Chapter 1
Optimization Approaches in Meta-Learning Models

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ABSTRACT

This book chapter provides a comprehensive overview of optimization approaches in meta-learning, focusing on techniques and their applications. Meta-learning is a subfield of machine learning that emphasizes acquiring knowledge from previous tasks and applying the same to new tasks in order to develop the models with improved learning process. Optimization plays a crucial role in meta-learning models by enabling the effective acquisition and utilization of knowledge across tasks. This chapter provides an overview of various optimization approaches employed in meta-learning models which entail changing the model's input parameters or learning algorithms to facilitate effective learning across various tasks or domains. The methods tackle the problem of effective learning without compromising with accuracy and precision in performance focusing on the benefits of meta-learning frameworks in practical situations which may be considered as the real-world applications of these approaches.

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1.1 Introduction to Meta-Learning

Meta-learning is the field of machine learning which refers to "learning to learn'', and involves understanding algorithms and metadata. Metadata is data that describes other data. Traditional machine learning algorithms focus on training a model which requires a large dataset. The difficulties that traditional machine learning techniques have when dealing with sparse data and the requirement for ongoing learning are the driving forces behind meta-learning. Gathering significant amounts of labelled data for every new activity or area can often be time-consuming, expensive, or even impractical in real-world situations. This problem is addressed by meta-learning, which uses prior information from related tasks or domains to speed up learning on new, unknown tasks. Meta-learning aims to find the best-performing algorithm and parameters of the algorithm, optimizing the number of experiments and resulting in better predictions in a lesser time (Khan et al., 2020). The algorithms applied in meta learning can adjust optimization and behave to be good at learning with just a few examples. The goal is to make it easy to achieve artificial general intelligence and move artificial intelligence closer to emulating how humans learn and solve problems. Meta-learning acts as a two-level learning process. The model accumulates general knowledge and creates a collection of parameter initializations or representations that are applicable to various tasks at the first level of learning, which entails learning from a set of fundamental tasks or domains. The second level involves modifying the model parameters or changing the representations to swiftly adapt to new tasks or domains, frequently with little data.

1.2 Key Concepts and Approaches

Meta-learning has a variety of approaches, such as metric-based, model-based, and optimization-based methods (Huisman et al., 2021) which helps to find the best-performing algorithm.

1) Meta-learning based on metrics entails the acquisition of a distance measure that may be applied to the comparison of instances from various tasks. The objective is to develop a statistic that the model can use to generalise to new tasks and accelerate learning.
2) Model-based meta-learning: This strategy involves studying a model that may be applied to produce new models for various tasks. The objective is to develop a model that can be generalised to new activities and produce models that excel at those tasks.