

HARMFUL ALGAL BLOOM, MACROINVERTEBRATE AND PLANKTON ID SMART DEVICE CLASSIFICATION APPLICATIONS & MONITORING

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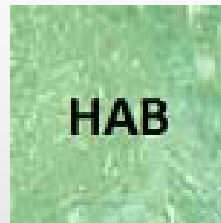


PROBLEMS

1. How can image analysis and machine learning techniques assist in developing cost-effective early monitoring of Harmful Algal Blooms?
 2. How can image analysis and machine learning techniques assist in real-time classification of microalgae, aquatic macroinvertebrates and plankton in the field?
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PROBLEM 1

Harmful Algal Bloom Smart Device Application (HAB App)
and monitoring



600+ Mile Long Ohio River Blue-Green Algae Bloom, Summer 2015

Toxic algae on the Ohio River

An algae bloom has been visible on nearly 700 miles of the Ohio River since it was first detected on Aug. 19. The toxin microcystin has been measured at high levels in many parts of the river. The Ohio EPA issues recreational “no contact” advisories when levels reach 20 ppb.



OHIO RIVER TOXIC ALGAE LEVELS

Date	Location	River mile	Microcystin level (ppb)
Sept. 16	Fish Creek, W.Va.	114	150
Sept. 9	Marietta, Ohio	172	250
Sept. 3	Athens Boat & Ski Club	200	130
Sept. 9	Point Pleasant, W.Va.	265	250
Sept. 9	Huntington, W.Va.	310	69
Sept. 9	Portsmouth, Ohio	357	590
Sept. 9	Cincinnati	470	1,900

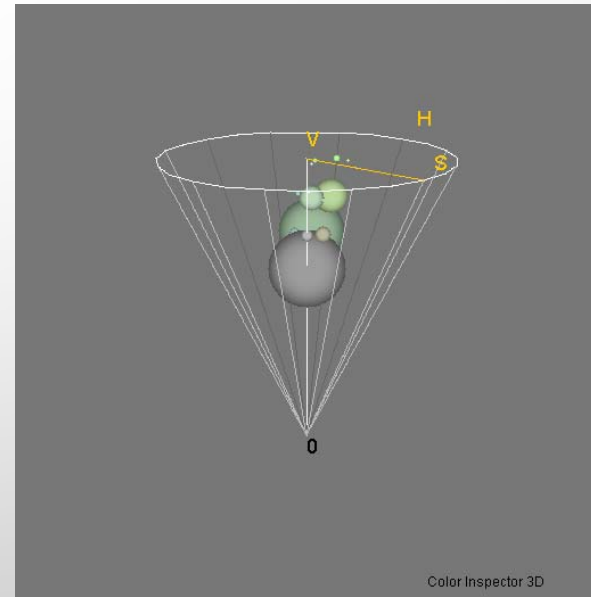
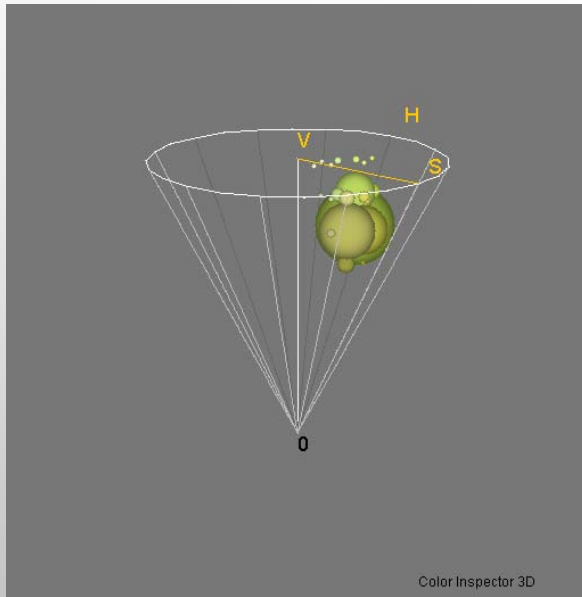
Source: Ohio River Valley Water Sanitation Commission; Ohio EPA STEVE LOPEZ / STAFF



GREEN VS. BLUE-GREEN ALGAE

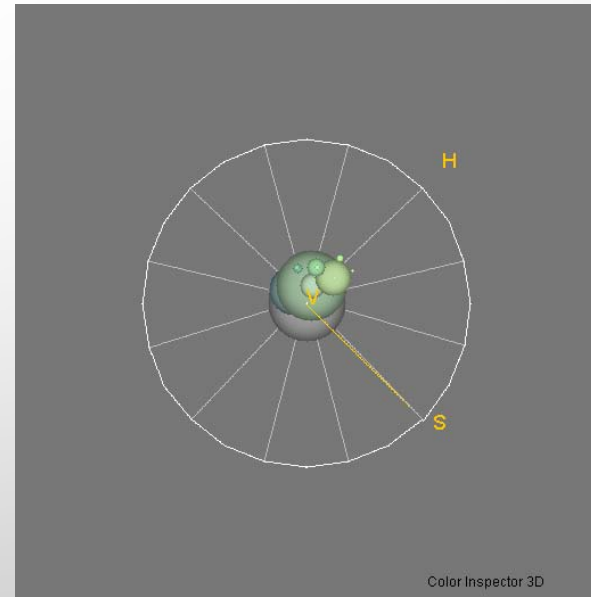
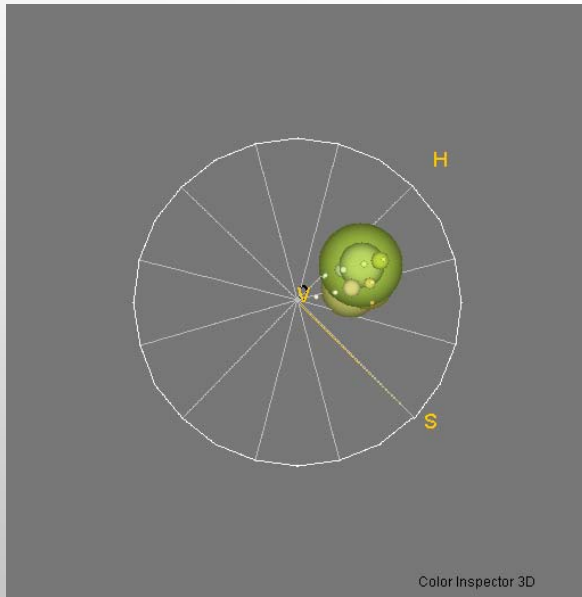


GREEN VS. BLUE-GREEN ALGAE



Hue-Saturation-Value Color Histograms

GREEN VS. BLUE-GREEN ALGAE



Hue-Saturation-Value Color Histograms

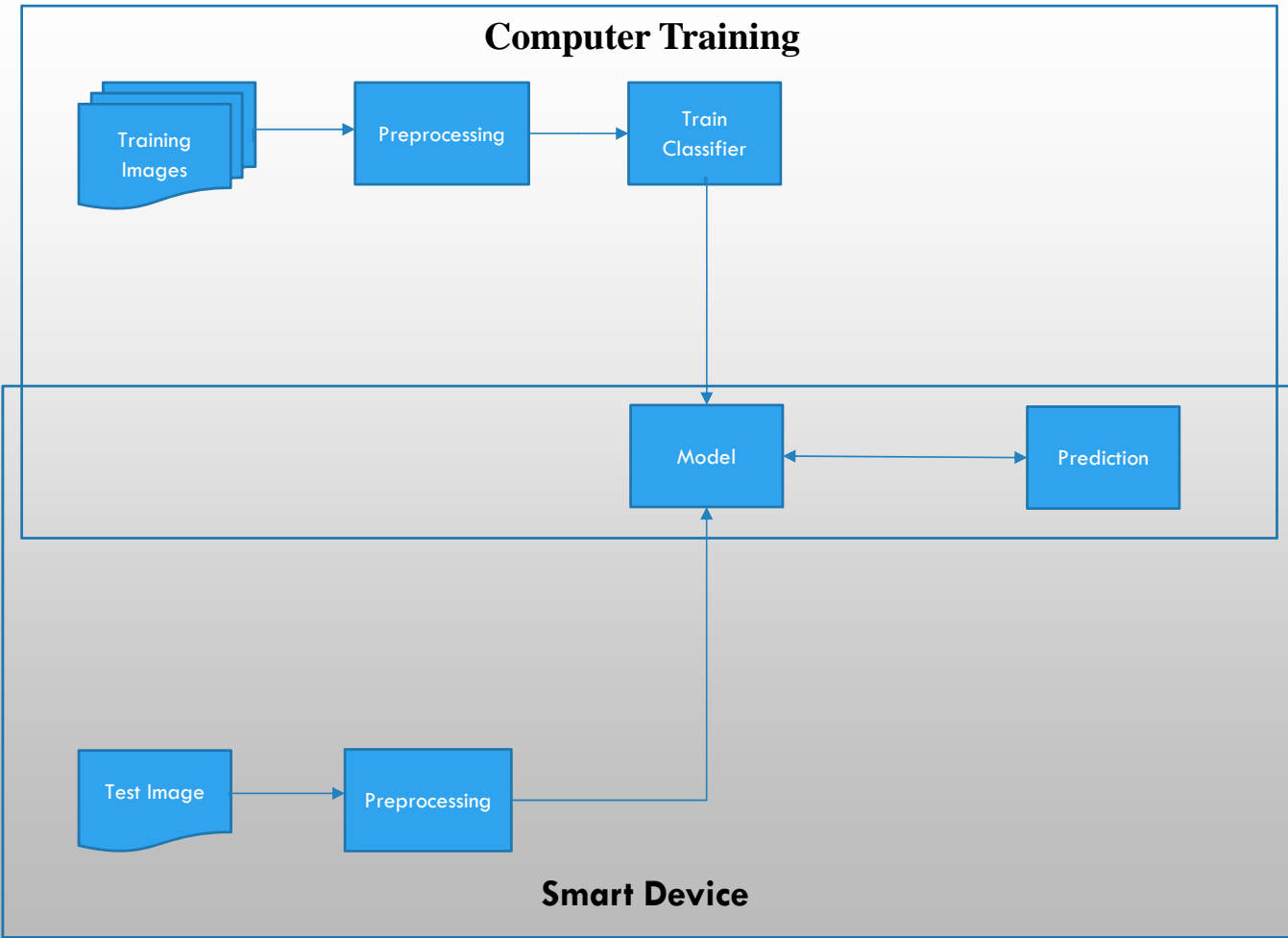
GREEN VS. BLUE-GREEN ALGAE CLASSIFIER

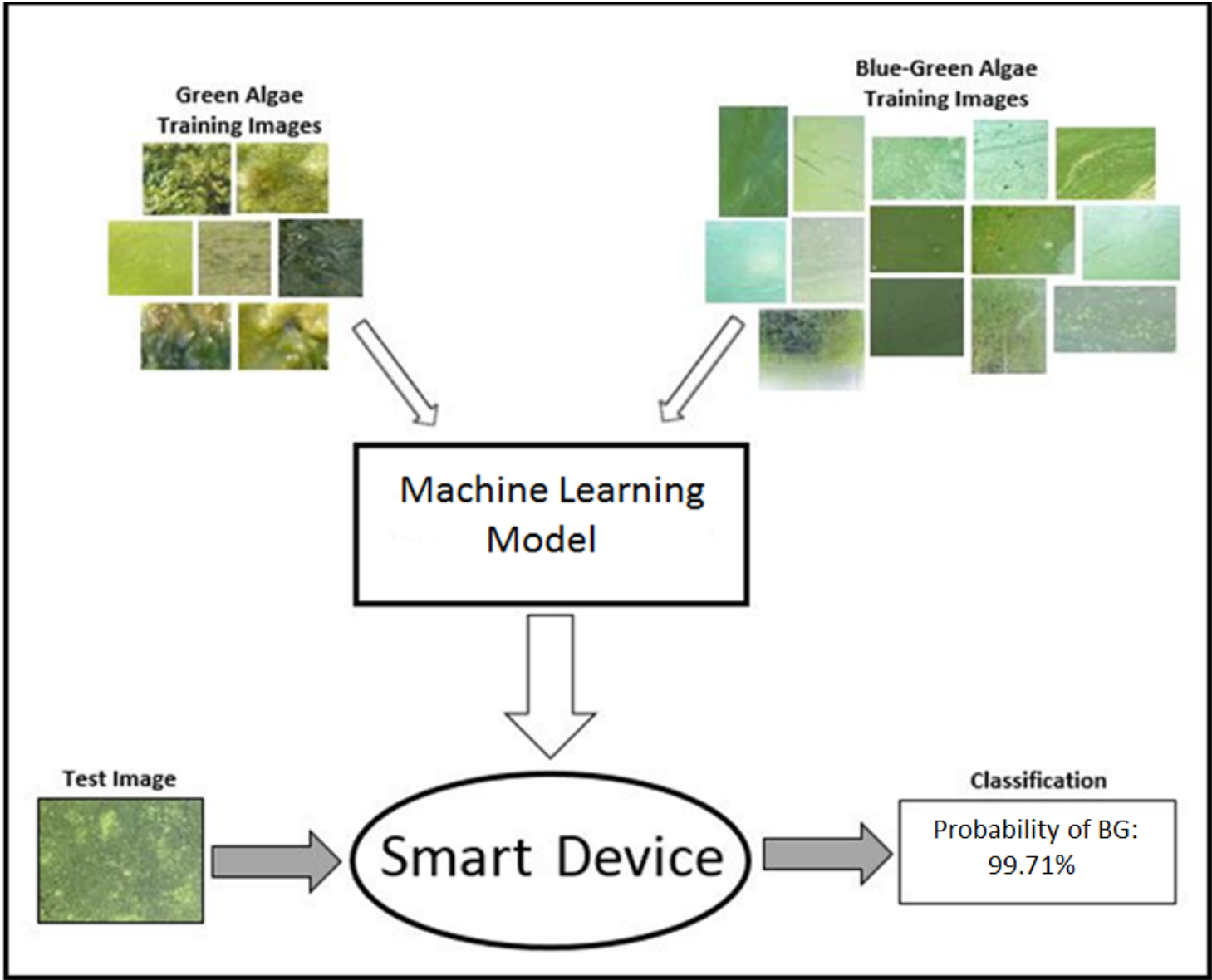
- The HAB APP uses a supervised machine learning classifier to distinguish between the hue-saturation-value color histograms of green and blue-green algae using correctly classified training images.
- The smart is device is then “trained” to distinguish between these, giving probability estimates for an unclassified test image.
- User then examines algae microscopically and, with assistance from a machine learning algorithm, follows a dichotomous key* for classification.



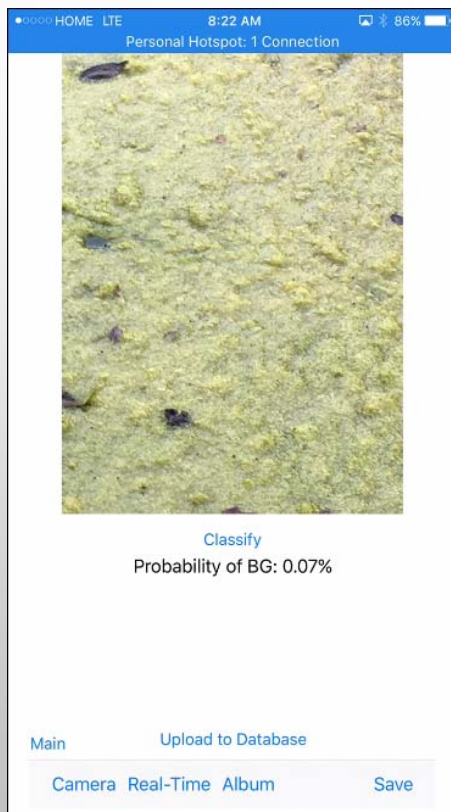
*Dichotomous key developed by NKU and partners is included in the application.

Smart Device Microscope





SMART DEVICE DEMONSTRATION (IPHONE-BETA)



PERFORMANCE

Confusion Matrix (70/30) n=52		Predicted	
		Green	Blue- Green
Actual	Green	6	0
	Blue- Green	0	9

95% Confidence Interval: (0.78,1)

Assuming the sample is random, we can be 95% confident that the accuracy is better than 78%.

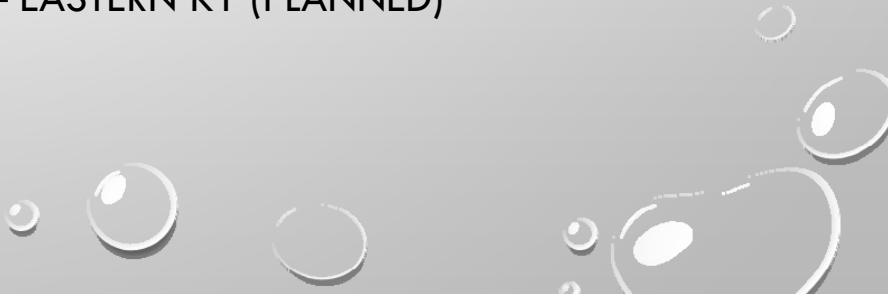


FIXED CAMERA MONITORING

- High Definition Security Camera with WiFi capability
- Powered by plug-in connection or solar array
- Images sent to server hourly during daylight hours

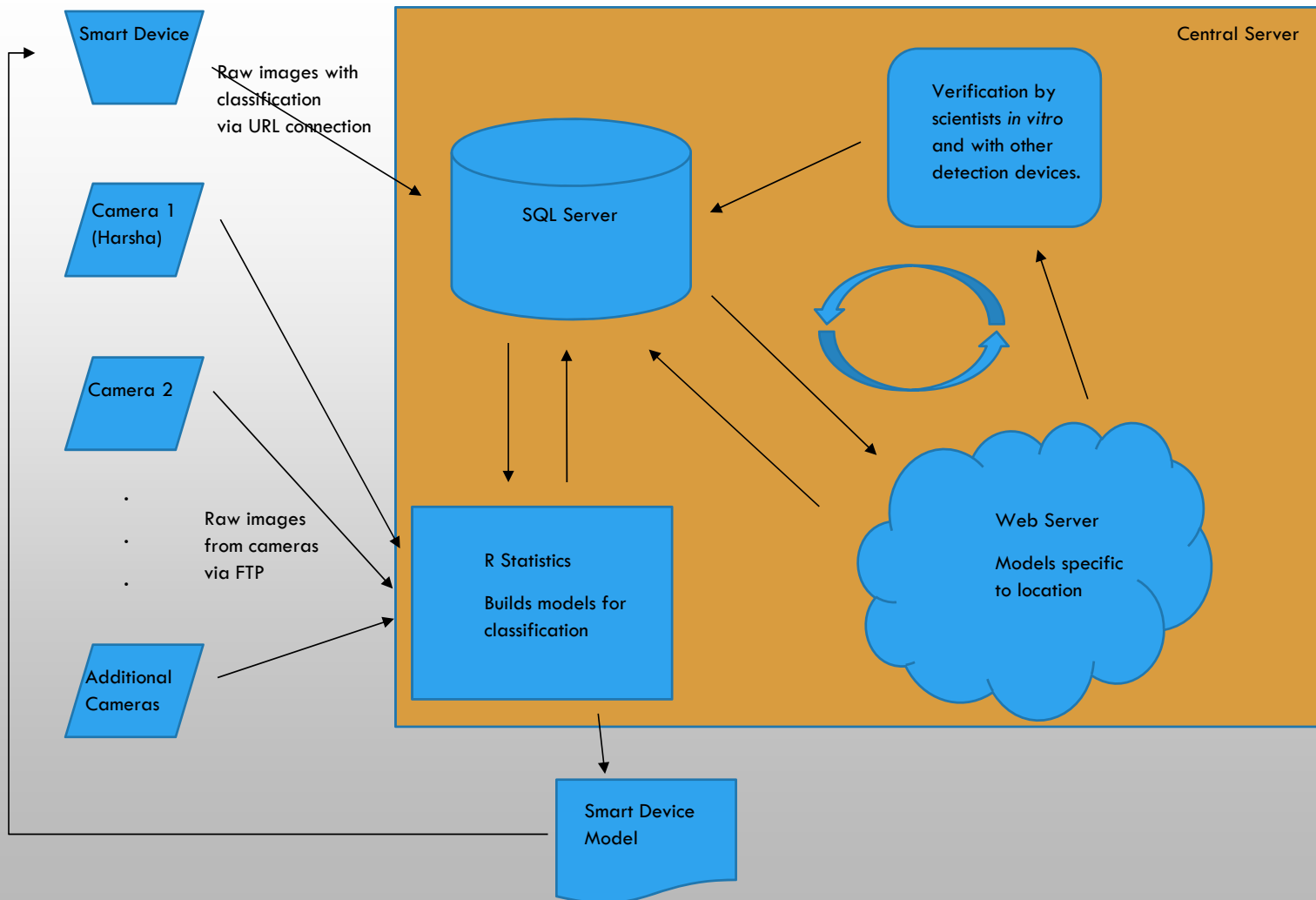


FIXED CAMERA SITES

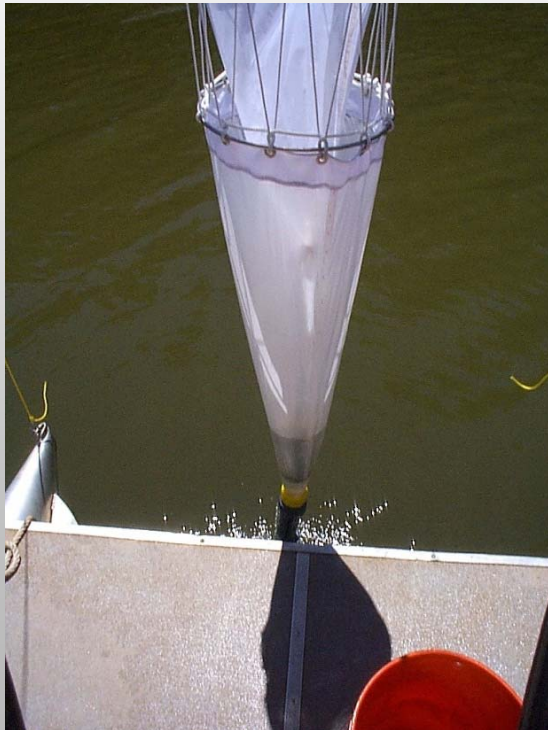
- LAKE HARSHA (EAST FORK) IN CLERMONT COUNTY, OH – 22,000 ACRE RESERVOIR SUPPLYING 6 MILLION GALLONS PER DAY OF DRINKING WATER AND SOURCE OF RECREATIONAL ACTIVITIES
 - OHIO RIVER IN DAYTON, KY – QUEEN CITY RIVERBOATS
 - OHIO RIVER IN CALIFORNIA, KY – THOMAS MORE COLLEGE FIELD STATION
 - KENTUCKY LAKE – WESTERN KY (PLANNED)
 - OHIO RIVER AT GREENUP & BYRD LOCKS AND DAMN – EASTERN KY (PLANNED)
 - DISCOVERY LAKE – NC (PLANNED)
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FIXED CAMERA SITES



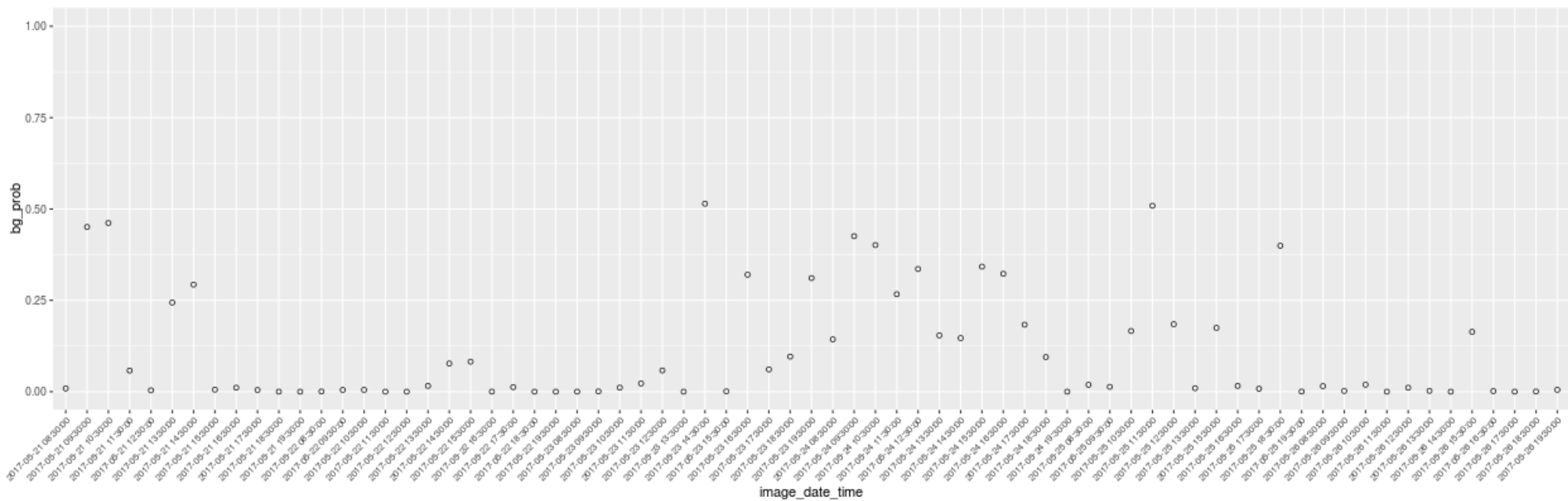


METHODS: AGENCY AND UNIVERSITY SCIENTISTS WILL ASSIST IN OPTIMIZING THE ALGORITHM BY EXTRACTING SAMPLES FROM SITES FROM WHICH IMAGES HAVE BEEN TAKEN TO VERIFY THE PRESENCE (AND AMOUNT) OF BLUE-GREEN ALGAE *IN VITRO* AND WITH OTHER DETECTION DEVICES.



CURRENT MONITORING – WEBSITE

[HTTPS://MATHSTAT.NKU.EDU/HAB](https://mathstat.nku.edu/hab)





PLANNED EXTENSIONS

SMART DEVICE APPLICATION

- PRINCIPAL COMPONENT ANALYSIS TO IMPROVE ACCURACY
- AUTOMATIC CLASSIFICATION AT THE MICROSCOPIC LEVEL*
- DOWNLOADABLE MODELS FOR ALGAE, PLANKTON, MACROINVERTEBRATES, ETC.

*96.6% classification accuracy of microalgae by shape and color (Coltelli, *et. al.*, 2013)

MONITORING

- ADD FIXED CAMERA STATIONS
 - PRINCIPAL COMPONENT ANALYSIS TO IMPROVE ACCURACY
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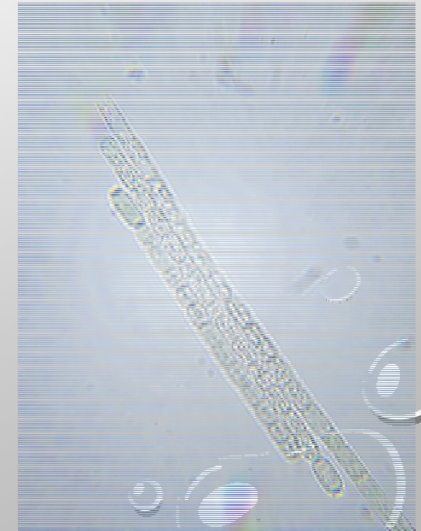
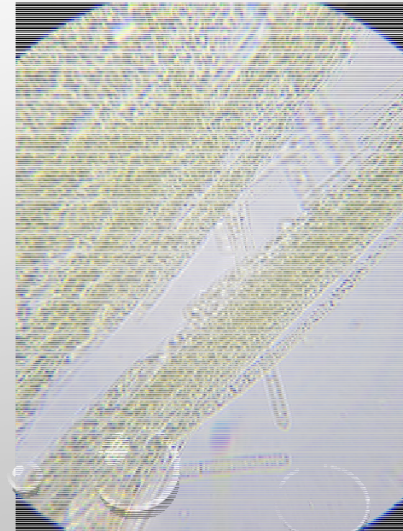
PROBLEM 2

Planned Macroinvertebrate/Plankton/Microalgae Smart Device Application



Aphanizomenon bloom
Big Bone Lake
Boone County, KY
February, 2017

Aphanizomenon at ~800x magnification
Taken with field microscope "Microbescope" at
<http://www.microbescope.com>

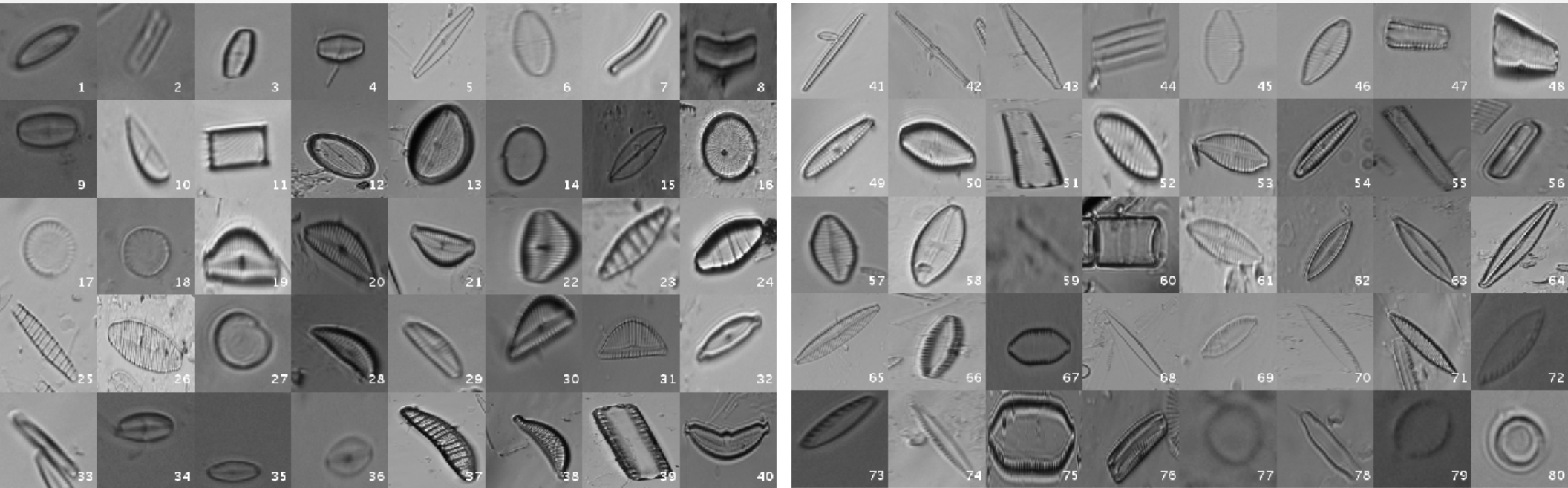


AUTOMATED CLASSIFICATION



*95.3% classification accuracy of eight taxa of benthic freshwater macroinvertebrates by shape (Joutsijoki, et. al., 2014)


AUTOMATED CLASSIFICATION



>99% classification accuracy of 80 species of diatoms
(Pedraza, *et. al.* 2017)



VISION

- Artificial neural network using environmental variables (including water color) to provide a water quality index and to predict harmful water quality “events” such as harmful algal blooms
 - Smart device application with downloadable models for classification (algae, macroinvertebrates, plankton, fish, other organisms), each using trained neural networks for classification
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COLLABORATORS

- Ecological Stewardship Institute at Northern Kentucky University
 - Northern Kentucky University Department of Mathematics and Statistics
 - Northern Kentucky University Department of Biological Sciences
 - Thomas More College Department of Biological Sciences
 - Marshall University Department of Biological Sciences
 - Ohio River Valley Sanitation Commission (ORSANCO)
 - Foundation for Ohio River Education (FORE)
 - Ohio Environmental Protection Agency
 - Oakland University
 - Lake Superior State University
 - Wayne State University
 - Michigan Department of Environmental Quality
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THANK YOU!

FOR QUESTIONS OR INTEREST IN BETA-TESTING, PLEASE CONTACT ME AT:

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