New low-shot object counting methods developed on EuroHPC Vega and the Arnes computing cluster

Object counting is crucial in applications ranging from cell growth analysis, to crowd estimation in video surveillance systems, to product counting on production lines. Classical methods are not applicable in these cases because they require large annotated training sets and struggle in dense scenarios. On the other hand, the methods developed at the Visual Cognitive Systems Laboratory at the Faculty of Computer Science and Information Science, University of Ljubljana, develop accurate counting with just a few training examples and represent a methodological leap in computer vision.

Initially, members of the Visual Cognitive Systems Laboratory (Nikola Đukić, Assoc. Prof. Dr. Alan Lukežič and Vitjan Zavrtanik), under the supervision of Prof. Matej Kristan, developed a machine learning method for counting objects with few or no training examples, called LOCA. The user labels only a few examples of a selected object category in an image, say three, and LOCA simultaneously learns a detection model and counts all other objects of the same category in the image. The main contribution of the method is a novel prototype computation procedure that separates visual and shape features, gradually adapts them to unlabelled objects in the image, and fuses them into final prototypes. This achieves a very good generalisation over the appearance of the objects, which improves the reliability of localisation. In addition to the interest of the research problem, LOCA is useful in many applications where the large datasets needed to learn classical recognition algorithms are not available, such as in biological research. LOCA was published at a prestigious conference *International Conference on Computer Vision - ICCV2023* and was already cited 16 times within 8 months since publication, while the freely available code on GITHub received 36 stars and 3 forks. The recognition of the method is also evidenced by the fact that in spring 2024 the Faculty of Computer Science and Information Science at the University of Ljubljana has signed a contract with Mathworks company, which plans to include LOCA in Matlab.

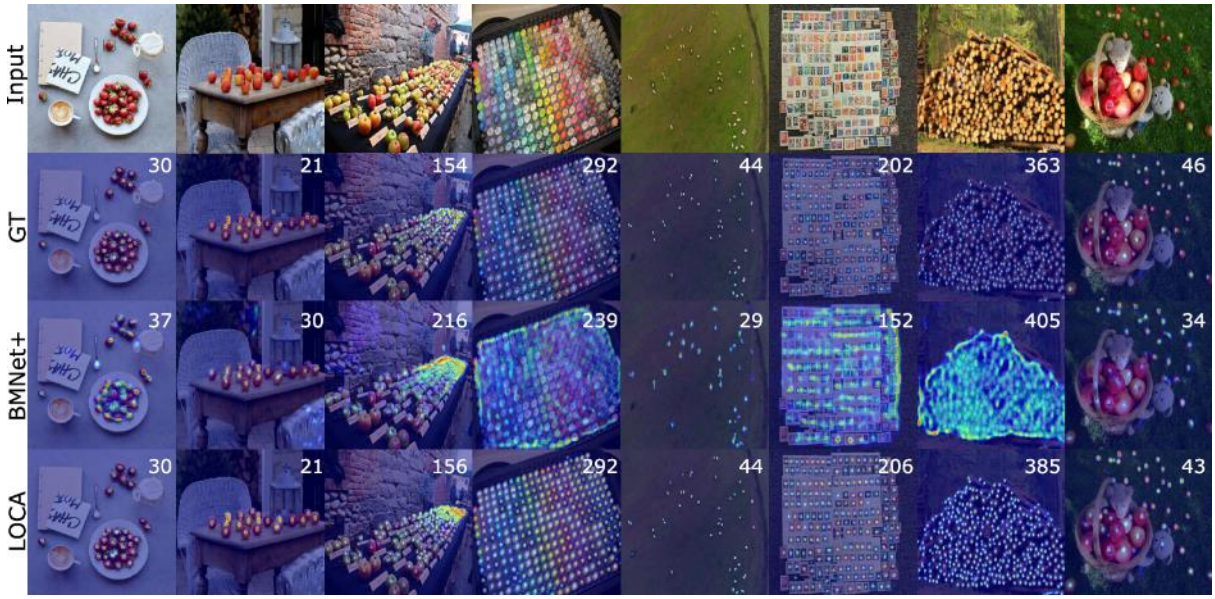

Figure 1: LOCA counting performance compared to related works [1].

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The members of the Visual Cognitive Systems Laboratory (Jer Pelhan, Assoc. Prof. Dr. Alan Lukežič and Vitjan Zavrtanik), under the supervision of Prof. Kristan, continued the development and extended the method LOCA with a detection model into a new method called DAVE, which is based on the original neural network architecture and is able to count with few or no training examples or with text queries and significantly outperforms the LOCA, thus setting a new qualitative milestone in counting. The main difference with related work is that it allows the localisation and detection of objects with high recall, whereas the method performs an introspection analysis with a statistical method that re-analyses the detection results, identifies outliers and thus removes false detections. An additional advantage of the DAVE architecture is that it allows all counting modes: (i) counting with few training examples, (ii) counting without training examples, and (iii) counting with text query, and outperforms all previous methods, including those specialised in a particular mode. The DAVE method was presented at the prestigious *IEEE / CVF Computer Vision and Pattern Recognition Conference - CVPR2024* in Seattle, and the freely available code on GITHub received 12 stars in just 5 days after publication.

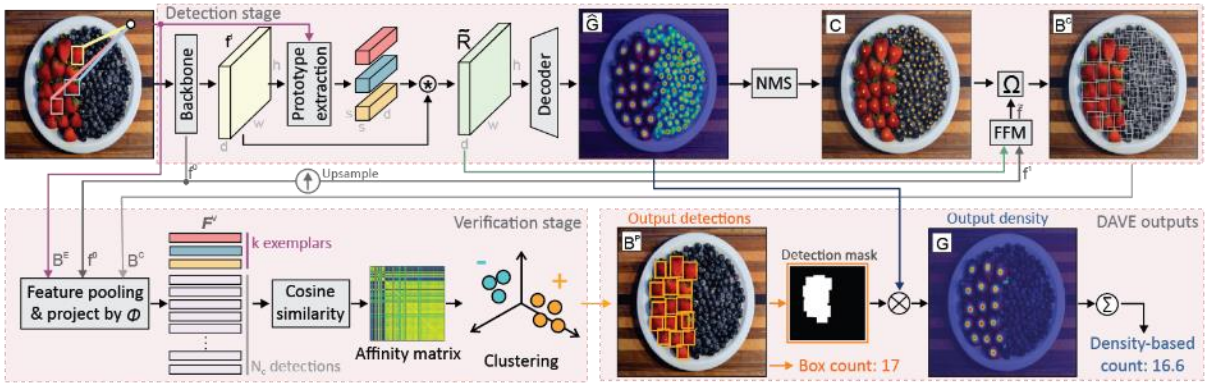

Figure 2: The metod DAVE consists of two stages, detection and verification, and outputs detected objects as well as an improved location density map [2].

Due to its remarkable results, the method DAVE sets a new milestone in AI, especially in the field of learning methods with few training examples, introduces a new paradigm in object detection, and enables numerous applications in areas such as biomedical image analysis, production line control, and general object counting, which could not be adequately addressed by classical methods.

In the highly competitive environment of computer vision, the success of deep model research such as LOCA and DAVE depends heavily on access to depends heavily on access to high-performance computing. The EuroHPC Vega supercomputer and the Arnes supercomputing cluster have therefore played a key role in the development of both methods, providing free access to researchers and accelerating development.

[1] *Djukić, et al., A Low-Shot Object Counting Network With Iterative Prototype Adaptation, ICCV 2023*. https://openaccess.thecvf.com/content/ICCV2023/papers/Dukic_A_Low-Shot_Object_Counting_Network_With_Iterative_Prototype_Adaptation_ICCV_2023_paper.pdf. [5 July 2024].

[2] Pelhan, *et al., DAVE – A Detect-and-Verify Paradigm for Low-Shot Counting, 2024.* https://arxiv.org/pdf/2404.16622. [5 July 2024].

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