Signal Transformer: Complex-valued Attention and Meta-Learning for Signal Recognition

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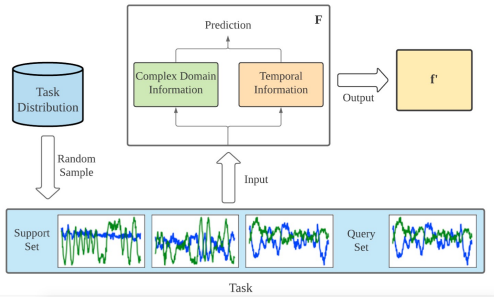
CAMEL: Complex-valued Attentional MEta Learner

What is CAMEL? CAMEL is a state-of-art meta-learning method leveraging attention and meta-learning in the complex domain for the problem of few-shot signal recognition.

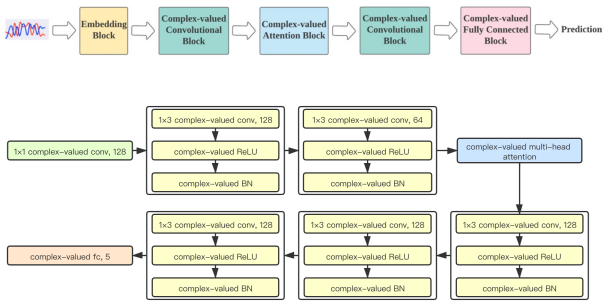
Why meta-learning?
- The collection and annotation of abundant data are notoriously expensive.
- The presence of noise is difficult because the signal data varies for different signal-to-noise ratios (SNRs).

Why complex value? To use the prior knowledge of the signals, i.e., complex domain and temporal information.

Why multi-head attention? Obtain the global and local connections in parallel.



The architecture of CAMEL



Datasets used in our signal classification tasks:
RADIOML 2016.10A
RADIOML 2016.04C
SIGNAL2020.02
(https://www.deepsig.ai/datasets)

Test results

- CAMEL has the state-of-the-art performance among all.
- CAMEL has a stable and great performance on the challenging dataset SIGNAL2020.02, which some models are not well performed.

	RADIOML 2016.10A		SIGNAL2020.02	
Method	1-shot	5-shot	1-shot	5-shot
MAML [5]	86.57%	94.50%	43.26%	67.77%
MAML+attention	95.80%	97.70%	54.44%	63.33%
MAML+complex	91.40%	96.38%	59.50%	64.00%
SNAIL [46]	71.18%	78.48%	35.01%	36.34%
Reptilec [47]	69.16%	92.32%	55.01%	69.39%
MAML+complex+CT [37]	96.40%	97.50%	58.40%	69.80%
CAMEL (ours)	**97.23%±0.13%**	**98.22%±0.08%**	**64.80%±0.10%**	**74.27%±0.15%**

Ablation study

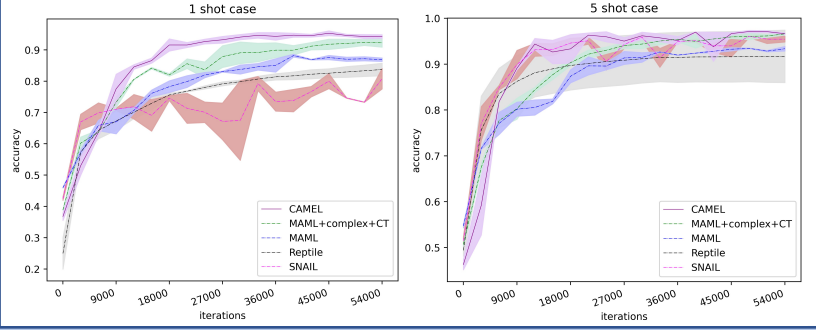
- How important is attention?
- How important is complex?
- How do the add of attention and complex to meta-learning work?

We divided the training set and test set in three ways and got the result, 1-shot case on on RADIOML 2016.04C:

Accurancy	SNR ≥ 0	SNR = 0	P-O set
MAML	87.20%	81.64%	89.06%
MAML+attention	93.00%	87.26%	91.90%
MAML+complex	91.10%	91.75%	91.30%
CAMEL (ours)	**93.70%**	**92.10%**	**96.30%**

Convergence curves of accuracy

The accuracy curves at 95% confidence interval on the dataset RADIOML 2016.04C.
- CAMEL could get the highest accuracy at a relatively fast convergence speed.
- CAMEL apparently outperforms other meta-learning models in accuracy and stability in both 1 shot and 5 shot cases.

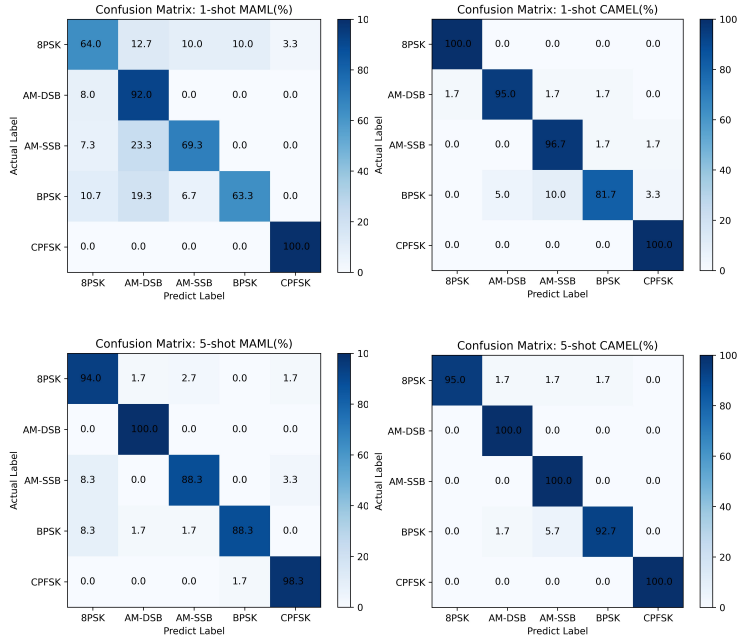


Conclusions

- CAMEL is a complex domain attentional meta-learning framework.
- complex-valued neural networks and attention are used to provide prior knowledge.
- we have designed the complex-valued meta-learning and complex-valued attention, which can be of independent interest.
- CAMEL has achieved the state-of-the-art results on extensive datasets.
- Future works will be focused on applying CAMEL on other types of datasets like video, music and time series.

Confusion matrix

Compare CAMEL with MAML in 1-shot and 5-shot cases for classification tasks on the dataset RADIOML 2016.10A.



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