Status recognition of water supply network based on neural network and IoT

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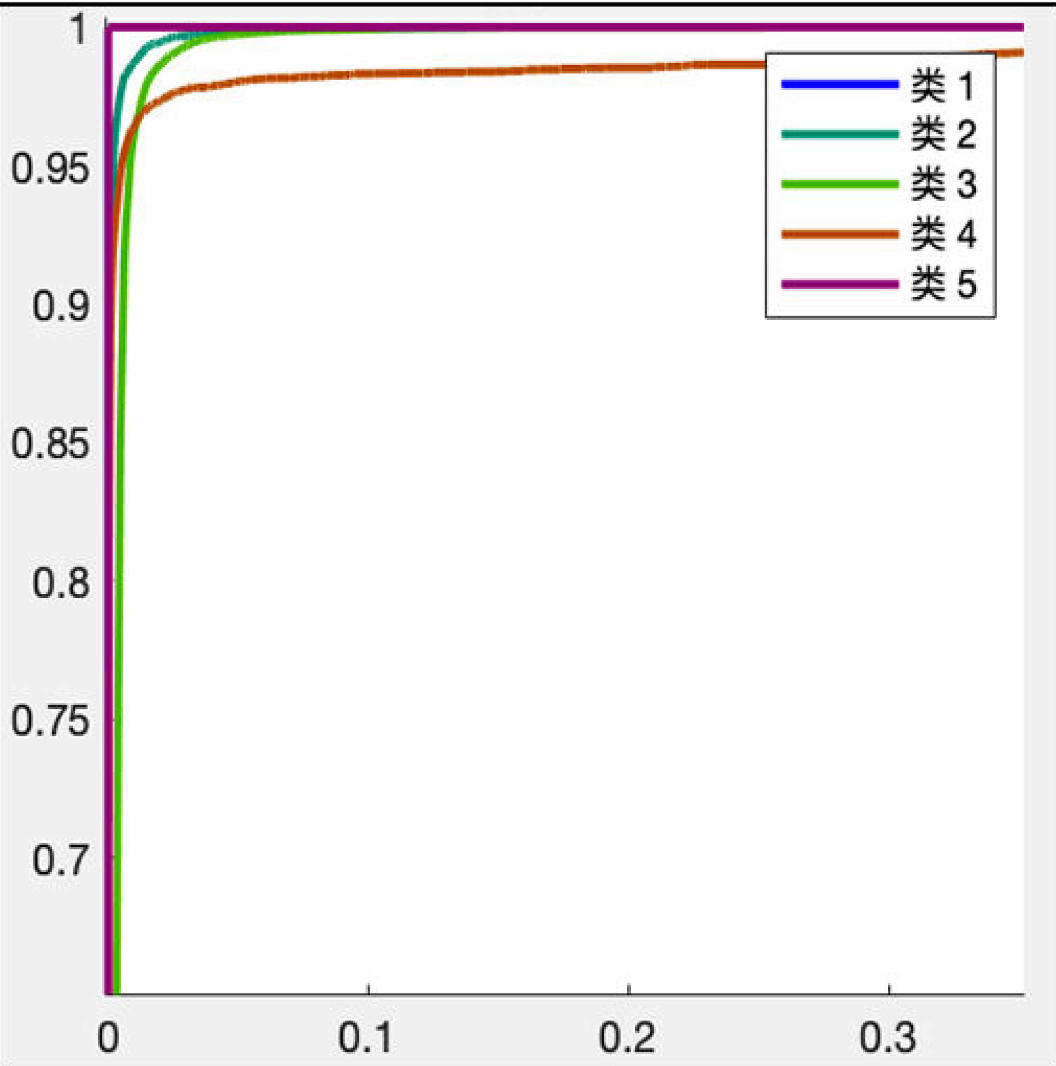
Objectives

Currently, the evaluation of the water supply network status typically relies on partitioned metering tests or hydraulic balance analysis of node flow and pressure data, based on the pipeline topology. However, these methods suffer from limited data volume and significant measurement interval errors, rendering them ineffective for efficient and precise analysis and evaluation of the pipeline's condition.

The evaluation of the water supply network status requires attention to two primary concerns: deviations in metering instruments and pipeline leaks. The results of the water balance test indicate significant discrepancies in leakage between upper and lower-level meters, approximately around 10%, which deviates considerably from the actual circumstances. Therefore, in cases of minor leaks or deviations in individual metering instruments, it is difficult to detect problems through manual analysis or simple calculation comparisons.

	1	2	3	4	5	
1	9050 10.1%	2 0.0%	0 0.0%	0 0.0%	0 0.0%	100.0% 0.0%
2	3 0.0%	8669 9.6%	243 0.3%	0 0.0%	0 0.0%	97.2% 2.8%
3	0 0.0%	320 0.4%	53462 59.4%	596 0.7%	0 0.0%	98.3% 1.7%
4	0 0.0%	0 0.0%	262 0.3%	8419 9.4%	4 0.0%	96.9% 3.1%
5	0 0.0%	0 0.0%	0 0.0%	4 0.0%	8966 10.0%	100.0% 0.0%
	100.0% 0.0%	96.4% 3.6%	99.1% 0.9%	93.3% 6.7%	100.0% 0.0%	98.4% 1.6%

Figner 1 Confusion matrix of training results



Figner 2 ROC curve of training results

Methods

The experiment utilized RS485 and NB-IoT remote transmission on the constructed test pipeline. Within the IoT control unit, Grubbs' method was integrated to eliminate outliers. The FFT library was employed for efficient frequency analysis, ensuring both frequency resolution and system optimization. The software service received and validated the upstream data from the IoT control unit, which was then subjected to IDFT and stored in the data server. The application server accessed this data for multidimensional comprehensive analysis, providing full coverage insights.

Based on the experimental pipeline at the National Metrological Center for City Energy (Chongqing), a neural network model based on water balance was rapidly constructed using MATLAB. For each measuring point, valve adjustments were made to simulate user water consumption patterns. This model effectively identifies metering discrepancies and assesses the status of the network. The results of this analysis are depicted in Figure 1 and Figure 2.

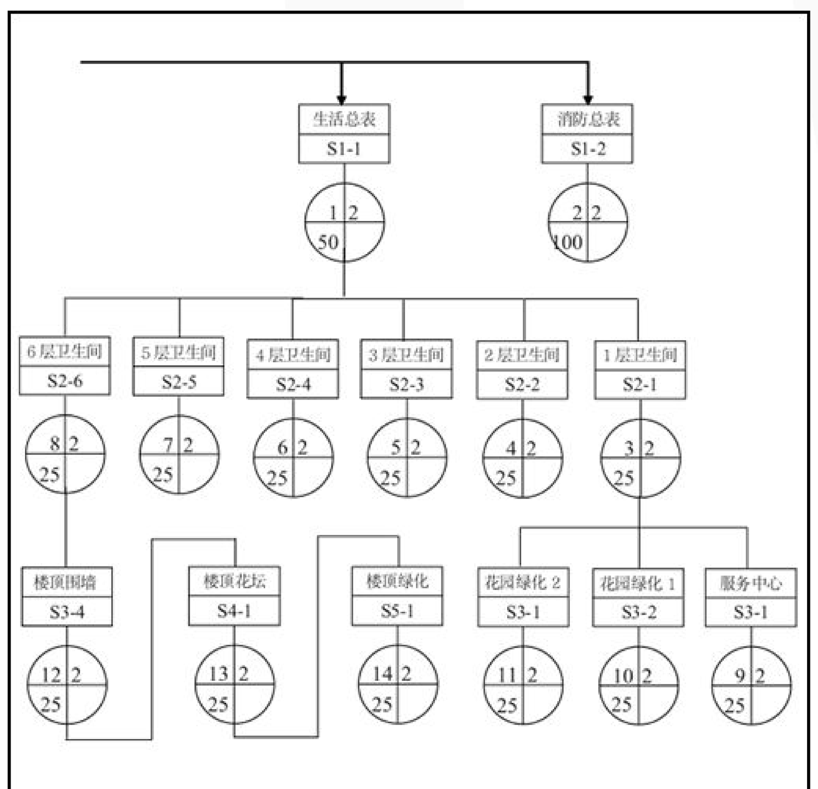
Results

Finally, the well-trained model was subjected to experimental validation,

Conclusions

Based on the experimental training of the simulated water supply pipeline network and the model verification in actual water balance tests, it can be concluded that the constructed neural network-based water supply network status model exhibits a high level of accuracy and holds a certain practical value.

This article explores a method that utilizes the IoT to rapidly acquire a large amount of metering data from water supply networks and employs neural network pattern recognition to evaluate water leakage and metering discrepancies. It effectively addresses the limitations of existing evaluation methods, which lack efficiency and accuracy, and provides an effective means of assessing the health status of water supply networks. Future considerations include the adoption of big data technology for automatic training on different network topologies. Additionally, the inclusion of more complex neurons for analyzing and estimating is envisioned, with the ultimate goal of establishing an evaluation and analysis system that is adaptable to all water supply networks.



Figner 3 Schematic of the actual pipeline topology

	1	2	3	4	5	
1	0 0.0%	0 0.0%	7 0.7%	0 0.0%	0 0.0%	0.0% 100%
2	0 0.0%	0 0.0%	41 4.1%	0 0.0%	0 0.0%	0.0% 100%
3	0 0.0%	0 0.0%	164 16.4%	0 0.0%	0 0.0%	100% 0.0%
4	0 0.0%	0 0.0%	296 29.6%	0 0.0%	0 0.0%	0.0% 100%
5	0 0.0%	0 0.0%	492 49.2%	0 0.0%	0 0.0%	0.0% 100%
	NaN% NaN%	NaN% NaN%	16.4% 83.6%	NaN% NaN%	NaN% NaN%	16.4% 83.6%

Figner 4 Confusion matrix of test results