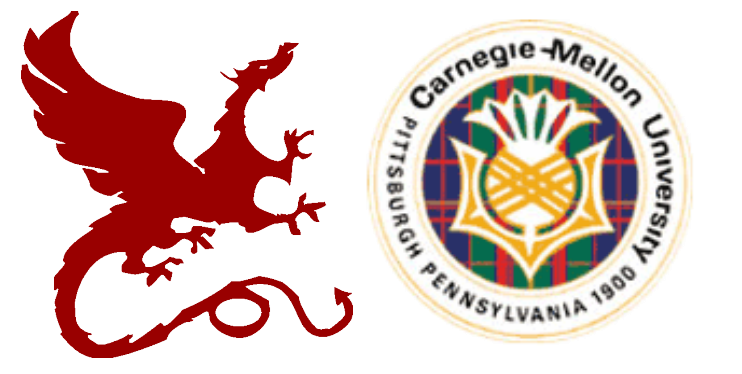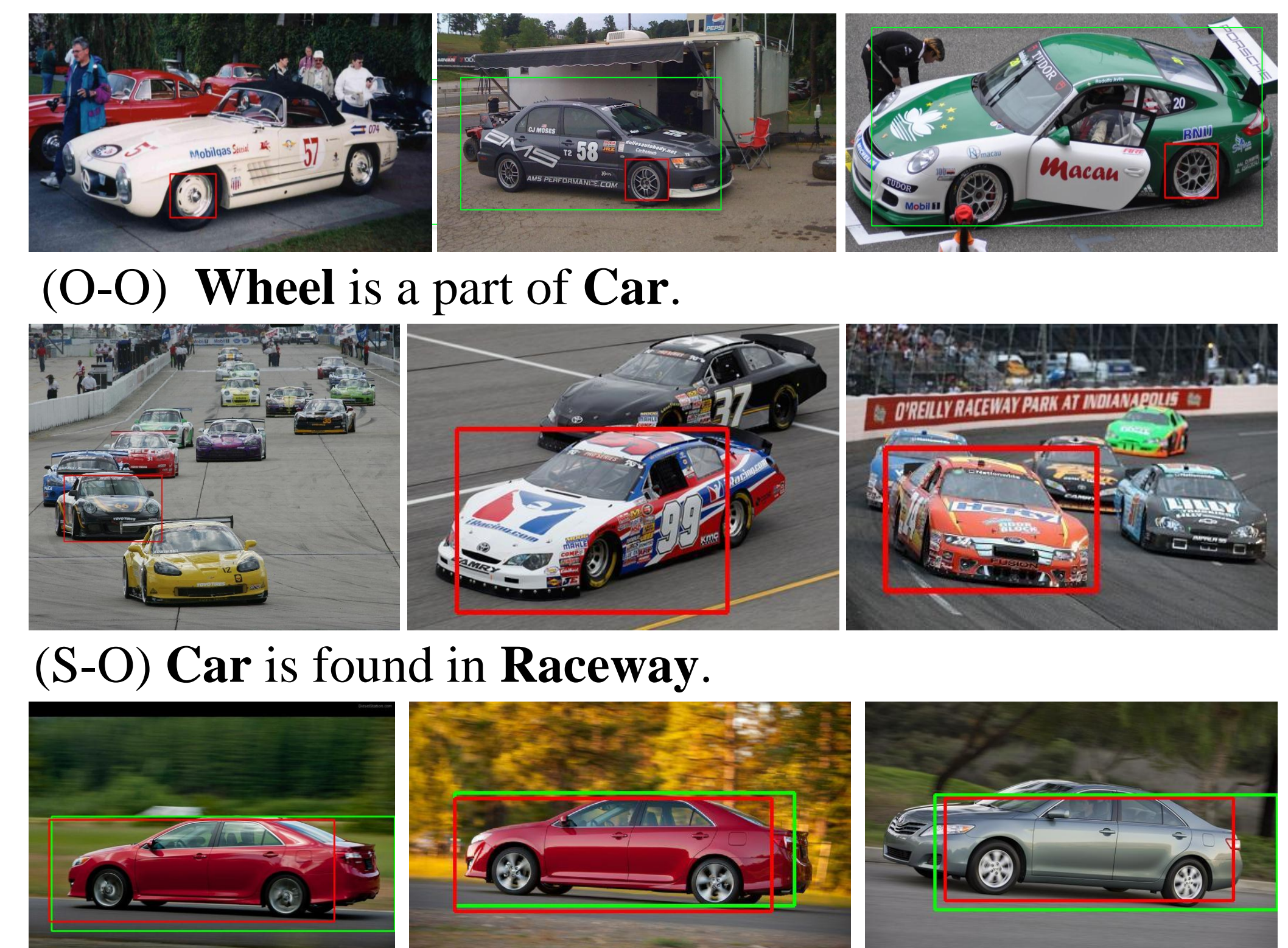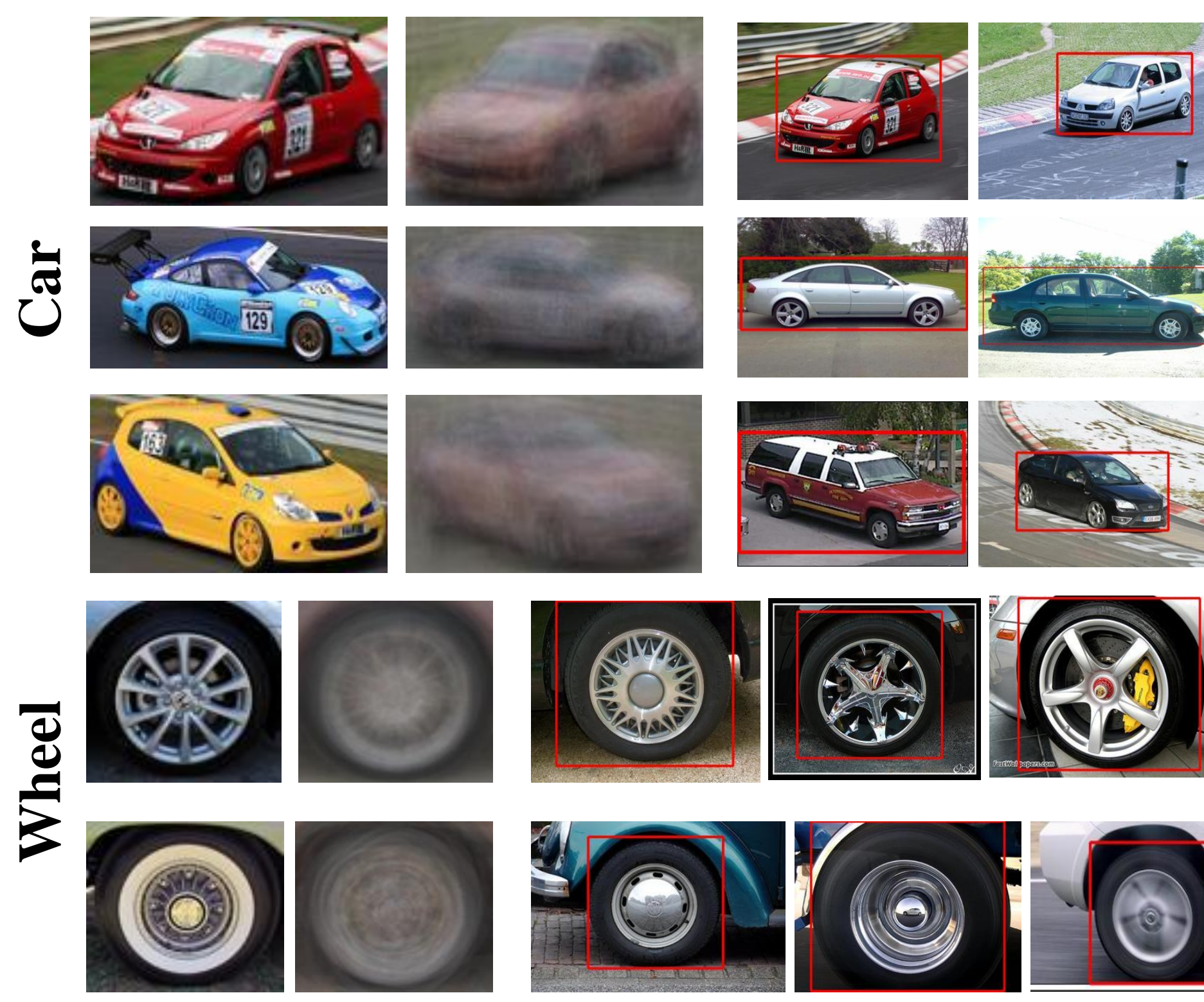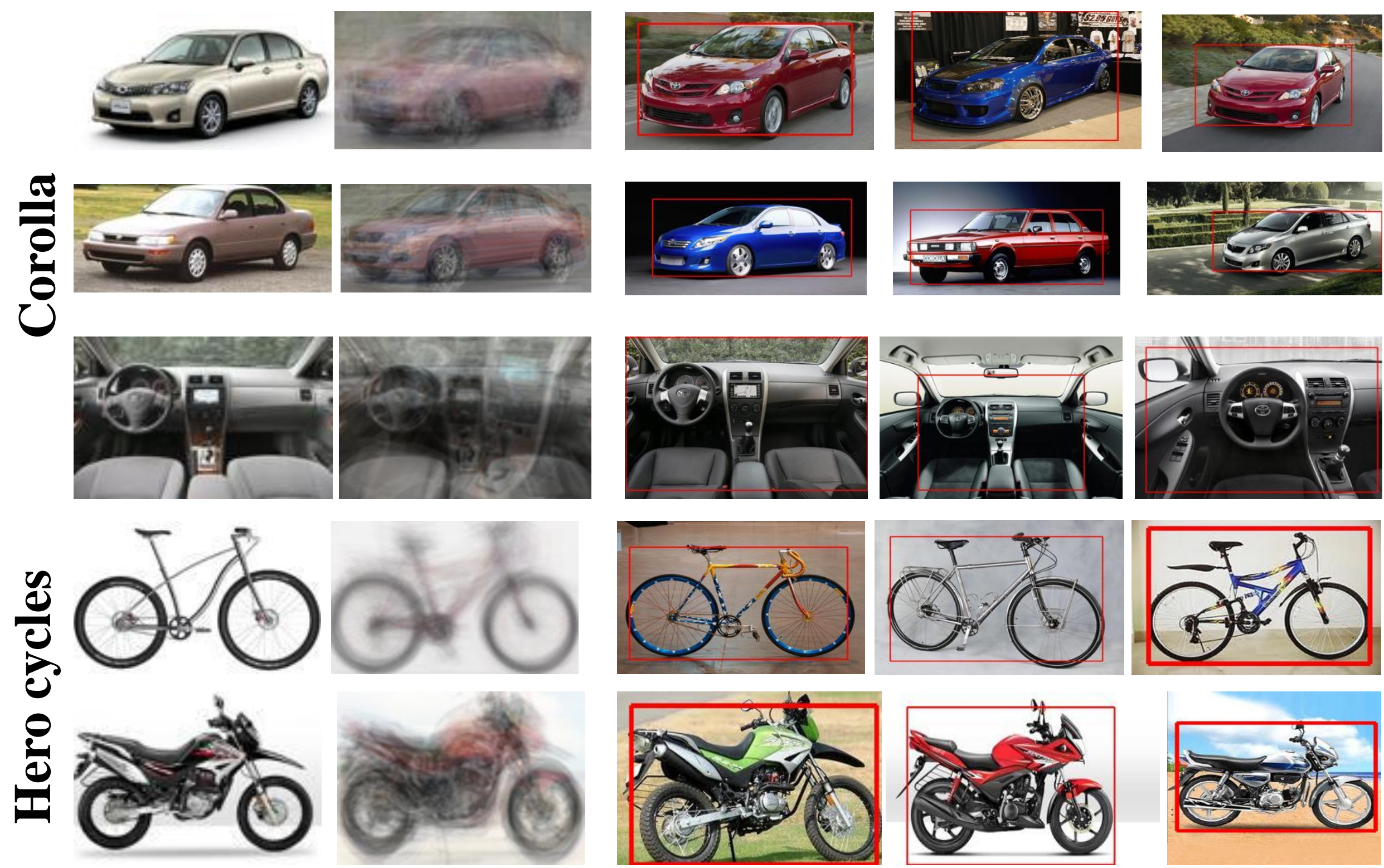# NEIL: Extracting Visual Knowledge from Web Data

Xinlei Chen, Abhinav Shrivastava, Abhinav Gupta

Carnegie Mellon University

All models and relationships can be found at www.neil-kb.com

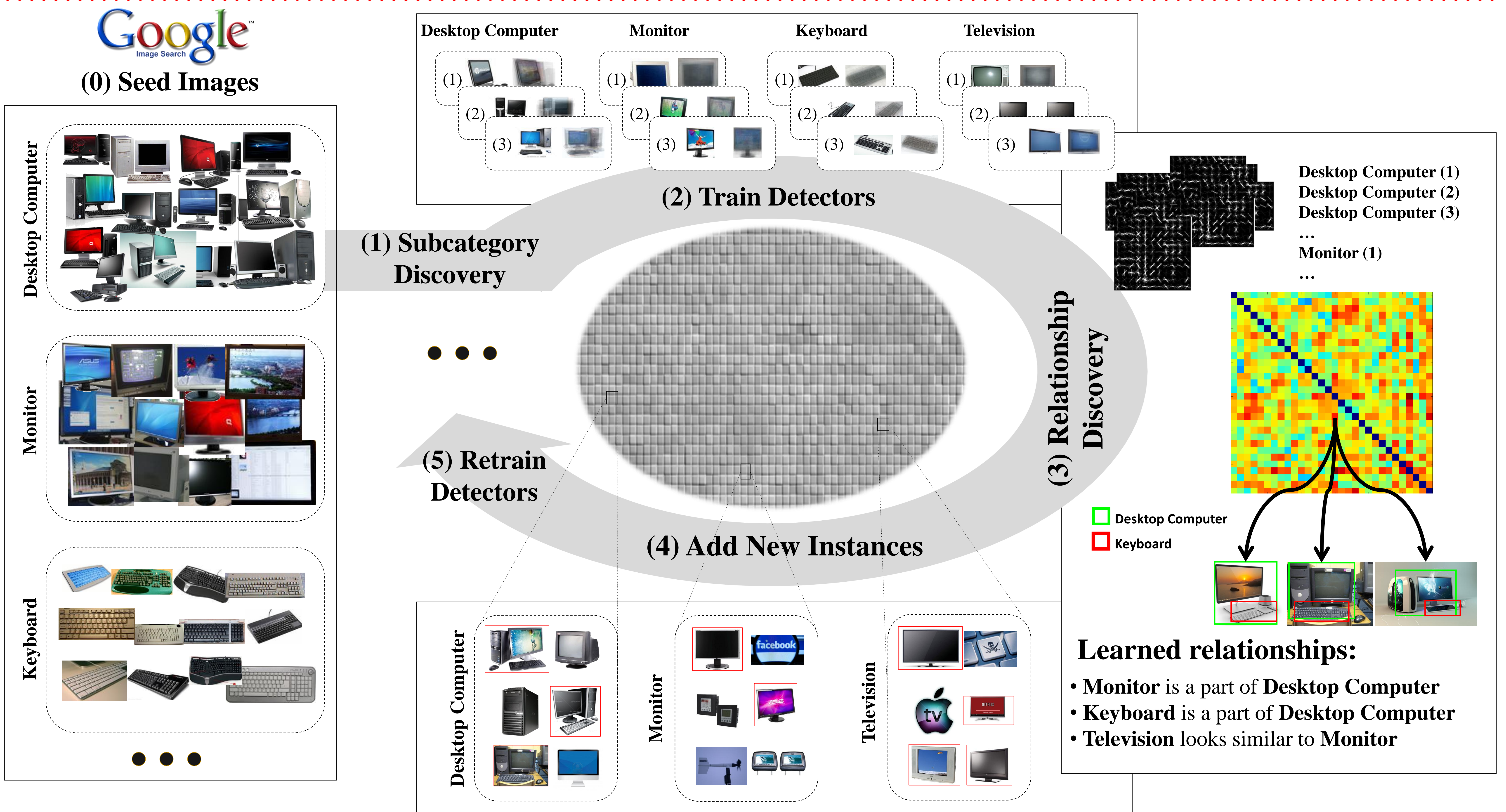**(a) Objects (w/Bounding Boxes and Visual Subcategories)**

(b) Scenes

(c) Attributes

(O-O) **Wheel** is a part of **Car**.

(S-O) **Car** is found in **Raceway**.

(O-O) **Corolla** is a kind of/looks similar to **Car**.

(S-O) **Pyramid** is found in **Egypt**.

(O-A) **Wheel** is/has **Round shape**.
(S-A) **Alley** is/has **Narrow**.
(S-A) **Bamboo forest** is/has **Vertical lines**.
(O-A) **Sunflower** is/has **Yellow**.

Visual Instances Labeled by NEIL

Relationships Extracted by NEIL

(0) Seed Images

(1) Subcategory Discovery

(2) Train Detectors

(3) Relationship Discovery

(5) Retrain Detectors

(4) Add New Instances

Desktop Computer (1)
Desktop Computer (2)
Desktop Computer (3)
...
Monitor (1)
...

Desktop Computer
Keyboard

Learned relationships:
- **Monitor** is a part of **Desktop Computer**
- **Keyboard** is a part of **Desktop Computer**
- **Television** looks similar to **Monitor**

Why NEIL Works?

1. Micro-Vision → Macro-Vision
2. Structure in Visual World
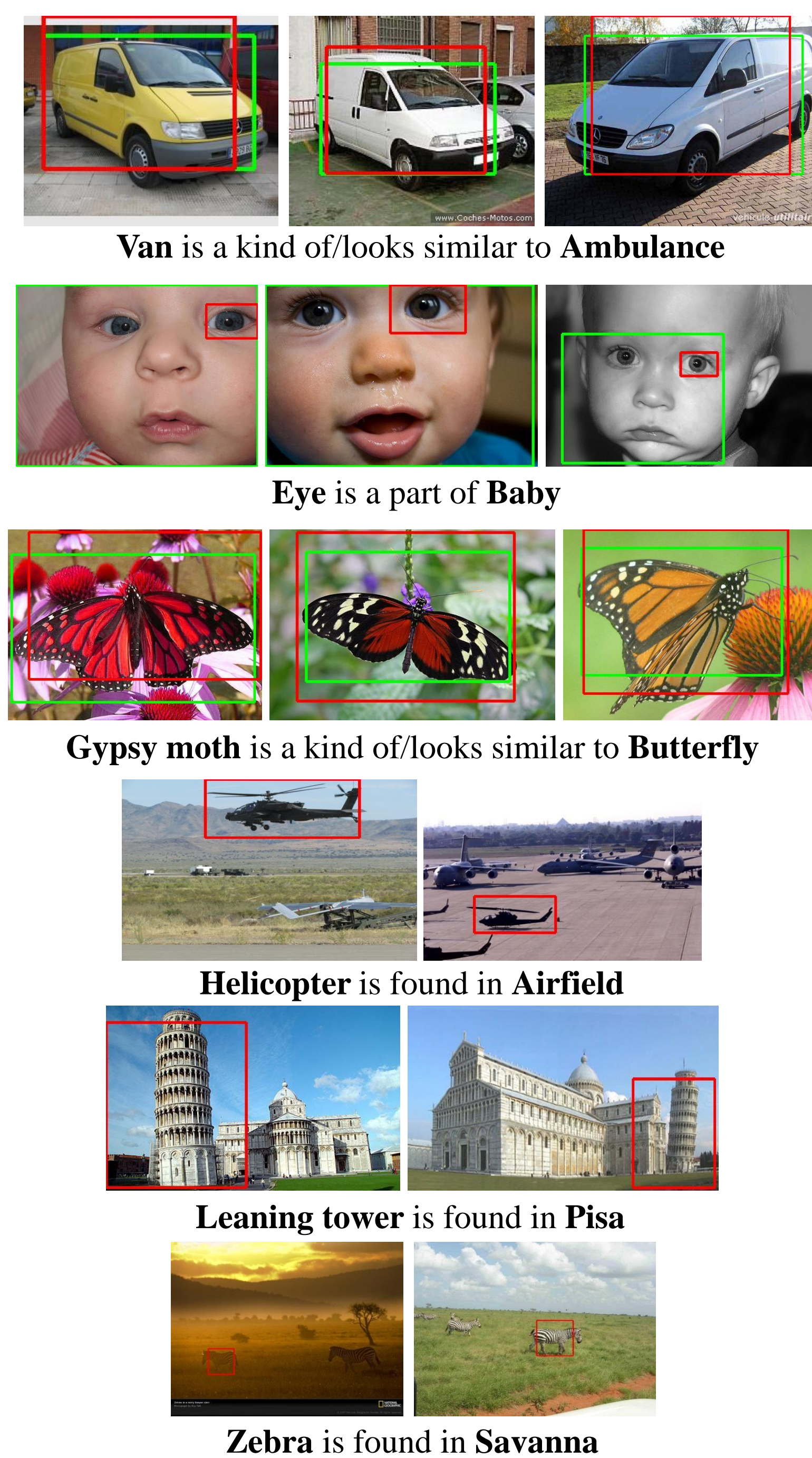3. Semantically-Driven Acquisition

Statistics

- Running for ~4 months on ~200 cores
- >2000 concepts, including >1000 objects, >1000 scenes, ~90 attributes
- Analyzed 5m images
  - Labeled 600K images
  - Discovered 3K relationships

Subcategories

Falcon

Nilgai

F18

Bean

Relationships

Van is a kind of/looks similar to **Ambulance**

Eye is a part of **Baby**

Gypsy moth is a kind of/looks similar to **Butterfly**

Helicopter is found in **Airfield**

Leaning tower is found in **Pisa**

Zebra is found in **Savanna**

More Relationships

Monitor is found in **Control room**
Washing machine is found in **Utility room**
Siberian tiger is found in **Zoo**
Baseball is found in **Butters box**
Bullet train is found in **Train station platform**
Cougar looks similar to **Cat**
Urn looks similar to **Goblet**
Samsung galaxy is a kind of **Cellphone**
Computer room is/has **Modern**
Hallway is/has **Narrow**
Building facade is/has **Check texture**
Trading floor is/has **Crowded**

Umbrella looks similar to **Ferris wheel**
Bonfire is found in **Volcano**

Scene Classification

	mAP
Seed Classifier (15 Google Images)	0.52
Bootstrapping (without relationships)	0.54
NEIL Scene Classifiers	0.57
NEIL (Classifiers + Relationships)	0.62

Object Detection

	mAP
Latent SVM (50 Google Images)	0.34
Latent SVM (450 Google Images)	0.28
Latent SVM (450, Aspect Ratio Clustering)	0.30
Latent SVM (450, HOG-based Clustering)	0.33
Seed Detector (NEIL Clustering)	0.44
Bootstrapping (without relationships)	0.45
NEIL Detector	0.49
NEIL Detector + Relationships	0.51