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# Machine learning and deep learningA review for ecologists

Maximilian Pichler, Florian Hartig

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| Author ORCID | 0000-0003-2252-8327 |
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# Abstract

Abstract The popularity of machine learning (ML), deep learning (DL) and artificial intelligence (AI) has risen sharply in recent years. Despite this spike in popularity, the inner workings of ML and DL algorithms are often perceived as opaque, and their relationship to classical data analysis tools remains debated. Although it is often assumed that ML and DL excel primarily at making predictions, ML and DL can also be used for analytical tasks traditionally addressed with statistical models. Moreover, most recent discussions and reviews on ML focus mainly on DL, failing to synthesise the wealth of ML algorithms with different advantages and general principles. Here, we provide a comprehensive overview of the field of ML and DL, starting by summarizing its historical developments, existing algorithm families, differences to traditional statistical tools, and universal ML principles. We then discuss why and when ML and DL models excel at prediction tasks and where they could offer alternatives to traditional statistical methods for inference, highlighting current and emerging applications for ecological problems. Finally, we summarize emerging trends such as scientific and causal ML, explainable AI, and responsible AI that may significantly impact ecological data analysis in the future. We conclude that ML and DL are powerful new tools for predictive modelling and data analysis. The superior performance of ML and DL algorithms compared to statistical models can be explained by their higher flexibility and automatic datadependent complexity optimization. However, their use for causal inference is still disputed as the focus of ML and DL methods on predictions creates challenges for the interpretation of these models. Nevertheless, we expect ML and DL to become an indispensable tool in ecology and evolution, comparable to other traditional statistical tools.



Keywords: machine learning, deep learning, artificial intelligence, ecological data analysis, predictive model


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