Watch, Ask, Learn, and Improve: a lifelong learning cycle for visual recognition

since 1558

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The WALI System for learning animal classifiers from YouTube data

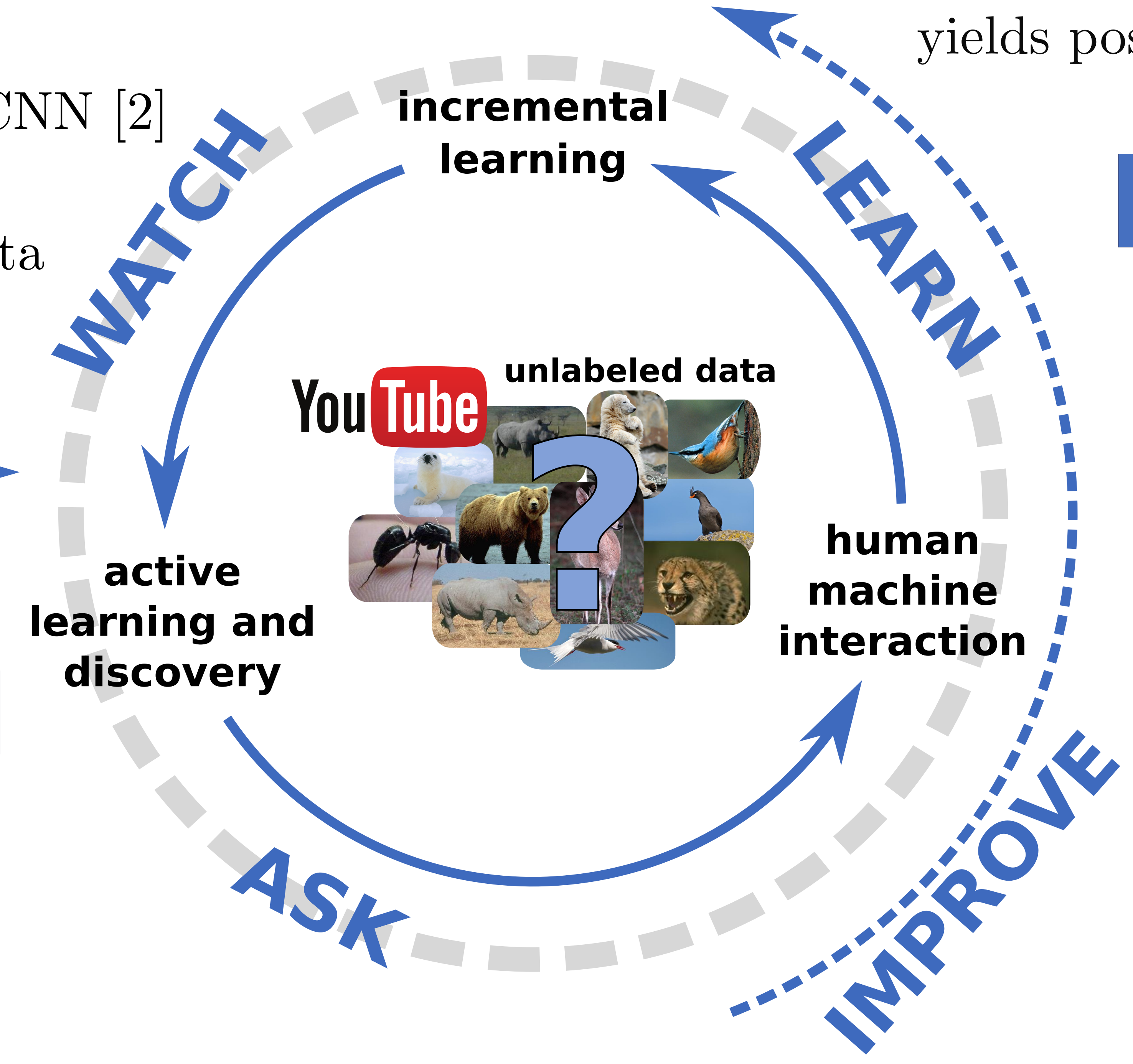
- **W**atch: download and watch YouTube videos autonomously
- **A**sk: actively select frames and ask human oracle for annotation
- **L**earn: incorporate new knowledge incrementally
- **I**mprove: the knowledge grows over time

Watch

- download and watch "animal documentary" videos from YouTube
- build long term memory out of 500 images which occurred during the last 5 hours of video
- normalized `relu7` features of BLVC AlexNet CNN [2] are used as feature representation
- every 10th frame is considered as unlabeled data

labeled training data

initial learning



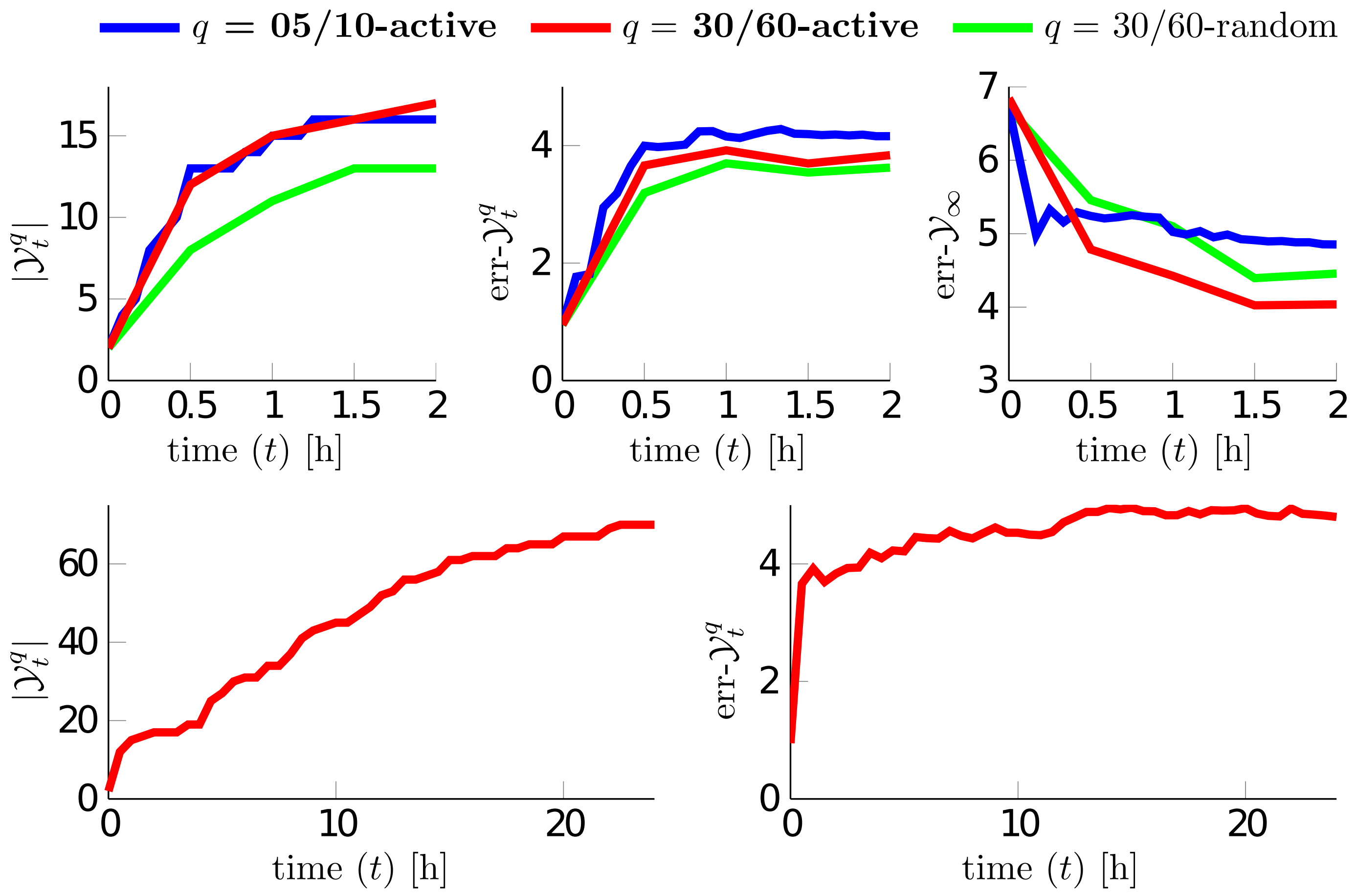
Ask

- one-vs-all classifier $\mathbf{w}_k^{\mathrm{T}}\mathbf{x}$ for each class $k \in \mathcal{Y}_t^q$
- active selection with 1-vs-2 strategy [3]:
$$\hat{k} = \operatorname{argmax}_{k \in \mathcal{Y}_t^q} \mathbf{w}_k^{\mathrm{T}}\mathbf{x}$$
$$q(\mathbf{x}) = \mathbf{w}_{\hat{k}}^{\mathrm{T}}\mathbf{x} - \operatorname{argmax}_{k \in \mathcal{Y}_t^q \setminus \{\hat{k}\}} \mathbf{w}_k^{\mathrm{T}}\mathbf{x}$$
- avoide inappropriate images via reject strategy [4]:
$$\tilde{q}(\mathbf{x}) = (1 - p(\text{rejection} \mid \mathbf{x})) \cdot q(\mathbf{x})$$

Learn

- update classifiers incrementally
- linear regression with quadratic loss function yields possibility for efficient updates [5]

Improve



- evaluation on corresponding ImageNet synsets [1]
- q = 05/10-active: watch 5 min and actively select 10 instances
- q = 30/60-active/random: watch 30 min and actively/randomly select 60 instances
- $|\mathcal{Y}_t^q|$: number of discovered classes
- err-$\mathcal{Y}_t^q$: hierarchical error [1] with respect to currently discovered classes $\mathcal{Y}_t^q$
- err-$\mathcal{Y}_\infty$: hierarchical error [1] regarding all classes $\mathcal{Y}_\infty$

[1] Olga Russakovsky, Jia Deng, Hao Su, Jonathan Krause, Sanjeev Satheesh, Sean Ma, Zhiheng Huang, Andrej Karpathy, Aditya Khosla, Michael Bernstein, Alexander C. Berg, and Li Fei-Fei. ImageNet Large Scale Visual Recognition Challenge. *IJCV*, 2015. [2] Alex Krizhevsky, Ilya Sutskever, and Geoffrey E Hinton. Imagenet classification with deep convolutional neural networks. In *NIPS*, 2012. [3] Ajay J Joshi, Fatih Porikli, and Nikolaos Papanikolopoulos. Multi-class active learning for image classification. In *CVPR*, 2009. [4] Christoph Käding, Alexander Freytag, Erik Rodner, Paul Bodesheim, and Joachim Denzler. Active learning and discovery of object categories in the presence of unnameable instances. In *CVPR*, 2015. [5] Ronald L. Plackett. Some theorems in least squares. *Biometrika*, 1950.