside lane		7	Car outside lane		3	Loitering
	6	Biker outside lane		8	Person exits car on street		4	Jaywalk
Test025	1	Biker on sidewalk		9	Person exits car on street		5	Loitering
	2	Jaywalk		10	Person opening trunk		6	Pedestrian reverses direction
	3	Jaywalk						

Table 3: Continued list of anomalies labeled in each testing video

detection. In *British Machine Vision Conference (BMVC)*, 2015. 3