S2.4.3 Waterborne Pathogen Detection Using a Smartphone Based Fluorescence Microscope and Machine Learning

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Giardia lamblia is a waterborne parasite that affects millions of people every year worldwide, causing the diarrheal illness known as Giardiasis. Timely detection of the presence of cysts of this parasite in drinking water will be highly beneficial for treating and preventing the spread of the disease, especially in resource limited settings. Here we present a field portable and cost effective optical platform for automated detection and counting of Giardia cysts in large volume water samples. This compact device is composed of a smartphone based fluorescence microscope, a disposable sample processing cassette, and a custom-developed smartphone application, named as GiardiaAnalyzer. This handheld microscope with a large field of view (FOV) (i.e. >0.7 cm2) weighs only ~180 g and operates using two AA batteries and a smartphone. The cassette mainly consists of porous filter membranes with sub-10 microns pore sizes and cotton absorbent pads and is capable of holding ~20 mL of water sample. The smartphone application provides a user interface and guides user to capture an image of the sample filter membrane and process it automatically using our custom-developed image processing algorithms and machine learning training data, consisting of >30,000 cysts with their labels and pre-defined 96 features/cyst, at our servers without the need of an expert. The total time from sample preparation to automated cyst counting is less than an hour for 10 mL of water sample. We have tested the sensitivity and specificity of the platform with several supervised classification models (e.g. Support Vector Machines (SVMs), and Neural Networks (NNs)) and demonstrated the performance of the device using water samples from different sources (e.g. tap water, non-potable water, and pond water) including flow cytometer enumerated Giardia spiked samples. It demonstrates a limit of detection of 12 cysts per 10 mL and an average cysts capturing efficiency of ~79% on our filter membrane along with a machine learning based cyst counting accuracy of ~94% using a bagging classifier. Providing rapid detection and quantification of waterborne pathogens, this field-portable imaging and sensing platform running on a smartphone could be useful for water quality monitoring in resource-limited settings.