3D Digital Holographic Microscopic Water Quality Detection System

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Water is essential for life, but accessing clean water is a challenge in many places due to pollution. In this study, we focus on plankton, tiny water organisms that can reveal a lot about water's health. When water gets polluted, the type and amount of plankton change, which is a warning sign of poor water quality. Traditional ways of studying plankton involve collecting water samples and analyzing them in labs, which takes a lot of time, the device used is also large and expensive. To make this process faster and more accessible, we use new technology: lensless digital holographic microscopy (LDHM). Based on the principle of LDHM, we designed a lightweight, low-cost, and remotely controlled hardware system with less than 300$ of cost and a weight of less than 500g. We've also integrated a multi-wavelength system and designed both a remote control system and a resolution enhancement algorithm using angular spectrum theory and the G-S iteration algorithm. The result of observing the USAF resolution board shows the resolution of our system is around 2.46 micrometers. After observing the paramecium sample slide, we successfully generated both 3D and 2D diagrams of both a single paramecium and a number of them. As a final experiment, after observing the water sample slide of a pond near the Princeton area, we used the level-set-based cell-segmentation method to count the cell number, thus estimating the plankton density, which is an important indicator of water quality. There are far more possible uses of this microscope, not only because of its low cost, lightweight, and small size, but also its ability to obtain 3D information, high accuracy, and large field of view compared to all microscopes in similar cost or size.