Avoiding Catastrophic Forgetting in Visual Classification using Human-Like Concept Formation

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Abstract

Deep neural networks have achieved remarkable success in the field of machine learning, particularly in vision tasks. However, they often suffer from catastrophic forgetting when learning new tasks sequentially. Despite different strategies such as regularization and replay methods, which try to mitigate the issue of catastrophic forgetting, neural networks, as parametric learning models, are hindered by varying hyperparameters that can affect their task-specific performance. At the same time, there's an unexplored domain in adopting human-like cognitive learning approaches, such as Cobweb (Fisher 1987), in visual categorization tasks.

In our current research we propose Cobweb/4V, a novel visual classification approach that builds on Cobweb, a concept formation approach that is inspired by the way humans incrementally learn new concepts over time. The Cobweb/4V stands out for its ability to use matrix representations for images and continuous features rather than nominal features. In addition, it incorporates the information-theoretic category utility, as established by (Corter and Gluck 1992) into its learning process. For image categorization, Cobweb/4V employs a reformed measure that is rooted in the original category utility (Corter and Gluck 1992) and Bayes' Theorem, aligning with the idea from Anderson (1991).

In our research, we conduct a comprehensive evaluation of our proposed method, Cobweb/4V, and demonstrate its proficiency in learning visual concepts. Our findings reveal that Cobweb/4V requires less data to achieve effective learning outcomes compared to traditional methods. Moreover, it exhibits more stable performance over time and achieves commendable asymptotic behavior, without catastrophic forgetting effects. Cobweb/4V's ability to retain prior knowledge while adapting to new information, combined with its data efficiency and strong performance, positions it as a promising alternative to traditional deep learning approaches.

Our analysis of the Cobweb/4V underscores its alignment with human-like learning models for vision tasks, characterized by its modular approach, on-demand composition, relational comprehension, piecemeal acquisition, incremental learning, guidance by existing knowledge, and rapid refinement (Langley 2022). The characteristics of Cobweb/4V mirror the innate learning strategies found in human cognition, suggesting a significant stride towards more intuitive AI systems. We conclude our study by discussing Cobweb/4V's promising capabilities in vision categorization tasks and propose a roadmap for future evaluations. This entails an expansive set of benchmarks and detailed comparisons with incremental learning techniques employed in neural networks, thereby setting the stage for a comprehensive understanding of Cobweb/4V's role in advancing more human-like learning models.

References

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