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Meta-Learning: Learning to Learn in Machine Learning

Dr. T.V.S. Padmaja[1*]

[1]*Principal & Head, Department of English.*

Abstract

Within the deep learning domain, one of the most active study areas is meta-learning. There are several perspectives within the Artificial Intelligence (AI) community that support the hypothesis that meta-learning is a stepping stone towards the development of Artificial General Intelligence (AGI). Recent years have witnessed an increase in the creative development of meta-learning systems. The most recent research results are compiled in this book to provide readers a comprehensive grasp of meta-learning and how it could affect different machine learning applications. With the help of this technological description, meta-learning and its applicability to real-world problems are intended to progress.

Keywords: Meta learning, Artificial Intelligence, Artificial General Intelligence, machine learning.

1 Introduction

"Meta learning" was first coined in the context of instructional brain research. Metalearning is the process of monitoring and controlling one's own learning, according to Biggs, one of the researchers who is now regularly quoted. Consequently, comprehending and altering the learning process at a level beyond just picking up subject-specific information is known as meta-learning. In this manner, a person who is ready and conscious of metalearning may assess their preferred method of learning and modify it to suit the demands of a particular assignment. This description of meta learning in an AI environment has many similarities. Subject knowledge transforms into base realising, which is the process of gathering

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experience for a single specified learning activity. Establishing proficiency with many applications of a framework for learning in line with higher level criteria is the focus of metalearning [1].

Over the past 20 years, artificial intelligence research has faced new challenges, including an explosion in the amount of available computations (including methods for post-processing, pre-processing, and parametrisation) and an exponential growth in the variety of applications made possible by advances in computing power and the ease with which computer-readable data sets can be obtained. Gaining a better grasp of AI via metal earning could be a lifesaver when it comes to avoiding time-consuming trial tactics for "calculation choice and beast power searches" for appropriate parametrisation. Understanding how to use a predictive model's prior performance on certain tasks may enhance the way a learning calculation is presented and increase the likelihood that one will understand why a given calculation performs effectively [2].

2 Literature Review

(Duan et al., 2024) [3] Improvements in technologies such as "microservices, cloud computing, and 5G" have led to a dramatic increase in the variety of technical aspects and the complexities of network management systems. The increasing needs for monitoring and maintenance have made conventional operations and maintenance approaches unsuitable due to the development in complexity. Consequently, an approach that leverages big data technologies and artificial intelligence (AI) called "artificial intelligence for IT operations (AIOps)" has emerged. AIOps is essential for improving customer happiness and service quality, increasing engineering efficiency, and cutting operational expenses. The main responsibilities of AIOps, including anomaly detection, log fault analysis, and classification, are covered in detail in this article. The lack of defect sample data has been shown to be a major difficulty in many AIOps activities, suggesting a logical fit between these jobs and few-shot learning. Inspired by model-agnostic meta-learning (MAML), we provide a novel anomaly detector, MAML-KAD, for application in a variety of AIOps tasks. Results demonstrate how meta-learning algorithms may be used in a broad range of AIOps activities and validate that they improve AIOps tasks. To further simplify AIOps, we built a platform that simplifies log collecting, caching, and alerting while integrating "meta-learning into its diagnostic core".

(Vettoruzzo & Bouguelia, 2023) [4] This paper offers a thorough technical overview of meta-learning with a focus on its practical applications when data may be costly or hard to get by. The most recent methods for meta-learning are examined, along with their connections to self-supervised learning, personalised federated learning, transfer learning, constant learning, multi-task learning, domain adaptation and generalisation, and self-supervised learning. The study emphasises the links between these subjects and the field of meta-learning, showing how developments in one field might benefit the other without unnecessary duplication of effort. The study also explores more advanced meta-learning problems, including unsupervised meta-learning, learning from complicated multi-modal task distributions, continuous meta-learning, and learning to effectively adjust to changes in data distribution. The report concludes by outlining unresolved issues and difficulties for further study in the area. In order to provide a comprehensive grasp of meta-learning and its possible influence on different machine learning applications, the most recent research results are compiled in this work. We think that this technical summary will further the research on meta-learning and how it relates to addressing problems in the real world.

(Cheng et al., 2023) [5] The overarching objective of AI in IT operations, or AIOps, is to maximise availability by integrating AI capabilities with the massive amounts of data produced by IT operations processes, especially in cloud infrastructures. This approach produces actionable insights. Artificial intelligence (AI) has many applications and a vast range of issues that it may be used to solve to improve operational efficiency. In this section, we analyse the AIOps vision, trends, possibilities, and difficulties, with a particular emphasis on the underlying artificial intelligence approaches. We go into great detail about the main categories of data that are released by IT operations activities, as well as the scope, difficulties, and applications of their analysis. The primary AIOps duties are divided into four categories: automated actions, root cause analysis, failure prediction, and incident detection. After talking about how each task's challenges are formulated, we provide a taxonomy of methods for resolving them. Additionally, we highlight relatively unexplored topics—particularly those that might greatly benefit from advancements in the literature on artificial intelligence. Insights into industry trends and prime investment prospects are also offered.

(Wang, 2022) [6] Presenting the successful "Artificial Intelligence for IT Operations (AIOps)" method we developed for a cloud storage array, which enables us to handle irregular hard disc failure data and forecast disc failure, is the primary goal of this post. In order to remove unnecessary raw data, first preprocessed the imbalanced disc data. In accordance with "SMART (Self-Monitoring, Analysis, and Reporting Technology)" properties, 14 basic characteristics were obtained in order to construct training features for disc failure prediction. Second, generated over 1500 features using 16 extraction techniques and a feature extraction package named Tsfresh. We used a significance test in conjunction with the Benjamini Yekutieli approach to identify the most relevant characteristics in order to expedite the machine learning process. As a single predictive model is not anymore performing adequately on the imbalanced dataset, we suggest using the outcomes of predictions from three algorithms—XGBoost regression, LSTM categorisation, and XGBoost classification—as novel characteristics input into a combined stacking learning model. This will allow for the generation of more precise and accurate prediction results. Disc failure and the need to replace the disc within the range of 0-14 days, 14-42 days, and longer can be reliably predicted using the suggested stacking ensemble learning model, according to the experimental findings.

(Kudari & Hembram, 2021) [7] One of the most significant aspects of natural development is the process of learning. Meta-learning is the term used to describe learning algorithms in machine learning that acquire information from other learning algorithms. All machine learning systems gain from the repeated use of meta-learning. However, in terms of adaptability degree, meta-learning is quite different from base-learning. With a year-long process of progressive progression towards evolution, it presents both advantages and difficulties of its own. We refer to this approach as Learning to Optimise. It is an optimization-based formulation of meta-learning that automatically learns how to create an optimisation algorithm. A thorough examination of meta-learning in detail is necessary to comprehend how it really impacts different industries and if it makes things easier or harder. The most interesting part of this work is the difficulties we have in achieving this objective and the advantages for research usage. Within the deep learning domain, one of the most active study areas is meta-learning. There are several perspectives within the Artificial Intelligence (AI) community that support the hypothesis that meta-learning is a stepping stone towards the development of Artificial General Intelligence (AGI).

(Hospedales et al., 2021) [8] The field of meta-learning, or learning-to-learn, has seen a dramatic surge in attention in recent years. In contrast to traditional AI techniques, which start with a fixed learning algorithm and work their way up to solving problems, meta-learning tries to enhance the learning algorithm itself based on the knowledge gained from many learning episodes. This paradigm offers a way to address many of the traditional deep learning problems, such as generalisation and bottlenecks in data and processing. The current state of meta-learning is outlined in this survey. First, we go over terminologies and place meta-learning in relation to other related disciplines like hyperparameter optimisation and transfer learning. Next, we suggest a novel taxonomy that offers a more thorough analysis of the current landscape of meta-learning techniques. We study meta-learning's possible applications and successful applications, including reinforcement learning and few-shot learning. Lastly, we address open research questions and potential directions.

3 Conclusion

The emergence of meta-learning has been quite significant, and its potential to extend human progress makes it very valuable. This research's primary goal was to draw attention to its persistence and the difficulties and advantages that came with it. While meta-learning seems to be highly popular, applying these algorithms to real-world issues is still exceedingly difficult. These will probably get more dependable and trustworthy because to improvements in meta-learning algorithms, specialised machine learning hardware, and computing power that is always increasing. We review effective implementations of meta-learning and its possible applications, including reinforcement learning and few-shot learning. Lastly, we address open research questions and potential directions. The scientific community has given meta-learning a lot of attention, and there is a growing collection of tools available for fast learning, adaptability, few-shot learning, and other applications. Within the deep learning domain, one of the most active study areas is meta-learning. There are several perspectives within the Artificial Intelligence (AI) community that support the hypothesis that meta-learning is a stepping stone towards the development of Artificial General Intelligence (AGI).

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