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A Study on CNN based Production Yield Prediction Algorithm for Increasing Process Efficiency of Biogas Plant

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Abstract

Recently, as the demand for limited resources continues to rise and problems of resource depletion rise worldwide, the importance of renewable energy is gradually increasing. In order to solve these problems, various methods such as energy conservation and alternative energy development have been suggested, and biogas, which can utilize the gas produced from biomass as fuel, is also receiving attention as the next generation of innovative renewable energy. New and renewable energy using biogas is an energy production method that is expected to be possible in large scale because it can supply energy with high efficiency in compliance with energy supply method of recycling conventional resources. In order to more efficiently produce and manage these biogas, a biogas plant has emerged. In recent years, a large number of biogas plants have been installed and operated in various locations. Organic wastes corresponding to biogas production resources in a biogas plant exist in a wide variety of types, and each of the incoming raw materials is processed in different processes. Because such a process is required, the case where the biogas plant process is inefficiently operated is continuously occurring, and the economic cost consumed for the operation of the biogas production relative to the generated biogas production is further increased. In order to solve such problems, various attempts such as process analysis and feedback based on the feedstock have been continued but it is a passive method and very limited to operate a medium/large scale biogas plant.

In this paper, we propose "CNN-based production yield prediction algorithm for increasing process efficiency of biogas plant" for efficient operation of biogas plant process. Based on CNN-based production yield forecasting, which is one of the deep-leaning technologies, it enables mechanical analysis of the process operation process and provides a solution for optimal process operation due to process-related accumulated data analyzed by the automated process.

Keywords: *Biogas, Biogas plant, CNN, Production yield*

1. Introduction

Currently, the seriousness of the problem of energy resources is emerging in the international community,

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such as the depletion of fossil energy resources, which are essential energy for human life, and the environmental destruction of existing fuel production methods. To solve this problem, Research on technology is actively under way. Since bioenergy, which is recognized as the next generation innovative renewable energy, is extracted from biogas produced by biological decomposition process from organic materials such as livestock manure or food wastes, energy resources and environmental aspects such as organic matter treatment and environmental purification which has various advantages [1].

Biogas processing technology is anticipative research on organic waste in order to minimize environmental destruction. Currently, the biogas plant is leading the market in Europe and Japan due to lack of waste landfill sites due to overcrowding. The ban on marine discharges of sewage sludge and livestock manure started in 2012, the marine wastewater in 2013 Due to the ban, the government is now planning to reduce the total amount of organic waste by 2020, and the biogas plant market will continue to expand [2].

The raw materials used in the biogas treatment process are various types such as livestock manure, food waste, agricultural and industrial wastes, raw materials that can be recycled as raw materials. Depending on the kind of raw materials, the technology applied to the treatment process is different, so it is necessary to arrange a plurality of treatment processes corresponding to each raw material or to construct only a treatment process capable of coping with one raw material which is mainly used [3]. These problems cause limitations in the efficiency of biogas plant operation. In addition, due to the inefficiency of the organic material treatment process to cope with various raw materials, economic loss can be incurred such as the cost for the biogas plant facility and the facility driving and maintenance cost compared with the facility driving and maintenance cost. In order to overcome the above limitations, this paper proposes a new method to simulate the process efficiency of the biogas plant by using supplementary resources for rapid pretreatment of organic wastes in the process of biogas treatment, we propose a CNN-based production yield prediction algorithm to improve the process efficiency of gas plant.

In this paper, following the introduction of chapter 1, in Chapter II, we conducted related research on the base knowledge and element technology, in Section III, we propose a CNN-based production yield prediction algorithm to improve the process efficiency of a biogas plant. Conclusions are made in Chapter IV and the end of this paper is concluded.

2. Related Work

The biogas plant is installed and operated for the purpose of developing renewable energy required due to efficient treatment of various kinds of organic wastes generated in everyday life and depletion of resources, and it is widely spread all over the world. Using a biogas plant can significantly reduce environmental impacts, reduce consumption of fossil energy, and reduce a significant amount of waste. Due to the superiority of bio-energy, it is emerging as a promising technology for future renewable energy, and the demand for biogas plant is continuously increasing [4]. Organic wastes, which are biogas production resources in biogas plants, exist in diverse types such as foodstuffs, waste water, sewage sludge, and livestock manure, Individual wastes must be processed to process the waste. However, when anaerobic digestion of organic wastes is performed systematically without systematic process, various problems such as lowered production yield, inefficient process operation, and economic loss are incurred. In order to solve this inefficient process operation problem, this paper introduces the concept of CNN (Convolutional Neural Networks) and proposes a production yield prediction algorithm that enables efficient operation of processes, such as systematic introduction of raw materials and increase of production yield.

Deep learning, which is a generic term for CNN, refers to mechanical learning that performs complex operations through a combination of various nonlinear transformation techniques, unlike conventional

machine learning. Deep learning is based on neural networks, and neural networks are statistical learning algorithms inspired by biological neural networks, particularly the brain [5]. In the case of existing neural networks, it is difficult to apply to the actual technology because of disadvantages such as overloading. Recently, due to the development of hardware such as GPU, complicated computation processing time has been significantly reduced. There are various types of neural network models such as Feed-Forward Neural Network, Radial Basis Function Network, and Kohonen Self-Organizing Network. The most widely used neural network models are CNN and RNN [6]. CNN (Convolutional Neural Network) consists of one or several layers of convolutional and general neural networks, and additionally uses weighting and pooling layers. It is designed to use minimal preprocessing. CNN has the advantage of being able to train through the standard inverse delivery, which makes it easier to train than other feed-forward artificial neural networks and uses fewer parameters. RNN is a neural network that constitutes a directed cycle between units that make up an artificial neural network. It is widely used in language processing, such as handwriting and natural language, because memory inside the neural network can be used to process arbitrary input. The circular neural network structure has various structures other than Fully Recurrent Network (LSTM) and long term memory network (LSTM). However, when there are many neurons or many inputs, performance is degraded.

In this paper, to improve the process efficiency of the biogas plant, we intend to incorporate the deep learning technology based on the neural network and propose CNN as the neural network model. As the environment, disturbance factors, and other variables such as the chemical formula depend on the type of organics used in the biogas plant, a large number of neurons are formed and CNN is more efficient than RNN.

3. Main Concept

3.1 Main concept design for efficient process operation of biogas plant

In this paper, we use CNN-based deep leaning technique to extract the most efficient raw material arrangement and influent form when producing bio - energy based on the raw material input in the process of biogas plant. Due to the process characteristics of the biogas plant, the individual processes are carried out according to the type of the raw material to be introduced, and the performance (production yield) also depends on the feedstock. Therefore, CNN - based production yield prediction algorithm was applied to ensure the optimal yield of biogas production compared to the biogas plant process of the same process conditions (process time, operation amount, etc.). In order to predict the production yield, the optimal biogas production process is extracted by finding the combination of raw material inflow that shows the highest production yield based on the neural network analysis, based on the repeated experimental data that had been previously performed. That is, it is possible to find the most efficient arrangement according to the kind of the organic wastes to be introduced, to derive a process for operating the optimal process, to express it to the manager, or to apply it to the mechanization process, leading to efficient operation of the biogas plant.

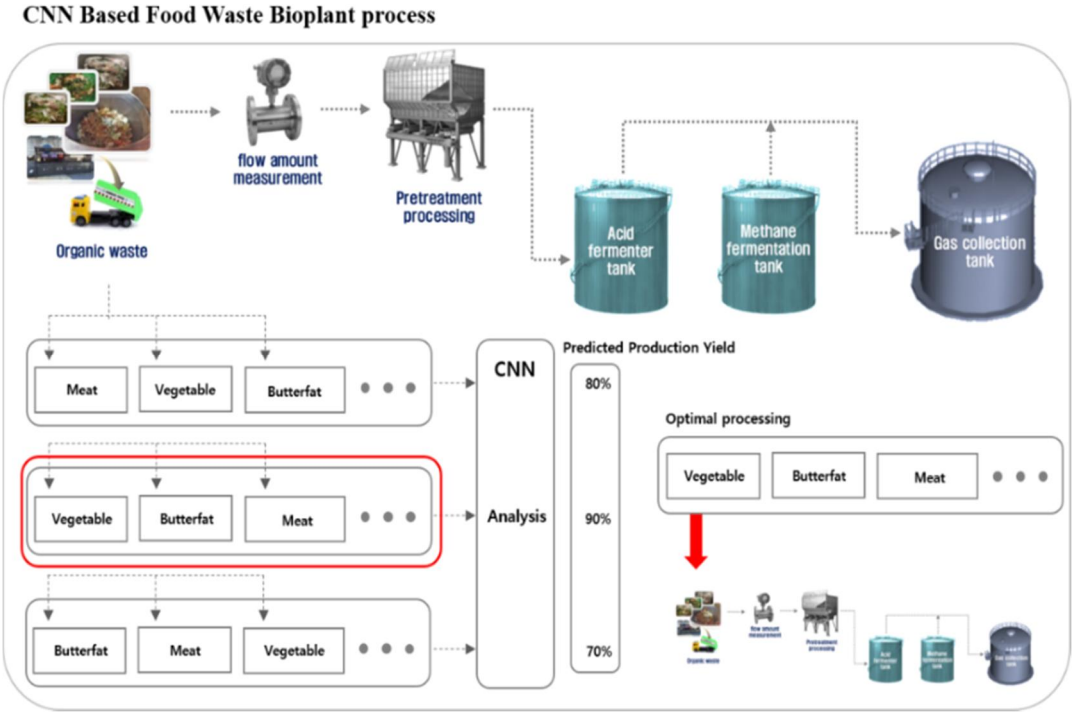

Figure 1. CNN based Food Waste biogas plant process concept

Figure 1 shows a biogas plant treatment process for treating food waste. Based on the CNN-based production yield prediction algorithm, the production yield is predicted according to the type of food wastes introduced. Based on the predicted production yield, it is possible to find the most efficient combination of raw materials and apply them to the process, thus enabling efficient operation of the biogas plant. In this paper, we propose CNN - based production yield prediction algorithm to improve the process efficiency of biogas plant.

3.2 CNN based production yield prediction algorithm

'CNN-based production yield prediction algorithm for increasing process efficiency of biogas plant' is an algorithm to improve the efficiency of the biogas plant process by estimating the biogas production based on the combination of raw materials used in the biogas plant process using CNN, which is one of artificial neural network technologies.

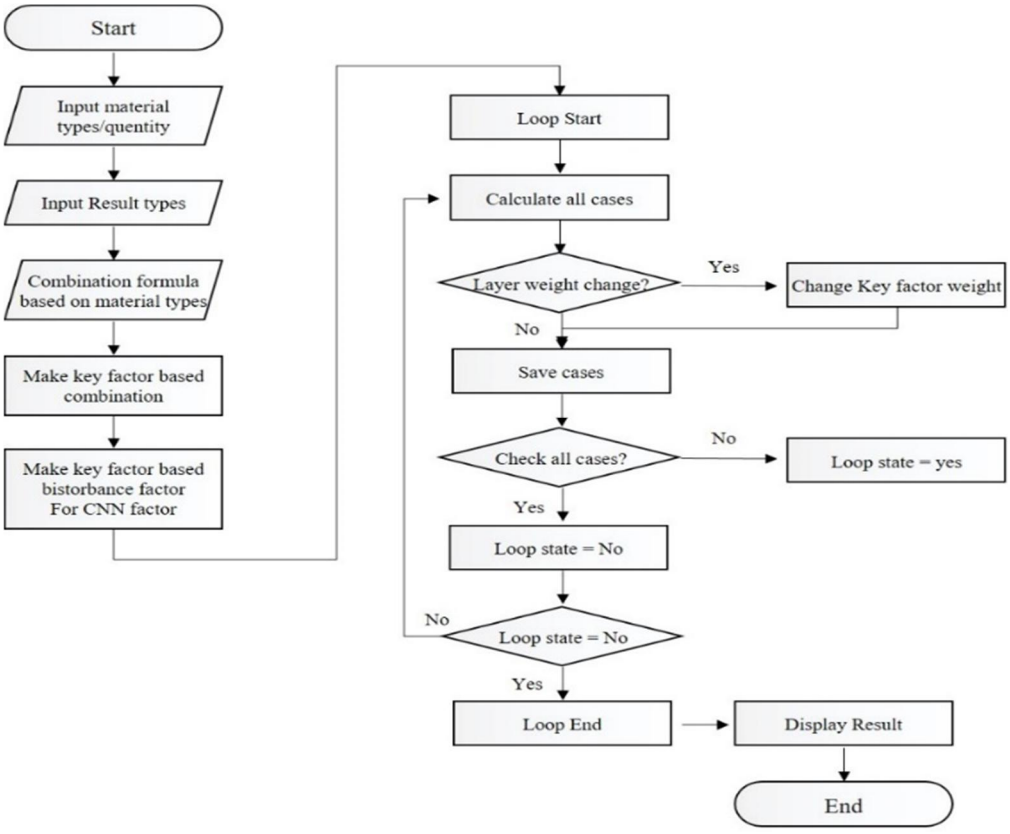

Figure 2. Flow chart of CNN based production yield prediction

First, input the type and amount of raw materials used in the biogas plant, and enter the biogas combination formula that can be generated according to the type and amount of the raw material. After that, the initial setting is completed by inputting the type of biogas to be produced. Once the initial settings are completed, the key factor analysis is performed to construct a layer for CNN. The layer consists of three layers. There are layers according to the biogas plant environment, layers according to the combination of raw materials, and layers according to biogas plant obstruction factors. The layer according to the biogas plant environment is a layer containing the key factors such as the accommodation space, temperature, and pressure generated by performing the combination formula. The weight of the key factor changes depending on the environmental change factors such as the change of the product pressure of the heat and the gas due to the raw material reaction and the temperature change. The layer according to the combination formula of the raw materials refers to the biogas generated by combining the raw materials, and the additional products such as by-products. The production of additional products can affect the process of the incoming biogas plant, changing the weight of the key factor. Layer due to biogas plant obstruction factor is a layer that includes key factor for factors that interfere with biogas plant process such as error caused by machine malfunction, power shutdown status. When the initial layer construction is completed, the number of all cases is performed according to the kind of the raw material and the sequence. If the weight of the generated layer is changed, it is not reflected if it is changed. In all cases, the number is stored, and when the search for the number of cases is completed, the descending order is searched to find the combination formula with the highest production yield. Such a mechanism can be applied to the biogas treatment process through the combined formula of the extracted raw materials to enable efficient process processing.

4. Conclusion

In this paper, we propose CNN based production yield prediction algorithm which can be applied to biogas plant in order to solve the problem of process operation efficiency in biogas production through organic matter treatment in biogas plant. Conventional biogas plant processes operated economically and technically inefficient processes such as installing multiple process facilities to treat various kinds of organic matter, or constructing a treatment process capable of coping with only a single raw material. Although many attempts continue to be made to analyze and provide feedback on the process of handling input materials from bio gas plants, it is a passive analysis method, and it is very limited to operate large and medium sized bio gas plants. In order to solve this problem, CNN-based biogas production yield prediction which can extract the raw material combination with the highest production yield by searching all the cases for the inflow raw materials and sorting the results in descending order when the number search of the case is completed Algorithm. It is an innovative technology because it can secure the efficiency and economically efficiency of the process operation by presenting the raw material combination formula that enables the optimum biogas production yield to the manager when the algorithm is applied.

In order to improve the process efficiency of the proposed biogas plant, CNN-based production yield prediction algorithm is expected to be applicable not only to food waste organic wastes in biogas plant but also to various types of waste processing such as livestock manure and sewage sludge. It will be possible to utilize it efficiently in various fields related to energy production.

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