UNIVERSITI TEKNOLOGI MARA

MODELING WATER PH NEUTRALISATION BEHAVIOUR IN A SMALL-SCALE HYDROPONIC SYSTEM USING THE NARX-PSO MODEL

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ABSTRACT

Nutrients are essential to optimising plant growth. However, the introduction of fertiliser affects the pH level of the nutrient solution. This, in turn, would affect the plants' growth as each type of plant requires a specific pH range to grow optimally. Conventionally, in hydroponics applications, pH adjustment is performed manually. Manual adjustment of pH solutions is prone to estimation errors, particularly when the pH levels change drastically. This problem can be attributed to the slow response of the solution to the addition of alkaline or acidic mixtures and its sensitivity to minute errors in mixture delivery. The control of pH neutralisation is challenging yet vital due to the highly nonlinear characteristics of the process. The need to regulate the pH value at a specific level arises from environmental, legislative, and quality standards. There was a delay in changes in pH level (reduced or increased) due to the acid, and alkaline solutions are not entirely dissociated. For these reasons, a mathematical model to estimate the solution's pH would help improve the delivery accuracy of the alkaline and acidic mixtures. There has been related research done in the past. However, little extensive study has been done to optimally construct the model from a system identification (SI) perspective. This study represents a pH water neutralisation behaviour using the Nonlinear Autoregressive model with Exogeneous Inputs (NARX). This study also optimised parameters for the MLP-NARX model using the Particle Swarm Optimisation algorithm (PSO). The project begins with input and output data acquisition, leading to the development of the MLP-NARX model. Model performance was then evaluated by analysing the model fit and residual distribution. Several parameters have been set in optimising using PSO, such as values of particles, random seed and maximum iterations, cognition and social learning rate, and particle velocity and position. The model fit and residual distribution have also been analysed for this model. Then, a comparison of its performance between these two models has been made. The best optimal lags space and hidden nodes were at lag 29:30:30:49 for input1/acid (n_{u1}): input2/alkaline (n_{u2}) : output/pH (n_y): hidden nodes (h), based on the minimal total correlation value of 0.01503, with an MSE of 0.01213. Based on the OSA, correlation, and histogram test, the MLP-NARX- PSO model performance was accepted with the highest accuracy. The model performance was accepted based on a correlation test since the signal at this lag was more than 95% of the confidence interval region. When total correlation is compared between the MLP-NARX and MLP-NARX-PSO models, the MLP-NARX-PSO model clearly outperforms the statistical errors generated by the MLP-NARX model. Therefore, this demonstrated that the MLP-NARX-PSO succeeded in optimizing the MLP-NARX model. The MLP-NARX-PSO model also recorded a very minimal error, and this proved that a good agreement was established between the predicted and actual pH values.

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