Skip to Main Content

TER_LEAKAGE_DETECTION_SYSTEM_OF_PIPE_LINE_USING_RADIAL_BASIS.pdf

by

WATER LEAKAGE DETECTION SYSTEM OF PIPE LINE USING RADIAL BASIS FUNCTION NEURAL NETWORK

A.EJAH UMRAENI SALAM, MUH. TOLA
Department Electrical, Engineering, Hasanuddin University, Jl.Perintis Kemerdekaan KM.10, Makassar 90234, Indonesia

MARY SELINTUNG, FAROUK MARICAR
Departmen Civil Engineering, Hasanuddin University, Jl.Perintis Kemerdekaan KM. 10, Makassar 90234, Indonesia

ABSTRACT: Clean water is an essential and fundamental human need. Therefore, its supply must be assured by maintaining the quality, quantity and water pressure. However the fact is, on its distribution system, leakage happens and becomes a common world issue. One of the technical causes of the leakage is a leaking pipe.
The purpose of the research is how to use the *Radial Basis Function Neural* (RBFNN) model to detect the location and the magnitude of the pipeline leakage rapidly and efficiently. In this study the RBFNN are trained and tested on data from EPANET hydraulic modelling system.
Method of Radial Basis Function Neural Network is proved capable to detect location and magnitude of pipeline leakage with of the accuracy of the prediction results based on the value of RMSE (Root Meant Square Error), comparison prediction and actual measurement approaches 0.000049 for the whole pipeline system.

Keywords: *Radial Basis Function Neural Network*, Leakage Pipeline, EPANET, RMSE.
.

1. Introduction

Water is an essensial need in human life, thus the good management and distribution of water resource, are required. The distribution system carries the treated water from treatment plant to the residential, office and water-consumed-industrial. To distribute the water to the costumers with sufficient quality, quantity and water pressure, it needs a decent piping system. But in distribution process, loss of water due to leakage pipe occured.

One of the losses suffered by the treatment system and water distribution is leakage problem. In general, leakage pipeline is classified into 2 categories, physical leakage and commercial leakage. Physical leakage is visible and invisible leakage at ground level whereas commercial leakage is came from water stealing (illegal consumption/connection) [2].

There are many methods used to detect the leakage. In outline, the leakage pipe methods are divided into 2 methods, acoustic method and non-acoustic method Acoustic method is a technique using a portable device to sense sound waves that arise along the pipeline, the sound waves indicate a leakage point on the pipeline. The method is able to detect the fitting location at below the ground level. However, it has some weakness because it is distorted easily by its surrounding noises such as traffic sound. Also because, sound waves is highly dependent on pipe material used and signal strenght depends on the land size and soil condition. Therefore, it is difficult to detect a signal from plastic pipe and skilled-experienced-labors are urgently needed on this method [3].

Non-acoustic method is performed by injecting tracing substances, Helium gas (He), into the pipeline. If there is a broken or leaked pipe, the water and helium gas will come out of the pipe. The technique is costly and high risk, because the water will be contaminated. Thus it is uncommonly used for leakage detection.

Pipe line leakage causes a pressure changed at each junction/intersection point of pipeline [7]. Hence, it is possible to perform a computerized analysis of the changed pattern of pressure to detect those leakages.

The research will be accomplished with leakage detection modelling using Artifical Neural Network method Radial Basis Fuction Algorithm in analyzing the water pressure in order to detect the pipe line leakage.

2. Methodology

The research aims to predict the location and magnitude of pipeline leakage at junction/intersection pipe, based on pressure-changed data when the leakage occured with 4 meter distance from pipeline, using Artificial Neural Network (ANN) Radial Basis Function Algorithm.

The general scheme of the research is shown in Figure 1.

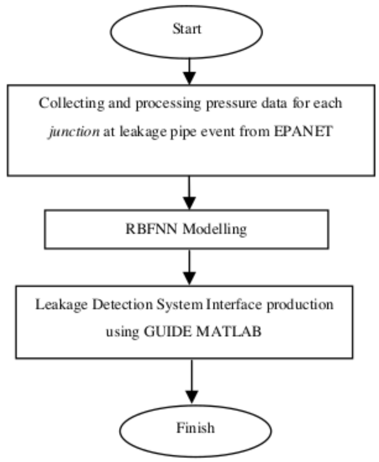

Fig 1. General Research Stage

In the process of data processing with the Radial Basis Function Neural Network to obtain a good prediction results with a high degree of accuracy, it requires a lot of training data leakage that can be obtained from the simulation using EPANET 2.0 as the software system for monitoring hydraulic pipelines [6].

2.1.Input Data Processing

Pressure input data is obtained from EPANET 2.0 software by adjusting the input data, in form of water discharge in reservoir, which is main source of water flow in pipeline, pipe length and diameter, elevation and demand (average water demand of each junction) and roughness level of each pipe. The result is pressure input data of 38 pipes and 44 junctions/intersections with different pattern data of pressure changed.

After designing the pipeline system with EPANET 2.0 software, the next stage is creating leakage simulation by changing junction emitter coefficient at the leakage point preferred. Emitters are an equipment related to junction and become model of the flow through the nozzle or orifice to the athmosphere. Emitter functions in EPANET are :

$$EC = Q/ P^{P\ exp} \quad (1)$$

EC is the emitter coefficient, Q is the water discharge, P is the fluid pressure, P exp is the pressure exponential. Therefore, emitter coefficien is water discharge per unit pressure with liter per second per meter of pressure ($L\ s^{-1}\ m^{-1}$). For head nozzle and sprinkle, P exp is equal to 0,5 [5].

Emitter coefficient is used for leakage simulation has range 0 – 0,3 with 0,005 interval. Average pressure in pipeline is 3,739158 m. hence, 0,005 emitter coefficient will produce 0,01 L/s leakage. The simulated leakage is around 0 – 0.6 L/s.

There are 44 sets of leakage cases at junction and 623 sets of leakage cases on pipe with 4 meter distance for each leakage point and emitter coefficient ranging from 0 to 0,3 at this simulation. Overall, there are 40.020 various leakage magnitude and location data. The data is used for training data on developing RBF Model. By studying the pattern of changes in the pressure data thus implementation methods of Radial Basis Function Neural Network (RBFNN) can be performed. The data obtained were then classified into 70 % learning data consisting of input data and target data and the rest are used as testing data. Pressure data of each pipe junction is used as input data, whereas leakage magnitude and location along the pipeline are the target data.

2.2. Training of Radial Basis Function Neural Network System

Training process is must be completed before Radial Basis Function Neural Network predicts the leakage magnitude and location on junction and pipeline. Training process on this methods has 3 steps, input the variable data at training process, adjusting spread value and neuron/epoch, and error value calculation. Adjusting spread and epoch value aims to minimize the error.

Fig 2. Pipeline system at Taman Khayangan Resident, Makassar, using EPANET 2.0 Software

Steps of training process on Radial Basis Function Neural Network are :

1. Loading input data as pressure-changed data on junction/intersection or pipeline
2. Data normalization process to attain data interval, 0 - 1
3. Network initialization to be trained and will predict the upcoming data using Matlab function, NEWRB
4. Network training process using train function on Matlab application. Training process is accomplished to learn the pattern of input data, thus the system will obtain the best performance and achievement percentage for the pipe leakage magnitude and location.

The research using 3 layer on Radial Basis Function Neural Network structure, there are input layer, hidden layer and output layer with 2 neurons. Amount of the neuron determination on the hidden layer is obtained by trial and error experiments until it reaches small error and faster training time. The amount of neuron on hidden layer is equal to training epoch value. Maximum amount of neuron is up to amount of junction on pipeline.

RBFNN system will predict the location and magnitude of pipeline leakage in quantitative form, in other word, it has numerical result. After collecting the data, Radial Basis Function Neural Network will be designed using MATLAB Application R2008a. Before predicting process, RBFNN system design is consist of 2 stage, training stage and validation stage.

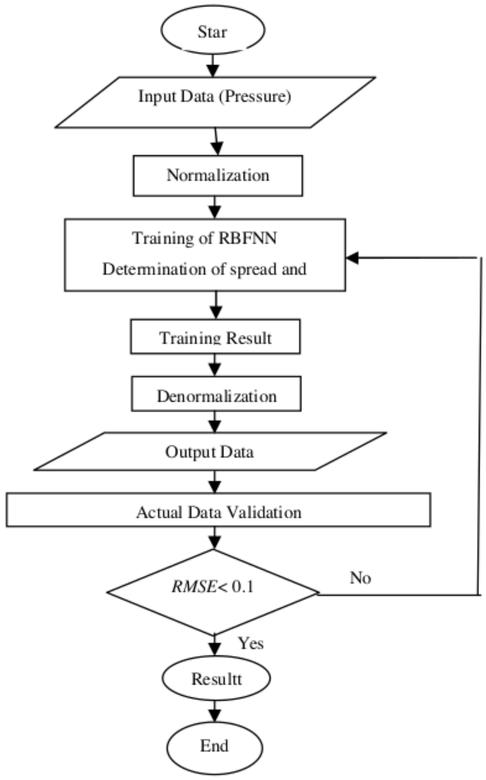

Fig 3. Flowchart Implementation of RBFNN System

3. Result and analysis

The experiment data on this research is data of junction pressure when the leakage occured, and have range between 0 – 0.6 L/s. To detect the leakage location for every leakage magnitude simulated, model for every pipe is used. It is because of the pressure changed on every junction differs on each pipe.

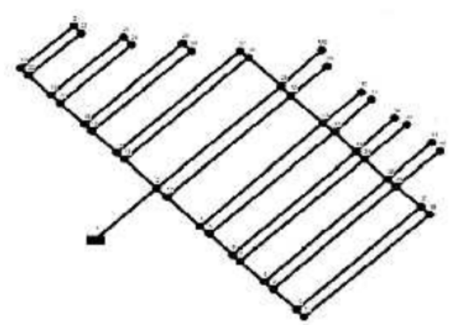

Fig.4. Position pipes in pipeline system at Taman Khayangan Resident, Makassar

Training data on predicting leakage location and magnitude is input variable data (pressure data on every junction/intersection pipe). While target data is pipe leakage location and magnitude data.

Testing stage is accomplished after training stage finished, using random data of input pressure and the output target is the leakage location and magnitude in pipe 1328 and 1921 as shown in fig 5 dan fig 6.

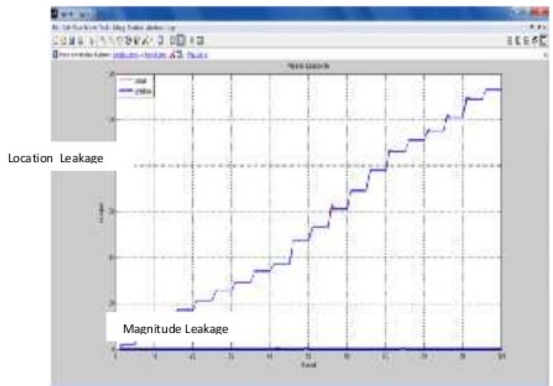

Fig 5. Graph of Prediction Result and Actual Target Data of Leakage Location and Magnitude on Pipe 1328 (between Junction 13 and 28)

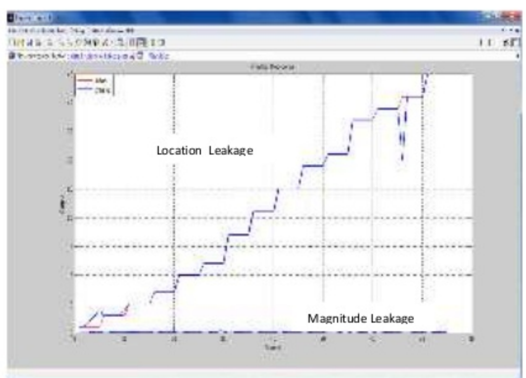

Fig 6. Graph of Prediction Result and Actual Target Data of Leakage Location and Magnitude on Pipe 1921 (between Junction 19 and 21)

To compare the prediction performance accuracy of RBFNN Method, Root Mean Square Error (RMSE) value is used and assessed. It is given on the following equation :

$$RMSE = \frac{\sqrt{\sum_{i=1}^{n}(P-a)^2}}{n} \qquad (2)$$

Where :

n	: Amount of Input Data
P	: Actual Value
a	: Prediction Value

After RBFNN calculating, RMSE value is obtained and it is 0.000049 for the entire existing pipe on pipeline system.

Using GUI Interface, the system will be user-friendly and easy to operate for leakage detection. Thus with existing button, presure data input for the experiment can be accomplished easily and the display result of leakage locatioan and magnitude will be directly seen.

Fig 7. Display Result on the Interface

4. Conclusion

Detection of Leakage Location and Magnitude using Radial Basis Function Neural Network (RBFNN) Method obtains 0.000049 of RMSE Value for the entire existing pipe on pipeline system. The RMSE value indicates, that the developed RBFNN Model can detect the leakage location and magnitude on pipeline with accurate result.

References

Elviralita, Yoan. 2011. *Pengembangan Metode jaringan Syaraf Tiruan dengan Fungsi Basis Radial (FBR) Fuzzy dan aplikasinya,* Universitas Indonesia, Depok.

Djamal. I., Ali . F., Nugroho,R., Kretarto,A., dan Utami,R. 2009. *Penurunan Kehilangan Air Pengalaman Jakarta Setelah Kerjasama Pelayanan Air Minum Pemerintah-Swasta 1998-2008*. Badan Regulator PAM Jakarta, Jakarta.

Fuchs, H.V. and Riehle, R. 1991. *Ten years of experience with leak detection by acoustic signal analysis*. App. Acoust. 33(1), 1-19.

Jalalkamali. A, Jalalkamali, N. (2011)**.** *Application of Hybrid Neural Modeling and Radial Basis Function Neural Network to Estimate Leakage Rate in Water Distribution Network*.World Applied Sciences Journal 15 (3): 407-414.

Mashford, J et all.(2009).*An approach to leak detection in pipe networks using analysis of monitored pressure values by support vector machine***.** 2009 Third International Conference on Network and System Security.IEEE Computer Society,pp. 534 -539.

Rossman, Lewis A. 2000. *Epanet 2 User Manual Versi Bahasa Indonesia*. Water Supply and Water Resources Division National Risk Management Research Laboratory,Cincinnati, OH 45268

Van Zyl, J.E. and Clayton, C.R.I. (2007)**.** *The effect of pressure on leakage in water distribution systems*. *J.Water Management,* 160(2), June 2007, p 109-114. (Proc. Inst. of Civ. Eng. UK).

Yang, Qing. Guo, Bin. Lin, Min. 2010. *Differential pressure prediction in air leak detection using RBF Neural Network,* College of Metrology and Measurement Engineering China JiLiang University Hang Zhou, China.

TER_LEAKAGE_DETECTION_SYSTEM_OF_PIPE_LINE_USIN.

ORIGINALITY REPORT

%9	%4	%4	%6
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University College London Student Paper	%4
2	Myrna V. Casillas, Luis E. Garza-Castanon, Vicenc Puig. "Extended-horizon analysis of pressure sensitivities for leak detection in water distribution networks: Application to the Barcelona network", 2013 European Control Conference (ECC), 2013 Publication	%1
3	www.researchgate.net Internet Source	%1
4	pt.scribd.com Internet Source	%1
5	Submitted to University of Glasgow Student Paper	%1
6	RABUNG, FRANS, and JON B. HINWOOD. "FROM DYNAMIC SAND BEACH TO STATIC RUBBLE MOUND", Asian And Pacific Coasts 2011, 2011. Publication	%1

7	www.hindawi.com Internet Source	1%
8	www.linuxpromagazine.com Internet Source	1%
9	Submitted to Birkbeck College Student Paper	<1%

EXCLUDE QUOTES	ON	EXCLUDE MATCHES	< 5 WORDS
EXCLUDE BIBLIOGRAPHY	ON		