CSE 3046: PROGRAMMING FOR DATA SCIENCE

THEORY DIGITAL ASSIGNMENT

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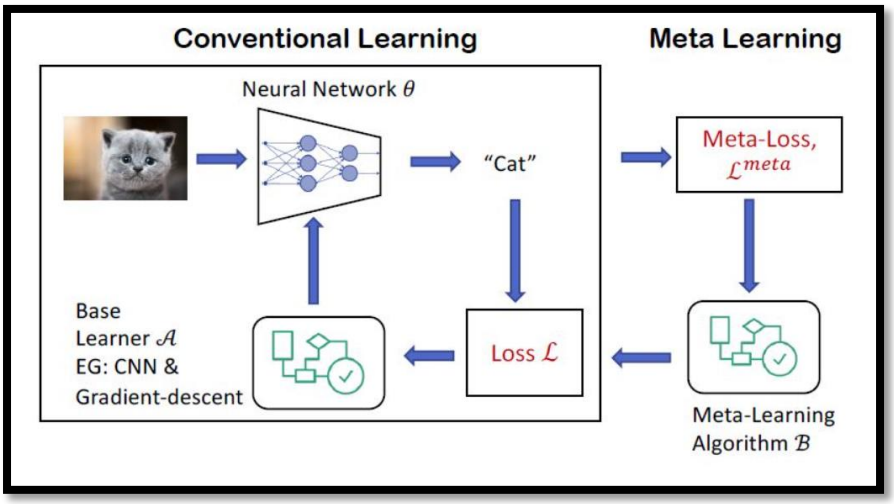
META LEARNING

Have you ever wondered what is Meta?
Meta usually refers to details about something else and signifies raising the level of abstraction one step. Over the past five years, interest in meta learning has increased. Now that we are familiar with the word "meta," let's analyse how the term is used in machine learning, such as "meta-learning."

META LEARNING:

Learning about one's own learning and learning processes is the focus of the meta learning, subfield of metacognition. Its current meaning of an abstract recursion, or "X about X," comparable to its use in meta-knowledge, meta-memory, and meta-emotion, is where the term "meta" derives from.

Metadata from learning algorithms is used as an input by these algorithms. They then formulate forecasts and offer data regarding the outcome of these learning algorithms. Data about data is what metadata is to non-technical users. For instance, the size, resolution, style, date of creation, and owner of an image can represent its metadata in a learning model.



While tasks are addressed from scratch using a preset learning algorithm in conventional learning, meta-learning tries to enhance the algorithm by taking into account the experience of numerous learning episodes.

A Formal definition:

Conventional machine learning aims to produce a model **fθ** that can be used to make predictions **ŷ =fθ(x)** for data inputs **x**.
For example, recognizing objects in images, or transcribing speech in audio. This is achieved by applying a learning algorithm **A** that inputs a training dataset **Dtr={(xi,yi)}** and outputs the trained model **θ***.

$$\theta^* = \mathcal{A}_\phi(D^{tr}) = \text{argmin}_\theta \mathcal{L}(D^{tr}, \theta)$$

The algorithm is usually hand-designed and typically performs a minimization with respect to some loss function $\mathscr{L}$,

For example by iterative gradient descent with respect to θ, **θt=θt−1−α∇θL(Dtr,θ)**. The performance of the resulting model f_{θ^*} depends on many factors that go into the design of the learning algorithm, such as neural architecture and optimization strategy. These are made explicit above in the quantity ϕ that parameterizes learning algorithm Aϕ.

Meta-learning aims to derive new learners that lead to better learning performance when used for training. To achieve this, we may exploit a whole set of learning tasks (e.g., prior objects to recognize in computer vision), each of each of which is divided into a training and validation set .

D={Dtrj,Dvalj}Mj=1. In this case the meta-training procedure should optimize the learner to solve this whole set of datasets.Meta-learning therefore involves two layers learning optimization: an inner optimization performed by the base learner Aϕ updates the model θ to solve L, and an outer optimization performed by the meta-learner B updates the base learner ϕ to solve Lmeta.

Meta-Learning with Recurrent Models:

A pattern that is repeated. Meta-learning is a technique that is used with recurrent neural networks and long short-term memory networks. In order for this technique to operate, an LSTM model must first be trained to learn a certain dataset before being used as the basis for another learner. It accounts for the optimization technique used to train the primary model. The parameterization of the meta-inherited learner enables it to quickly initialise and converge while still being able to adapt to changing conditions.

How does meta learning work?

Typically, the outputs and metadata of machine learning algorithms are used to train a meta learning algorithm. Its abilities are evaluated after training and used to produce final predictions.
For example, we may want to train a model to label different breeds of flowers-bikes.

- We first require a set of annotated data.
- On the training set, many ML models are constructed. They might concentrate just on particular dataset subsets.
- These models' performance is enhanced by the meta training procedure.
- On the basis of the knowledge gained through the earlier training process, the meta training model can also be utilised to create a new model from a small number of examples.

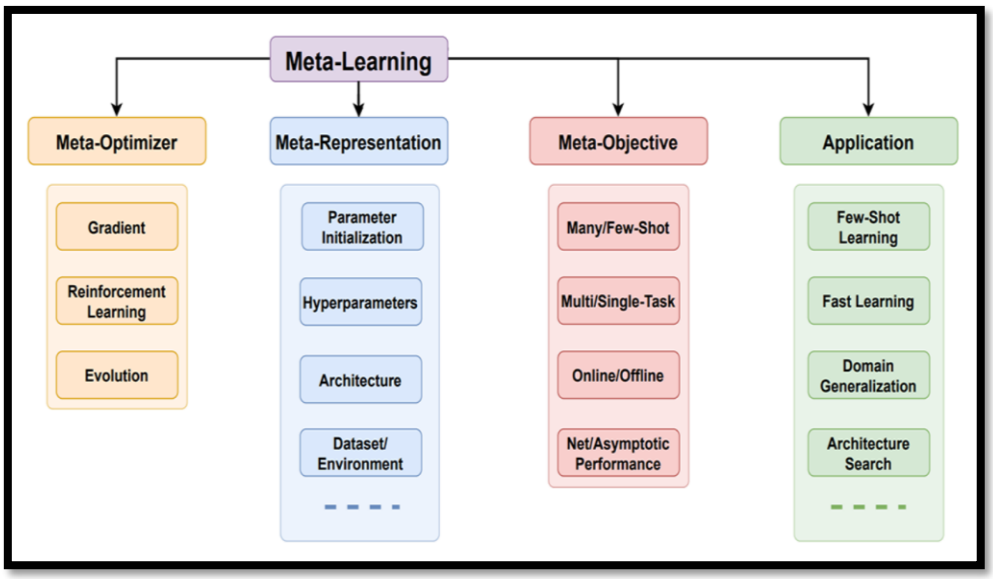
Meta-learning in an AI system is the capability to learn to perform a variety of complex tasks by applying the concepts it learned for one task to other activities.Meta-learning seeks to improve the algorithm by taking into account the experience of several learning episodes, in contrast to conventional approaches to AI, which solve tasks from scratch using a fixed learning algorithm.

Meta-learning in Reinforcement Learning:

Reinforcement learning meta-parameters should be adjusted to account for animal performance and environmental dynamics. Here, we recommend a dynamic, adaptive meta-reinforcement learning technique for fine-tuning these meta-parameters. Both a non-linear control task and a simulation of a Markov decision task were used to test our technique. Our findings demonstrate that, in both static and dynamic contexts, the algorithm reliably determines the proper meta-parameter values and manages the meta-parameter time course.

Meta Learning algorithm

Algorithms that learn how to aggregate the predictions from ensemble members, such as stacking, are commonly referred to as meta-learning algorithms. There are three key design axes that go into defining a particular instantiation of a meta-learning algorithm. They are



Meta-Optimizer

The search method the meta-learner use to find a better learner is defined by the meta-optimizer. Common strategies include reinforcement learning and gradient-descent (RL)

Meta-Representation

The search space in which the meta-learner will look for a better learner is specified by the meta-representation. The space of neural architectures is searched, for instance, using neural architecture search (NAS).

Meta-Objective

The meta-objective, which will be unique for each use-case, describes the objective of meta-learning. The design of the loss and related inputs for the outer optimization are the main determinants of it. To find a learning algorithm that is data efficient, for instance, we employ small datasets in meta-learning for few-shot learning.

Application

There are a wide variety of emerging application directions such as learnable data augmentation, dataset distillation, meta-learning for domain generalization,etc

Benefits of Meta Learning:

1)Higher model prediction accuracy:

Optimization of learning algorithms, such as tuning hyperparameters for the optimal outcomes. Thus, a meta-learning algorithm is used to execute this optimization work, which is typically carried out by a human.

2)Building more generalized models:

Learning to answer multiple problems at once, not just one: One model's training on one particular set of data is not the main emphasis of meta-learning.

3)A faster,cheaper training process:

Supporting learning from fewer examples and increase speed of learning processes by reducing necessary experiments.

4)Ease of algorithms:

Helping learning algorithms better familiarize to changes in conditions, categorizing clues to design better learning algorithms.

CONCLUSION:

- Meta-learning describes machine learning algorithms that acquire the knowledge and understanding from the outcome of other machine learning algorithms.
- Meta-learning also refers to algorithms that learn how to learn over a set of related prediction tasks, referred to as multi-task learning.
- Meta-learning algorithms are ensemble learning techniques that learn how to combine predictions from ensemble members, such as layering.
- Meta learning algorithms take as input learning algorithm metadata. They then formulate forecasts and offer data regarding the outcome of these learning algorithms.