Improved Contrastive Predictive Coding for Time Series Out-Of-Distribution Detection with Human Activity Data

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Abstract

Contrastive Predictive Coding (CPC) is a well-known self-supervised learning method that naturally fits time series data. This method has been recently leveraged to detect Out-of-Distribution (OOD) inputs, where it is often viewed as the task of classifying positive pairs of context/feature representations versus the negative ones. In this work, by taking a different perspective, we propose a CPC-based OOD detection method for time series that does not require any negative samples at test time and is theoretically related to a probabilistic type of uncertainty estimation in the latent representation space. Our method extends the standard CPC by using a radial (distance-based) score function both in the training loss and as the OOD measure, in addition to quantizing the context (replacing it by cluster prototypes) at test time. The proposed method is applied to detecting OOD human activities with wearable sensors data and shows promising performance on HAR and KU-HAR datasets without using activity labels in training.

Introduction

- Contrastive learning (CPC) can be treated like a classification task (positive vs. negative representation pairs);
 Classification uncertainty can be used for OOD detection. But this requires negative instances and softmax computation at test time ⇒ Alternative: positive conditional probability in latent space (Zimmermann et al, 2021)
- Key idea I: a negative-sample free OOD score through replacing log-bilinear function in CPC with RBF kernel
- Prototypes and memory modules have been found promising in image (reconstruction based) OOD detection
- Key idea II: Combining the CPC with prototype assumption idea via quantizing context vectors, i.e., mapping them to their nearest cluster mean



Results

Method	HAR		KU-HAR	
	AUROC	FPR	AUROC	FPR
QR-CPC (Proposed)	75.6	46.8	83.5	39.5
CPC-Anomaly (CL)	65.4	78.4	68.4	58.1
Skip-Step CPC (CL)	73.9	47.7	69.0	54.8
COCA No.Augment (CL+OC)	69.9	44.7	76.2	89.8
Deep SVDD (OC)	65.6	68.7	75.5	53.1
OC-SVM (OC)	70.0	43.3	56.7	59.5

HAR: One class assumed as OOD (average over 6 classes); KU-HAR: "outdoor" activities assumed as OOD; FPR=FPR@95TPR

