Continuous Biooptical Monitoring of Microalgae Crops

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Overview

Current microalgae farming methods are challenged by biotic and abiotic stresses, which often induce irreversible damage, including sudden batch collapse. Available stress monitoring techniques suffer from low-resolution, high costs, and intermittence. Moreover, the time it takes for current methods to detect stress is often too long, resulting in extensive biomass yield losses. The proposed in-situ microalgae monitoring platform enables automated and continuous tracking of spectral cues indicative of environmental and physiological stress, allowing for early detection and intervention. The system promises to optimize resource culture protocols and ultimately secure enhanced and stable biomass yields at lower costs.

The Need

Thanks to their high area productivity, high biomass, oil, protein, and carbohydrate contents, microalgae are considered one of the most promising feedstocks for sustainable production of multiple commodities, including human and animal nutritional supplements, cosmetics, pharmaceuticals, CO_2 capture, bioenergy production, nutrient removal from wastewater and biofuels. Microalgae farming is challenged by a variety of biotic and abiotic stresses, including bacterial and viral contaminations, grazers, competition with other algae, nutrient depletion, and suboptimal light and temperature swings. These sources of stress often go undetected until late stages, after which response and batch salvage efforts prove futile. Current monitoring protocols are labor-inefficient, tedious, sporadic, and costly and involve offline monitoring, with analyses performed off-site. Continuous online, in-situ monitoring for early detection of potential sources of stress is expected to maintain high quality, stable and reproducible production, translating to profitable microalgae farming.

The Solution

A system for continuous, automated, inexpensive optics-based, early detection of microalgae stress.

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Technology Essence

A team led by Profs. Koren, Rudich, and Vardi, including Yossi Bolless and Adi Volpert, developed a new technology for continuous, automated, early detection of microalgae stress. The technology is comprised of light-weight, small, weather-proof optical measuring devices (OMDs), which continuously collect spectral signals (absorption and fluorescence) response from the culture growth unit and transmit them to the central unit, where they are processed using artificial intelligence methods. The system can be modified to include a tailor-designed light source and spectral measurement probe to optimize the spectral information. The growth unit supports dilute, saturated and static sample culturing under varying conditions to drive training and inference of robust stress-indicative spectral signatures for each algae species and stress condition. The spectral signatures and their variances collected over time serve as the input data for the deep-learning process that ultimately identifies and classifies stress responses.

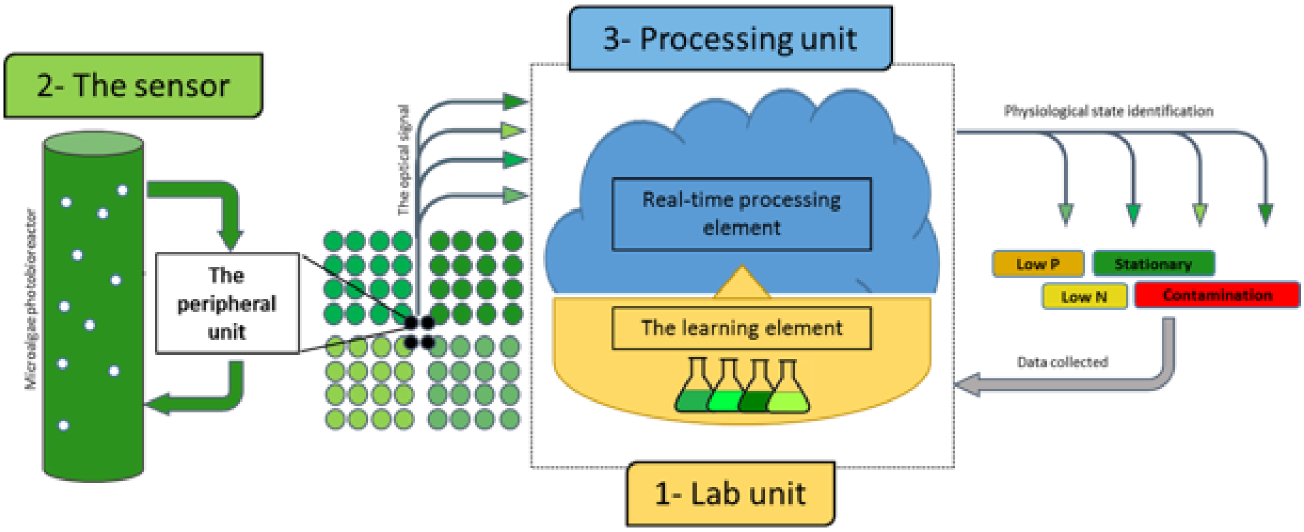

Figure 1. A schematic of the continuous bio-optical microalgae monitoring system.

Applications and Advantages

Advantages

- The novel continuous monitoring system has multiple advantages over existing monitoring techniques:
- Automated and Continuous
- Online
- Noninvasive
- Eliminates substantial financial losses
- Minimized need for optical data
- Enables optimization of growth conditions (light, temperature, nutrients)
- Enables immediate intervention
- Supports growth system up-scaling

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Applications

- Monitoring of microalgae farming
- Aquaculture monitoring (fish, macroalgae, mollusks)
- Water quality monitoring

Development Status

The team has demonstrated the performance of the system under laboratory conditions and is currently working on expanding its multi-spectral libraries to include an array of physiological stresses and multiple algae strains. In addition, it is working on tailoring this technology to field conditions. A proof-of-concept study in a microalgae farm is expected to begin soon. A patent protecting this invention has been submitted.

Market Opportunity

The global microalgae market was valued at $977.3 million in 2020 and is projected to reach $1,485.1 million by 2028 (1). As the microalgae is a rich source of minerals and nutrition such as vitamin A, B1, B2, C, E, protein, and as it also has iron and magnesium, the microalgae market has the potential for development. Using our technology to produce tremendous amount of microalgae, it could be widely used in the upper market as dietary supplement, food/feed, pharmaceutal, cosmetic and biofuels

Patent Status

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