

Chapter 6

Utilizing Machine Learning for Enhanced Weather Forecasting and Sustainable Water Resource Management

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ABSTRACT

Every phase of human life is influenced by nature; therefore, weather forecasting and water management are challenging tasks as they work according to environmental changes. The traditional weather forecasting model was done using historical data in a physics model, which leads to unsteady results. With machine learning and artificial intelligence advancement, weather forecasting and water management have undergone revolutions to predict future data analysis. This chapter provides an overview of essential weather forecasting attributes and different data acquisition and preprocessing elements in water management. The chapter's subsequent sections detail the many stages needed for weather forecasting and the various machine-learning algorithms that may be used to forecast weather conditions by recognizing patterns and then analyzing them. In addition to this, the chapter also highlights applications of water resource management. Since water is a vital resource, automation and controlling allocation and distribution are crucial tasks, which are also outlined.

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INTRODUCTION

Climate change is the global phenomenon that is most talked about in this generation. It is known to cause natural calamities like storms, cyclones, and floods. From this fact stems the need to have accurate systems to help us tackle these issues. The advancement of technology can provide real solutions to such problems. This chapter focuses on two significant issues. The first is weather forecasting, and the second is water management. Both these topics are closely related since they deal with monitoring and using natural resources.

As weather conditions keep changing, predicting weather forecasts around the globe is very important. According to the study conducted by Salcedo-Sanz et al. (2023), traditional numerical weather prediction methods involve using historical data in a physics model that simulates the atmosphere's behavior based on thermodynamics and fluid dynamics principles, leading to unsteady results. These models use a system of partial differential equations to represent the physical processes governing the atmosphere's motion and thermodynamics, and they aim to predict how the atmosphere will evolve. However, these systems, which include partial differential equations for a given physical model that are unstable and incurred uncertainties in the initial measurements of the atmospheric conditions, restricted accurate weather forecasting only for a few days, after which weather forecasts became significantly unreliable. To get beyond the limitations above and enhance forecasting for precise results, meteorologists have combined Machine Learning (ML) algorithms with traditional methodologies that use historical data to train models, and then these models will be used to anticipate future data analysis.

However, the current generation's most pressing problem is the unprecedented pressure on water resources. Furthermore, unabating water scarcity and extreme weather conditions like floods and dry spells are perceived as the biggest threats to global prosperity and stability. There is an increased level of awareness in acknowledging the fact that there is a need to preserve and use water resources more efficiently to reduce wastage and avoid drought situations. Several researchers have predicted that the world is bound to face extreme water scarcity. A study conducted by Parwal (2015) discusses the water management issues faced in India. The author emphasizes the high demand for water sources for agriculture, industries, cooling, and extraction. The author also sheds light on the outcome of various reports published by world-renowned bodies that mention the country's dire state of water resources. It is, therefore, imperative to maintain the integrity of the planet's natural reserves.

Additionally, a report published by ADRI (India Water Facts, 2017) highlights the major concerns faced by India about water management. It states that the country faces a problem of water depletion. It mentions that rainfall, occurring annually, is a significant source of replenishment for water sources, contributing about 58% of the total replenishment sources. It also states that 70% of the water sources are polluted with contaminants like arsenic and fluoride.

Furthermore, in another study conducted by Cosgrove and Loucks (2015), the paper discusses the challenges and possible future directions for effective water management. It may seem at times that a particular area has an adequate supply of water; however, the spatial and temporal distribution of the water resource is inadequate, and the regions located away from the source will most definitely face challenges in getting access to the water and also in distributing it efficiently. The authors also elaborate on the failure of traditional methods, as previously erroneous estimates and incomplete studies led to problems like disruption and overallocation of resources. Overuse of resources has also been the cause of pollution of water sources. The tremendous increase in population has led to high per capita water consumption. With the population still on the rise, the water sources are also bound to increase consump-

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