Multi-Label Zero-Shot Learning with Structured Knowledge Graphs

Chung-Wei Lee[1], Wei Fang[1], Chih-Kuan Yeh[2], Yu-Chiang Frank Wang[1]

[1]Department of Electrical Engineering, National Taiwan University, Taiwan [2]Machine Learning Department, Carnegie Mellon University, U.S.A

CVPR 2018 SALT LAKE CITY • JUNE 18-22

Motivation

- Humans are able to utilize semantic concepts between objects of interests for reasoning. Can machines take advantages of such structured prior knowledge for recognition of multiple (or even unseen) object?

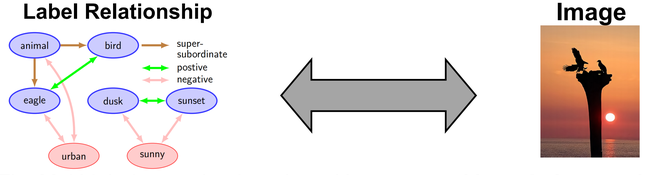


Fig. Multi-label zero-shot learning with **structured knowledge graphs.**

Contributions

- Our proposed model is *among the first* to advance **structured information** and **knowledge graphs** for multi-label zero-shot learning (ML-ZSL).
- Our model advances a **label propagation** mechanism in the semantic space, which allows prediction of unseen labels (i.e., labels not seen during training).
- With comparable performances on standard multi-label classification tasks, our method performs favorably against recent models for ML-ZSL.

Experiments

- ML-ZSL: Setup same as Fast0Tag[1].
  - 81 labels from NUS-WIDE as unseen classes.
  - 1000 noisy labels - 75 duplicated/unseen labels as 925 seen classes.
- Generalized ML-ZSL: training on 925 seen classes, testing on all 925 + 81 = 1006 classes.

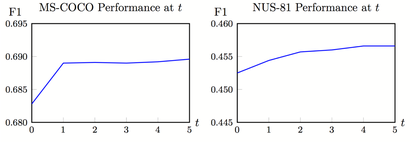
Multi-label Classification

	NUS-WIDE (81 classes)	MS-COCO (80 classes)
WARP[2]	39.5	61.2
Logistics	43.9	66.9
Fast0Tag[1]	40.1	61.2
Ours	**45.7**	**69.0**

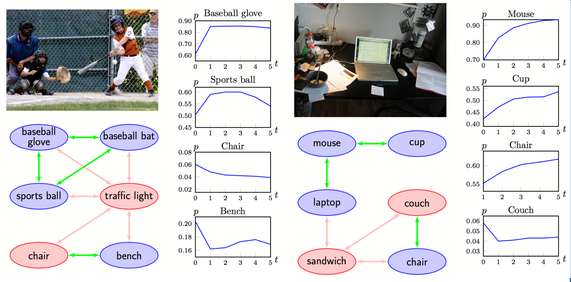
Multi-label Zero-Shot Classification

	ML-ZSL	Generalized ML-ZSL
Fast0Tag (top-3)	27.2	-
Fast0Tag (top-10)	-	21.9
Ours w/o Prop.	28.1	23.9
Ours	**30.6**	**24.2**

F1 Measure for Multi-label Classification



Constructed Knowledge Subgraphs and Predicted Label Probabilities



[1] Zhang et al. Fast Zero-Shot Image Tagging. In *CVPR 2016.*
[2] Gong et al. Deep Convolutional Ranking For Multilabel Image Annotation. In *CoRR 2013.*

Proposed Approach

Initial Prediction / Label Propagation (w/ structured graph knowledge) / Final Prediction

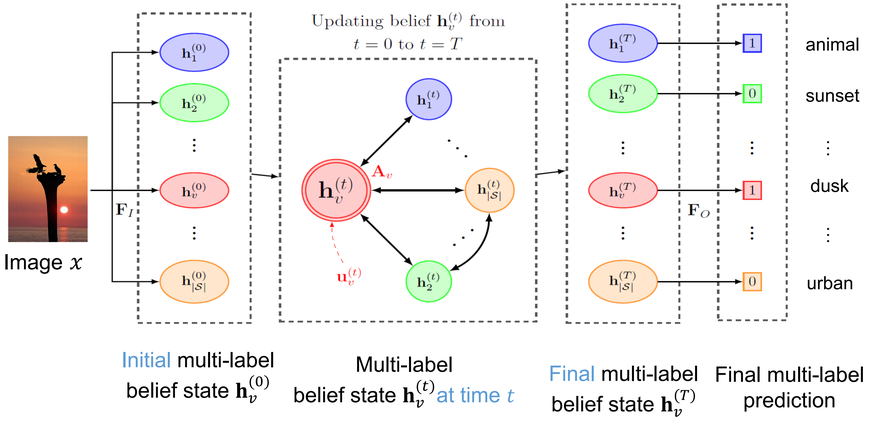


Fig. **Structured graph propagation** for multi-label classification

Label Propagation

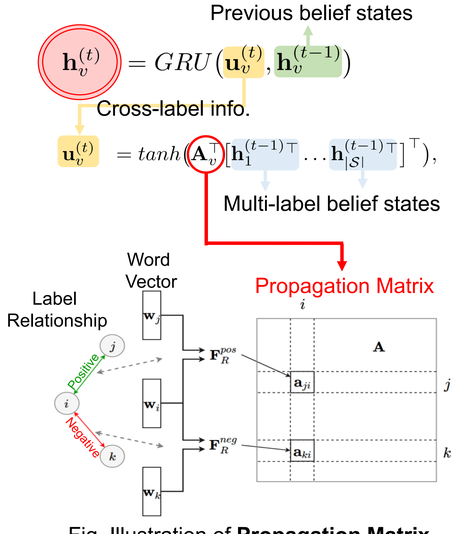


Fig. Illustration of **Propagation Matrix**

Zero-Shot Inference

- Improve ML-ZSL via iteratively propagating information between labels

Final prediction: $\mathbf{F}_O(\mathbf{h}_v^{(T)})$

Iterative

$\mathbf{h}_v^{(t)} = GRU(\mathbf{u}_v^{(t)}, \mathbf{h}_v^{(t-1)})$

$\mathbf{u}_v^{(t)} = tanh(\tilde{\mathbf{A}}_v^\top [\mathbf{h}_1^{(t-1)\top} \dots \mathbf{h}_{(|\mathcal{S}|+|\mathcal{U}|)}^{(t-1)\top}]^\top)$

- Propagation matrix $\tilde{\mathbf{A}}_v^\top$ for unseen labels can be obtained from
  - Learned model $\{\mathbf{F}_R^{pos}, \mathbf{F}_R^{neg}\}$
  - Word vectors of unseen labels