Introduction to Machine Learning

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Problem Definition of Machine Learning: How to extract meaningful information from data.

Machine learning gives you tools to achieve this goal. Several definitions of machine learning are given with increasing detail.

Definition 1. Machine learning is the process of gaining expertise from experience. □

Definition 2: Machine learning is simply curve fitting, or regression analysis with a very large number of parameters. □

Definition 3. As per Philippe Rigollet (2015), MIT notes.

Figure 1: The machine learning blackbox (left) where the goal is to replicate input/output pairs from past observations, versus the statistical approach that opens the blackbox and models the relationship.

Thus machine learning is the field of study that gives computers, the ability to learn without being explicitly programmed. □

Definition 4. As per Tom Mitchell, *Machine Learning* 1997. A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P; if its performance at the tasks T, as measured by P, improves with the experience E. □

The above definition means: Improve on task T, with respect to performance metric P, based on experience, E.

Examples

1. T: Playing checkers.

   P: Percentage of games won against an arbitrary opponent.

   E: Playing practice games against itself.

2. T: Recognizing hand-written words.

   P: Percentage of words correctly classified.

   E: Database of human-labeled images of handwritten words.

3. T: Driving on four-lane highways using vision sensors.

   P: Average distance traveled before a human-judged error.

   E: A sequence of images and steering commands recorded while observing a human driver.

4. T: Categorize email messages as spam or legitimate.

   P: Percentage of email messages correctly classified.

   E: Database of emails, some with human-given labels. □

A precise definiton of machine learning based upon statistical learning theory is given else where.

1. **Machine Learning Methodology**

Machine learning methodology / technique has three steps.

Step 1: Training.

Step 2: Testing

Step 3: Inference.

Step 1: Training

(a) Data collection - samples.

(b) Model selection - probability distribution to model process.

(c) Parameter estimation - values / distributions.

Step 2: Testing: Test the algorithm with the data not used in training. If response is satisfactory, then model is ready (go to Step 3), otherwise collect more data and train the model (go to Step 1).

Step 3: Inference: Find response to queries.

2. **Relevant Disciplines**

– Artificial intelligence

– Statistics

– Bayesian methods

– Computational complexity theory

– Information theory

– Signal processing

– Philosophy

– Psychology and neurobiology

- Statistics
- Linear algebra
- Multivariate calculus
- Optimization
- Economics
- Visualization
- Engineering
- Databases

3. **Some Examples where Machine Learning is Used**

- Data mining: Using historical records to improve decisions. Example: medical records yield medical knowledge.

- Software applications: That we cannot program by hand. Example: autonomous car driving, and speech recognition.

- Self customizing programs. Example: news reader that learns user interests.

- Credit card fraud detection.

- Spam filtering

- Digit recognition on checks, zip codes etc.

- Detecting faces in images
- MRI image analysis
- Recommendation system
- Search engine
- Handwriting recognition
- Scene classification
- etc...