2023 Global Conference on Information Technologies and Communications (GCITC)
Karnataka, India. Dec 1-3, 2023

IoT Based Smart Irrigation System for Crops and Water Leakage Detection Using Image Processing

Shubham .H. Ranpise [1,4], Hritik Mandve [1,4], Surya Charan [1,2], Prashant Pal [1,2], Shashank Kumar Singh [1,2], Saurabh Bansod [1,3], Yogesh Kumar [1,2]
[1]National Institute of Electronics and Information Technology Aurangabad, India
[2]Scientist'B' [3]Scientist'C'
[4]B. Tech (Electronic System Engineering)

2023 Global Conference on Information Technologies and Communications (GCITC) | 979-8-3503-0816-7/23/$31.00 ©2023 IEEE | DOI: 10.1109/GCITC60406.2023.10426197

***Abstract*— this paper will provide an image-processing technique for locating a water leak in subterranean pipes. When intelligent cities started to appear, several countries began to address this problem by utilizing technologies like intelligent water networks. However, this idea seeks to contribute to the context of smart cities using less complex and non-destructive technology. This study also makes a case for replacing the pretreatment stage of image processing with deep learning or machine learning techniques. It will be shown that this feature helps emphasize interesting spots and boost contrast. Thermal images of the soil's surface collected with an underground water leak were used to test the hypothesis. These conditions were presented in a lab using a flawless sandy soil model. Three sensors—ultrasonic sensors, soil moisture sensors, and temperature sensors—that are connected to a Raspberry Pi are used in this project. The system will use the idea of image processing to collect data from the plants. Before the fertilizer provision procedure is continued, this data will be compared to the Leaf Color Chart (LCC) chart. The project aims to create an effective irrigation system based on IoT. Utilizing sensors and image processing to improve irrigation effectiveness and monitor the soil's humidity, moisture, and temperature levels year-round.**

Keywords: IoT, MEL , ANN, GBT,SSL.

I. INTRODUCTION

Every nation's economy depends heavily on agriculture. A system based on science and technology must be developed for sustainable water use since, on average, agriculture utilizes 85% of the freshwater available to humans. Since population expansion, this proportion will become more essential regarding water consumption. Several ways may be used to save water using a variety of approaches, from the most simple to the most cutting-edge. Our suggested idea will reduce the amount of work the farmers must do. We must create an intelligent irrigation system that will deliver water according to a predetermined method based on how much the crops need.

Additionally, it will monitor the soil's temperature and moisture content all year round. As a result, the quantity of produce will rise, and farmers will make more money than they did before. The labor burden of framers visiting the felid will decrease thanks to our projects' monitoring method. Framers will be able to watch real-time photographs of the crop using the installed cameras, and they will be able to spot plant deterioration that may halt the field from degrading further. In the root zone of the plants, the system contains a dispersed wiring network of soil moisture and temperature sensors.

Moreover, a gateway unit manages sensor data, activates the motors, and sends information to a web page. Here, soil moisture, soil temperature, and ultrasonic sensors are employed as sensors. The base station's microcontroller automates the watering system if the soil moisture or temperature parameters exceed a set threshold. The idea of picture processing is the following variable that will activate the motor. LCC compares a plant's degree of greenness and will provide a value based on it. The quantity of fertilizer, or N-level, will be given to the plants after comparing the acquired importance with the user feed value. The system's values will all be presented in tabular form with time and date stamps.

II. LITERATURE SURVEY

The authors of [1] created a WSN with heat sensors to detect water leaks in pipelines. In this instance, the algorithm recognizes temperature variations in the soil above the leaking and alerts the user to a potential leak site. The scientists claimed that a leak may be found when the soil temperature varies by 0.5 °C, but they also acknowledged a significant weakness in their method since the environment might have a significant impact on the results. In addition, the technique relies on the presumption that the soil is made mostly of sand, making it ineffective in concrete or brick.

In [2] employed a collection of basic sensors, mostly flow meters, to collect data on water flow in pipes and transfer that data over LoRaWAN to a cloud server. Leaks are found using a straightforward adjutant sensor comparison, which categorizes a potential leak based on the difference in flow rates between the two sites. Although the technique used and the system are both well-presented in this work, our approach benefits from the use of machine learning to identify leaks, which enables a more in-depth study. The possibility to put a system almost anywhere is increased by NB-IoT. Fewer publications were discovered while searching for ML methods to identify water leaks.

In [3], An NB-IoT system that uses ultrasonic sensors to pinpoint the location of pipeline breaches is shown. When a leak is discovered, the system notifies the user of its site using the Doppler effect from ultrasonic sensors to detect even the slightest variation in water moving past the pipes. Support Vector Machine (SVM) is used for this data processing and has a 92% accuracy rate. Additionally, this technology is not available to many users due to the needed pricey sensors.

The authors of [4] employed a collection of ML algorithms to train data from smart meters placed next to water distribution pipes to find leaks. The algorithms were trained on several pipes for one day, some of which did not leak, and then the learned models were tested separately. Leaks occurred 25 times during testing, with the following ML models detecting them: random forest—75-96%; decision trees—72-94%; and k-nearest neighbors (KNN)—76-92%. The completed training experienced 21 leaks in 8 pipes, which from our perspective is considered a modest dataset. Despite the excellent findings, it is still reasonable to conclude that the significant variation in accuracy among the different models is mostly caused by the limited dataset used. In addition, the research is crucial for guiding our selection of the algorithms to evaluate in our system, particularly random forest, that exhibit superior performance.

According to [5] the idea of a system that tracks irrigation systems and other water distribution systems using a wireless sensor network, which provides precise leak detection with the help of an autonomous learning algorithm. The comprehensive explanation of the whole system architecture includes information on hardware, connection, and data analysis.

According to [6] a recommendation for a system that monitors irrigation systems and other water distribution systems using a wireless sensor network, which, with the help of an autonomous learning algorithm, provides precise leak detection. The comprehensive explanation of the whole system architecture includes information on hardware, connection, and data analysis.

According to [7] Compared to classification models like KNN, ANN, and rule-based approaches, the multi-strategy ensemble learning (MEL) method has performed well in maximizing the detection rate and minimizing false positives. The bagging methodology, which combines many GBT classifiers into a parallel ensemble method, has been shown to offer additional advantages. The suggested MEL technique works considerably better, which causes reports of false positives to decline by a sizeable order of magnitude.

According to [8] a fresh solution is based on machine learning (ML) for finding and identifying breaches in water distribution networks (WDN). This unique framework, clustering-then-localization semi-supervised learning (CtL-SSL), uses the topological connectivity of WDN and its leaking properties for WDN division and sensor placement, and monitoring data is then employed for leakage identification and leakage localization. The CtL-SSL framework is utilized for two testbed WDNs & achieves 95% leakage detection accuracy and around 83% final leakage localization accuracy. The suggested CtL-SSL framework enhances the leak detection method by lowering the quantity of data required, aiding with the placement of the best sensors, and pinpointing leakage utilizing WDN zone partitioning for leakage.

According to [9] Leakage detection and localization are the initial steps in reducing water loss in a network. The sooner the maintenance staff can locate and stop the leak, the sooner they can save precious resources. The authors of this study have looked at the technologies now in use and the market trends. Three critical factors are present in this industry:

- Sensor-based information gathering
- Data analysis based on algorithms
- Results are sent to the server through communication links.

An MCU handles the on-site administration of these three tasks.

[10] describes a method for locating water leaks or obstacles in a hilly region. The primary approach is to compare the vibrations pipes produce at different water levels. As water runs through PVC pipes, vibrations are captured using wireless sensors. We use machine learning algorithms for these vibration records to find any leaks and obstructions that can disturb the normal water flow.

According to [11] a machine learning-based acoustic leak detection system for the distribution of water mains. To distinguish between leak and no-leak scenarios utilizing acoustic signals, the issue is framed as a binary classifier. Several detection parameters taken from acoustic signals, such as power spectral density and time-series data, have been used using a supervised learning approach. Over the course of many months, data sets for training and validation were gathered from several cities in North America. The proposed approach uses a multi-strategy ensemble learning (MEL) approach with a gradient boosting tree (GBT) classification model, outperforming other classification models like KNN, ANN, and rule-based approaches of maximization of detection rate and minimization of false positives.

In [12] a visible light source unit accentuates the effusion edge's reflecting qualities. Meanwhile, infrared and visible light photographs of the potential effusion are captured in high quality. To recover the area of interest for segmentation purposes and transmit this information to the visible light picture to establish the effusion contour, a customized image processing algorithm extracts the probable effusion characteristics from the infrared image. Finally, a classification-based decision-support tool based on the picture contour closure is activated. The suggested system's implementation is evaluated in a genuine industrial setting.

III. EXISTING SYSTEM

The system is made up of several water flow monitoring sensors that are dispersed throughout the water distribution pipeline to gather data as water passes by them. This data is then sent to the aggregation node, which serves as the central node of our system and is in charge of communicating with the server and transferring the sensor data. The data is kept on the server and put through the ML algorithm to be examined and interpreted. From here, the information is presented to the user as being utterly ordinary inside the system, based on the analysis performed by the algorithm, or it will notify the user of probable water leak areas. Figure 1 helps to explain this rationale further.

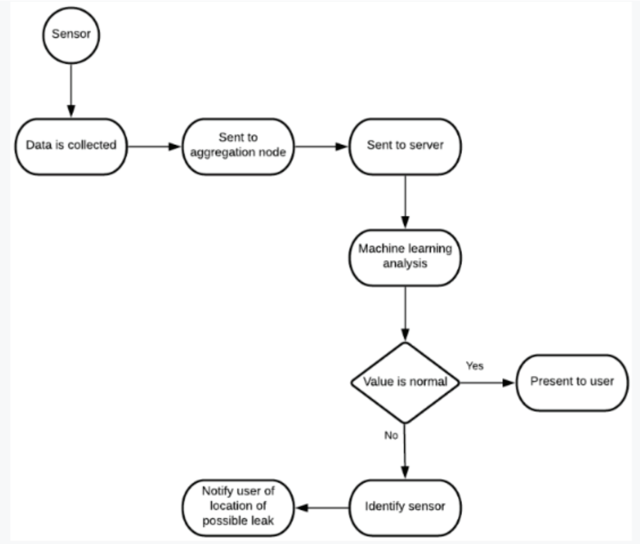

Fig. 1. Existing System logic

IV. METHODOLOGY

Our suggested research employs a machine learning or deep learning technique based on a classification algorithm to detect water leaks utilizing synthetic datasets and real-time water leak data. For a further description of the suggested Detection classifier-based architecture, see the picture. Figure 2 depicts the proposed system architecture with the detection classifier. First, we acquired data from various sources, including several online apps, actual data on water leaks, and a few synthetic data sets from other sources.

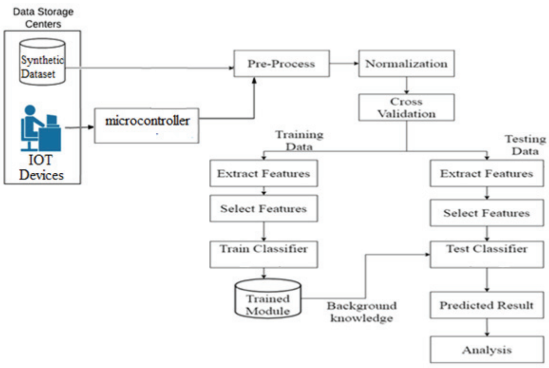

Fig. 2. System Architecture

A. *Implementation Process Data Acquisition:*

Some real-time data sources, such as Kaggle, the UCI Machine Learning Repository, and others, are among the sources from which we collect data. The data must be pre-processed before the classification activity is carried out to improve the results by addressing the missing values and eliminating the redundant features in the selected dataset. The dataset must be handled quickly throughout the DM process for the best outcomes.

B. *Preprocessing:*

Distortion correction during pre-processing makes a photo better and streamlines further processing. Color space conversion, cropping, smoothing, and enhancement are standard pre-processing methods. This module's usefulness changes depending on the picture quality. Cropping is also crucial if photographs are taken in an uncontrolled situation with complicated backdrops. Both manual and automated methods employing functions are possible.

C. *Segmentation:*

Segmentation separates the picture into areas strongly associated with the items of interest. Features of a well-segmented picture, such as the number of histogram peaks, simplify distinguishing between healthy and contaminated samples.

D. *Feature Extraction:*

Typically, color, texture, and form qualities are how images are seen. Histograms and moments are often used to characterize colour. Texture may have attributes including contrast, homogeneity, variance, and entropy. Similar traits include form, roundness, area, eccentricity, and concavity. While heterogeneous datasets need the use of many features, the texture is found to be the most effective for the Water Leakage detection method. Various methods are used for feature extraction.

E. *Classification:*

A crucial component of water leakage detecting systems is classification. The technology uses an image to detect water leakage. Consequently, type in this context is defined as grouping Water leaking photos according to detected circulating. The classifier must first be trained using images from a training set to classify or recognize pictures from the test set. To identify Water Leakage detection in various cultures, researchers have investigated a variety of machine learning or deep learning techniques. The classifier will distinguish between an image with no leakage and one with leakage.

F. *Methodology*

1) *Soil Moisture Sensor: -*

The volumetric water content of the soil will be measured. Soil moisture sensors measure the volumetric water content indirectly by utilizing some other property of the soil, such as electric resistance, dielectric constant, or interaction with neutrons since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighting of a sample. as a substitute for the moisture level.

G. *Image Processing Unit*

Digital image processing uses computer algorithms to perform image processing on digital pictures. It makes applying a much more comprehensive range of algorithms to the input data possible. It may assist in avoiding problems like the buildup of noise and signal distortion during processing. This paper also presents an algorithm for image segmentation technique used for automatic detection of N content in the leaf with the help of a typical LCC chart, in addition to classifying plant leaf diseases, i.e. identifying unhealthy regions of plant leaves using image processing and genetic algorithms.

V. RESULT AND DISCUSSIONS

In our proposed experimental model, we used 100 images for detection and classification purposes. Different cross-validation technique is used for module training as well as module testing. The 70-30% data splitting standard approach has been utilized for training and testing. Finally, as a result, the system describes the specific test image as healthy and not healthy plants. Below Table 1 shows the data distribution model before classification.

TABLE I. DESCRIPTION OF TRAIN AND TEST DATASET

Dataset	Healthy plant	Not Healthy plant	Total
Train-Data	25	45	70
Test-Data	18	12	30
	43	**57**	**100**

Below Figure 2 describes a visual categorization of the training and testing dataset according to class label.

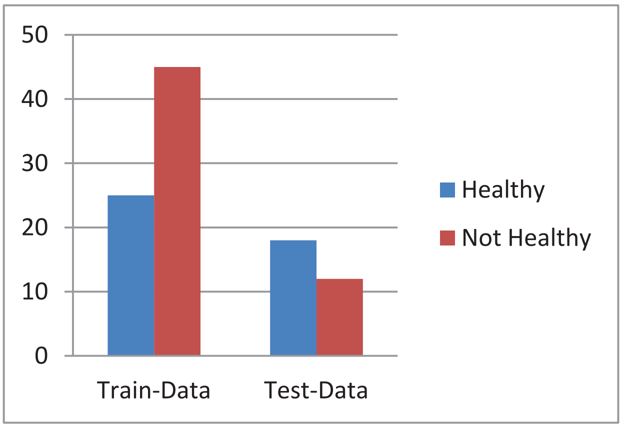

Fig. 3. Training and testing data splittingprocess

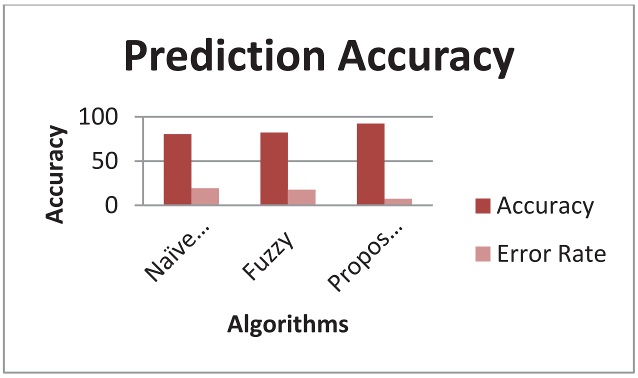

Fig. 4. Classification Accuracy ExistingSystem and Proposed System

VI. CONCLUSION

There is water loss everywhere and leaks in the water distribution system. This study created a technique for digitally processing photos to identify and locate underground water leaks. It used the machine learning or deep learning function in the pre-processing step to contrast and enhance regions of interest. The method was used to raw pictures from a lab experiment. The first portion of this research's main goal was to qualitatively assess how well this algorithm performed in finding and precisely locating the water leak. According to the literature, the parameter used in the deep learning or machine learning function was chosen after experimenting. The morphological and texture operations were also used to improve the results further. The first analysis's high degree of success in the image results indicates how promising this method is. Based on a successful outcome, the second half of this study, which tries to validate this algorithm for quantitative analysis of photos, implies that the recommended approach may be enhanced. This idea may assist in managing water supplies in the context of smart cities, even in places with modest technological expenditures.

REFERENCES

[1] Awwad, A.; Yahya, M.; Albasha, L.; Mortula, M.M.; Ali, T. Remote Thermal Water Leakage Sensor with a Laser Communication System. IEEE Access 2020, 8, 163784– 163796.

[2] Slaný, V.; Lučanský, A.; Koudelka, P.; Mareček, J.; Krčálová, E.; Martínek, R. An integrated iot architecture for smart metering using the next-generation sensor for water management based on lorawan technology: A pilot study. Sensors 2020, 20, 4712.

[3] Lin, H.; Lin, H.; Fang, X.; Wang, M.; Huang, L. Intelligent Pipeline Leak Detection and Analysis System. In Proceedings of the 15th International Conference on Computer Science & Education (ICCSE), Delft, The Netherlands, 18–22 August 2020; pp. 206–210.

[4] Fereidooni, Z.; Tahayori, H.; Bahadori-Jahromi, A. A hybrid model-based method for leak detection in large-scale water distribution networks. J. Ambient. Intell. Humaniz. Comput. 2020.

[5] Alves Coelho, João, André Glória, and Pedro Sebastião. "Precise water leak detection using machine learning and real-time sensor data." IoT 1.2 (2020): 474-493.

[6] Liu, Yang, et al. "Water pipeline leakage detection based on machine learning and wireless sensor networks." Sensors 19.23 (2019): 5086.

[7] Ravichandran, Thambirajah, et al. "Ensemble-based machine learning approach for improved leak detection in water mains." Journal of Hydroinformatics 23.2 (2021): 307- 323.

[8] Fan, Xudong, and Xiong Yu. "An innovative machine learning based framework for water distribution network leakage detection and localization." Structural Health Monitoring 21.4 (2022): 1626-1644.

[9] Islam, Mohammed Rezwanul, et al. "A Review on Current Technologies and Future Direction of Water Leakage Detection in Water Distribution Network." IEEE Access (2022).

[10] Moulik, Soumen, et al. "Water leakage detection in hilly region PVC pipes using wireless sensors and machine learning." 2020 IEEE International Conference on Consumer Electronics-Taiwan (ICCE-Taiwan). IEEE, 2020

Shubham .H. Ranpise currently pursuing B.Tech from the National Institute of Electronics and Information Technology, Aurangabad Maharashtra in Electronic System Engineering.

Hritik Mandve currently pursuing B.Tech from the National Institute of Electronics and Information Technology, Aurangabad Maharashtra in Electronic SystemEngineering.

Prashant Pal received an M.Tech degree in Visual Information & Embedded Systems from the Department of Electronics &Electrical Communication Engineering, Indian Institute of Technology Kharagpur. Received B.Tech in Electronics andCommunication Engineer, College of Technology, Pantnagar, G.B. Pant University of Agricultural and Technology. He is currently working as Scientist B at the National Institute of Electronics & Information Technology, Aurangabad, Maharashtra, India.

Shashank Kumar Singh received B. Tech degree in Electronics & Communication Engineering from United College of Engineering & Research, Allahabad, Uttar Pradesh, India. He received his M.Tech degree in Digital Communication from Rajiv Gandhi Proudyogiki Vishwavidyalaya University in Bhopal, Madhya Pradesh. He is currently working as Scientist B at the National Institute of Electronics & Information Technology, Aurangabad, Maharashtra, India.

Saurabh Bansod received a B.E. degree in Electronics Engineering from KDK College of Engineering, Nagpur Maharashtra. He received his M.Tech degree in Electronics and Instrumentation from the National Institute of Technology, Rourkela. He is currently working as ScientistC in National Institute of Electronics & Information Technology, Aurangabad, Maharashtra, India.

Yogesh Kumar received B.Tech degree in Computer Science Engineering from Vishveshwarya Institute of Engineering and Technology, GB Nagar, Uttar Pradesh, India. He is currently working as Scientist B at the National Institute of Electronics & InformationTechnology, Aurangabad, Maharashtra, India.