Machine Learning Concepts

Lecture 10

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Machine Learning

Computers are programmable devices that can be used for very different computational tasks. In general, computers are programmed task-specifically. Hence, we need to write different codes for different tasks.

Rather than explicity programming a computer to do a specific task, it can find out how to act for this task using the input data via machine learning.

Examples of Machine Learning

Many examples exist for Machine learning applications and many of them is getting in to our daily lives.

One reasonably popular one is self-driving cars. Google initiated a big project that is named Waymo and has recently achieved substantial successes.

Details and introductive video is presented in the official web site of Waymo: https://waymo.com/

If we think about all possible decisions and manuevers in a traffic that a driver can give and do, we can see that such an application is not possible or feasible to be coded explicitly without using machine learning.

Examples of Machine Learning

Another famous example that we may come accross in our daily lives resides in mobile phones.

Mobile assistant Siri is one example of ML applications in mobile phones. It proccesses the human voice, extacts commands and questions and returns an answer accordingly.

Think about all possible questions a person can ask and think if you can code all possible answer to those questions explicitly. Do you think such an approach would be feasible?

Types of Machine Learning

There are different types of machine learning algorithms.

They can be classified into two classes:

- Supervised Machine Learning
- Unsupervised Machine Learning

This classification is based on whether machine learning algorithm requires labeled data or not.

Supervised Machine Learning

Supervised machine learning algorithms requires labeled data as input. This labeled data is also called as ground truth. The algorithm learns the parameters of a function/functions that relates the input features to these labels.

In biomedical engineering, machine learning algorithms that is used for diagnosis are in general supervised machine learning algorithms.

Supervised Machine Learning

we can group supervised learning algorithms into two categories:

- Classifiers: Labeled data contains discrete class labels such as malignant and benign for tumor types or healty and ill for patients. We can further group classifiers into two categories: binary classifiers and multi-class classifiers, depending on the number of classes.
- Regressors: Labeled data contains continous numbers rather than class labels (remember least squares regression from our previous lectures).

Unsupervised Machine Learning

Different from supervised machine learning algorithms, unsupervised machine learning algorithms do not require labeled data as input.

These algorithms generally used to infer/reveal information about the structure of the input data/features.

Clustering algorithms such as k-means and dimensionality reduction algorithms such as PCA and t-SNE are examples of unsupervised learning algorithms.

Training & Test Set

In machine learning, it is very crucial to seperate the data into training and test sets.

Training set is composed of data which the learning algorithm discovers the optimum parameters. This is the data which is used for learning.

Test set is the data that is used to evaluate the performance of the learning algorithm.

Generalization & Overfitting

In cases where we do not provide sufficient labeled data as input and when the complexity of the learning algorithm is high, overfitting may occur.

In case of overfitting, the learned model is not generalizable which means even it achieves highly accurate results on the training set, it produces results with poor accuracy on the test set.

This is one important reason of why we split the data before training.

The Performance

Assume we want to find out/classify healthy and patients with cancer. Our classifier indicates cancer patients with label 1 (positive) and healhy ones with label 0 (negative).

We can have the following outcomes from our machine learning (ML) algorithm:

True Positive (TP): Patients who actually have cancer and labeled as 1 by our algorithm.
False Positive (FP): Patients who are actually healhy but labeled as 1 by our algorithm.
False Negative (FN): Patients who actually have cancer but labeled as 0 by our algorithm.
True Negative (TN): Patients who are actually healthy and labeled as 0 by our algorithm.

Confusion Matrix

These results can be shown as a matrix which is called a confusion matrix:

		True diagnosis	
		Positive	Negative
ML result	Positive	*TP*	*FP*
	Negative	*FN*	*TN*

The accuracy:

$$\frac{TP + TN}{TP + FP + FN + TN}$$