ARCADe: A Rapid Continual Anomaly Detector

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01.2021 @ICPR2020

Introduction

- Continual Anomaly Detection (CAD) is unexplored
- One model for multiple sequentially learned AD tasks
- Challenges: Catastrophic forgetting & Overfitting to the majority class
- Learn a learning strategy that can cope with these challenges
- ARCADe is a first and strong baseline for CAD

A Robust Continual Anomaly Detector ARCADe – Meta-Training

Algorithm 1 ARCADe Meta-training Procedure

Require: D_{tr}: Set of meta-training task-sequences
Require: β: Learning rate for the meta-update
Require: K: Adaptation set size

Randomly initialize model parameters $\boldsymbol{\theta}$ and parameter-specific learning rates $\boldsymbol{\alpha}$
while not done **do**
  Sample a batch of task-sequences S_i from D_{tr}
  Initialize meta-learning loss $L_{meta} = 0$
  for each sampled S_i **do**
    Adapt model initialization θ to S_i using the train set of each task and the learning rates $\boldsymbol{\alpha}$, yielding $\boldsymbol{\theta}'_{i,J}$
    Evaluate the adapted model $f_{\boldsymbol{\theta}'_{i,J}}$ on S_i using the validation set of each task to compute $L_{s,i}$
    $L_{meta} = L_{meta} + L_{s,i}$
  end for
  Update $(\boldsymbol{\theta}, \boldsymbol{\alpha})$: $(\boldsymbol{\theta}, \boldsymbol{\alpha}) \leftarrow (\boldsymbol{\theta}, \boldsymbol{\alpha}) - \beta \nabla_{(\boldsymbol{\theta}, \boldsymbol{\alpha})} L_{meta}$
end while
return Meta-learned parameters $\boldsymbol{\theta}$ and learning rates $\boldsymbol{\alpha}$

Algorithm 2 ARCADe Meta-testing Procedure

Require: θ: Meta-learned initialization
Require: $\boldsymbol{\alpha}$: Meta-learned parameter-specific learning rates
Require: S_{test}: A meta-testing task-sequence

Adapt model initialization θ to S_{test} using the train set of each task and the learning rates $\boldsymbol{\alpha}$, yielding $\boldsymbol{\theta}'_J$
Evaluate the adapted model $f_{\boldsymbol{\theta}'_J}$ on S_{test} using the validation set of each task included it

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Results – Comparison to baselines

Fig. 1. Retained accuracy on Omniglot

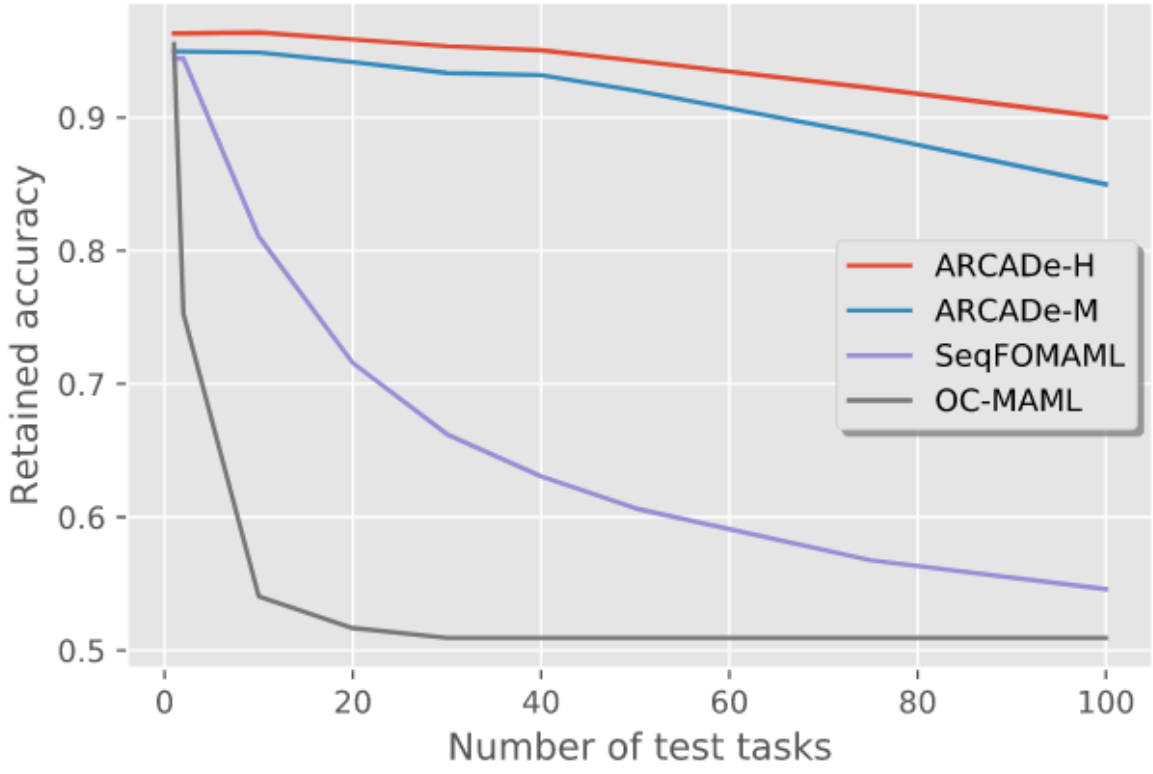
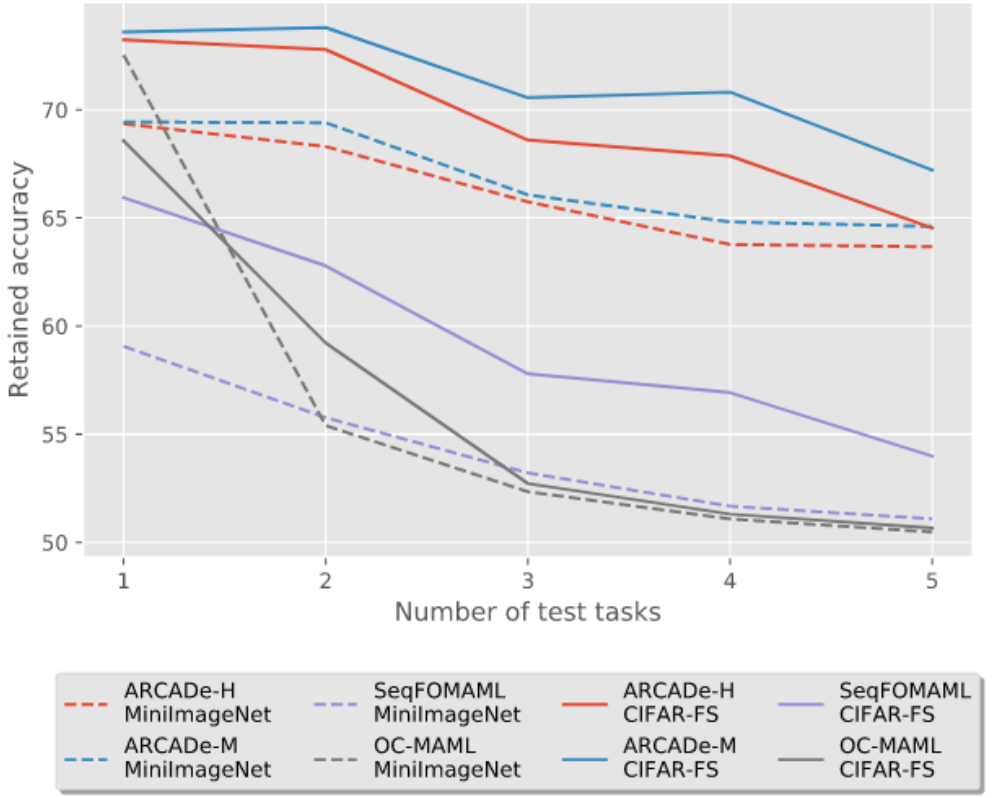


Fig. 2. Retained accuracy on MiniImageNet and CIFAR-FS



Results – The resulting learning strategy

Fig. 3. Layer-wise mean and percentage of positive learning rates meta-learned by ARCADe-M