GeometryPaste: Geometry-Based Copy-Paste Data Augmentation for Instance Segmentation

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Introduction

Instance Segmentation

- Detect and segment every object instance.

Input Output

- Many important applications: autonomous vehicles and robots, medical imaging, etc.
- Rare objects difficult to detect due to lack of data.
- **Copy-Paste** can help!

More  *= more AP*

Dataset

- Small dataset of roadwork objects from different cities.
- Some incorrect/missing annotations.
- 4,908 images, 15 categories.
- Generate 1,728 new **TTC Message Boards**.

Instance Distribution

Category	Train			Val	Test
	BL (3435)	CP (5163)	**GP** (5163)	492	981
Cone	7604	11367	11495	1203	2224
Fence	880	1286	1252	139	411
Drum	1189	1515	1497	150	1141
Barricade	1436	2422	2315	185	566
Barrier	1275	1918	1825	212	401
Work Vehicle	3106	4705	4634	457	870
Vertical Panel	5175	8987	8937	879	1912
Tubular Marker	4269	5658	5515	567	1562
Arrow Board	212	360	350	29	105
TTC Message Board	90	**1818**	**1818**	14	33
Other Roadwork Objects	191	289	309	20	63
Guide Sign	420	770	720	59	59
Road	2030	3865	3868	276	697
TTC Sign	2500	4046	3947	320	681
Work Equipment	280	382	407	44	41

Methodology

Overview

Generate realistic training images with Copy-Paste data augmentation to increase instance segmentation performance on rare roadwork objects. We copy objects from their original images and paste them onto new background images using both the geometry and context of the objects and background images.

Steps

1. Randomly choose objects

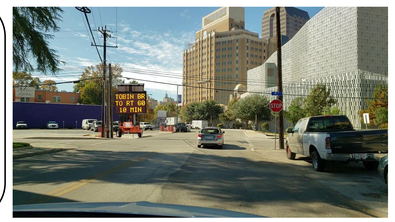
2. Randomly choose backgrounds

By [1],

$$y \approx y_c \frac{v_t - v_b}{v_0 - v_b} / (1 + (v_c - v_0)(v_c - v_t)/f^2).$$

Then,

$$v_t = \frac{y(v_0 - v_b)(f^2 + v_c^2 - v_0 v_c) + f^2 y_c v_b}{f^2 y_c + y(v_0 - v_b)(v_0 - v_c)}.$$

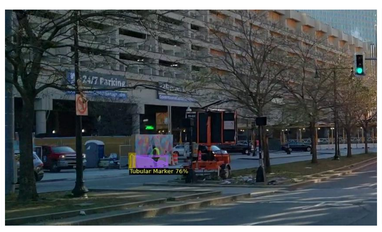


3. Select random point on road and scale accordingly

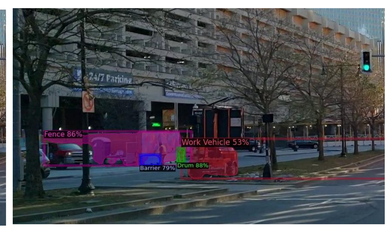
4. Paste

Results

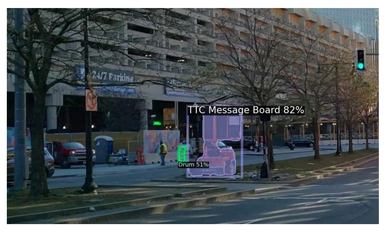
Ground Truth



Baseline



Random Copy-Paste

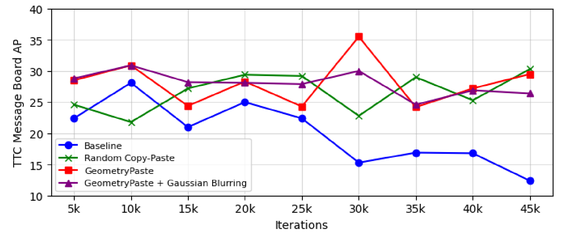


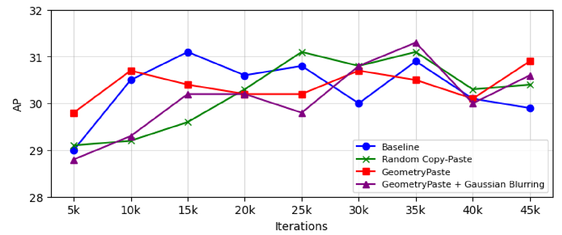
GeometryPaste

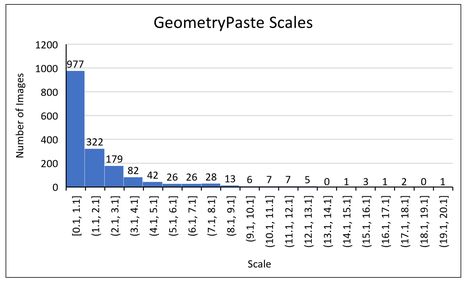
GeometryPaste + Gaussian Blurring

- Only **GeometryPaste** detected the TTC Message Board!

Analysis







- **GeometryPaste** achieved the highest TTC Message Board AP score (**35.5**)!
- **GeometryPaste + Gaussian blurring** achieved the **highest** overall AP score (**31.3**)!

Conclusion and Future Work

- GeometryPaste outperformed other methods, but more work is needed.
- Existing inaccurate annotations are problematic for the entire pipeline.
- Future work may include pasting additional objects and verification of annotation quality.

Acknowledgements

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References

[1] D. Hoiem, A. A. Efros and M. Hebert, "Putting Objects in Perspective," 2006 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'06), New York, NY, USA, 2006, pp. 2137-2144, doi: 10.1109/CVPR.2006.232.