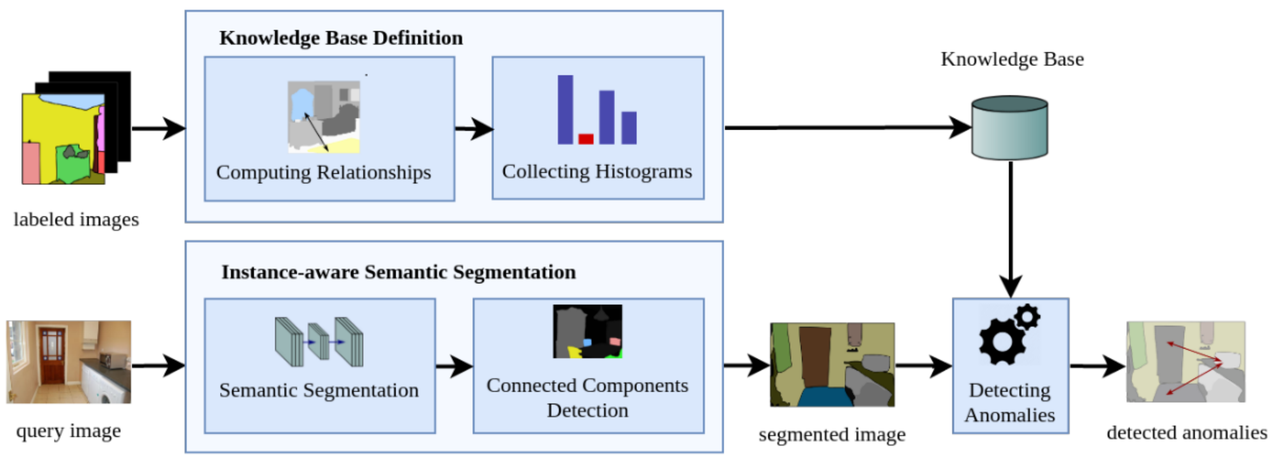
Detecting Anomalies in Image Classification by means of Semantic Relationships

Andrea Pasini

Supervisor: Elena Baralis

DAUIN, Politecnico di Torino



The **SAD (Semantic Anomaly Detection)** process

- **Knowledge Base Definition**. SAD learns common patterns in the object configurations for all the different object classes; like object *co-occurrence*, *relative positions* and *sizes*.
- **Anomaly Detection:** find in the segmented image object configurations which show a low likelihood according to the information stored in the knowledge base.

Motivation

- **Our goal**
  - inspect **anomalies in** the classification results produced by **semantic segmentation** neural networks
- **Definitions**
  - **anomaly:** entity which deviates from one or more *semantic rules* modeling *normal data*
  - **semantic image segmentation:** assigning a class label to each pixel
- **Points of strength** of our method
  - provides a human **understandable** description of the anomaly
  - highlights **potentially misclassified objects**
  - **semantic enrichment** of the image segmentation even when the classification is correct

Proposed methodology

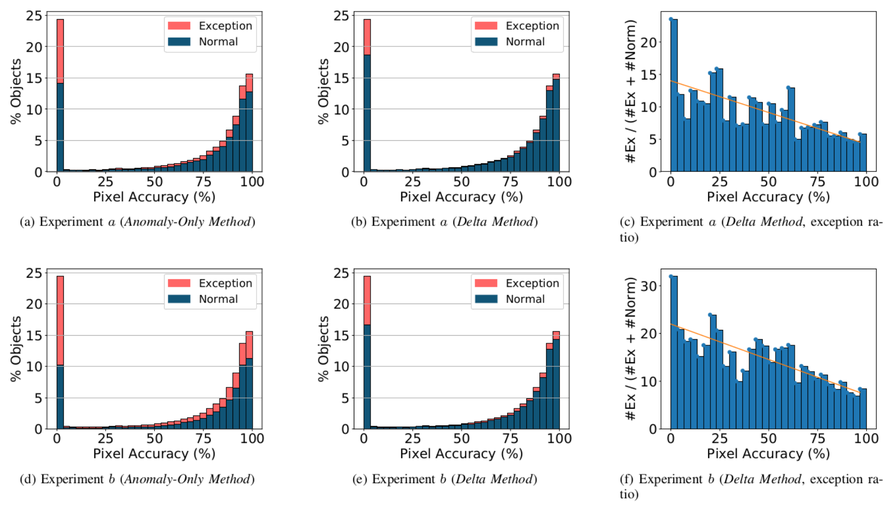
- **Contribution**
  a. defining **a knowledge base** to describe how objects of different classes are related together in the training images
  b. deriving a set of **relationships** between objects and in particular a new method to compute their relative position
  c. detecting **contextual anomalies** in segmented images by means of the semantic rules stored in the knowledge base

Results

Position relationship examples

Class Pair	Sup	Histogram
runway, sky	151	*below*=0.87 *side-down*=0.1
ball, pool table	33	*inside*=0.91 *above*=0.03
light, sink	1321	*side-up*=0.83 *above*=0.17

Anomaly detection



(a) Experiment *a* (*Anomaly-Only Method*) (b) Experiment *a* (*Delta Method*) (c) Experiment *a* (*Delta Method*, exception ratio)

(d) Experiment *b* (*Anomaly-Only Method*) (e) Experiment *b* (*Delta Method*) (f) Experiment *b* (*Delta Method*, exception ratio)

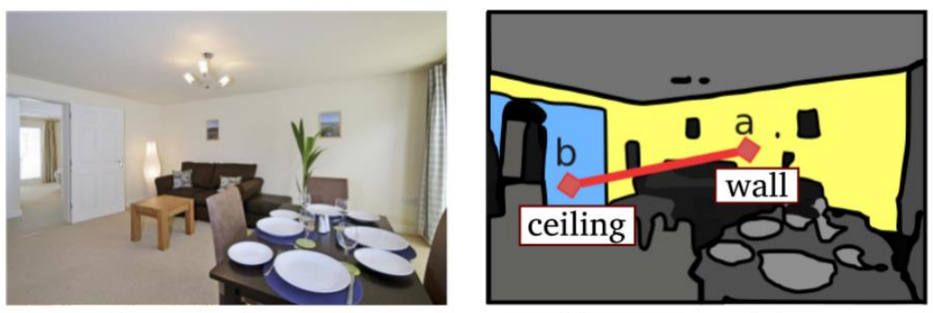
Precision Recall for the *exception* and *normal* classes

Experiment	Precision (Ex)	Recall (Ex)	Precision (Norm)	Recall (Norm)
experiment a, *Anomaly-Only Method* (Fig 10a)	0.6536	0.3601	0.5996	0.8339
experiment a, *Delta Method* (Fig 10b)	0.7440	0.1835	0.5708	0.9451
experiment b, *Anomaly-Only Method* (Fig 10d)	0.6152	0.5230	0.6328	0.7153
experiment b, *Delta Method* (Fig 10e)	0.7283	0.2596	0.5870	0.9157

Future work

- use prior knowledge extracted from **ontologies** to model more complex semantic relationships between objects
- build **semantic image descriptions** which consider the contextual information obtained from the object relationships

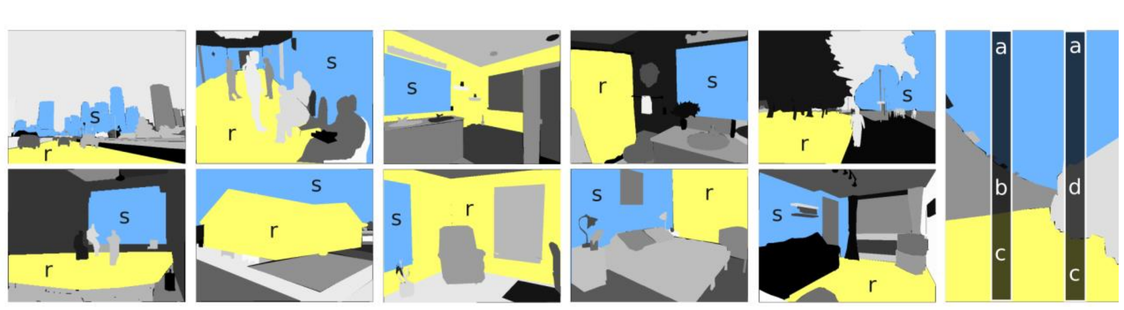
Examples of SAD output



a) query image b) segmented image

Anomaly: wall (a) on ceiling (b) has likelihood <0.01

c) model output



Object positions. The image shows the relationships between a subject (*s*) and a reference (*r*). The rightmost example shows the *string representation*, used to compute the object positions.