Chapter 7
Application of Machine Learning Techniques in Hydrometeorological Event Prediction

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ABSTRACT

Hydrometeorological events, such as floods and droughts, pose significant challenges to societies worldwide, causing loss of life and economic damage. Traditional methods of predicting such events often rely on statistical and physical models that are limited by their assumptions, uncertainties, and computational requirements. Machine learning (ML) techniques, with their ability to extract knowledge and insights from data, have shown great potential for improving the accuracy and lead time of hydrometeorological event prediction. This chapter reviews the use of ML for predicting hydrometeorological events focusing on flood and drought events. The chapter provides an overview of the application of ML techniques or algorithms for hydrometeorological events prediction. The chapter discusses data type, collection, and analysis for ML applications for predicting hydrometeorological events. The chapter presents case studies from different regions and highlights the benefits of ML-based approaches and the challenges. Finally, the chapter identifies future research directions.

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INTRODUCTION

Hydrometeorological events are natural phenomena due to the complex interplay between atmospheric, hydrological, and meteorological processes. These events can profoundly and often devastate human lives, economies, and the environment. Among the most common types of hydrometeorological events are floods, droughts, storms, landslides, and heat waves, each with unique characteristics and consequences.

Floods, one of the most destructive hydrometeorological events, result from heavy rainfall, snowmelt, or a combination of both, leading to an overflow of water in rivers, streams, and other water bodies. The inundation of land causes widespread damage to property, infrastructure, and agricultural fields and poses a significant threat to human safety. The destruction caused by floods often requires extensive recovery and rehabilitation efforts (Morán-Tejeda et al., 2019; Quesada-Román & Villalobos-Chacón, 2020).

Conversely, **drought** occurs when a region experiences an extended period of inadequate precipitation, resulting in a water deficit. These dry spells can have severe economic and social impacts, particularly in agriculture-dependent regions. Crop failure, water scarcity, and food insecurity are expected consequences of prolonged droughts, which can trigger economic losses and social upheavals (Haile et al., 2020).

Storms encompass a variety of intense weather phenomena, such as hurricanes, tornadoes, and thunderstorms. Strong winds, heavy rainfall, lightning, and thunder characterize these events. Storms can cause significant damage to infrastructure, homes, and natural ecosystems. Hurricanes, in particular, are notorious for their destructive potential, causing widespread devastation in coastal regions (Yang et al., 2023).

Landslides are another hazardous hydrometeorological event occurring when soil, rock, or other materials move down a slope. Heavy rainfall, earthquakes, or human activities like construction or mining can trigger landslides. The impact of landslides can be catastrophic, resulting in the destruction of homes, roads, and other infrastructure and posing a severe risk to human life (Lacroix et al., 2020).

Heatwaves are prolonged periods of excessively high temperatures and humidity. These extreme weather events can have severe health implications, particularly for vulnerable populations such as the elderly, young children, and individuals with pre-existing medical conditions. Heat-related illnesses and deaths can significantly increase during heat waves, making them a pressing public health concern (Zeppetello et al., 2022).

This chapter primarily focuses on predicting drought and flood events using machine learning. Understanding and predicting drought and flood events are crucial for effective disaster preparedness, risk mitigation, and climate adaptation. These events can have far-reaching consequences, and their increasing frequency and intensity due to climate change necessitate advanced prediction and early warning systems. The application of machine learning techniques in hydrometeorological event prediction holds immense promise in improving the accuracy and effectiveness of forecasting models. By harnessing the power of data-driven approaches and innovative algorithms, we can enhance our ability to forecast floods, and drought events, empowering communities to take proactive measures and build resilience against these natural disasters.

Overview of Machine Learning and Its Potential for Hydrometeorological Event Prediction

In recent years, machine learning techniques have emerged as a powerful and promising approach to enhance the prediction of drought and flood events. The Role of Machine learning, a subfield of artificial