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Intelligent Prediction System for Gas Metering System Using Particle Swarm Optimization in Training Neural Network

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Abstract

In this paper, a study on development of prediction model based on an intelligent systems is discussed for gas metering system in order to validate the instrument reliability. In providing reliable measurement of gas metering system, an accurate prediction model is required for model validation and parameter estimation. The intelligent prediction system has been developed for gas measurement validation. Then the project focused on the application of particle swarm optimization (PSO) and Genetic Algorithm (GA) in training neural network prediction model in enhancing the performance of Intelligent Prediction System (IPS). In this study, the three experiment has been conducted to improve the accuracy of the neural network prediction model. The comparison of the performance of PSONN and GANN with pure ANN is presented in this paper. The results shows that the proposed PSONN model give promising results in the prediction accuracy of gas measurement.

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Keywords: neural network; particle swarm optimization; genetic algorithm; prediction; gas metering system

1. Introduction

The increasing energy demand in nowadays modern innovation become industrial concern towards energy efficiency for energy saving. It is a vital for the accuracy and reliable metering system in oil and gas industry to maintain the billing purposes. This is because of inaccuracy of product selling to the client will bring about lost income to the organization. A slight error in the bill calculation will lead to huge financial impact. Between validation periods, the field device might be drifted and flow computer giving unknown readings and other scenarios that might lead to billing issues. Measurement readings from billing equipment will sometimes freeze, overshoot and even zero readings. Due to reliability concern, smart meters applying artificial intelligence is one of the future technologies that can be genuine global solution[1]. Therefore, it is an extra effort to develop a monitoring system tool to verify the billing data generated by measuring equipment and subsequently will enhance overall billing integrity. To achieve the objective, a prevailing tool that can be used is the hybrid method which neural network are combined with PSO and GA algorithm. The hybrid methods are mostly outperformed than non-hybrid methods[2]. It can predict the performance and accurately forecast the instrument measurement and in addition provide a reliable metering system for billing integrity.

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Nomenclature

ANN	Artificial Neural Network
PSO	Particle Swarm Optimization
GA	Genetic Algorithm
IPS	Intelligent Prediction System

1.1. Gas Metering System

Accurate measurement of gas flow through pipelines is vital to reduce energy loss. One of the greatest concerns is whether the amount of money buyer paid is justified with the amount of products sold. The metering system required critical examination which result in cost reduction. The measurements of gas metering station along the pipeline system are used to compute energy supplied for customer which consists of measuring equipment (e.g. pressure and temperature transmitter), turbine meter, flow computer and gas chromatography. These measurement will be utilized for energy consumption calculation for billing purposes. Fig.1 shows the billing process from supplier to customer.

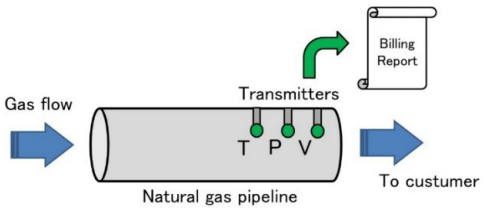

Fig. 1. Billing process of gas consumption

The metering system do not have any reference system to validate its accurateness which also is defined as standalone system. Sometimes, instruments fault may occurred that lead to billing issue. Prediction and analysis on what will happen plays important role in economic operation. Thus, accurate and robust prediction model can significantly improve the billing results. Reliable billing verification tool also plays a significant role to increase work efficiency of billing-correction. To manage this world issue, the human and computational intelligence must be developed for achieving high accuracy of prediction model of process parameter prediction.

1.2. Intelligent Prediction System

The implementation of the intelligent system varies in prediction, classification, clustering and pattern recognition[3]. A data driven technique based on historical data can be used to design reliable prediction model. For example, nonlinear estimation of wind power optimization is done by ANN[4]. It used global optimization based on ANN. Therefore, Artificial Neural Network (ANN) method is proposed to be the intelligent prediction model to learn the behavior of fault and providing reliable data for billing purposes. There are several factors that affect the model development: model inputs; data pre-processing; learning algorithm and activation function[5]. Selection of ANN architecture also describes the model performance in view of its robustness and reliability of the system. The most popular training algorithm in prediction application is backpropagation method (BP). The examples of BP algorithm are gradient descent, Lavenberg-Marquardt, Lavenberg-Marquardt with Bayesian regulation[6]. In this paper proposed the optimization method to be applied in training ANN to have better prediction value. The approaches of hybrid intelligence is used to predict more accurate and reliable energy[7]. Therefore, PSO and GA is introduced in optimizing the weights and biases from ANN training.

1.3. Particle Swarm Optimization

PSO was first established by Kennedy and Eberhart as a solution to the complex non-linear optimization problem by imitating the behavior of bird flocks in the concept of function-optimization by means of a particle swarm[8]. PSO is also well-known as population-based search method based on the behavior of elements in nature such as fish schooling and birds flocking. The population follows its leader which affected by the best-positon of each particle in the whole swarm. This phenomenon is called the global best PSO (or *gbest* PSO)[9]. Every individual will adjust its position according its own best position which follows toward group's objective. The particle is called as personal best (or *pbest* PSO). A local best PSO (or *lbest* PSO) occurred when the *pbest* corresponds to the position in neighbour's experience. Lastly, all the particles will finally move toward the desired location. To achieve this condition, the velocity of the particle is updated as in equation (1) where the particles move to a new position close to