Abstract:

Knowledge Understanding using Capsule Deep Learning Approaches

Limited training data, high dimensionality, image (generated from spatiotemporal signals in BCI) complexity and similarity between classes are the main challenges confronting deep learning (DL) methods and can result in suboptimal classification performance. Most DL methods employ Convolutional Neural networks (CNN), which contain pooling in their architecture. Pooling loses valuable information and exact spatial correlations between different entity parts. More importantly, the new viewpoint of an object in the image cannot be preserved by pooling. The Capsule Neural Network (CapsNet) has been introduced to address these shortcomings by preserving the hierarchy between different entity parts in an image, even when using limited training samples [1], [2].

The potential for advancements in CapsNets methods has been demonstrated in the multidisciplinary field, including hyperspectral imaging, image classification, segmentation, video detection, and human movement recognition. Motivated by CapsNet, we have recently developed an end-to-end DL architecture, the Hybrid Capsule Network (HCapsNet), with the state of the art result for hyperspectral image classification while using extremely fewer training samples [3]. Also in another study, the proposed CapsNet architecture yielded encouraging results for the investigation of infant intrinsic movement at various phases of the new experiment in collaboration with the Human Brain and Behavior Lab at Florida Atlantic University (Prof Kelso and colleagues) [4]. The result showed the performance of 2D CapsNets in assessing the spatial relationships between different body parts using 2D histogram features.

The non-invasive electroencephalography (EEG) provided by wearable neurotechnology is a massive challenge for AI. My study also focused on developing novel AI algorithms to address the issues involved with decoding EEG signals into control signals for neurotechnology based on brain-computer interfaces (BCIs). These methods are expected to be well-suited for BCI applications, particularly when learning various EEG properties with limited training data (typically the case for BCIs). Upon recent work for decoding imagined speech using CNNs we also applied CapsNet to direct speech BCIs [5]. In this research, the CapsNet architecture is modified using multi-level feature maps and multiple capsule layers.

In addition, the new Tier 2 Northern Ireland High-Performance Computing facility enabled us to train models in deep approaches with enormous processing power. Therefore, Massively parallel computing using Asynchronous Successive Halving Algorithm (ASHA) is used for hyperparameter optimisation.

Since CapsNet is still in its early stages of development and has demonstrated promising results on several challenging datasets, this method has the potential to develop relationships with colleagues in other disciplines, which could result in new research applications.

References

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