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University of Bahrain
College of Engineering
Department of Chemical Engineering

Comparative modeling of microalgae-based bioethanol production using statistical and artificial intelligence approaches

Abstract

The bioethanol obtained from microalgae was examined and proposed as another alternative fuel among the current utilized fuels. Several prediction models were employed to predict the bioethanol production rate based on two data sets. The first data set has five factors and the second has 3 factors . Two artificial intelligence algorithms were used : artificial neural network and support vector regression and comparing them to a statistical method called response surface methodology .Finally ,SVR has the best results among all methods .

Objective and Motivation

Fossil fuels are considered one of the most reliable sources of energy at the present time, but their disadvantages are that they are not environmentally friendly, and the gases emitted from them cause corrosion in the crust of the atmosphere. An alternative source was thought, and one of the most important sources was Bioethanol, which is an environmentally friendly source and is considered a promising source for the future, as it was extracted from microalgae. The main project objective is to create a prediction model for bioethanol production. At first, response surface methodology (RSM) is utilized to get the prediction values and know how each variable affects the model. Next, artificial neural network (ANN), and support vector regression (SVR) are used to apply the main concepts of machine learning and its basics. To know which of the three models has the best fit, each model is tested and examined in various ways to choose the best model for the application.

Design and Implementation

The design of the project was mainly based on two experimental dataset. The first data has five factors, namely (substrate concentration ,Inoculum size, fermentation time ,PH ,temperature) and the second depends on three factors, namely (PH, temperature, Incubation time). These values were applied to a set of programs which is (RSM) response surface methodology, then the model was developed by two artificial intelligence programs, (ANN) artificial neural networks and (SVR) support vector regression. We compared the obtained values in order to find the best way to develop the model. Minitab was used to carry out RSM analysis. Center composite design (CCD) was used, with each factor holding five levels. There are five factors being used, which are called independent variables. The artificial neural network has an output, input, and hidden layers. The first step is to Set the hyperparameters. Then, to run the model using Nftool in MATLAB, and train the system until the best predictive values are obtained. Finally, for the SVR model, we used the best combination of hyperparameters to obtain the optimum performance, then ran the model using MATLAB Regression Learner, and compared it to the two previous models.

Results

Data set 1	RSM	ANN	SVR
R^2	0.935582134	0.993710065	0.9983
MAE	0.256774097	0.042583333	0.05848791
MAPE	2.82381059	0.44918518	0.627569623
RMSE	0.308506884	0.09640172	0.062041229

Data set 2	RSM	ANN	SVR
R^2	0.826242625	0.930574331	0.9662
MAE	0.821911235	0.38478	0.310690931
MAPE	14.6129549	5.789791731	4.357698307
RMSE	0.984938984	0.671924042	0.442641309

Conclusion

It is worth noting that bioethanol, produced from microalgae through a series of processes, and is deemed an alternative energy source to fossil fuels. This project presented three predictive techniques which are RSM, ANN, and SVR. Five and three inputs were inserted for each predictive technique, and it was proved that SVR is the best among the rest of the techniques. As the R^2 was 0.998 and 0.966 for data set 1 and 2, respectively .

Student Name:
1- Nawaf Khalifa almuqahwi
2-Fahad Adnan
3-Ali Alsalem

Student ID:
1-20166129
2-20143672
3-20178520

supervisor Name:
1-Dr. S. M. Zakir Hossain