RECSM Summer School:

Machine Learning for Social Sciences

Session 1.2:

Introduction to Machine Learning

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What Is Machine Learning?

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Definition of Machine Learning

Machine Learning

Learning

The process of converting experience into knowledge.

Machine Learning

Machine learning is automated learning. We program computers so that they can learn from input available to them.

- The input to a learning algorithm is training data (experience).
- The output of a learning algorithm is knowledge, which we can use to perform some task (e.g., prediction, pattern detection).
- A successful learning algorithm should be able to generalize (inductive inference).

(Shalev-Shwartz and Ben-David 2014, 19ff.)

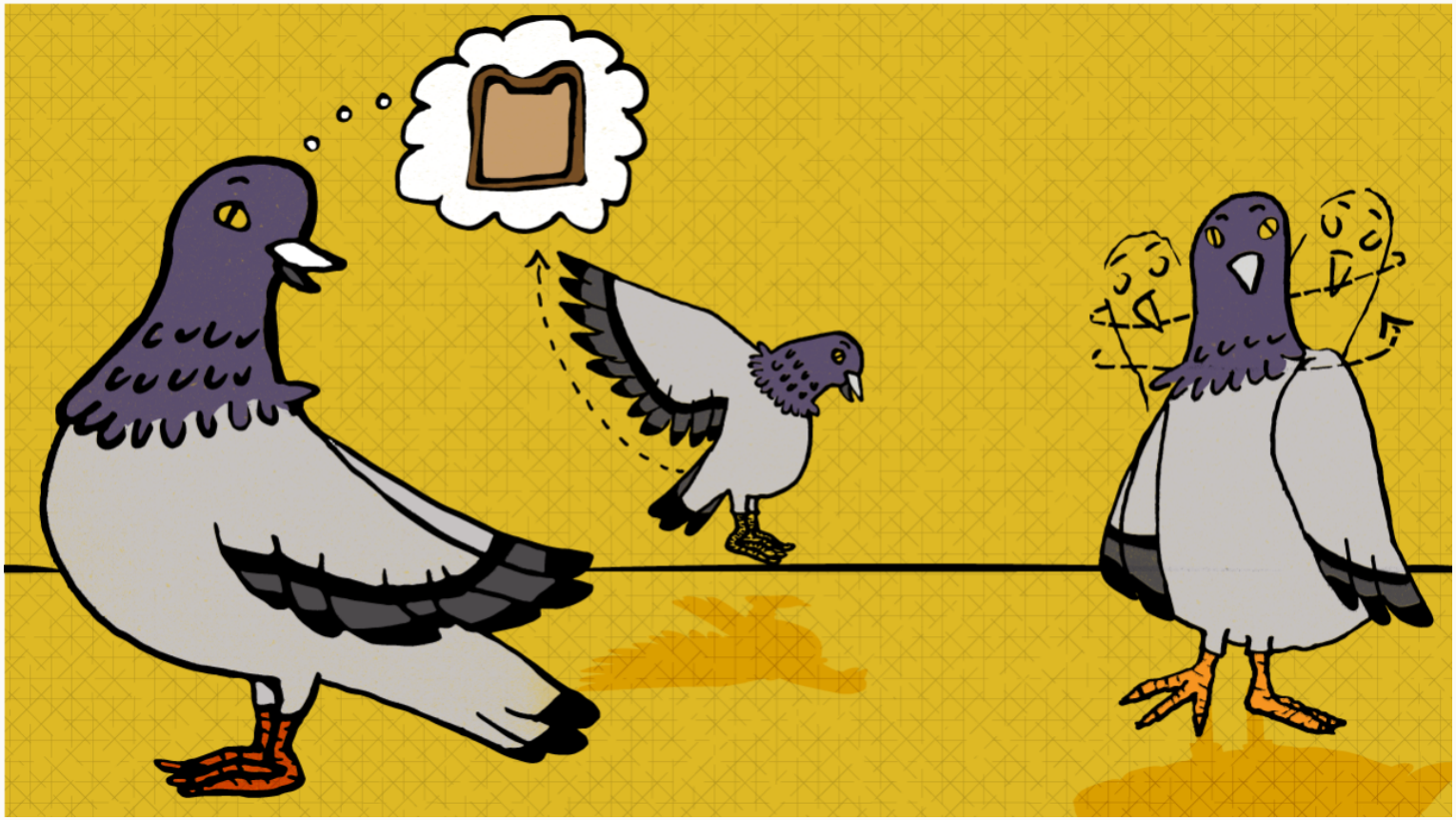
What Is Machine Learning?

Learning Examples

Learning Example I: Bait Shyness in Rats

(Image: dreamstime.com)

Learning Example II: Pigeon Superstition



(Image: vocativ.com)

What Distinguishes Successful from Unsuccessful Learning?

- Incorporation of prior knowledge that biases the learning mechanism (inductive bias).
- The stronger the prior knowledge (or prior assumptions), the easier the learning from further examples.
- The stronger the prior knowledge (or prior assumptions), the less flexible the learning.
- We will come back to these issues in our discussion of the selection of machine learning methods.

When Do We Need Machine Learning?

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When do we rely on machine learning rather than directly program computers to carry out the task at hand?

- **Complex tasks:** Tasks that we do not understand well enough to extract a well-defined program from our expertise (e.g., analysis of large and complex data, driving).
- **Tasks that change over time:** Machine learning tools are, by nature, adaptive to the changes in the environment they interact with (e.g., spam detection, speech recognition).

Types of Machine Learning

Types of Machine Learning

Supervised Learning

- Data: for every observation $i = 1, \ldots, n$, we observe a vector of inputs x_i and an output y_i.
- Goal: fit a model that relates output y_i to inputs x_i in order to accurately predict the output for future observations.
- If Y is quantitative, then this problem is a regression problem; if Y is categorical, then it is a classification problem.

Types of Machine Learning

Unsupervised Learning

- Data: for every observation $i = 1, \ldots, n$, we observe a vector of inputs x_i but no associated output y_i.
- Goal: learning about relationships between the inputs or between the observations.