Chapter 8
AI-Decision Support System: Engineering, Geology, Climate, and Socioeconomic Aspects' Implications on Machine Learning

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ABSTRACT

From the impact of several corporeal, mechanized, ecological, and civic conditions, underground water pipelines degrade. A motivated administrative approach of the water supply network (WSN) depends on accurate pipe failure prediction that is difficult for the traditional physics-dependent model to provide. The research used data-directed machine learning approaches to forecast water pipe breakdowns using the extensive water supply network's historical maintenance data history. To include multiple contributing aspects to subterranean pipe degradation, a multi-source data-aggregation system was originally developed. The framework specified the requirements for integrating several data sources, such as the classical pipe leakage dataset, the soil category dataset, the geographic dataset, the population count dataset, and the climatic dataset. Five machine learning (ML) techniques are created for predicting pipe failure depending on the data, like LightGBM, ANN, Logistic Regression, K-NN, and SVM algorithm.

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INTRODUCTION

The management of the WSN depends on providing a consistent and secure water supply. The main parts of a WSN are water distribution pipelines, which transport water from water treatment facilities to users. Since some of the subterranean water pipes in US metropolitan communities were installed in the 19th century, this corrosion is particularly severe for those pipelines. Each year, over 2 trillion gallons of potable water are lost due to the more than 700 water main breaks that occur daily in Canada and the United States. Water pipe breakdown may result in huge financial losses and have a negative effect on society or the environment. The US Water Service Agency estimates that the substitution expenditures of the US's current WSNs and their expected expansions would total more than $1 trillion over the next twenty years. These terrible problems put pressure on management to adopt management practices for long-term improvement and credible pipe failure estimation models to implement preventive support for loss minimization.

In order to create accurate prediction models, it is essential to identify the important variables (also known as input variables) that affect pipe failure. Experimental testing, finite element models, and historical data analysis have all been used in the last several decades to evaluate numerous elements that might cause pipe breakage. These elements can be extensively divided into 3 categories, such as physical, operational, and environmental, according to a recent assessment. The pipe's age, length, material, and diameter are among the physical parameters that are most often taken into account. For instance, Kettle and Goulter used statistical methods to determine the connection between pipe diameters and break probability.

Longer pipes are more likely to fail, as established by (Tai. P. et al. 2023). The frequency of prior failures is the operational component that has been studied the most. These studies show that a pipe's likelihood of failure is often correlated with the frequency of prior failures along the line. Another typical operating component for pipes in the WSNs is water pressure. Inside H_2O pressure and the likelihood of breakage in cement and metal pipes are shown to be positively correlated. Environmental elements may also be a role in pipe malfunctions. The variables consist of soil categories, climate, and traffic volumes. Additionally, a lot of these aspects are often much unknown. Previous research has shown the impact of many climatic variables, including temperature and rainfall, on pipe malfunctions. The findings suggested that the likelihood of pipe failure might rise with greater temperature swings. It is important to comprehend how these three different kinds of contributing elements interact with the likelihood of pipe failure. In addition to the components listed above, it is becoming clearer that cooperation with various sorts of conditions, like social and economic issues, must also be taken into account in performing forecast for WSNs. For instance, current research on the dependability and flexibility of communities took into account the impact of configuration collapse and population-related data. But, the current pipe failure prediction model has only seldom taken these considerations into account. Meanwhile, shareholders are keenly focused in interpreting the processes of the key contributing causes to pipe failures in order to implement informed resource allocation choices. This is in addition to establishing reliable and effective techniques for pipe failure assessment. Although earlier research looked at the effects of several parameters on the likelihood of pipe collapse, the comparative relevance (i.e., level of the effect) is still not properly known. So, while creating a pipe collapse prediction model, the interpretability factor is equally crucial.