INTISARI

PENGEMBANGAN MODEL PREDIKSI DAN KLASIFIKASI FASE PERTUMBUHAN MIKROALGA *Euglena gracilis* IDN 22 BERBASIS *RECURRENT NEURAL NETWORK*

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Kemampuan memprediksi fase pertumbuhan dan meramalkan biomassa mikroalga secara akurat sangatlah penting dalam proses budidaya terutama dalam penentuan waktu panen yang tepat. Kondisi lingkungan budidaya di luar ruangan yang fluktuatif menjadi tantangan karena dapat mempengaruhi pertumbuhan mikroalga sehingga durasi budidaya dapat bervariasi. Keberadaan IoT telah dimanfaatkan untuk pemantauan pertumbuhan dan lingkungan budidaya mikroalga secara cepat dan otomatis. Namun demikian, pemantauan fase pertumbuhan dan peramalan biomassa masih bertumpu pada analisis manual.

Penelitian ini mengusulkan model klasifikasi fase pertumbuhan mikroalga dan model peramalan biomassa mikroalga menggunakan *metode recurrent neural network* (RNN) yang memanfaatkan data pemantauan berbasis IoT. Model klasifikasi fase pertumbuhan dikembangkan dengan menggunakan arsitektur multisaluran (*multistream*) RNN yang dalam penelitian ini disebut dengan FEM-RNN. Adapun model peramalan biomassa dikembangkan menggunakan model RNN standar baik dengan Vanilla RNN, LSTM, dan juga GRU.

Model-model yang diusulkan pada penelitian telah dievaluasi menggunakan data IoT pemantauan budidaya mikroalga di lingkungan luar. Hasil evaluasi model klasifikasi fase pertumbuhan menunjukkan akurasi 0,978, 0,989, dan 0,951, berturut-turut untuk FEM-RNN yang berbasis Vanilla RNN, LSTM, dan GRU. Sementara itu, model peramalan biomassa mikroalga menunjukkan GRU memiliki kinerja tertinggi untuk peramalan pada horison dua, empat, dan enam jam ke depan dengan R^2 berturut-turut 0,87, 0,83, dan 0,78 dan MAPE berturut-turut 3,18%, 4,39%, dan 5,36%.

Kata kunci: Mikroalga, IoT, RNN, Klasifikasi Fase Pertumbuhan, Peramalan Biomassa

ABSTRACT

DEVELOPMENT OF PREDICTION MODEL AND GROWTH PHASE CLASSIFICATION OF MICROALGAE *Euglena gracilis* IDN 22 BASED ON *RECURRENT NEURAL NETWORK*

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The precise prediction of growth phases and accurate forecasting of microalgae biomass are crucial for enhancing the cultivation process especially in determining the right harvest time. However, fluctuating environmental conditions in outdoor cultivation present a significant challenge, as these variations can impact microalgae growth, resulting in discrepancies in the duration of cultivation. The implementation of the Internet of Things (IoT) has been utilized to enable rapid and automated monitoring of microalgae cultivation growth and environmental conditions. However, the assessment of growth phases and biomass forecasting still largely depends on manual analysis.

This study proposes microalgae growth phases classification and biomass forecasting model using the recurrent neural network (RNN) approach, leveraging IoT-based monitoring data. The growth phase classification model is developed using multistream RNN architecture which in this study is referred to as FEM-RNN. The microalgae biomass forecasting model is developed using a standard RNN models namely Vanilla RNN, LSTM, and GRU.

The proposed models were evaluated using IoT data monitoring microalgae cultivation in outdoor environments. The results of the growth phase classification model evaluation achieve accuracies of 0.978, 0.989, and 0.951, respectively for FEM-RNN based on Vanilla RNN, LSTM, and GRU. Meanwhile, the microalgae biomass forecasting model showed that GRU had the highest performance for forecasting at two, four, and six-hour horizons with R^2 of 0.87, 0.83, and 0.78 respectively and MAPE of 3.18%, 4.39%, and 5.36% respectively.

Keywords: Microalgae, IoT, RNN, Growth Phase Classification, Biomass Forecasting