KI DELTA LEARNING
Scalable AI for Automated Driving

Continual Learning for Class- and Domain-Incremental Semantic Segmentation

Tobias Kalb

WP 2.1

Use-Case in Delta Learning

A scalable deep learning-based perception system for autonomous driving requires the ability to adapt to a continually changing environment. So that it can adapt to new "Deltas" as they arise. However, state-of-the-art deep neural networks require complete retraining when encountering new data. Therefore, in our research we investigate continual learning methods for semantic segmentation that enable a deep learning model to incrementally adapt to new domains and classes.

Technical Problem

The challenge in continual learning is that training data is arriving incrementally with either changing input or output distributions. The goal is to achieve high accuracy on all observed data without re-visiting previous observed data. Therefore, the model has to balance the capability of retaining its knowledge and the ability to acquire knowledge from new data. If the model is too plastic, it will suffer from forgetting of old knowledge. On the other hand, if the model is too stable it will retain its knowledge, but it will not be able to adapt to new data.

Technical Solution

In order to identify promising approaches for continual semantic segmentation we adapt regularization-based and replay-based learning methods to the task of semantic segmentation. Replay-based methods store a small subset of previous training data and incorporate it during further training. Regularization-based methods either constrain parameter updates on important parameters (EWC [1], L2) or use knowledge distillation to retain previous knowledge (LwF [2], CIL [3]).

Evaluation

We evaluate the selected approaches in a class- and domain-incremental setting. For the domain-incremental setting we train the network first on BDD100k (USA) and sequentially on Cityscapes (Germany). In this setting the replay-based methods perform the best using only 0.45% of the original dataset for replay. For the class-incremental setting, we divide the Cityscapes dataset into 3 subsets with each having a disjoint set of classes. The model is than trained incrementally on these subsets. In this setting only knowledge distillation-based methods enable the model to effectively distinguish between all classes. This indicates that domain- and class incremental learning require a different set of methods.

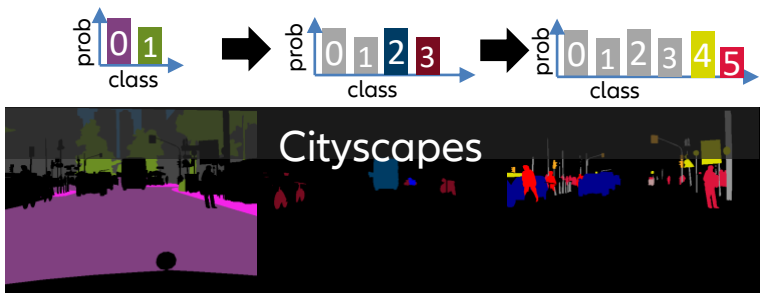

Figure 1: Class-Incremental training setup. Each set contains a disjoint set of classes, which leads to a changing output distribution

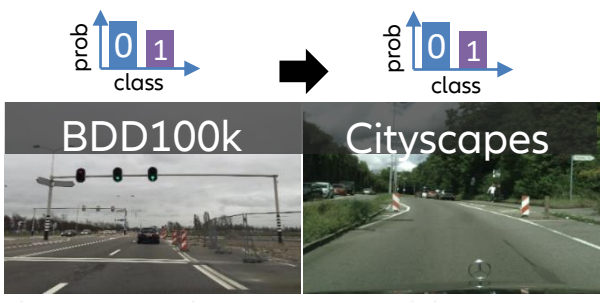

Figure 2: Domain-Incremental training setup. The models are firstly trained on BDD100k and then on Cityscapes.

Method	mIoU [%] on all Classes
Offline	68.7
FT	16.1
L2	39.8
CIL [3]	**56.6**
Replay	39.8
CIL + Replay	56.0

Table 1: Evaluation on Cityscapes divided into three subsets each containing a disjoint set of classes. Results are reported for testing on all classes simultaneously.

Method	mIoU [%] on all Domains
Offline	59.1
FT	49.9
L2	46.6
LwF [2]	44.0
Replay	**56.1**
LwF + Replay	52.6

Table 2: Evaluation for Domain-Incremental learning. The models were sequentially trained on BDD and Cityscapes. Reported results are averaged on both test sets.

Countries

References:

[1] J. Kirkpatrick, R. Pascanu, N. Rabinowitz, J. Veness, and G. Desjardins, "Overcoming catastrophic forgetting in neural networks," 2015.
[2] Z. Li and D. Hoiem, "Learning without Forgetting," IEEE Trans. Pattern Anal. Mach. Intell., vol. 40, no. 12, pp. 2935–2947, 2018, doi: 10.1109/TPAMI.2017.2773081.
[3] M. Klingner, A. Bär, P. Donn, and T. Fingscheidt, "Class-incremental learning for semantic segmentation re-using neither old data nor old labels," arXiv,. Available: http://arxiv.org/abs/2005.06050.

Porsche Engineering
driving technologies

For more information contact:
Tobias.Kalb@porsche-engineering.de

Partners

External partners

KI Delta Learning is a project of the KI Familie. It was initiated and developed by the VDA Leitinitiative autonomous and connected driving and is funded by the Federal Ministry for Economic Affairs and Energy.

KI FAMILIE

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

www.ki-deltalearning.de @KI_Familie KI Familie