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Multilabel classification through structured output learning

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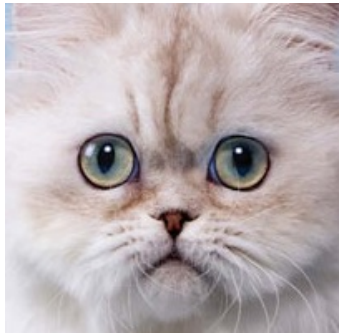
Example: dog vs. cat?

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

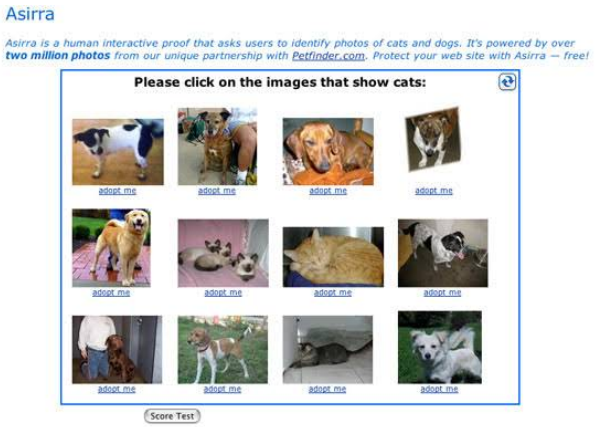



- Computer digitalize each picture into 100×100 pixels.
- Given a new picture, we want to answer: is it a dog or a cat?
- Simple task for human, dog, or cat.
- Golle (2008) claimed this is a difficult task for machines with only 82.7% accuracy.
- In 2013, 98.5% accuracy was reported in a Kaggle competition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

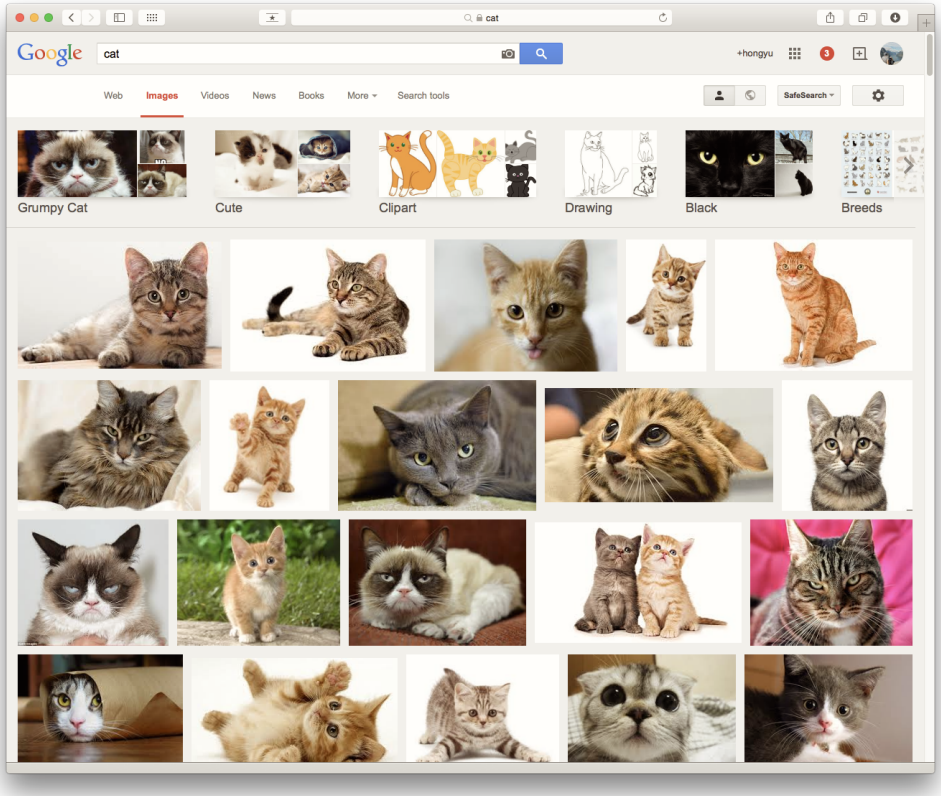
- ASIRRA system (Elson et al., 2007) uses images.



- 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

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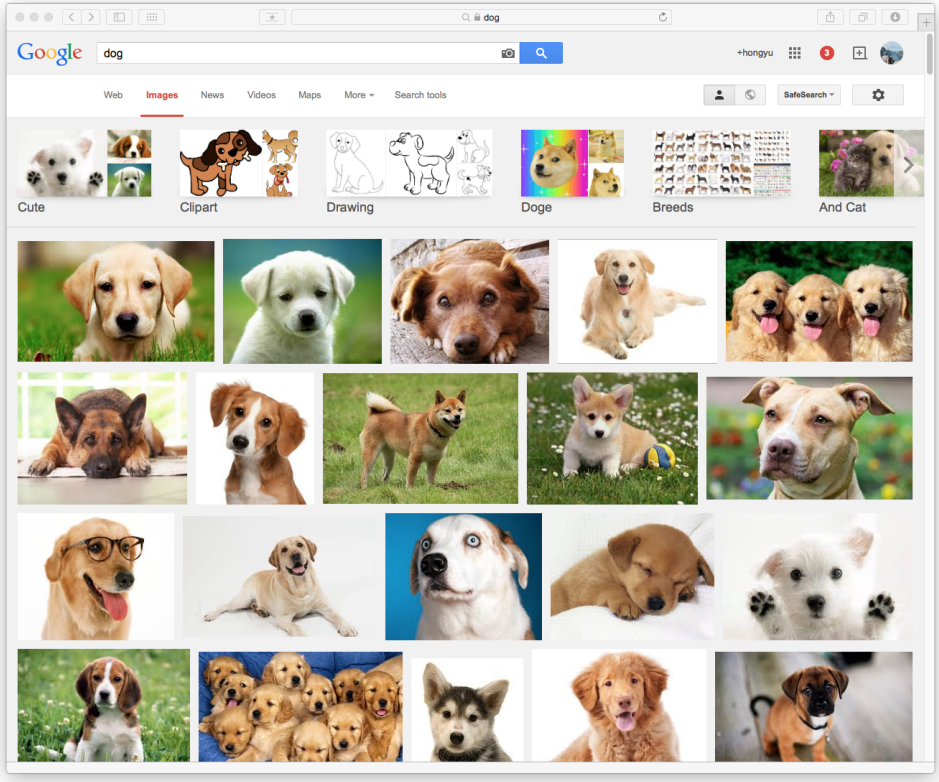

Single label classification

- 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., {(image#1, dog), $\cdots$, (image#5001, cat), $\cdots$}.
  - 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
  - Data come in pairs $(\mathbf{x}, y) \in \boldsymbol{\mathcal{X}} \times \mathcal{Y}$, sampled from some unknown distribution $P(\mathbf{x}.y)$.
  - $\boldsymbol{\mathcal{X}} = \mathbb{R}^d$ is a domain of input, $\mathcal{Y} = \{+1, -1\}$ is a domain of output.
  - We are given a set of training data $\mathcal{S} = \{(\mathbf{x}_i, y_i)\}_{i=1}^m$.
  - Learn a mapping function $f \in \mathcal{H}$ that predict the best output of an input

$$\mathbf{x} \xrightarrow{f} y$$

Future work

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To get benefit?

- Fingerprint identification
- Voice recognition
- Information assistant

To contribute?

- SETI@home
- Rosetta@home
- Foldit

Bibliography

Ahn, L. V., Blum, M., Hopper, N. J., and Langford, J. (2003). Captcha: Using hard ai problems for security. In *Proceedings of the 22Nd International Conference on Theory and Applications of Cryptographic Techniques*, EUROCRYPT'03, pages 294–311, Berlin, Heidelberg. Springer-Verlag.

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