UAV-based imagery analysis with machine learning to facilitate microbial water quality monitoring of irrigation ponds

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Surface waters can contain pathogenic microorganisms that may be detrimental to individuals consuming produce grown with irrigation. Fecal indicator organisms, primarily Escherichia coli, are commonly used to estimate the potential presence of pathogens in irrigation waters. Concentrations of E. coli in the water of irrigation ponds are often highly variable in space and time. Water sampling that is frequent in time and dense in space, is impractical. Unmanned aerial systems (drones, or UAVs) have shown the potential to provide informative imagery. We hypothesized that the UAV-based imagery can facilitate the microbial water quality monitoring in ponds by reflecting the differences in bacteria habitats. Six times over the summer, we coupled monitoring of 17 water quality parameters of 23 locations across an irrigation pond in Maryland with 14 images captured by a MicaSense RedEdge M and modified GoPro cameras. The modified GoPro Images were demosaiced into red, green, and blue bands for each of the cameras. The random forest methodology was used to evaluate the accuracy and reliability of relationships between several combinations of measured explanatory variables, and the logarithm of the E. coli concentration as the variable to predict. Random forest models with only imagery data as the explanatory variables, and models with all measured data as explanatory variables had coefficients of determination between 0.5 to 0.6, and 0.6 to 0.7, respectively. The most important explanatory variables for the model with only imagery input were digital numbers obtained from the blue band of the “visible only” filter image, and from the red bands of the “infrared only” and “visible only” filter images. When all measurements were used, the most important explanatory variables were concentrations of chlorophyll a and fluorescent dissolved organic matter, as well as and digital numbers from the red band of the “infrared only” filter image. There appears to be a potential for the UAV-based imagery to provide dense spatial coverage of ponds with subsequent delineation of a small number of relatively uniform zones for informed water sampling.