# RECALL: Replay-based Continual Learning in Semantic Segmentation

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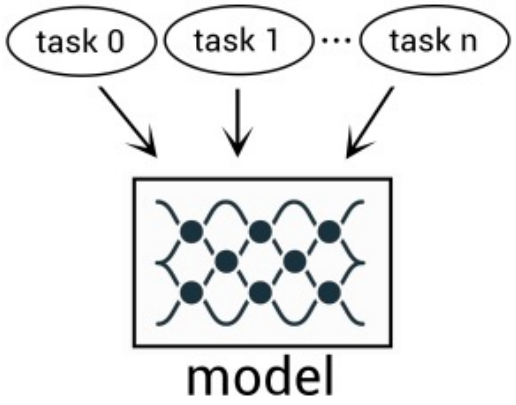
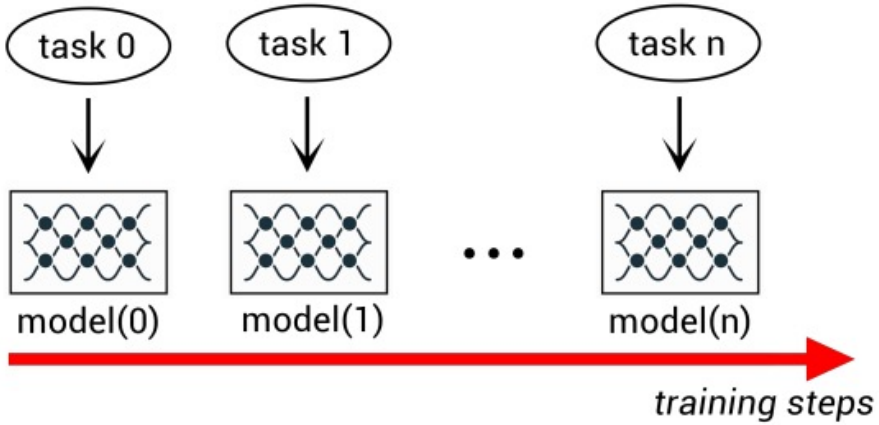
# Incremental Learning




## Standard supervised learning

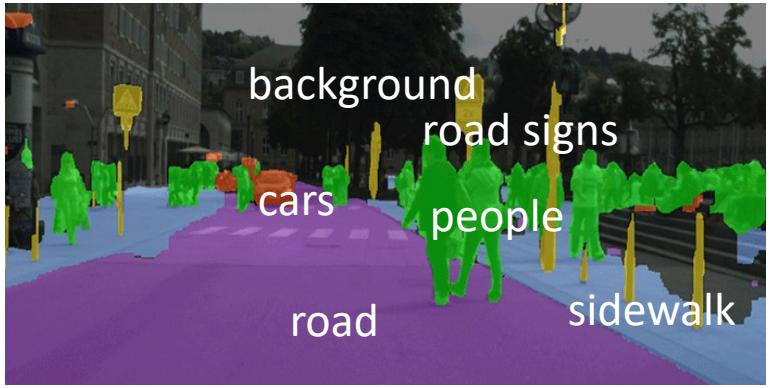
Data is acquired first, then all tasks are learnt jointly

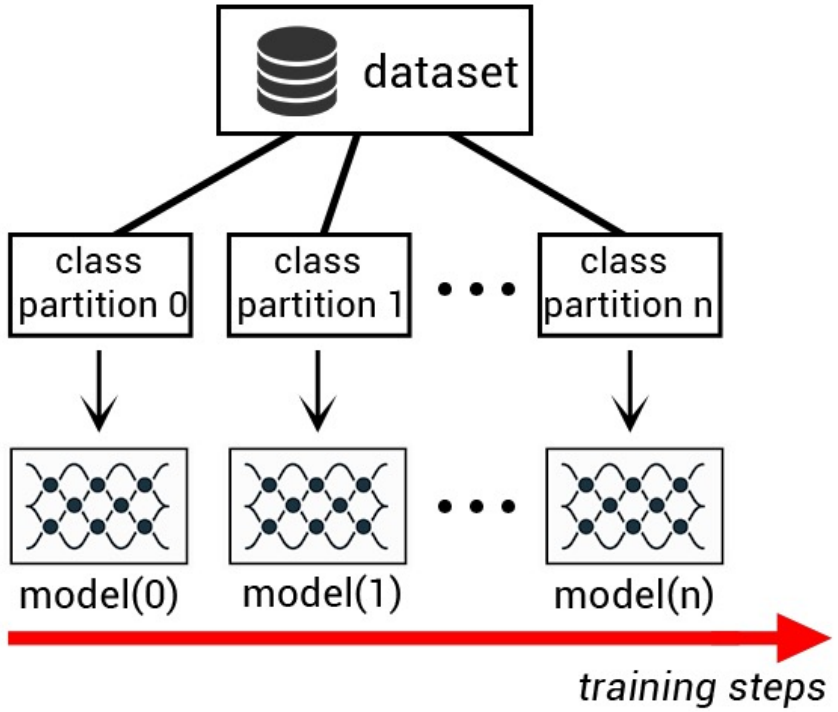



## Incremental learning

Tasks are sampled and learnt over multiple steps

# Problem and Setting



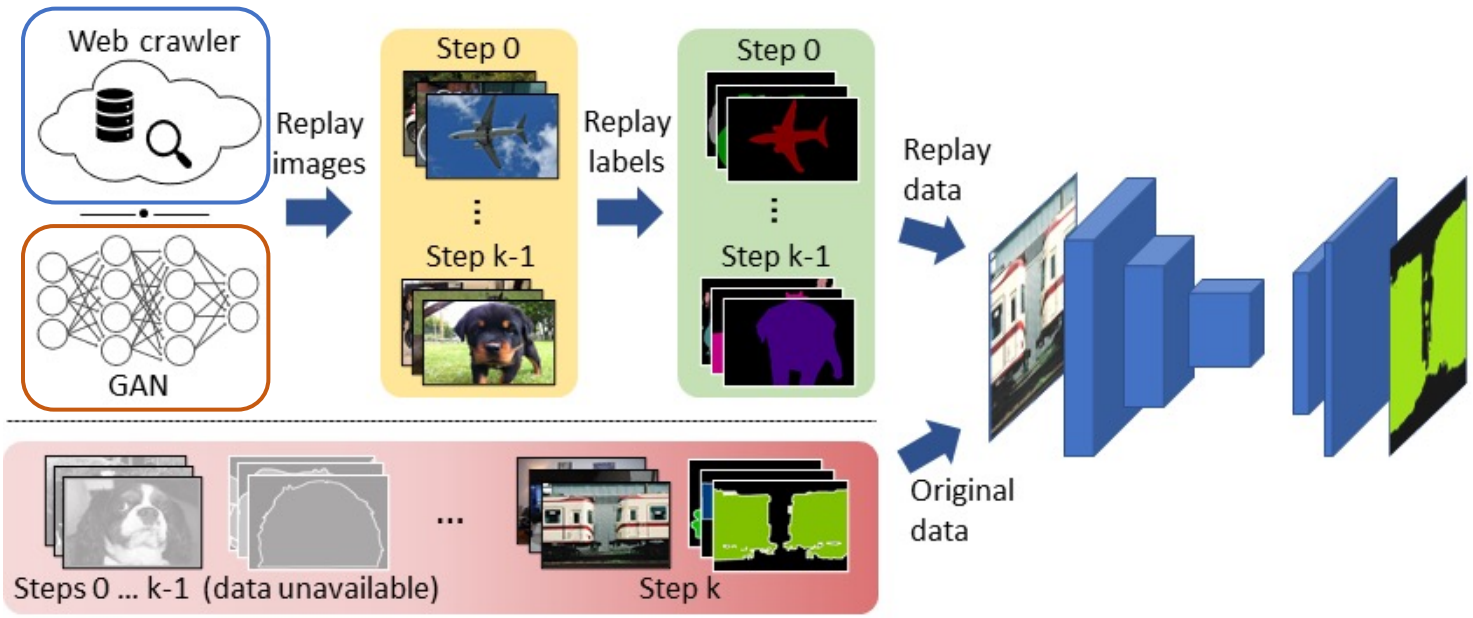

## Setting

- Semantic segmentation
- New classes = new tasks learned sequentially without old data

## Problem

*Catastrophic forgetting:* the model learns the new classes but forgets the old ones

# Replay Data




- We use BigGAN.
  Brock A., et al., "Large Scale GAN Training for High Fidelity Natural Image Synthesis" ICLR 2018

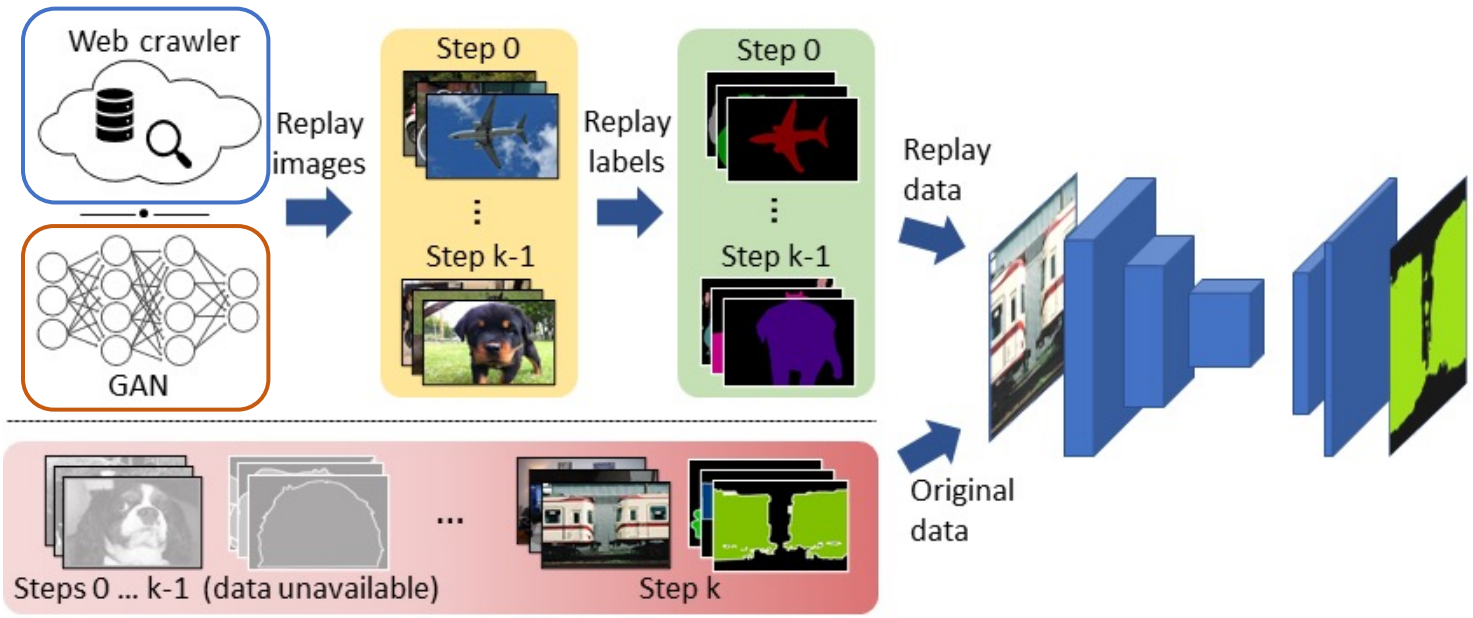
- We get images from a Web crawler.

flickr
www.flickr.com

**IDEA:** interleave the current available data with replay samples to mitigate catastrophic forgetting

- Past samples are generated using a GAN or a Web crawler
- **Problem**: labels for replay samples need to be computed

# Replay Data

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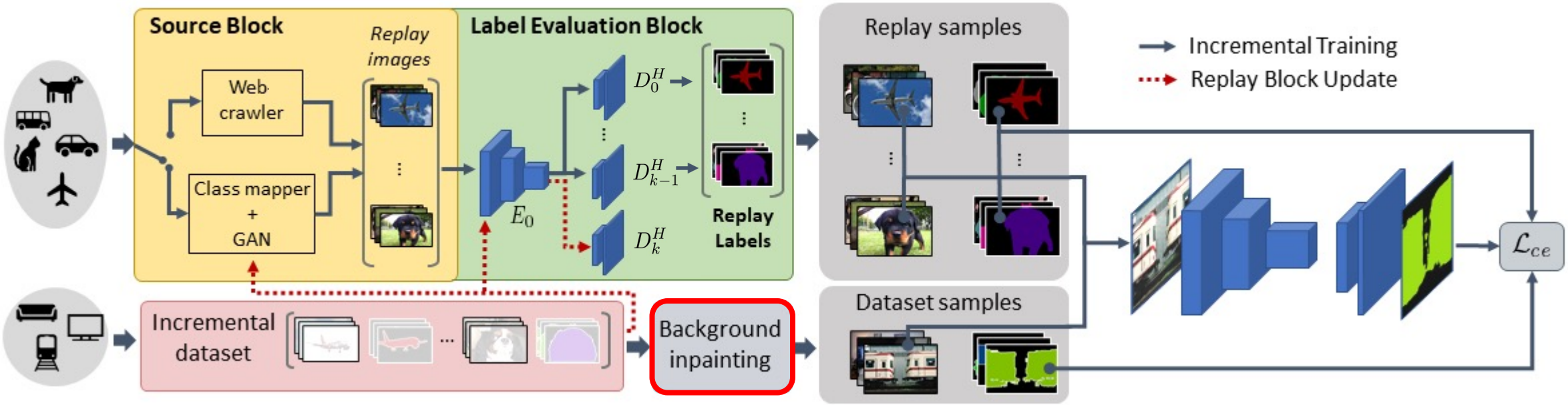
**Pascal**

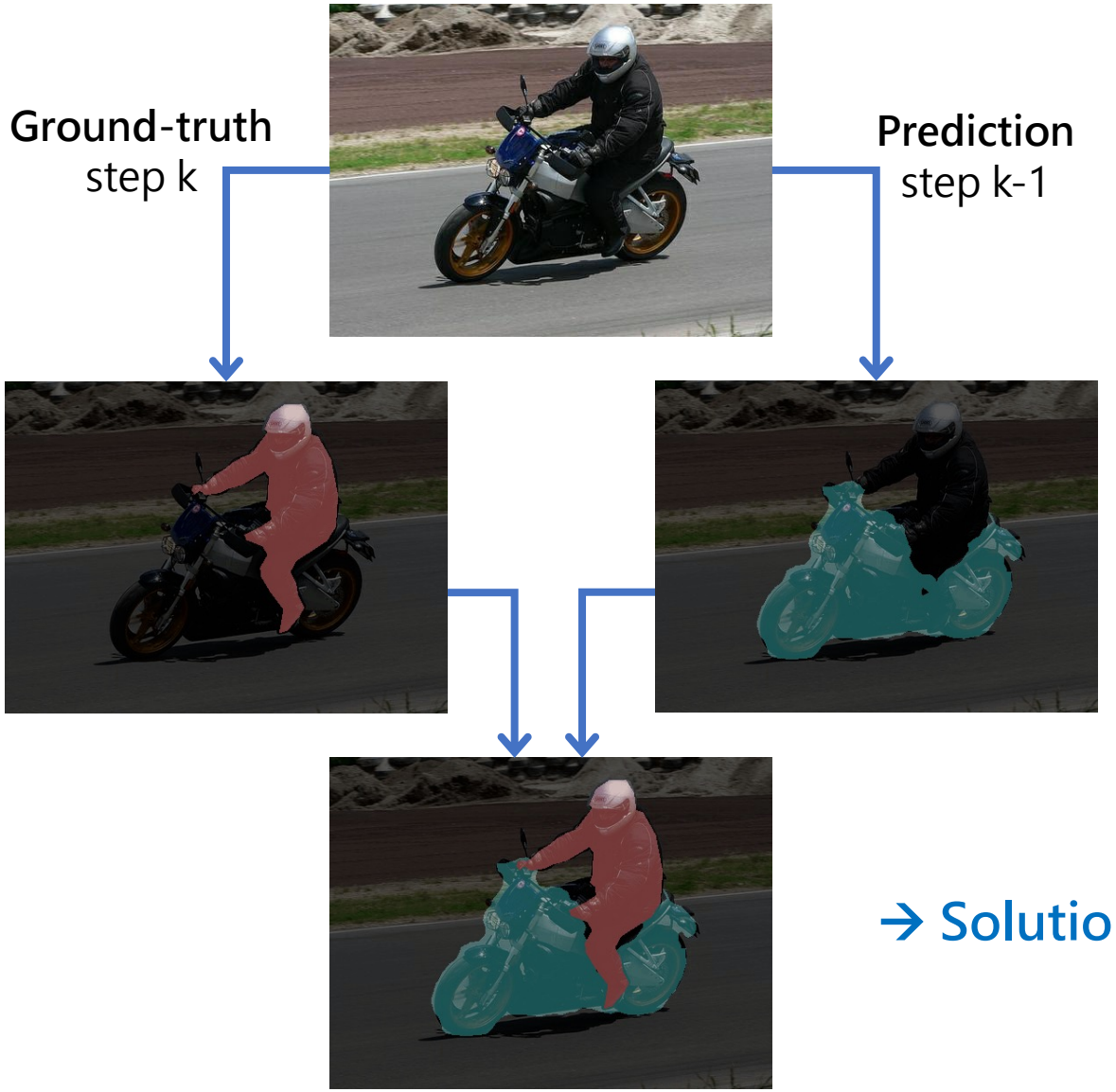
**GAN**

**Web crawler**

# Our Method


Source Block
Replay images
Web crawler
Class mapper + GAN
Label Evaluation Block
$E_0$
$D_0^H$
$D_{k-1}^H$
$D_k^H$
Replay Labels
Replay samples
Incremental Training
Replay Block Update
Incremental dataset
Background inpainting
Dataset samples
$\mathcal{L}_{ce}$

# Background Inpainting

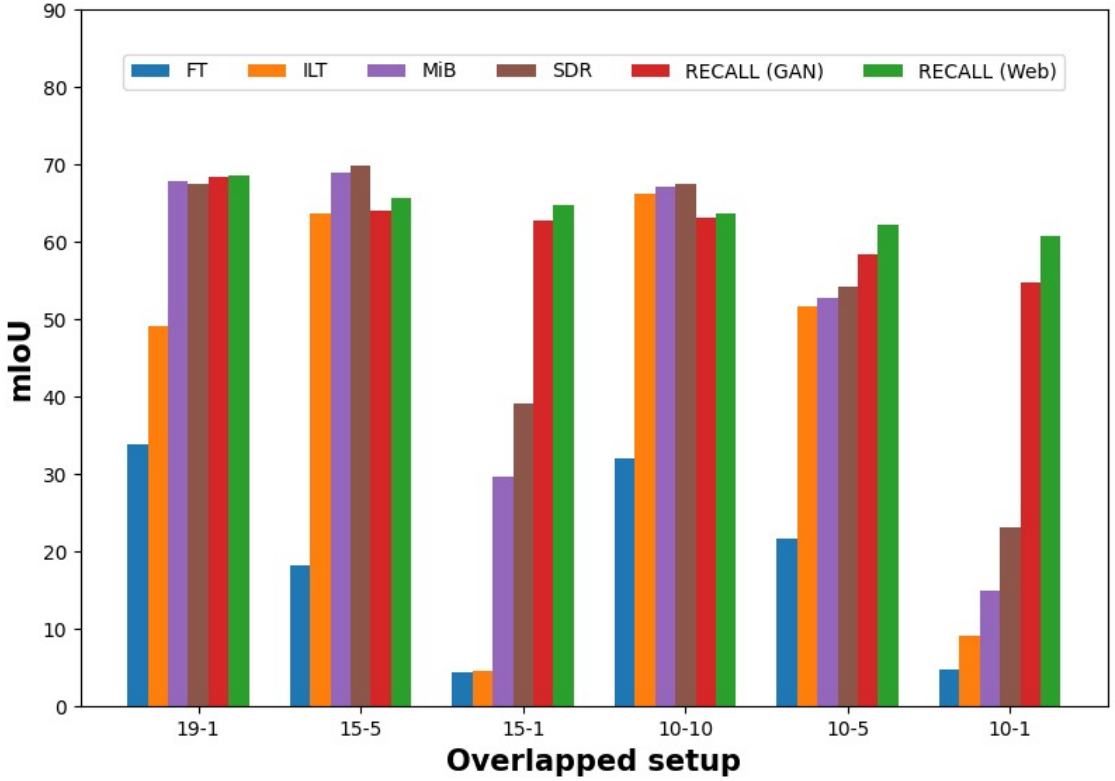


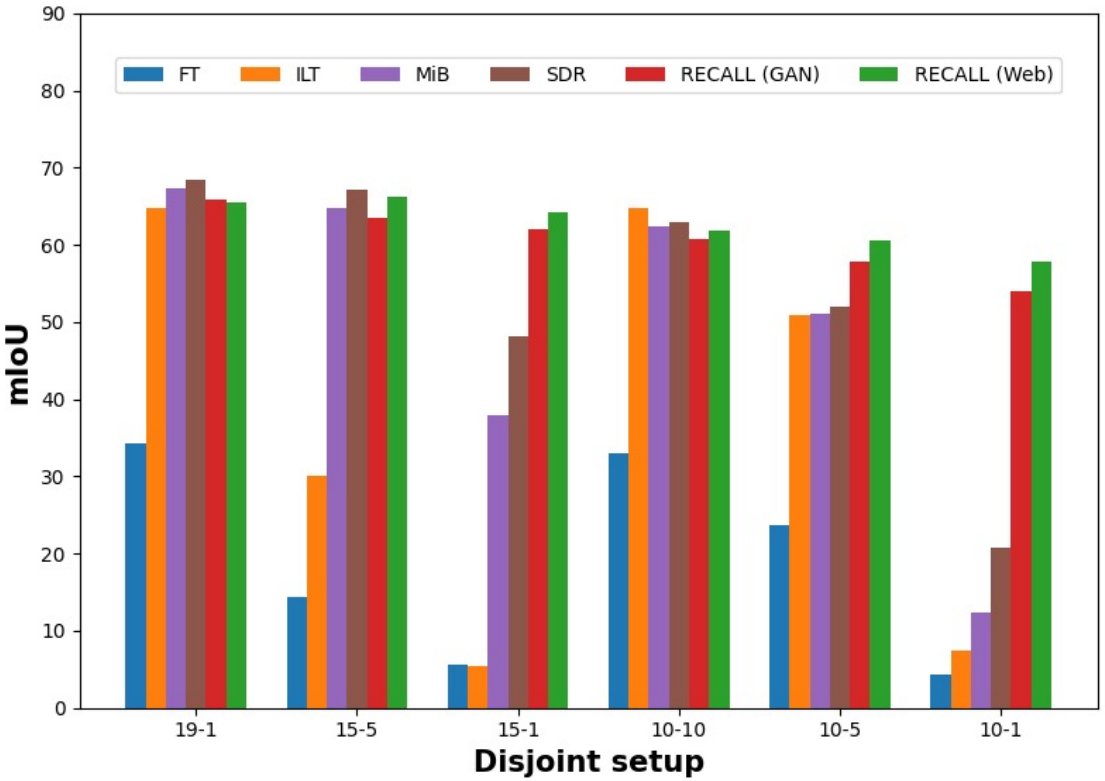

*Incremental step k:*

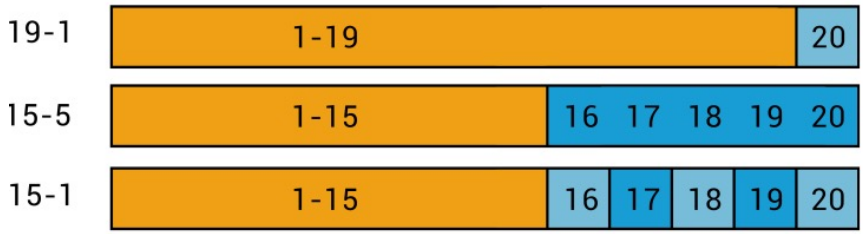
- Labels available only for **new categories**
- **Past classes** learnt in previous steps are annotated by *pseudo-labeling*

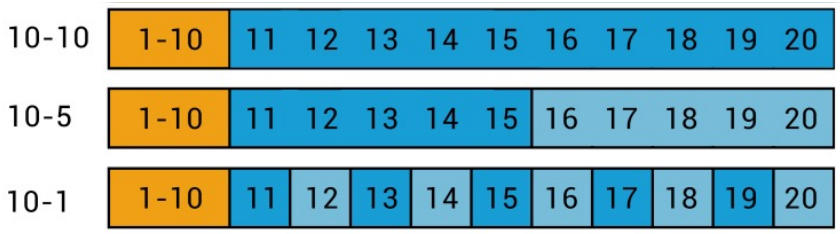
→ **Solution**: background inpainting

# Results – Pascal VOC2012




**ILT**: Michieli U. et al., "Incremental Learning Techniques for Semantic Segmentation", ICCVW 2019
**MiB**: Cermelli F. et al., "Modeling the background for incremental learning in semantic segmentation", CVPR 2020
**SDR**: Michieli U. et al., "Continual semantic segmentation via repulsion-attraction of sparse and disentangled latent representations", CVPR 2021

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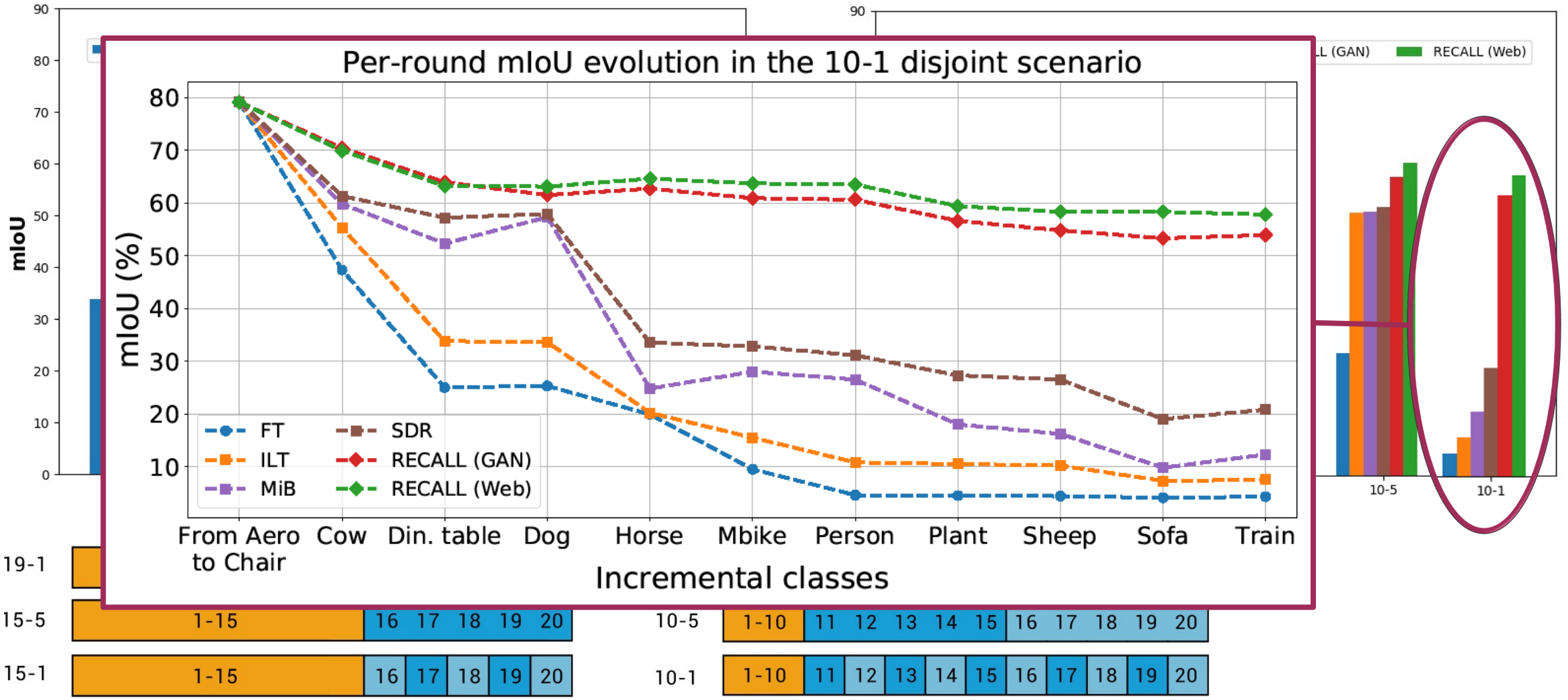


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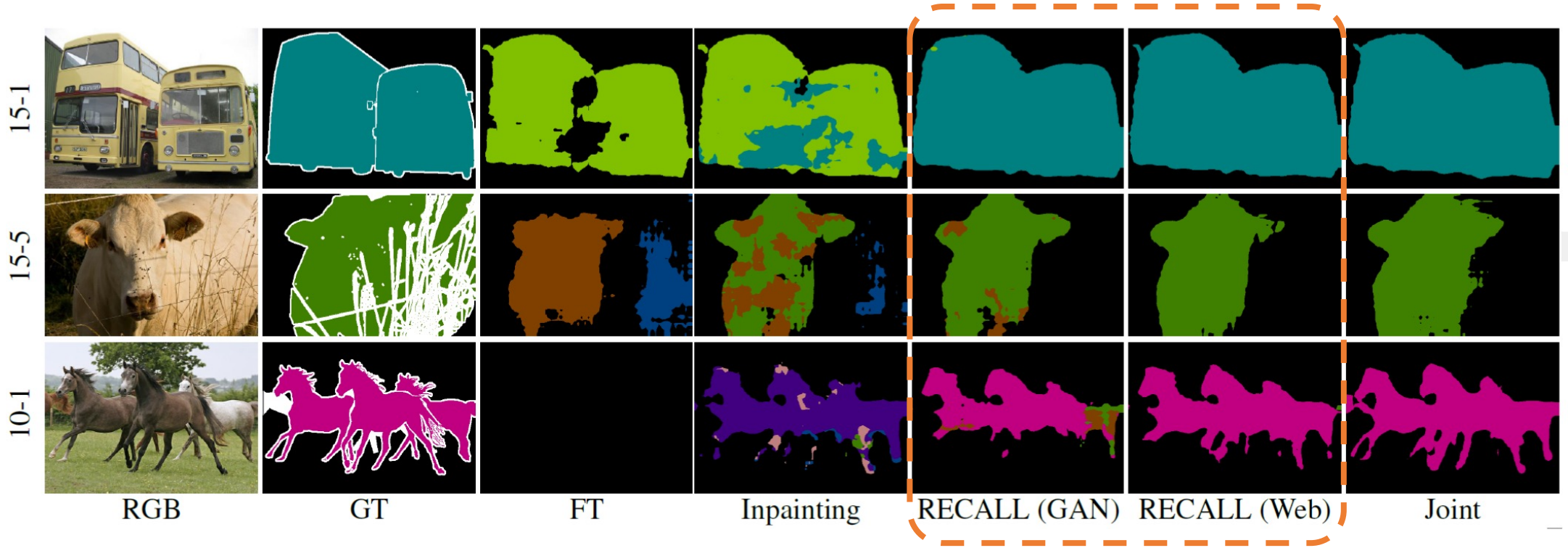
# Visual Results – Pascal VOC2012




- RECALL gets closer to *joint training*
- Visually similar classes are properly recognized:
  bus vs. train, sheep vs. cow

# Conclusion

- Use of replay data to alleviate *forgetting* in class-incremental learning:
  - GAN (BigGan)
  - Web crawler (Flickr)
- Self-inpainting to handle the *background shift*
- RECALL outperforms state-of-the-art methods
  - Especially when multiple incremental steps are performed

Code available: https://github.com/LTTM/RECALL/