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Incremental Learning for Scene Analysis

Presentation of the host laboratory

Based in Paris-Saclay campus, CEA-LIST is one of four technological research institutes of CEA TECH, the technological research direction of CEA. Dedicated to intelligent digital systems, it contributes to the competitiveness of companies via research and knowledge transfers. The expertise and competences of the 800 research engineers and technicians at CEA-LIST help more than 200 companies in France and abroad every year on subjects categorized over 4 programs and 9 technological platforms. 21 start-ups have been created since 2003.

The Computer Vision and Machine Learning for scene understanding laboratory addresses computer vision subjects with a stronger emphasis on four axes:

- Recognition (detection or segmentation of objects and persons)
- Behavior analysis (action and gesture recognition, anomalous behavior of individuals or crowds)
- Smart annotation (large scale annotation of 2D and 3D data using semi-supervised methods)
- Perception and decision-making (Markovian decision processes, navigation)
- The intern will join a team composed of 30 researchers (research engineers, PhD students, interns) and will be able to interact with peers working on related subjects and methods.

Context

Incrementally adapting an existing object detection model to detect new unseen classes with severe memory and computational constraints is a critical capacity in real-word applications such as robotics, self-driving vehicles or video surveillance. However, while human beings can easily recognize new objects continuously without forgetting the old knowledge, deep learning models can suffer from 'catastrophic forgetting'. In fact, adding new classes without using the old training dataset can cause a big degradation of performance on the original set of classes.

To overcome this issue, several methods use a memory buffer to save a set of the old dataset and re-use it to retrain the model with the new classes [1] or extend the model architecture by adding other detection heads. Others focus essentially on regularizing the training to minimize the discrepancy between responses for the old and the updated model [2]. The results of these methods are still limited compared to the models trained jointly with all the dataset. Recent methods identify instances of unknown objects as unknown and subsequently learn to recognize them when training data progressively arrive without retraining from scratch [3].

While various studies are conducted on image classification and object detection, only few methods [4,5] focus on incremental learning for other scene analysis tasks like semantic segmentation. However, semantic segmentation is a key task that computer vision systems must face frequently in various applications.

Objectives of the internship

- Analyze existing incremental learning for object detection and semantic segmentation methods and point their limitations.
- Propose and develop an incremental learning method with severe memory and computational constraints.
- Evaluate the developed method on public datasets (e.g. PASCAL VOC, MsCOCO).
- Publication of results will be encouraged.

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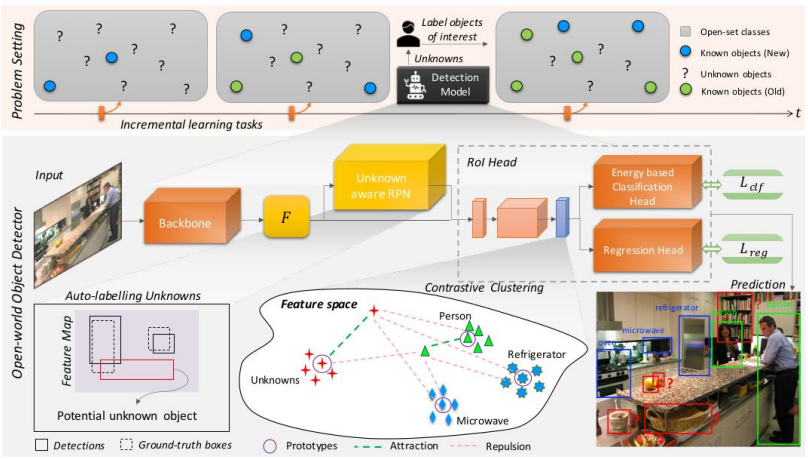

Figure 2: *Approach Overview: Top row:* At each incremental learning step, the model identifies unknown objects (denoted by '?'), which are progressively labelled (as blue circles) and added to the existing knowledge base (green circles). *Bottom row:* Our open world object detection model identifies potential unknown objects using an energy-based classification head and the unknown-aware RPN. Further, we perform contrastive learning in the feature space to learn discriminative clusters and can flexibly add new classes in a continual manner without forgetting the previous classes.

Figure (extracted from [3]): An example of incremental learning approach for object detection

References

[1] Konstantin Shmelkov, Cordelia Schmid, Karteek Alahari (2017) Incremental Learning of Object Detectors without Catastrophic Forgetting, *2017 IEEE International Conference on Computer Vision (ICCV)*.

[2] Shieh, J.-L.; Haq, Q.M.u.; Haq, M.A.; Karam, S.; Chondro, P.; Gao, D.-Q.; Ruan, S.-J (2020) Continual Learning Strategy in One-Stage Object Detection Framework Based on Experience Replay for Autonomous Driving Vehicle, *Sensors* 20, no. 23: 6777.

[3] K. J. Joseph, Salman H. Khan, Fahad Shahbaz Khan, Vineeth N. Balasubramanian (2021) Towards Open World Object Detection, *CVPR.*

[4] Umberto Michieli and Pietro Zanuttigh (2019) Incremental Learning Techniques for Semantic Segmentation, *ICCV.*

[5] Umberto Michieli, Pietro Zanuttigh (2021) Knowledge Distillation for Incremental Learning in Semantic Segmentation, *Computer Vision and Image Understanding (CVIU)*, Vol. 205.

Keywords

Object detection, semantic segmentation, deep learning, incremental learning, knowledge distillation.

Required level:	Engineer, Master 2
This internship opens the possibility of pursuing a thesis and R&D engineer in our laboratory.	
Duration :	6 months
Remuneration:	between 700 € and 1300 € depending on the training.
Required Skills : - Computer vision - Machine learning (deep learning) - Shape recognition - Python, C / C ++ - Mastery of a deep learning framework (in particular Tensorflow or PyTorch)	