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Editorial: Segmentation and classification: theories, algorithms and applications

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Editorial on the Research Topic
Segmentation and classification: theories, algorithms and applications

Segmentation and classification are fundamental tasks in image analysis and computer vision. In addition to having ubiquitous applications in a variety of different fields, segmentation and classification also have their own theoretical foundations, with the potential to nurture new methods with greater performance. However, the lack of communication between researchers with different research backgrounds, to some extent, limits the power of the state-of-the-art segmentation and classification methods developed in different fields and restricts the development of new and more powerful methods.

The goal of this Research Topic is to bring together the research challenges related to segmentation and classification in different fields in order to break down the subject barriers and deliver interdisciplinary solutions. Therefore, this Research Topic covered contributions related to segmentation and classification, including theoretical analyses, methodologies, algorithms, and applications.

This Research Topic consists of five original articles.

The first original paper by Bui et al. focuses on segmenting images degraded by blur and Poisson noise. The authors adopted a two-stage framework that finds a piecewise-smooth solution first, followed by k-means clustering. The piecewise-smooth solution is obtained by minimizing a nonconvex mathematical model involving the weighted difference of anisotropic and isotropic total variation as a regularization to promote the sparsity of image gradients. The alternating direction method of multipliers (ADMM) was applied to solve the nonconvex model, with convergence analysis being provided to validate the efficacy of the ADMM scheme. Numerical experiments on various segmentation scenarios (grayscale/color and multiphase) were conducted to showcase the great performance of the proposed segmentation method.

The second original paper by Poiret et al. focuses on hippocampal subfield segmentation, which is crucial to help understand volumetric trajectories across the lifespan; from the emergence of episodic memory during early childhood to memory impairments found in older adults. Hippocampal subfield segmentation is quite challenging because of their small sizes.

Since there is no unified segmentation protocol for the hippocampal subfields to date, the authors developed a novel, fast, and robust segmentation tool called hippocampal segmentation factory (HSF), leveraging an end-to-end deep learning pipeline. Detailed experiments showed that HSF can achieve closer to manual segmentation compared to other currently used tools regarding popular evaluation metrics. The authors also found faster growth and decay in men than in women for most hippocampal subfields, and a major inflection point at approximately 70 years old, where a fast and significant volumetric decrease occurs.

The third original paper by Liu et al. focuses on weakly-supervised semantic segmentation problems, including strategies regarding explainable AI shedding light on black-box deep learning models. Pointing out the time-consuming and labor-intensive issues of supervised deep learning-based models requiring a large number of manually annotated pixel-level labels, the authors proposed a novel weakly supervised semantic segmentation framework integrating image classification and segmentation. In particular, the framework contains a developed semantic segmentation network called Mixed-UNet containing two parallel branches in the decoding phase, leveraging the proposed strategy of multi-scale inference to refine class activation mappings (CAMs) by reducing the detail loss in single-scale reasoning. Extensive experimental results on medical imaging data demonstrated the great performance of the proposed Mixed-UNet in terms of computational efficiency and segmentation accuracy. Moreover, the results also showed that the multi-scale CAMs can capture more complementary object features compared to the single-scale inferred CAM, delivering better segmentation performance with a certain level of explainability.

The fourth original paper by Sundaresan et al. focuses on the automated detection of cerebral microbleeds (CMBs) on MR images, where both segmentation and classification tasks were exploited. CMBs are important problems to investigate in medical imaging since they are associated with white matter damage and various neurodegenerative and cerebrovascular diseases. Accurate automated detection of CMBs is therefore critical. To this end, the authors proposed a fully automated deep learning-based three-step algorithm including (i) an initial candidate detection step that detects CMBs with high sensitivity, (ii) a candidate discrimination step performed using a knowledge distillation framework, and (iii) a morphological clean-up step further reducing false positives using anatomical constraints. The CMB detection performance of the proposed method was evaluated thoroughly on four different datasets, with a detailed ablation study and cross-domain analysis (various modalities used in clinical settings). The proposed method can achieve state-of-the-art CMB detection performance, and the obtained CMB segmentation maps could also be used for obtaining an automated rating of CMBs.

The last original paper by Fernández-Rodicio et al. focuses on dynamic susceptibility weighted contrast-enhanced (DSC) perfusion studies in magnetic resonance imaging (MRI), which could provide valuable data for studying vascular cerebral pathophysiology in different rodent models of brain diseases. In this regard, the authors developed an open-source DSC-MRI quantification tool named Perfusion-NOBEL and based on Python. With just the manual delineation of masks, which should be done beforehand either semi-manually by drawing the ROIs or using any automatic segmentation tool, Perfusion-NOBEL can provide absolute perfusion maps, e.g., cerebral blood flow, cerebral blood volume, and mean transit time. For performance demonstration, the authors evaluated a total of 30 animals (i.e., 30 MRI rat brain scans of different models of brain diseases) with the developed Perfusion-NOBEL.

The Guest Editors would like to thank all the authors and reviewers for their great contribution to the Research Topic. The published papers convey a representative angle of the theoretical dimensions and practical insights in various research domains and application fields, with different types of methods (e.g., model-driven and data-driven) proposed regarding segmentation and classification. We hope that it will assist in a wide range of applications and inspire further research in this interdisciplinary area.

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Conflict of interest

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