Weakly Supervised Object Detection, Localization, and instance segmentation

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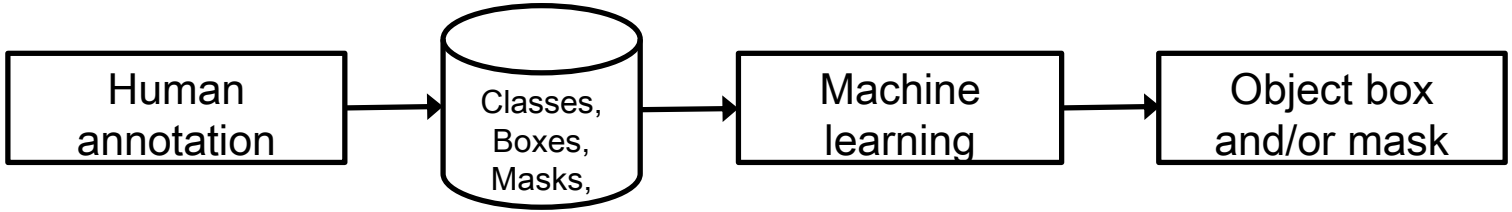
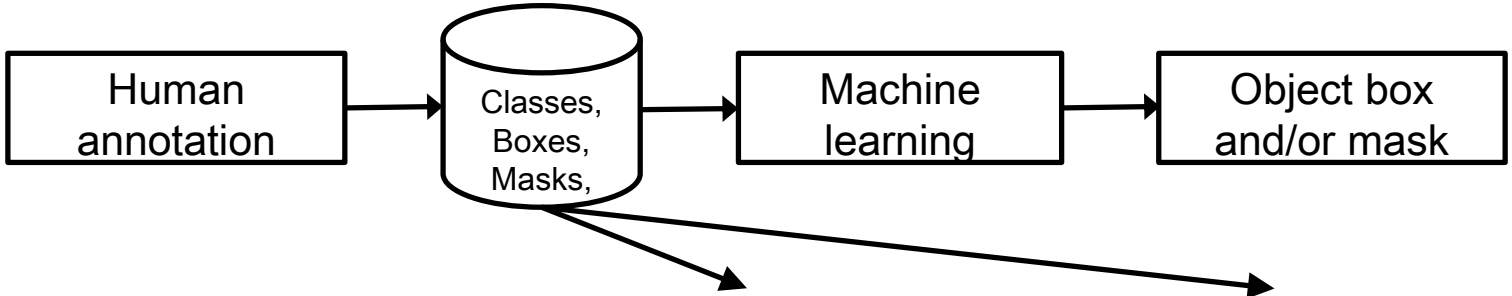
Problem

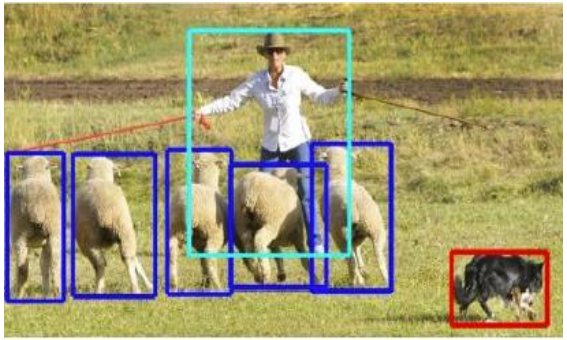
Supervised **object detection** and **instance segmentation** pipeline



Problem

Supervised **object detection** and **instance segmentation** pipeline





Bounding box annotation

Mask annotation

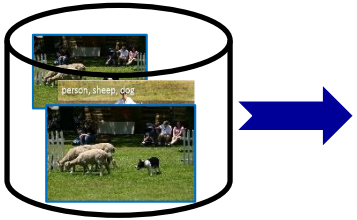
Problem

20k+ class → 100/c → 2M instances → 5min/I → **19 years /person**

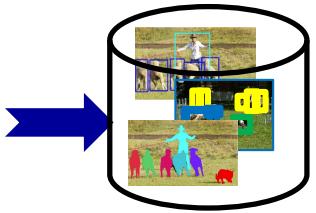
Copy from UIUC Yunchao's Slides

Problem

Imagery databases

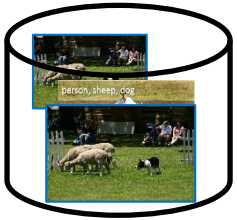


Training sets

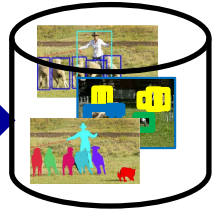


Solutions

Imagery databases

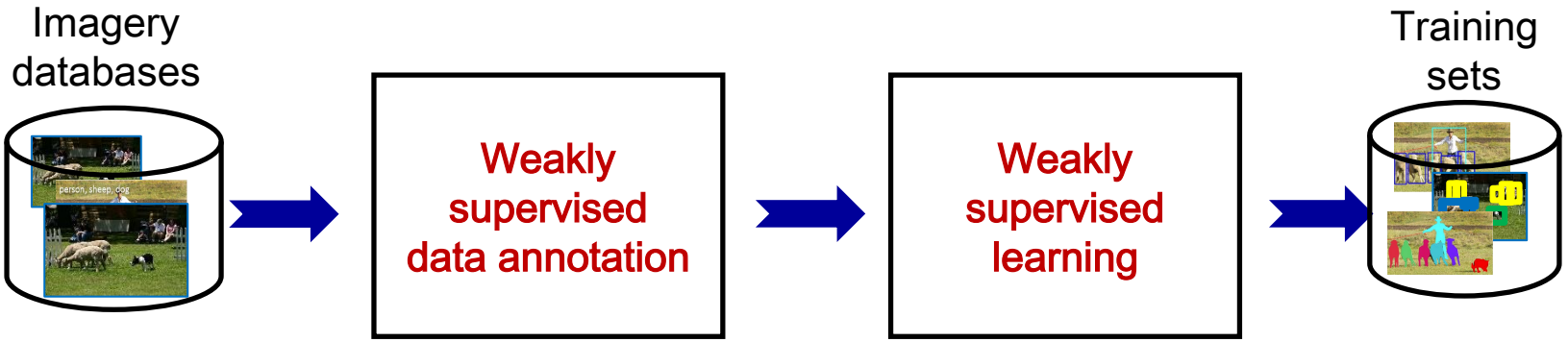


Training sets



Data annotation is **expensive**

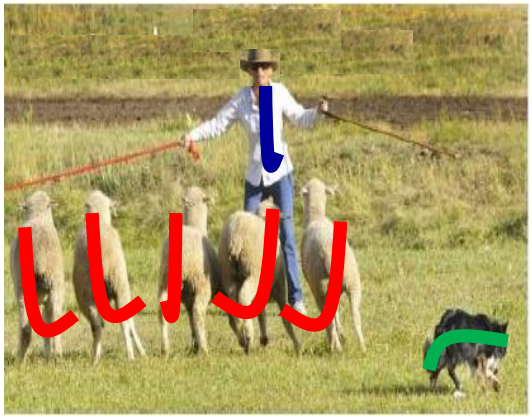
Solutions



Data annotation is **efficient and low-cost**

Solutions

Weakly Supervised Annotations



Scribes

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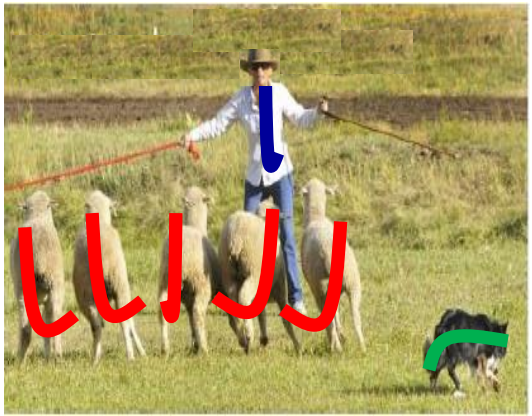
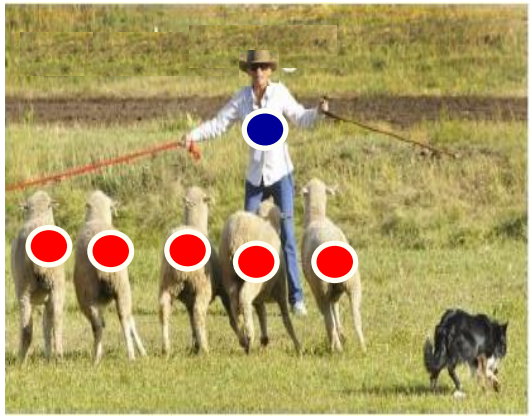
Solutions

Weakly Supervised Annotations



Scribes



Point

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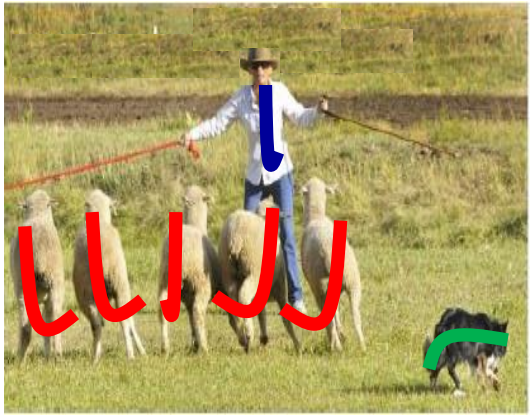
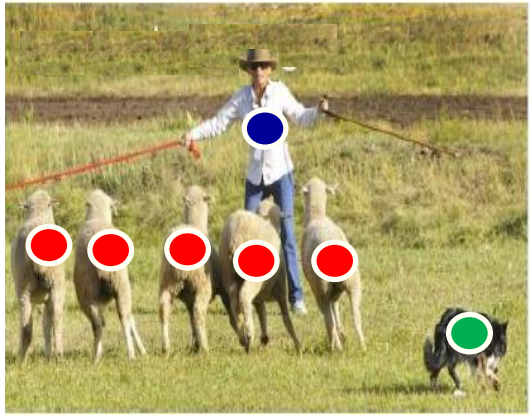
Solutions

Weakly Supervised Annotations



Scribes



Point

Person, Sheep, Dog

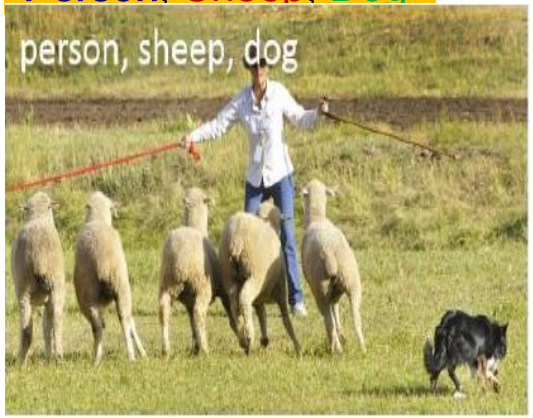


Image-level labels

The most efficient one

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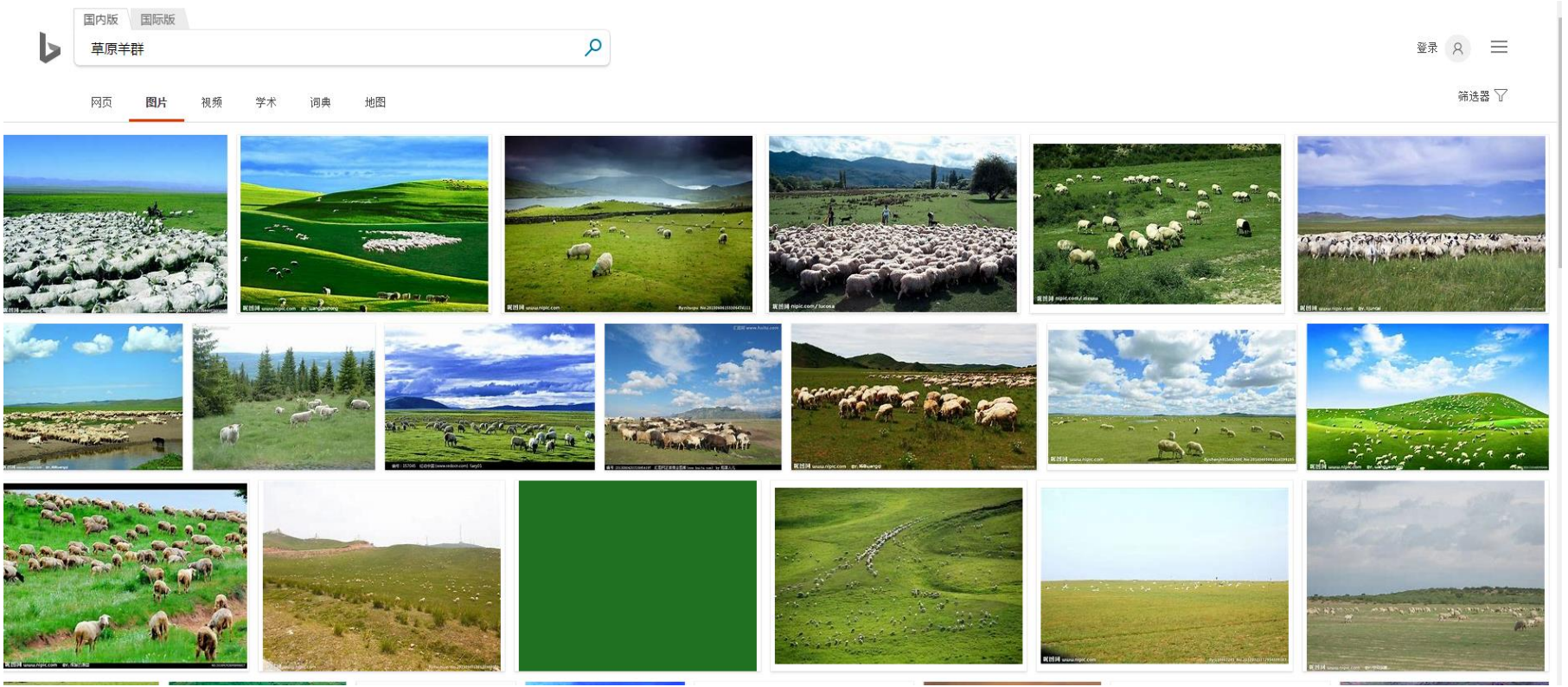
Solutions

Weakly labeled imagery is widely available on the Web



Solutions

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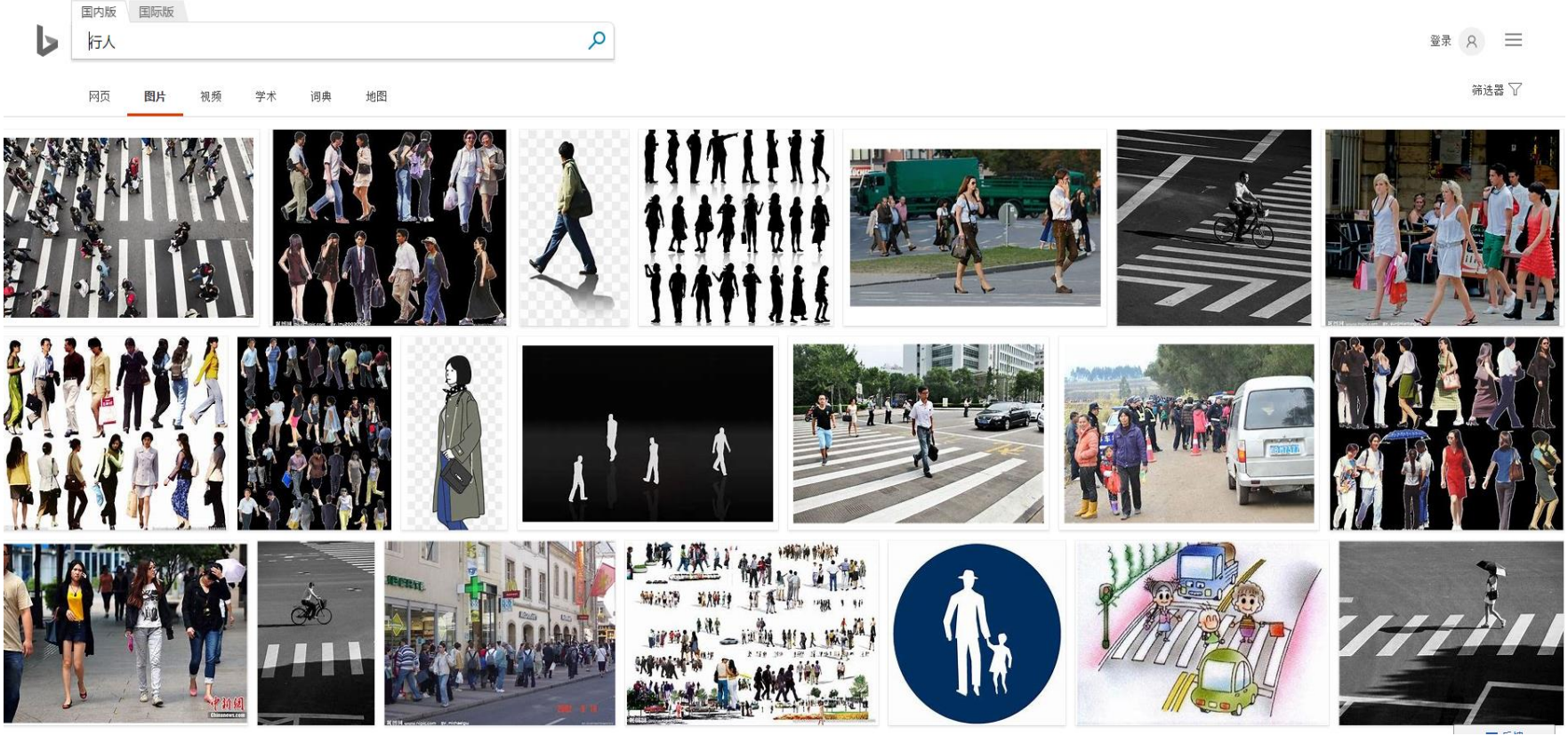
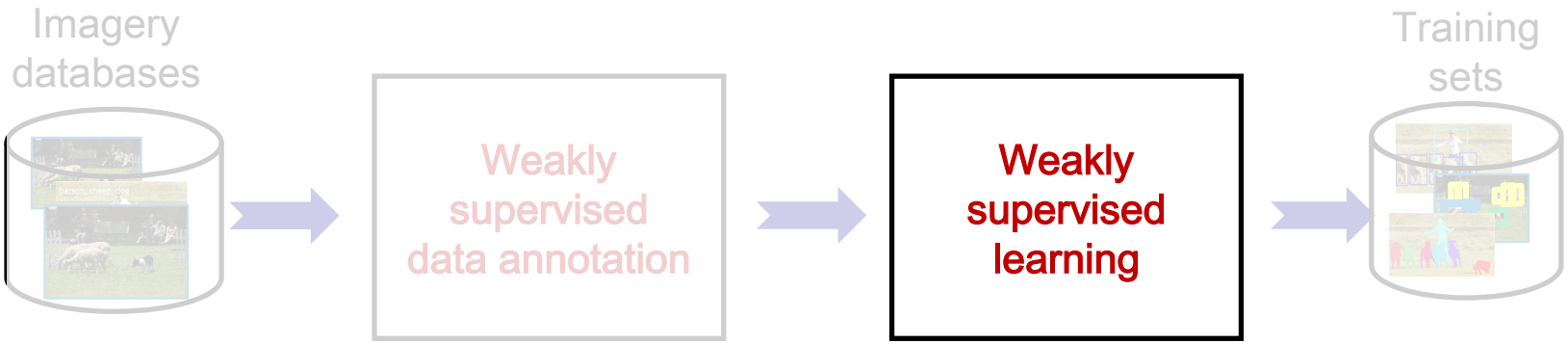
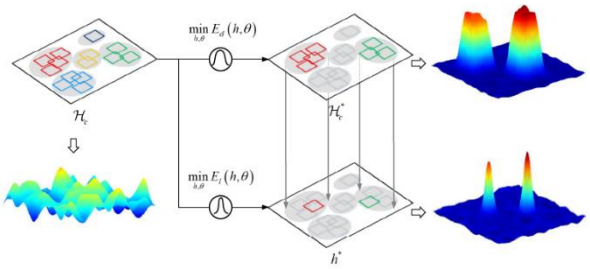


Solutions



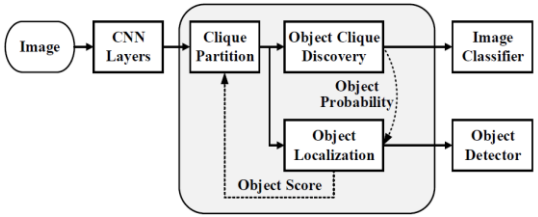
Data annotation is efficient and low-cost

Our works



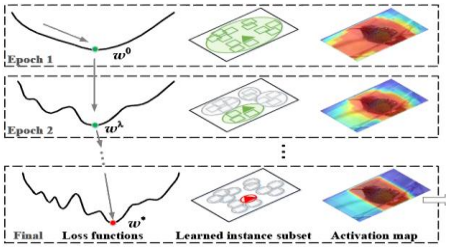
MELM

CVPR18: Min-entropy Latent Model (WSOD)



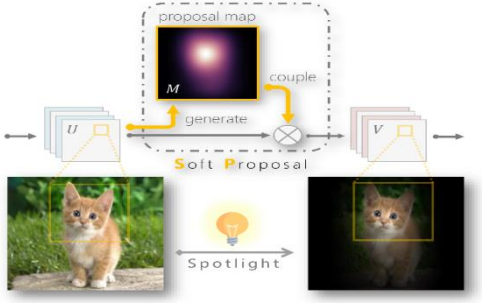
MELM+Recurrent Learning

PAMI2019: Recurrent Learning (WSOD)



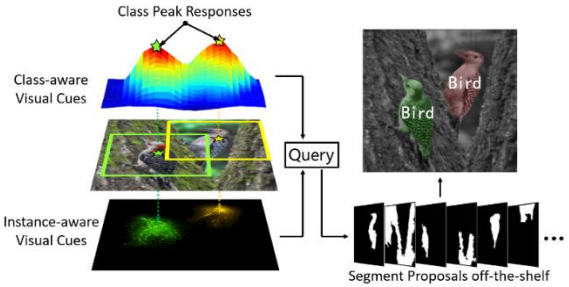
CMIL: Continuation Multiple Instance Learning

CVPR19 (WSOD)



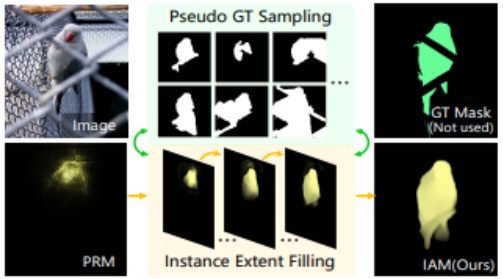
SPN

ICCV17: Soft Proposal Network (WSOL)



PRM

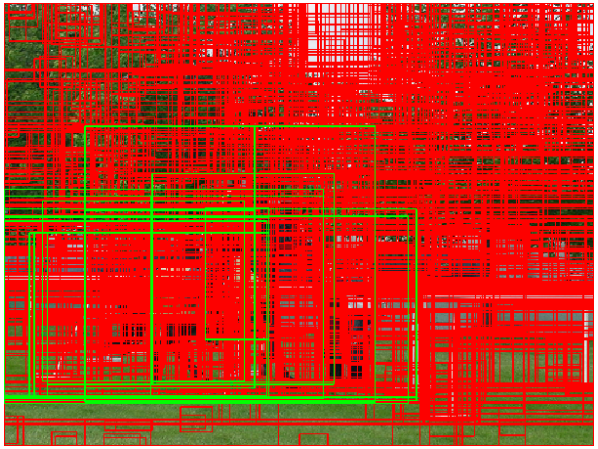
CVPR18: Peak Response Mapping (WSIS)



IAM

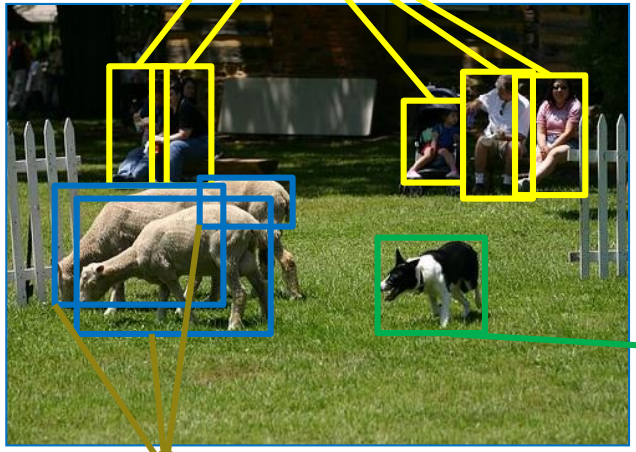
CVPR18: Instance Activation Map (WSIS)

Our works-Challenge analysis



Latent variable learning

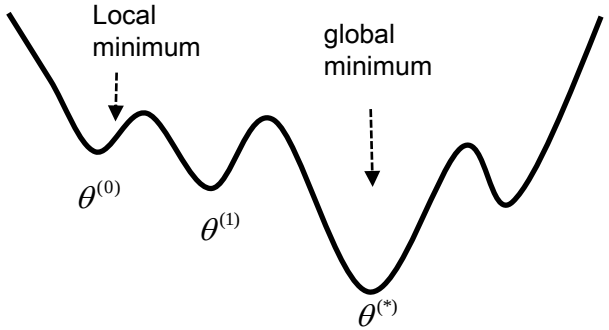
Multiple Instance learning



$$L(\Theta) = \frac{1}{2} \| \Theta \|^2 + \lambda \sum_i \max(0, 1 - y_i f(x_i, h_i))$$

$$f(x, h) = \max_h \Theta \cdot \Phi(x, h)$$

Our works-Challenge analysis



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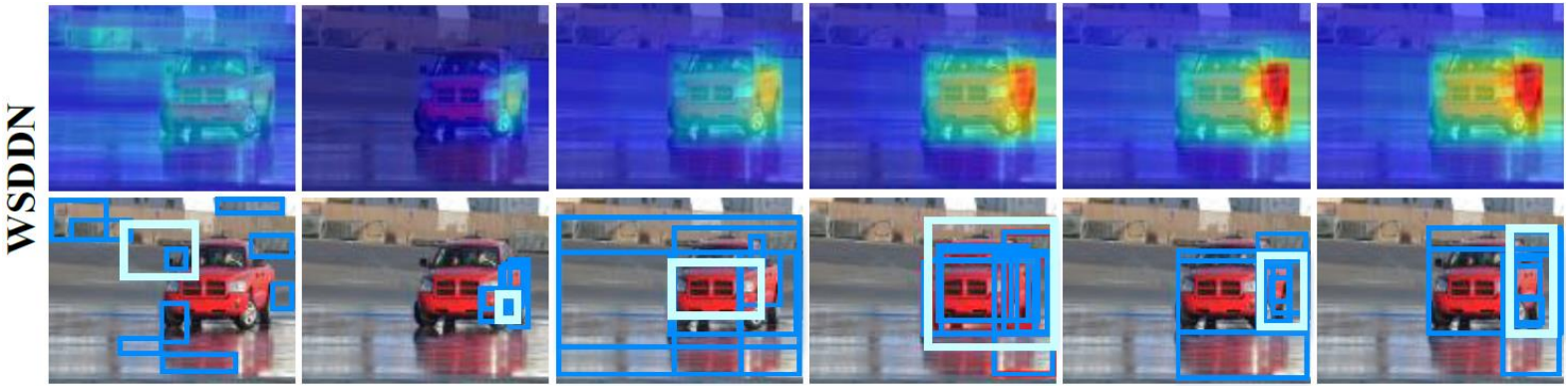
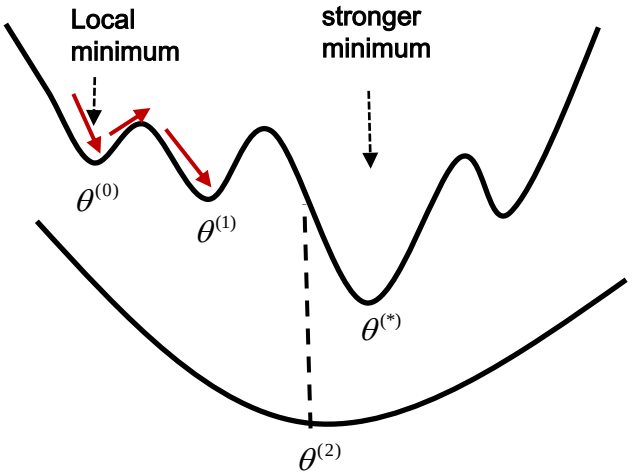
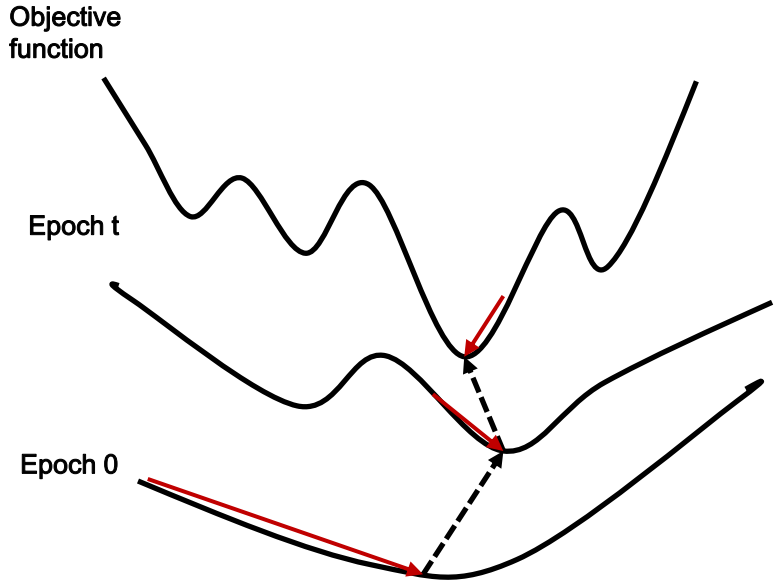


Our works-Methodology

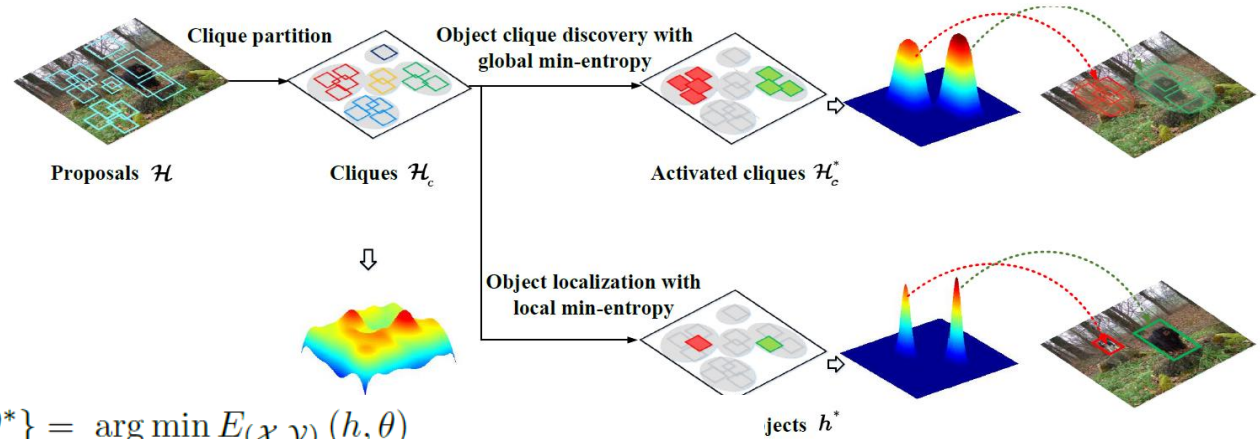


Convex Regularization



Continuation Optimization

Our works-Min-entropy latent model



$$\{h^*, \theta^*\} = \arg\min_{h,\theta} E_{(\mathcal{X},\mathcal{Y})}(h,\theta)$$
$$= \arg\min_{h,\theta} E_{(\mathcal{X},\mathcal{Y})}(\mathcal{H}_c,\theta) + \lambda E_{(\mathcal{X},\mathcal{Y},\mathcal{H}_c)}(h,\theta)$$

Object discovery

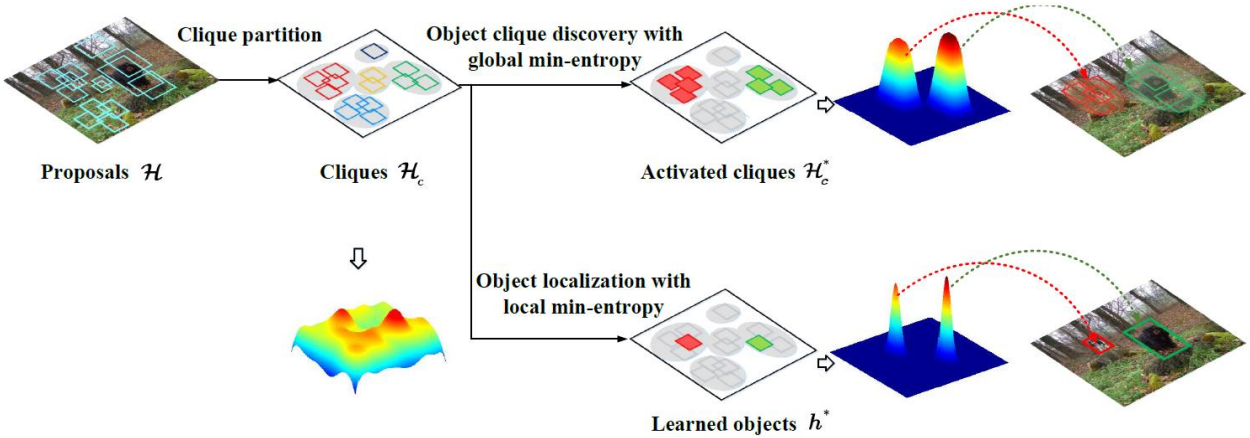
$$E_{(\mathcal{X},\mathcal{Y})}(\mathcal{H}_c,\theta) = -\log \sum w_{\mathcal{H}_c} p(y,\mathcal{H}_c;\theta)$$
$$L_{(\mathcal{X},\mathcal{Y})}(\mathcal{H}_c,\theta) = yE_{(\mathcal{X},\mathcal{Y})}(\mathcal{H}_c,\theta) - (1-y)\sum_h \log(1-p(y,h;\theta))$$

Object localization

$$h^* = \arg\min_{h\in\mathcal{H}_c^*} E_{(\mathcal{X},\mathcal{Y},\mathcal{H}_c^*)}(h,\theta)$$
$$E_{(\mathcal{X},\mathcal{Y},\mathcal{H}_c)}(h,\theta) = -\sum_{h\in\Omega_{h^*}} w_h p(y,h;\theta)\log p(y,h;\theta)$$
$$L_{(\mathcal{X},\mathcal{Y},\mathcal{H}_c)}(h,\theta) = E_{(\mathcal{X},\mathcal{Y},\mathcal{H}_c^*)}(h,\theta).$$

F. Wan, P. Wei, Z. Han, J. Jiao, Q. Ye, “Min-entropy Latent Model for Weakly Supervised object Detection,” IEEE CVPR2018

Our works-Min-entropy latent model

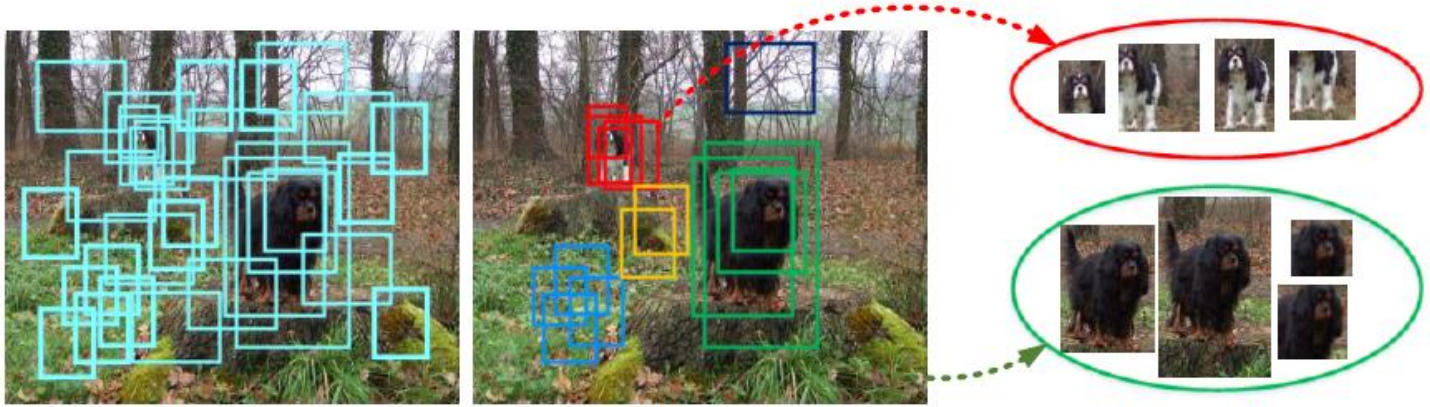


(1) Instance (object and object part) are collected with a **clique partition module**;

(2) Object clique discovery with a global min-entropy model;

(3) Object localization with a local min-entropy model

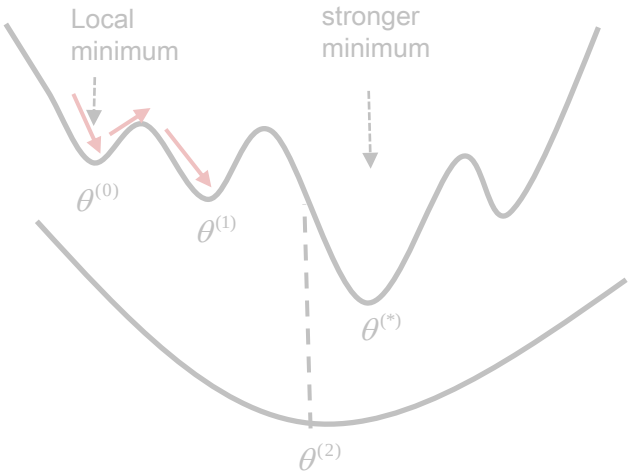
Our works-Min-entropy latent model



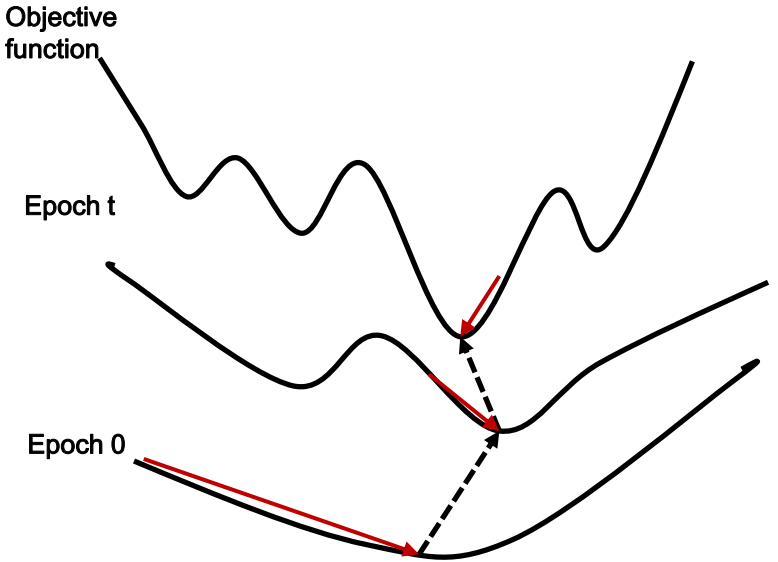
Clique partition:

$$\begin{cases} \bigcup_{c=1}^{C} \mathcal{H}_c = \tilde{\mathcal{H}} \\ \forall c \neq c',\ \mathcal{H}_c \cup \mathcal{H}_{c'} = \emptyset \end{cases}$$

Our works-Methodology

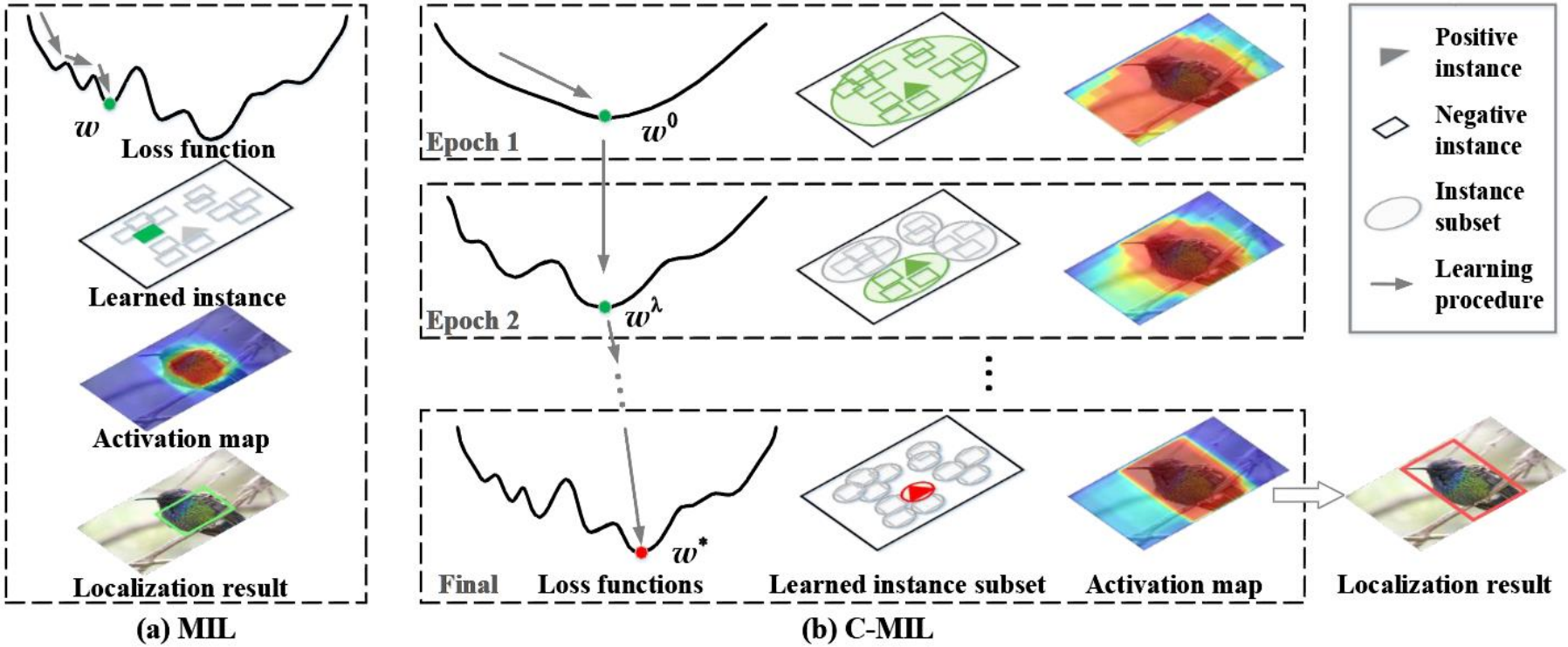


Convex Regularization



Continuation Optimization

Our works-Continuation Multiple Instance Learning



F. Wan, C. Liu, J. Jiao, Q. Ye, "**CMIL:** Continuation Multiple Instance Learning for Weakly Supervised object Detection (CVPR2019)

Our works-Min-entropy latent model

Input Image

Region Proposals

CONVs with ROI Pooling

FC (4096)

FC (4096)

Element-wise Multiplication

FC (N)

M1

Clique Partition

Object Clique Discovery

Global Min-Entropy

M2

Image Classification Loss

Image Label

Object Probability

Object Localization

Local Min-Entropy

FC (N+1)

M3

Softmax

Object Detection Loss

Pseudo Object Label

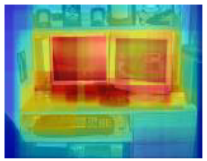
Object Score

Network Connection

Forward-only Connection

Object Score Heatmap

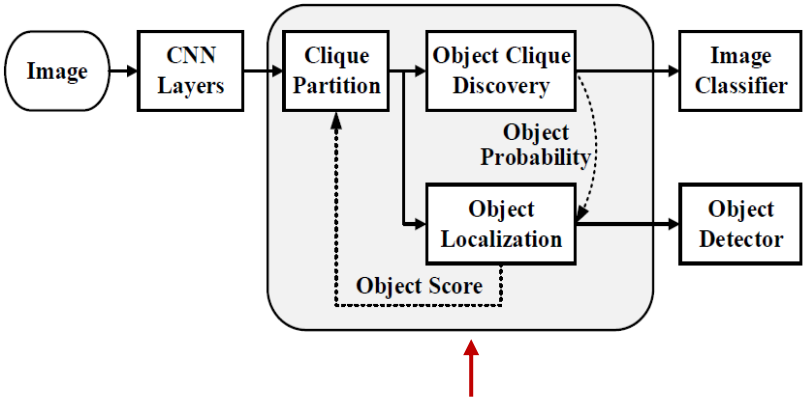
M1



M2

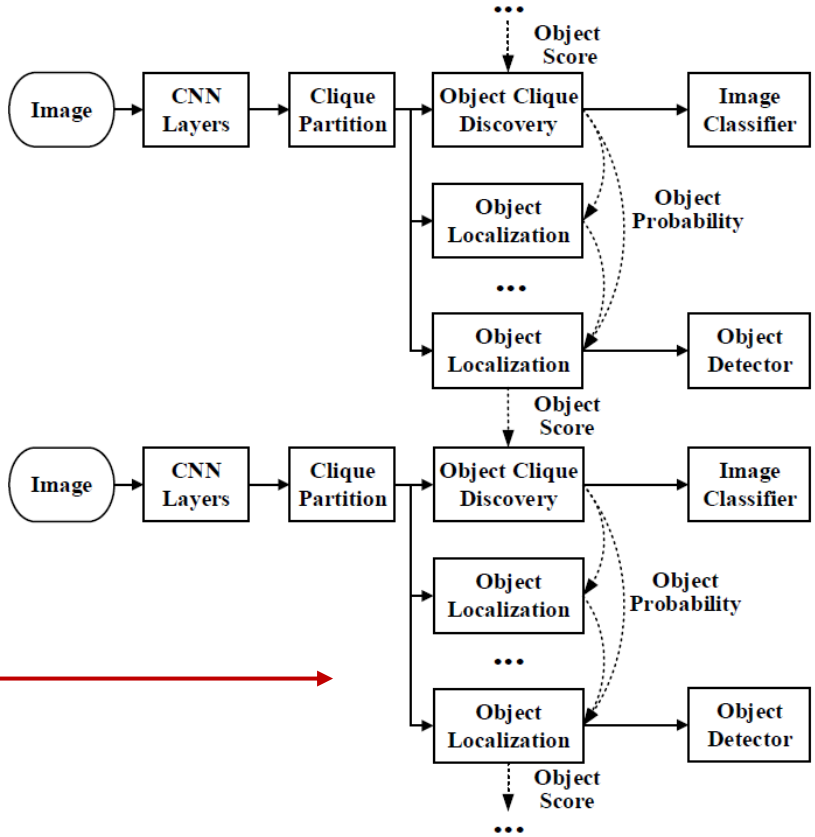
M3

Our works-Recurrent Learning



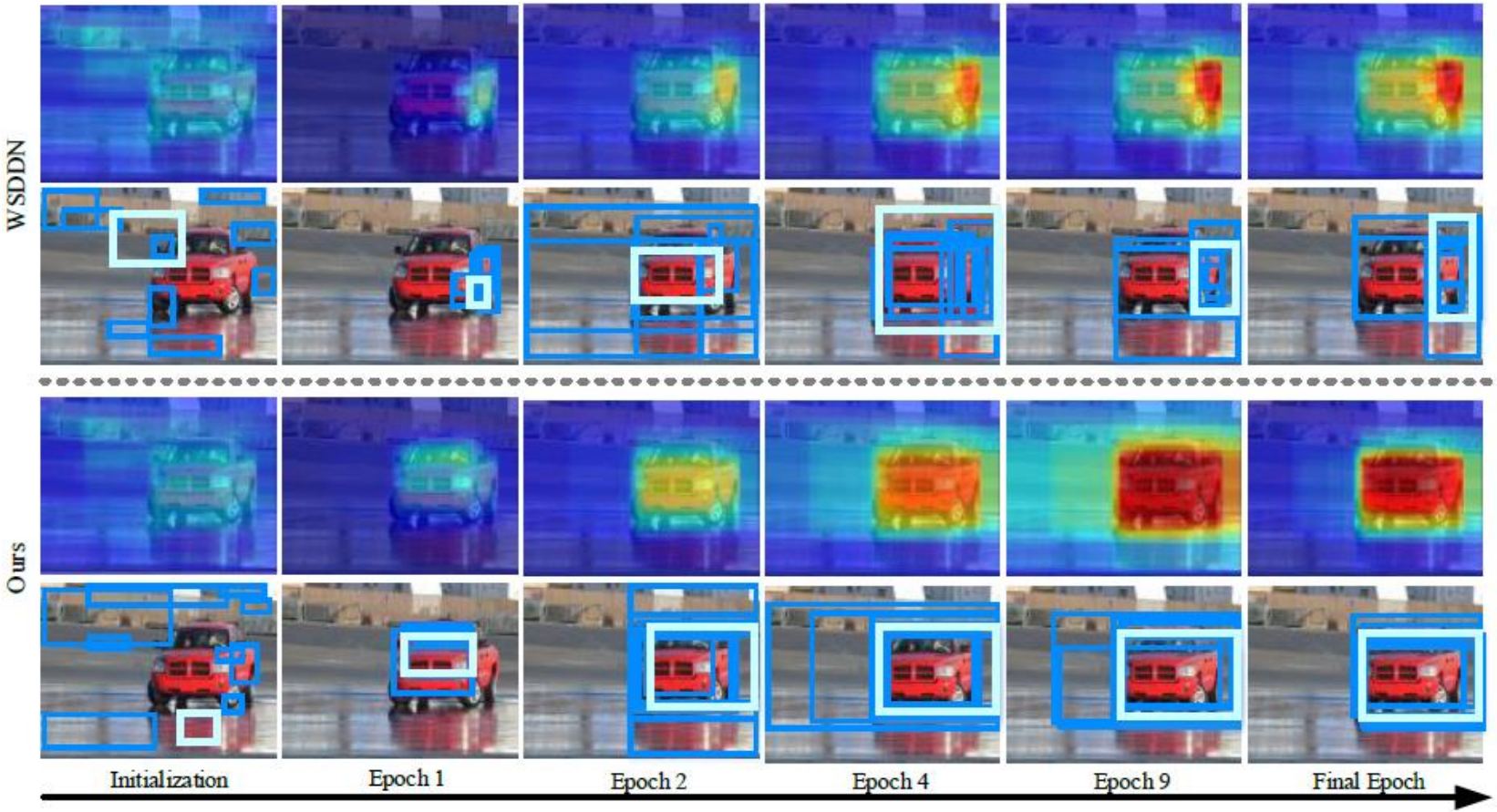
Recurrent Learning

Accumulated Recurrent Learning

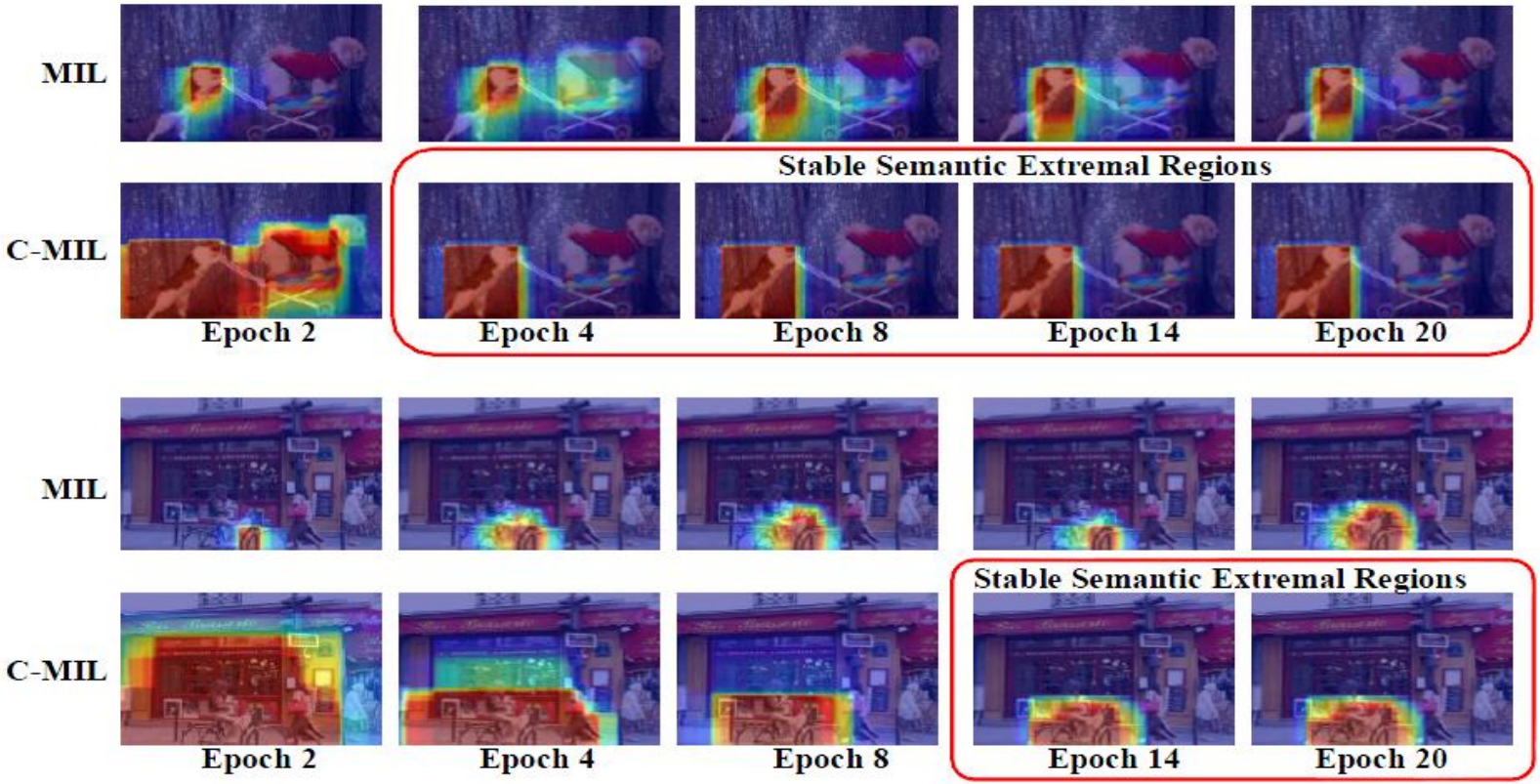


F. Wan, P. Wei, Z. Han, J. Jiao, Q. Ye, “Min-entropy Latent Model for Weakly Supervised object Detection,” IEEE Transactions on Pattern Analysis and Machine Intelligence (**PAMI**), DOI:10.1109/TPAMI.2019.2898858.

Our works-Results

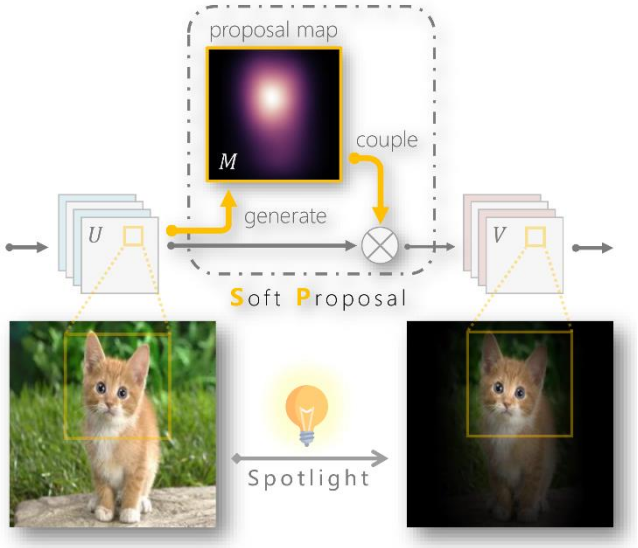


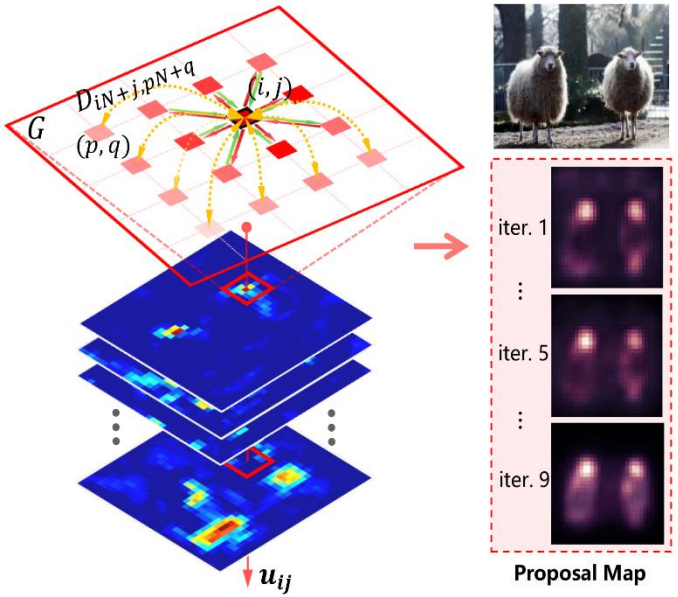
Our works-Results



SSER: Semantic Stable Extremal Region

Our works-Soft Proposal Network

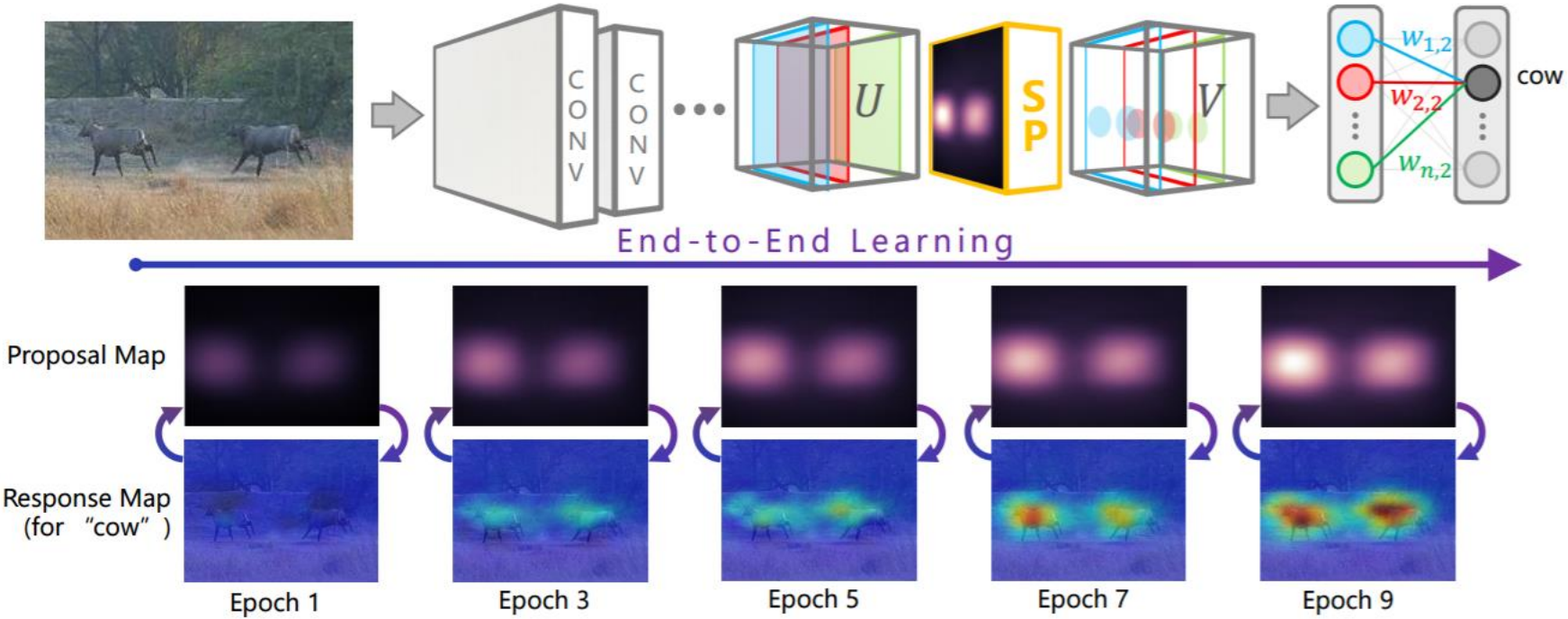




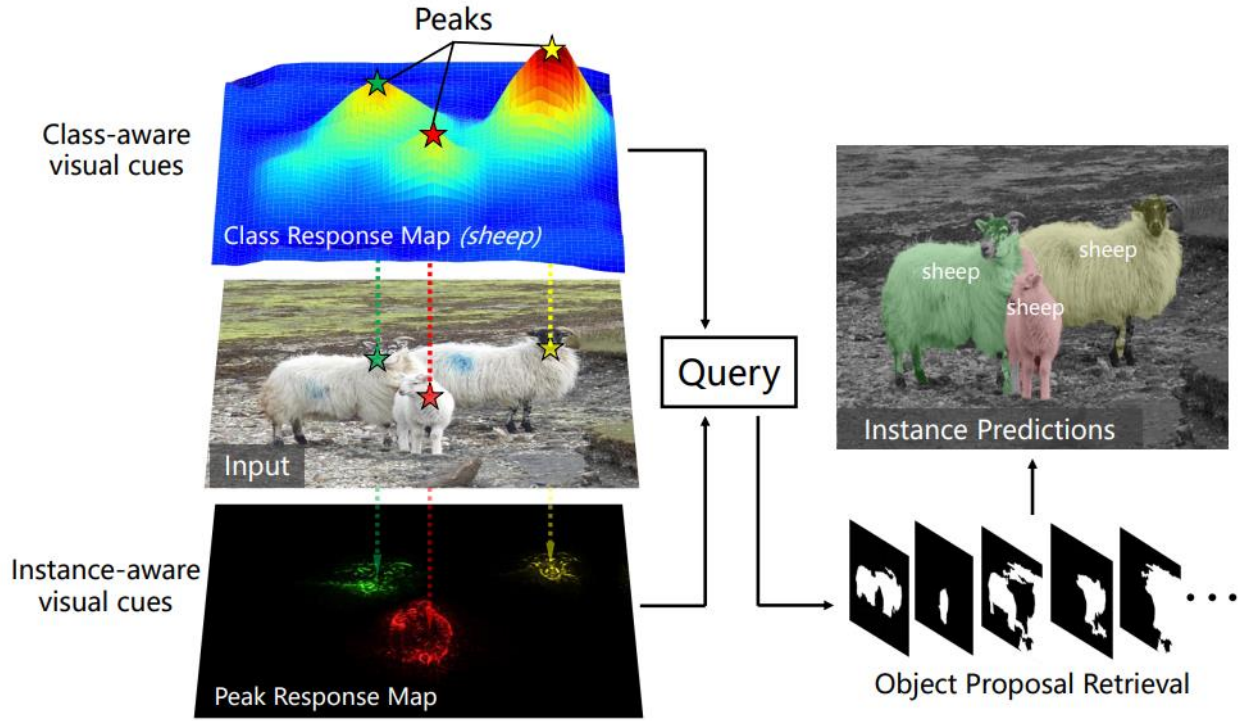
$$M \leftarrow D \times M. \qquad M \leftarrow D\left(U^l(W^l)\right) \times M. \qquad W^l = W^l + \Delta W(M)$$

Y. Zhu, Y. Zhou, Q. Ye, Q. Qiu, and J. Jiao, "Soft Proposal Network for Weakly Supervised Object Localization," in Proc. of IEEE Int. Conf. on Computer Vision (**ICCV**), 201

Our works-Soft Proposal Network

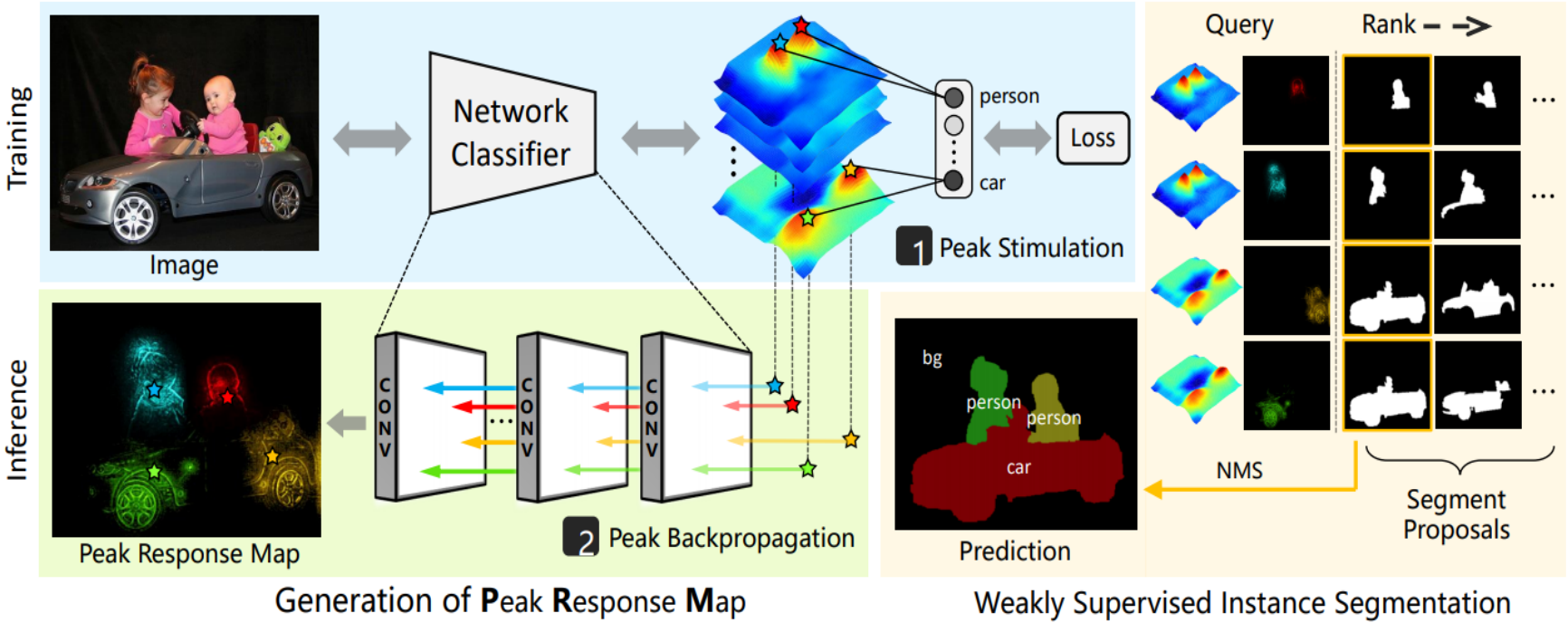


Our works-Peak Response Mapping

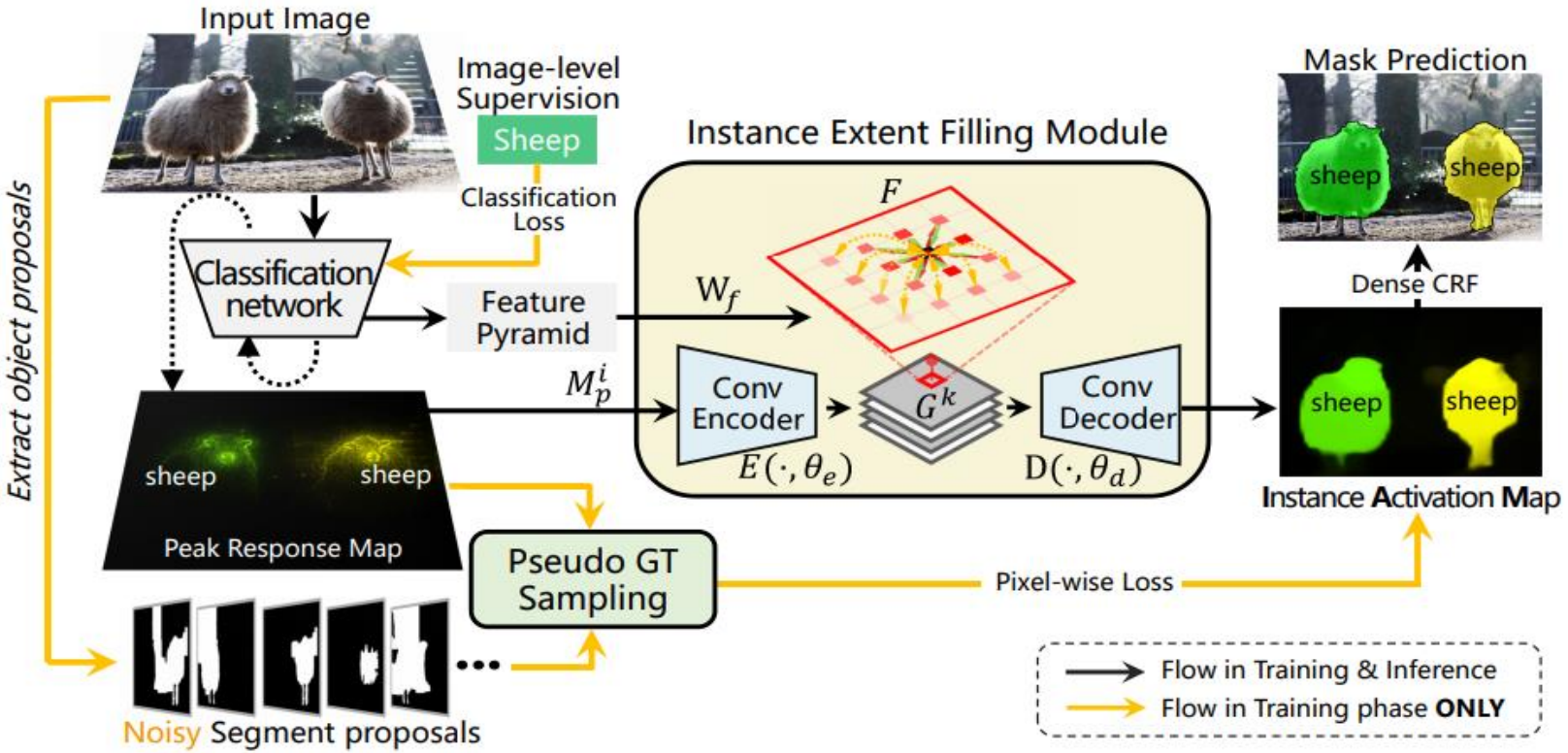


Y. Zhou, Y. Zhu, Q. Ye, Q. Qiu, J. Jiao, “Weakly Supervised Instance Segmentation using Class Peak Response, IEEE CVPR 2018 (**Spotlight**).

Our works-Peak Response Mapping

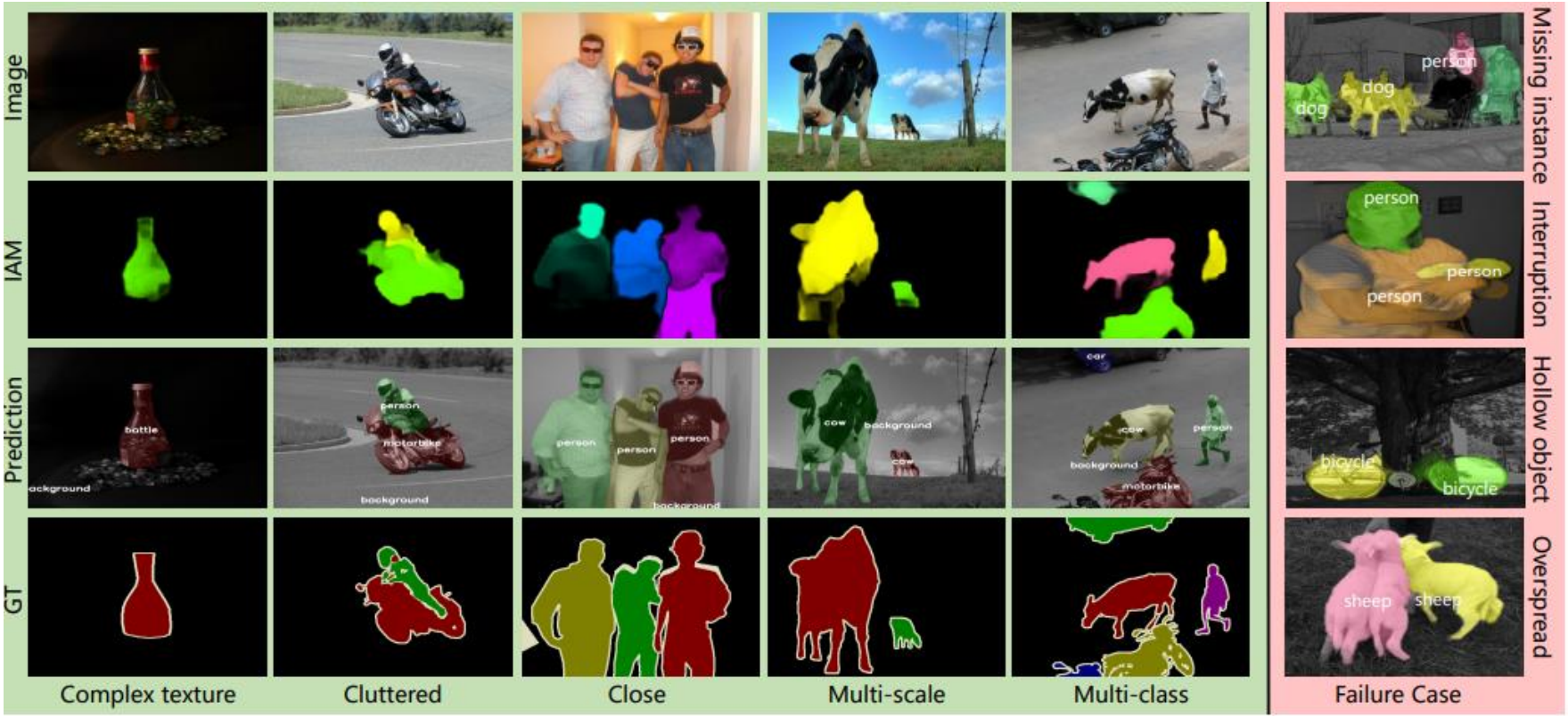


Our works-learning Instance Activation Maps



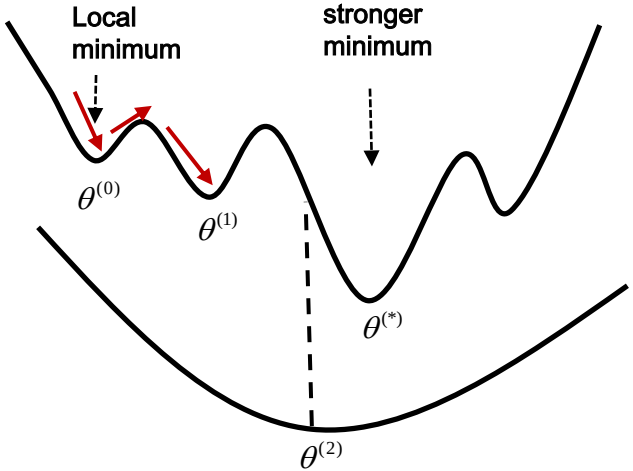
Y. Zhu, Y. Zhou, H. Xu, Q. Ye., D. Doermann, J. Jiao, “Learning Instance Activation Maps for Weakly Supervised Instance Segmentation,” IEEE CVPR 2019.

Our works-learning Instance Activation Maps

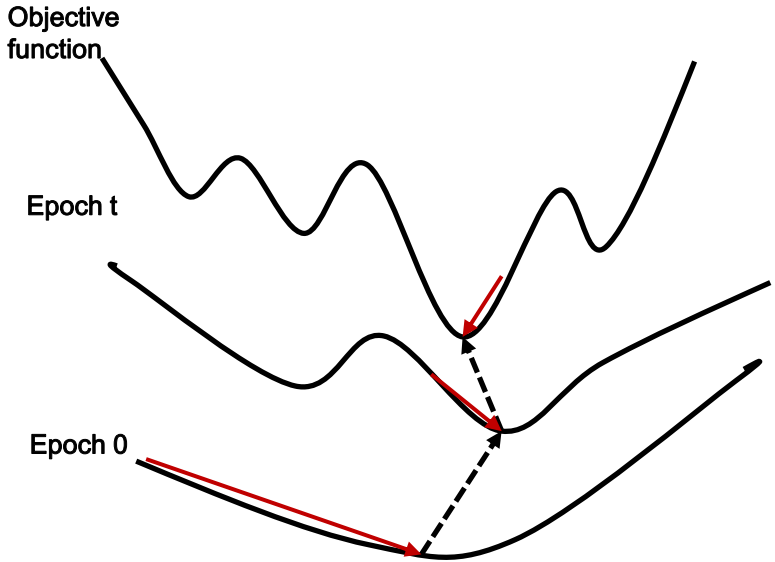


The future

Beyond regularization and continuation optimization



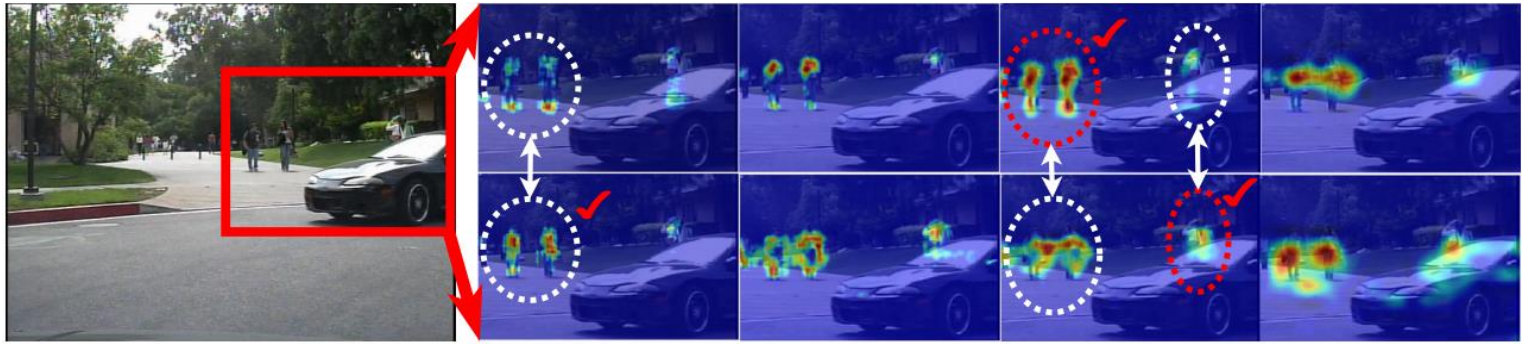
Convex Regularization



Continuation Optimization

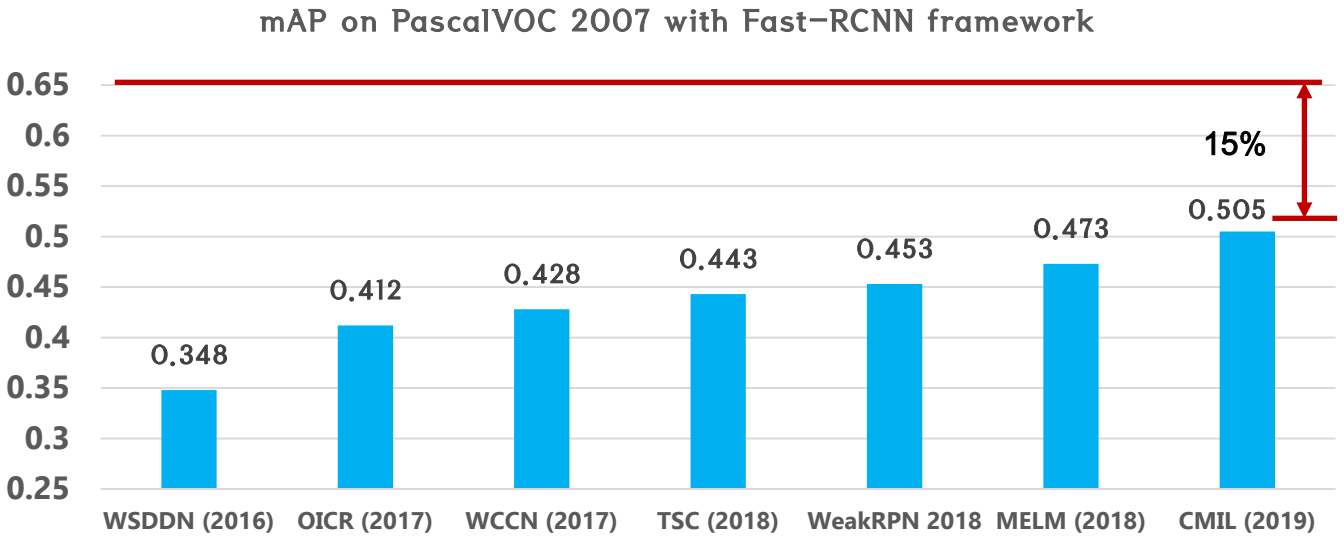
The future

Beyond weakly supervised detection and segmentation



The future

Fill the gap of supervised and weakly supervised methods



The future

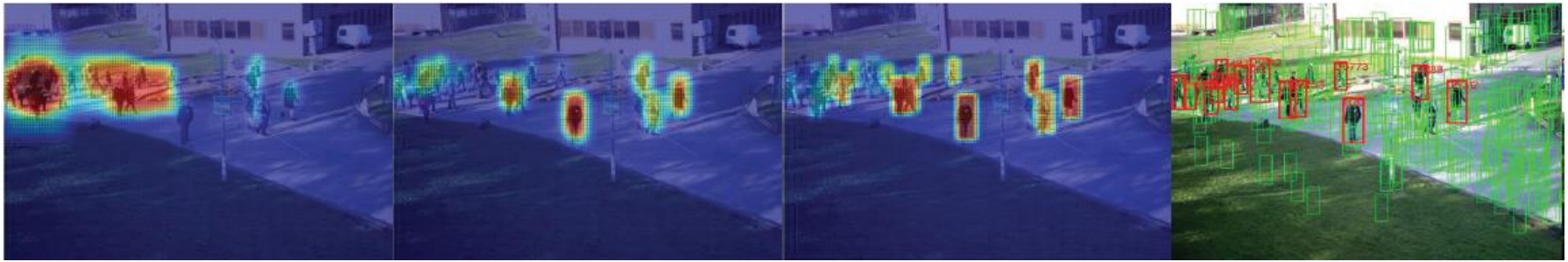
Weakly supervised detection meets X

X= Few-shot Active Learning | Online Feedback | Temporal

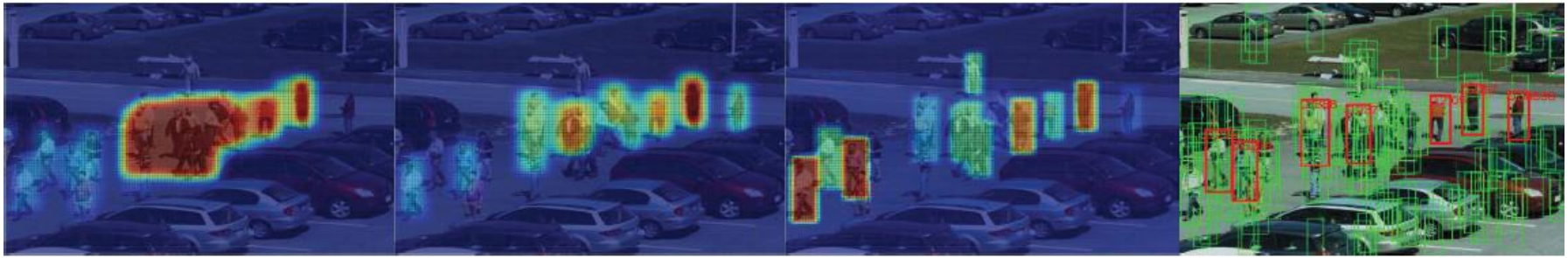
The future

X= Few-shot Active Learning | Online Feedback | Temporal

Pets2009 (crowd)



Towncenter (moving distracters)



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Thank!

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