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# ALIFE: Adaptive Logit Regularizer and Feature Replay for Incremental Semantic Segmentation

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<https://cvlab.yonsei.ac.kr/projects/ALIFE>

## Abstract

We address the problem of incremental semantic segmentation (ISS) recognizing novel object/stuff categories continually without forgetting previous ones that have been learned. The catastrophic forgetting problem is particularly severe in ISS, since pixel-level ground-truth labels are available only for the novel categories at training time. To address the problem, regularization-based methods exploit probability calibration techniques to learn semantic information from unlabeled pixels. While such techniques are effective, there is still a lack of theoretical understanding of them. Replay-based methods propose to memorize a small set of images for previous categories. They achieve state-of-the-art performance at the cost of large memory footprint. We propose in this paper a novel ISS method, dubbed ALIFE, that provides a better compromise between accuracy and efficiency. To this end, we first show an in-depth analysis on the calibration techniques to better understand the effects on ISS. Based on this, we then introduce an adaptive logit regularizer (ALI) that enables our model to better learn new categories, while retaining knowledge for previous ones. We also present a feature replay scheme that memorizes features, instead of images directly, in order to reduce memory requirements significantly. Since a feature extractor is changed continually, memorized features should also be updated at every incremental stage. To handle this, we introduce category-specific rotation matrices updating the features for each category separately. We demonstrate the effectiveness of our approach with extensive experiments on standard ISS benchmarks, and show that our method achieves a better trade-off in terms of accuracy and efficiency.

## 1 Introduction

Humans are capable of learning new concepts continually, while preserving or even improving previously acquired knowledge. Artificial neural networks are, however, prone to forget the knowledge they have learned if being trained with samples for new object/scene categories alone. The reason for this problem, so-called catastrophic forgetting [11, 27], is that parameters of neural networks change abruptly to handle new categories without accessing training samples for previous categories. A straightforward way to alleviate the problem is to re-train a model with training examples for entire categories observed so far, which is however computationally demanding.

Incremental learning is an alternative approach to learning new categories continuously without re-training on the entire dataset. While many methods have been proposed for incremental classification [4, 21, 23, 25, 33, 36], a few attempts explore incremental semantic segmentation (ISS), where training images for new categories are partially labeled to reduce the cost for manual annotation. That is, pixels for new categories are labeled only, while remaining ones are marked as unknown. The unknown regions should be considered separately, since they could contain previous categories along with ones that would be seen in the future.

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