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Multilabel classification through structured output learning

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Example: dog vs. cat?

- ▶ We have 5000 pictures of dog and 5000 pictures of cat.



- ▶ Computer digitalize each picture into 100×100 pixels.
- ▶ Given a new picture, we want to answer: is it a dog or a cat?
- ▶ Simple task for human, dog, or cat.
- ▶ Golle (2008) claimed this is a difficult task for machines with only 82.7% accuracy.
- ▶ In 2013, 98.5% accuracy was reported in a Kaggle competition (<https://www.kaggle.com/c/dogs-vs-cats>).

In human verification system

- ▶ Human verification system is a program that protects website from robots by generating and grading test that human can pass but machine cannot.
- ▶ CAPTCHA system (Ahn et al., 2003) uses distorted text.



- ▶ ASIRRA system (Elson et al., 2007) uses images.

Asirra

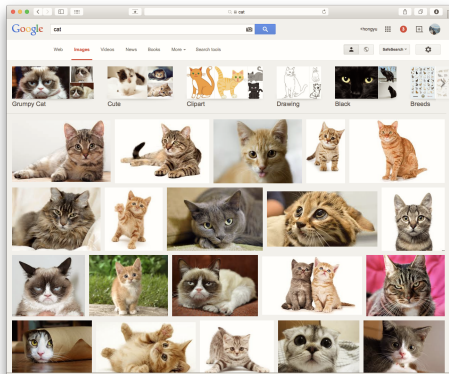
Asirra is a human interactive proof that asks users to identify photos of cats and dogs. It's powered by over two million photos from our unique partnership with [iStockphoto.com](#). Protect your web site with Asirra -- free!



- ▶ To test if the ASIRRA system is safe from machine learning attack.
 - ▶ One should get all 12 pictures right!
 - ▶ Accuracy for machine is $(98.5\%)^{12} \approx 83.4\%$.

In search engine

- ▶ If machine can assign cat/dog to all pictures correctly, we can search pictures with keywords.
- ▶ Search all cat pictures.



In search engine

- ▶ If machine can assign cat/dog to all pictures correctly, we can search pictures with keywords.
- ▶ Search all dog pictures.



Single label classification

- ▶ In machine learning, the problem is known as *single label classification*.
 - ▶ Input is an object
e.g., an image.
 - ▶ Output is an attribute of the object called *label*
e.g., dog or cat?
 - ▶ Explore a set of known object and label pairs called *Training data*
e.g., $\{(\text{image\#1}, \text{dog}), \dots, (\text{image\#5001}, \text{cat}), \dots\}$.
 - ▶ Learn a *mapping function* that predict the label of a new object
e.g., (new image, dog or cat?)
- ▶ Mathematically, we define the single label classification problem

Future work



To get benefit?

- ▶ Fingerprint identification
- ▶ Voice recognition
- ▶ Information assistant

To contribute?

- ▶ SETI@home
- ▶ Rosetta@home
- ▶ Foldit

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