

Brooklyn Atlantis: Where aquatic robots and citizen scientists meet to monitor the environment

Maurizio Porfiri

Department of Mechanical and Aerospace Engineering
New York University Tandon School of Engineering
Brooklyn, NY 11201

Measurements and Observations in the 21st
Century Conference
November 21, 2016 – Frascati, Rome

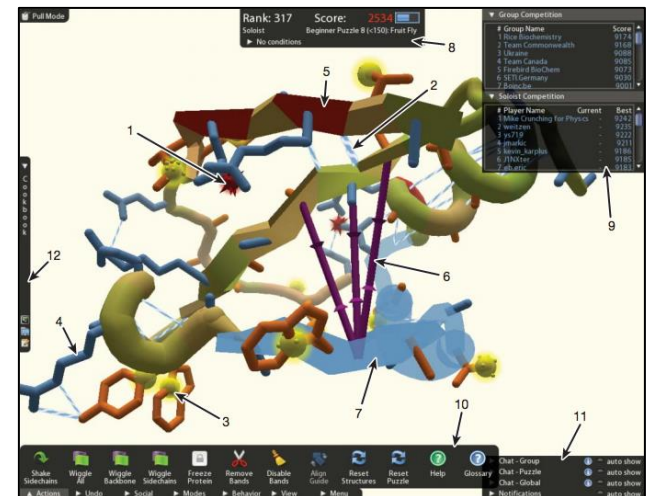
<http://faculty.poly.edu/~mporfiri/index.htm>

mporfiri@nyu.edu

- Classification of data often requires significant manpower
- Citizen-science involves members of the general public to contribute to science projects, and has been successfully utilized for:
 - Classification of galaxies (Galaxy Zoo)
 - Solving protein structures (Foldit)
- These projects offer benefits to both the scientists leading the projects (by providing useful data) and the citizen scientists performing the tasks (by educating them)



Galaxy Zoo [Corke, AER, 2009]



Foldit [Cooper, Nature Letters, 2010]

Motivations and goals

- There is room for improvement in levels of participation in citizen science projects
- Establish a citizen science-based environmental monitoring project that supports hypothesis-driven studies on human-machine interaction
- Develop a means for increasing overall contribution in citizen science projects
- Extend the motivational drivers of citizen science to benefit other activities



Gowanus Canal: Where it is



Gowanus Canal: Who lives there

- Nonetheless, some fish, birds, and small mammals call it home



Brooklyn Atlantis

- An aquatic robot takes pictures, gathers water quality data using a variety of sensors, and uploads them to a web-based interface
- Socially-interacting citizen scientists help with environmental monitoring by analyzing captured images



Aquatic robot: Design

- Lightweight, allowing to be Deployed by a single person
- Dual thrusters for high maneuverability
- Water quality sensors measure pH, conductivity, dissolved oxygen, and temperature
- Images and video captured above and below water
- GPS and on-board computer provide autonomous operation



Aquatic robot: Details

Water quality sensor



GPS

Front camera

Thrusters

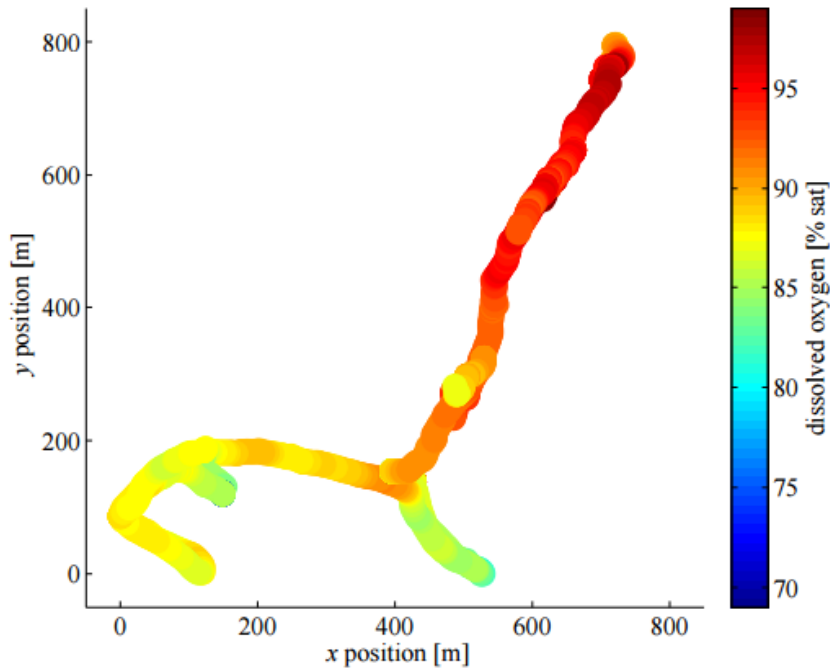
Interactive panoramas



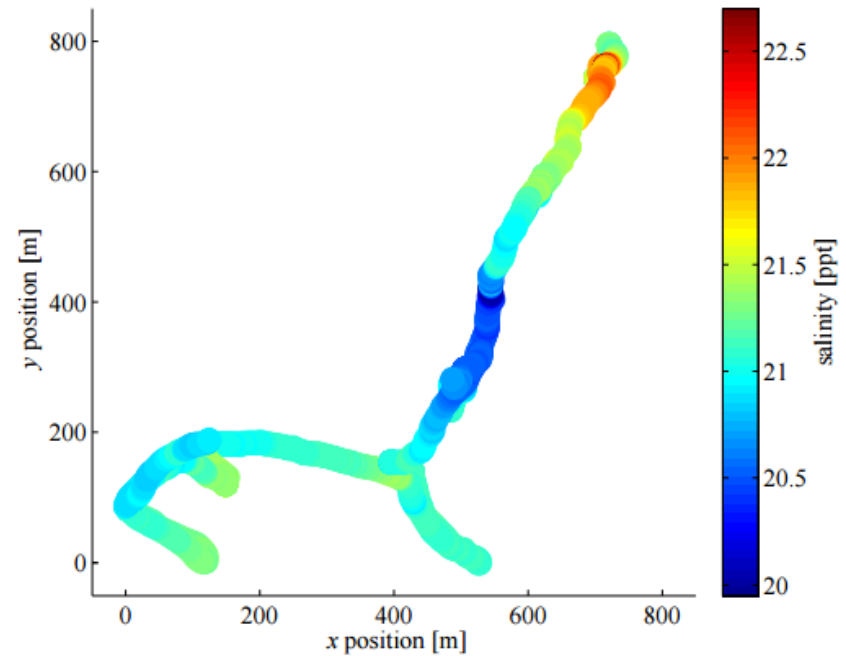
Deployment



Sensor data: Straight from the Canal



(a) Plot of dissolved oxygen

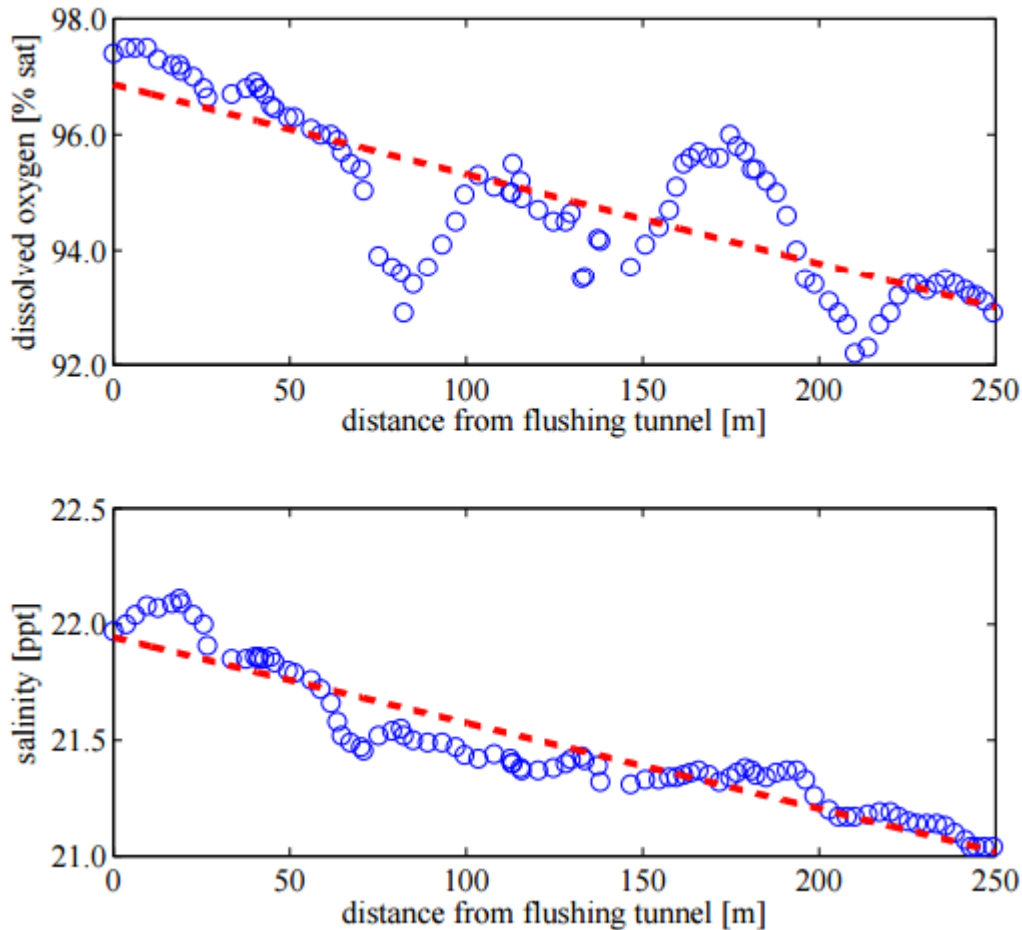


(b) Plot of salinity

Pairing GPS and water quality data allows for finding trends

- Water quality varies throughout the canal
- Turning basins in particular have lower levels of dissolved oxygen

Sensor data: Looking into them



Trend in dissolved oxygen and salinity is a result of EPA intervention

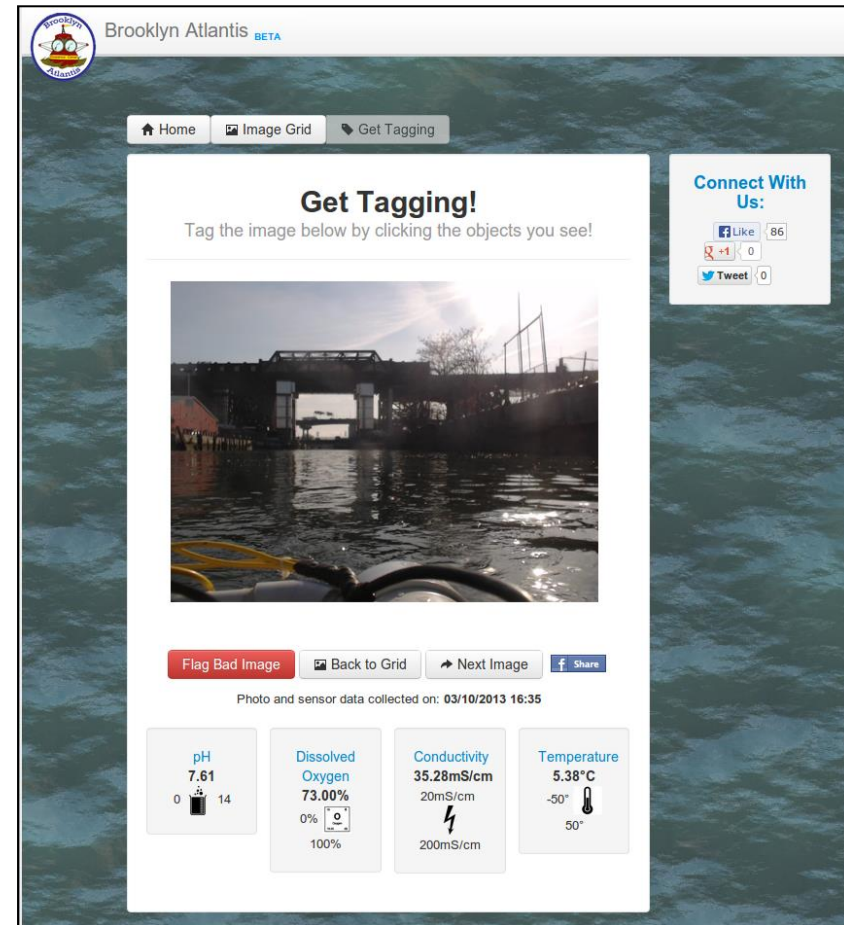
- Dissolved oxygen and salinity increase approaching the north end of the canal
- Result of salt water pumped into the canal to create flow

Citizen participation

- Citizen scientists analyze the image data collected by the robot through a web-based interface

Website based on the BOSSA framework

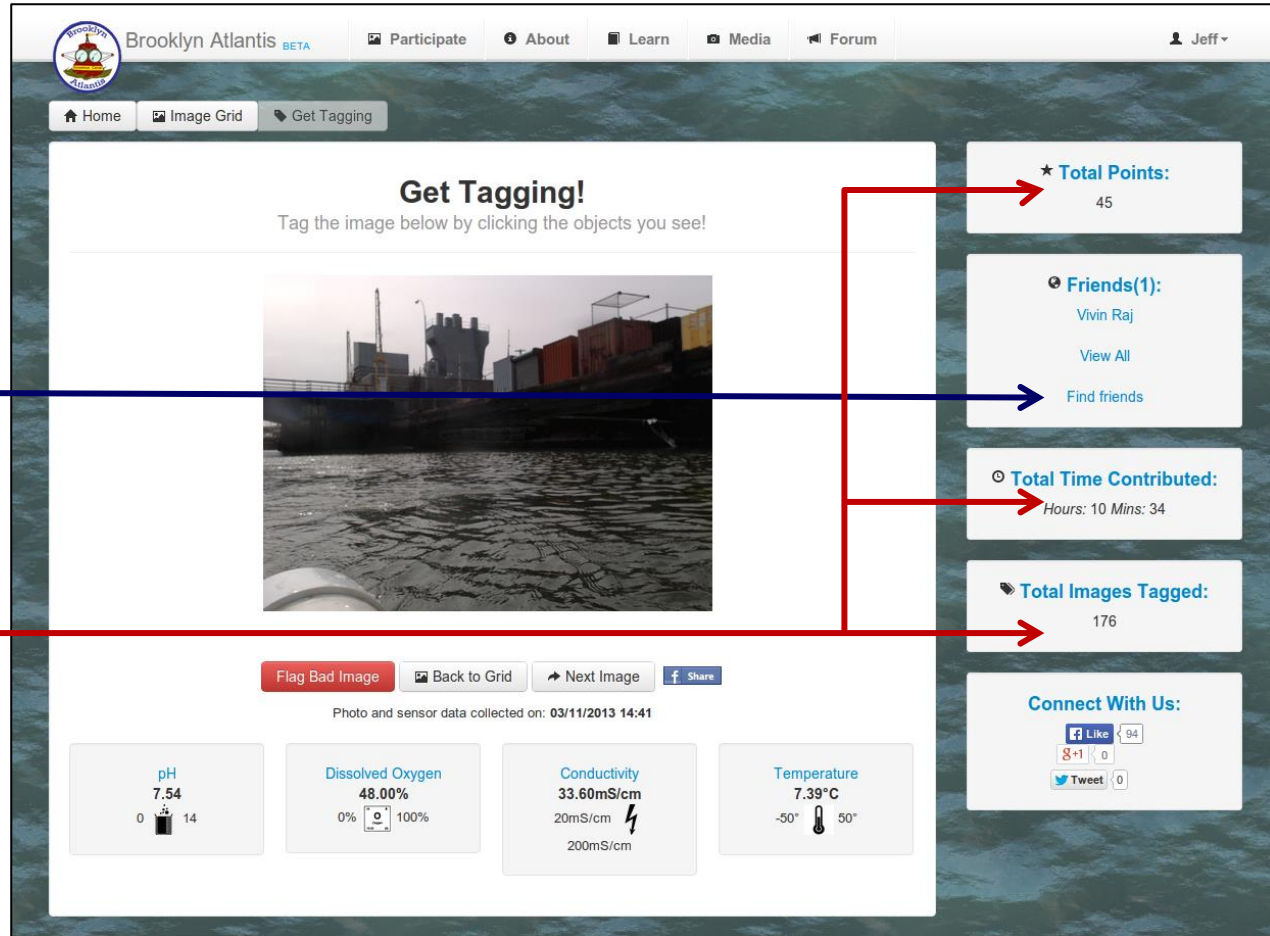
- An admin interface allows for assigning users into groups with different features
- The variation of features among groups enables hypothesis driven research on networks of humans and machines



BrooklynAtlantis.com

Brooklyn Atlantis seeks to increase participation by varying:

- Ability to form Friendship networks
- Display of performance



The screenshot displays the Brooklyn Atlantis web interface. At the top, there is a navigation bar with links: Home, Image Grid, Get Tagging, Participate, About, Learn, Media, and Forum. The user is logged in as Jeff. The main content area features a 'Get Tagging!' section with a photo of a ship and the instruction 'Tag the image below by clicking the objects you see!'. Below the photo are buttons for 'Flag Bad Image', 'Back to Grid', 'Next Image', and 'Share'. At the bottom, there are four sensor data boxes: pH (7.54), Dissolved Oxygen (48.00%), Conductivity (33.60mS/cm), and Temperature (7.39°C). On the right side, there is a sidebar with statistics: Total Points (45), Friends(1) (Vivin Raj), Total Time Contributed (Hours: 10 Mins: 34), Total Images Tagged (176), and a 'Connect With Us' section with social media links.

Increasing participation: Hypothesis-driven study

Get Tagging!

Tag the image below by clicking the objects you see!

Another user has recently added 0 tags to this image



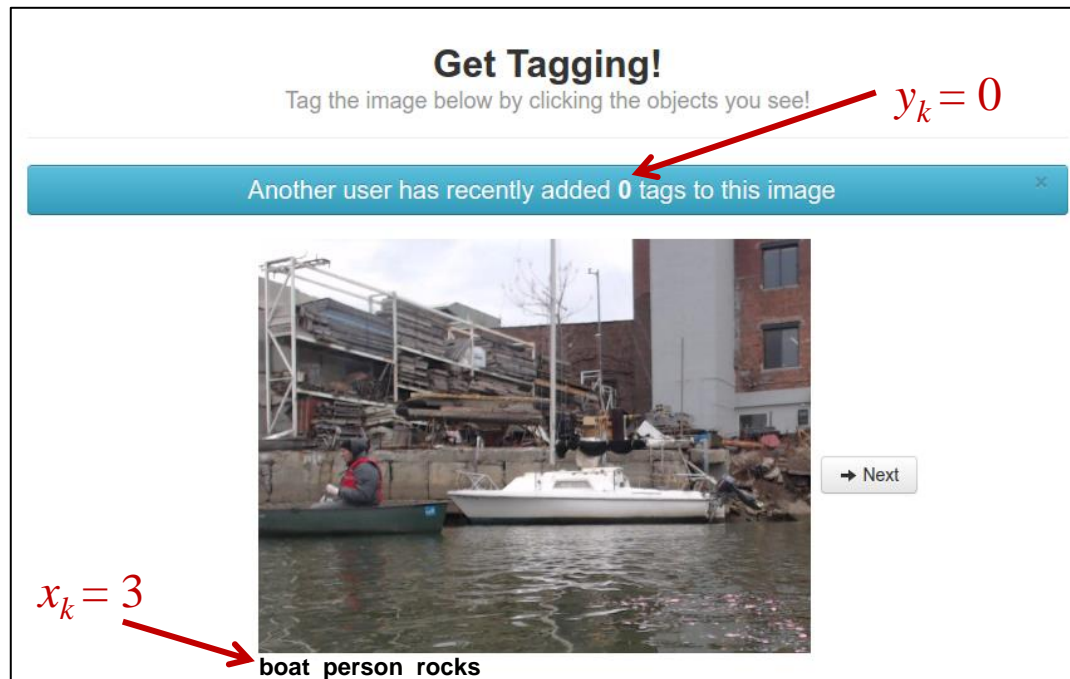
→ Next

boat person rocks

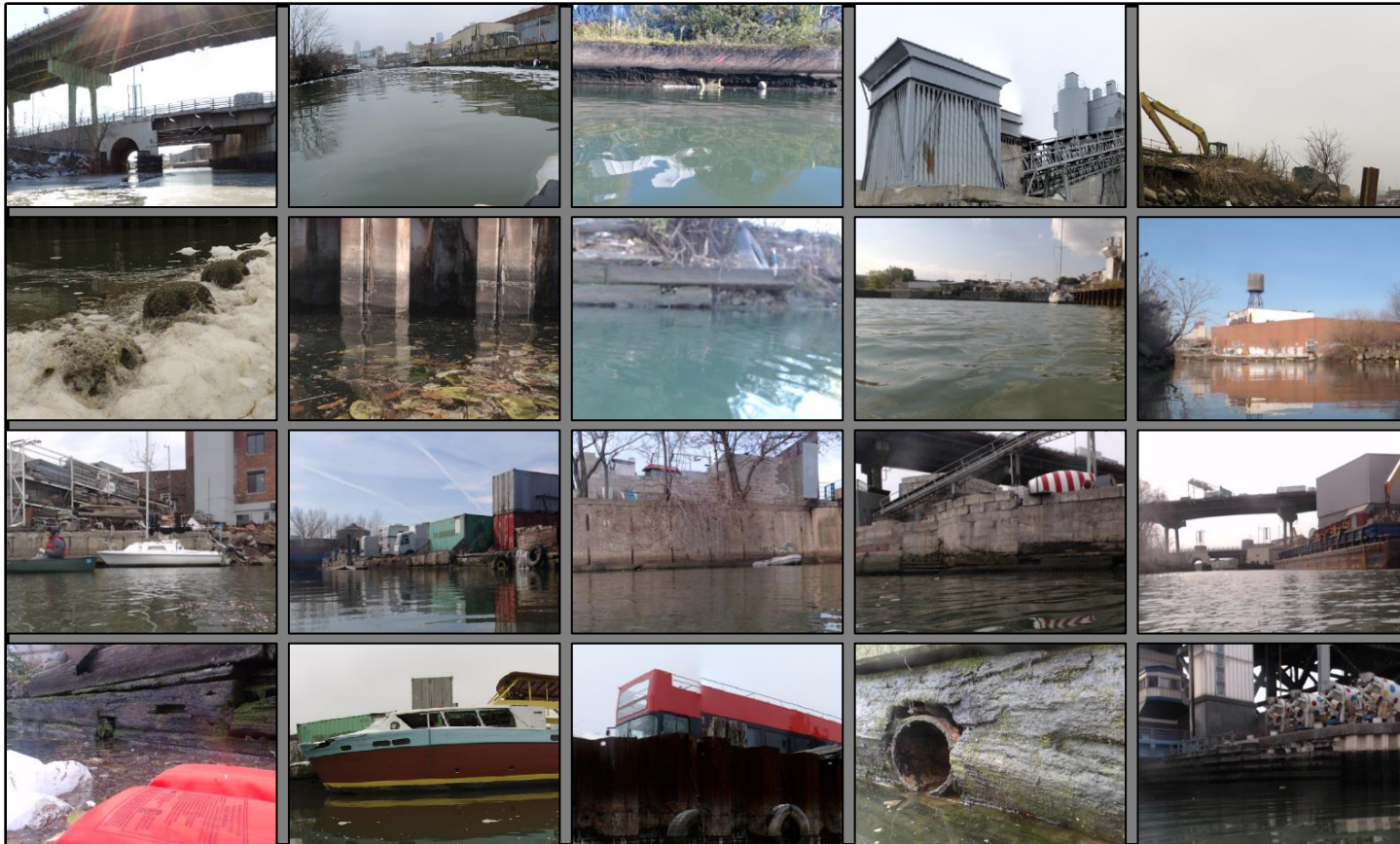
Increasing participation: Experimental conditions

Behavior of virtual peer is systematically varied to understand social influence on citizen science contribution

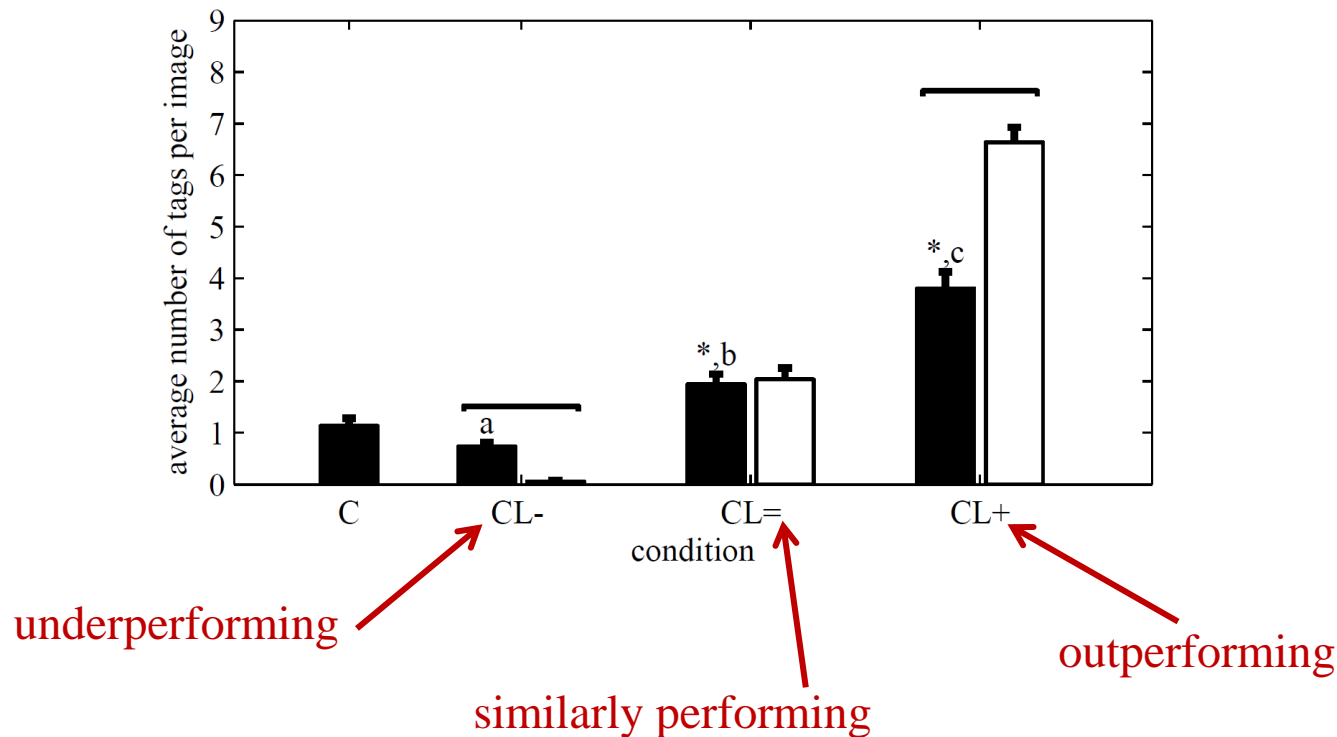
- Control condition to gauge baseline behavior
- Two open-loop conditions (step and ramp behavior)
- Three closed-loop conditions (underperforming, similarly performing, and outperforming behavior)



Increasing participation: Images analyzed



Increasing participation: Results



Number of tags per image depends on behavior of virtual peer

- CL- participants performed the worst
- CL= participants contributed twice as many tags as the control group
- CL+ participants contributed the most, offering 4x more tags than the control group

In a broader setting, citizen science has the potential to serve for motivation for rehabilitation exercises



MIT-Manus



GENTLE/s



REO-GO



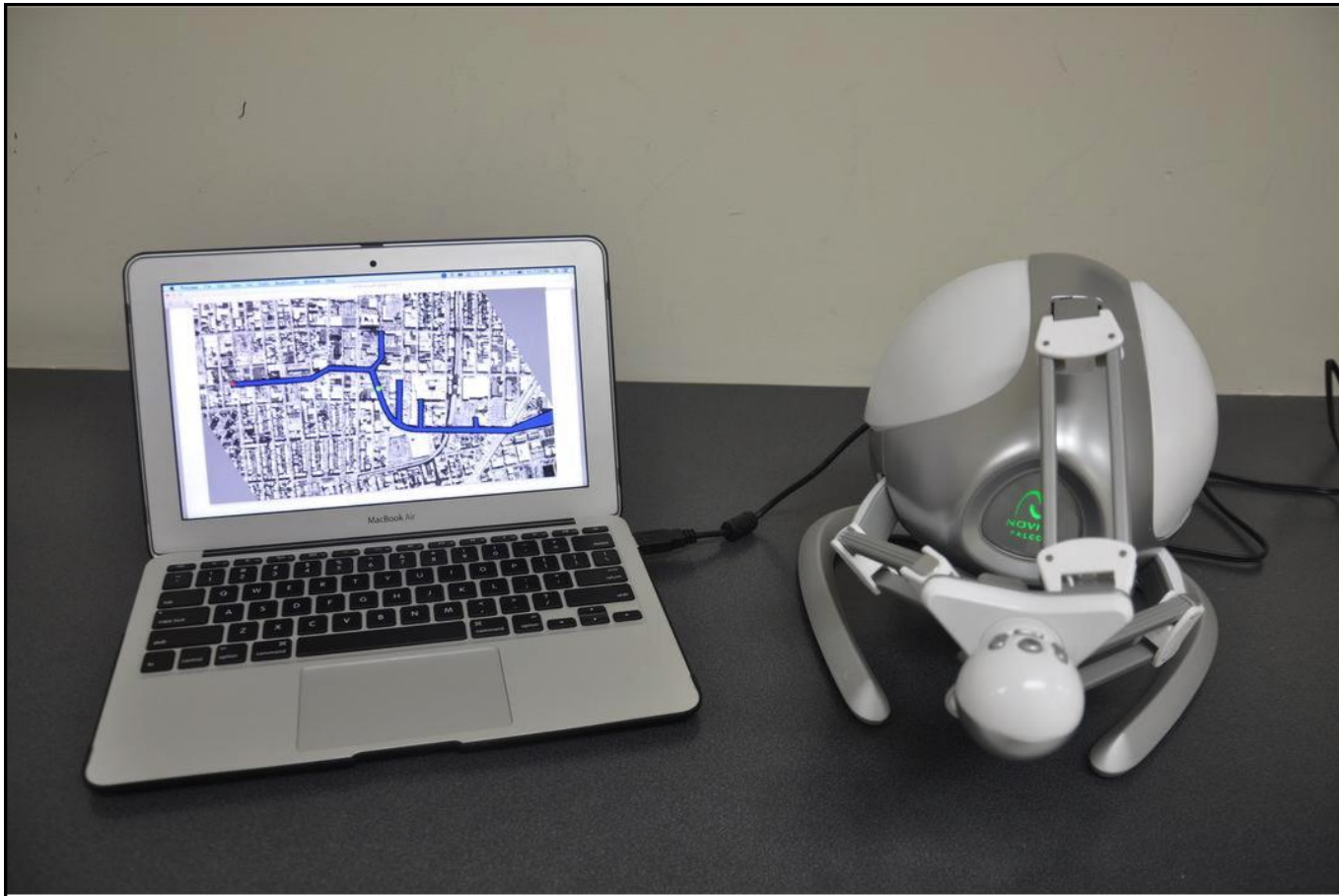
MIME

Rehabilitation is often needed to regain independence after brain damage

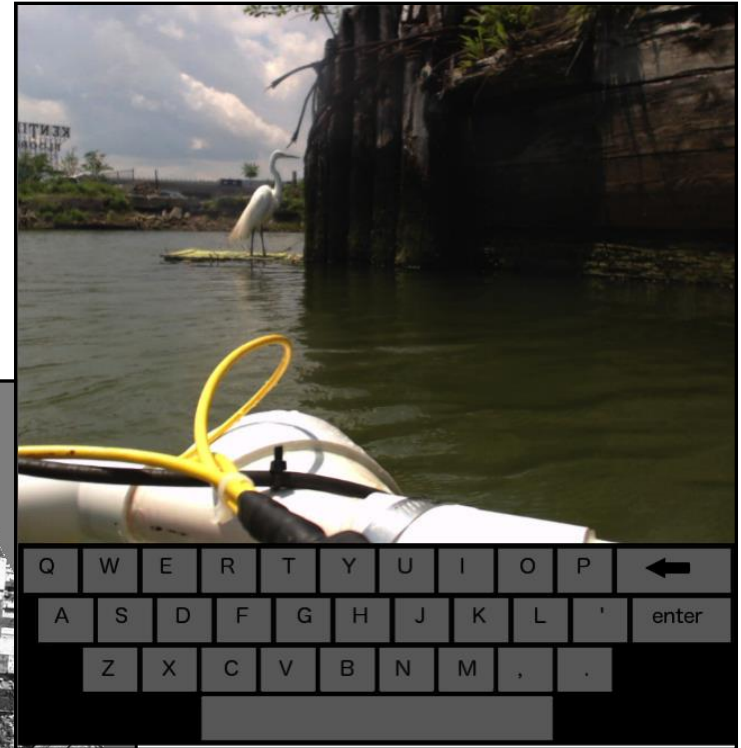
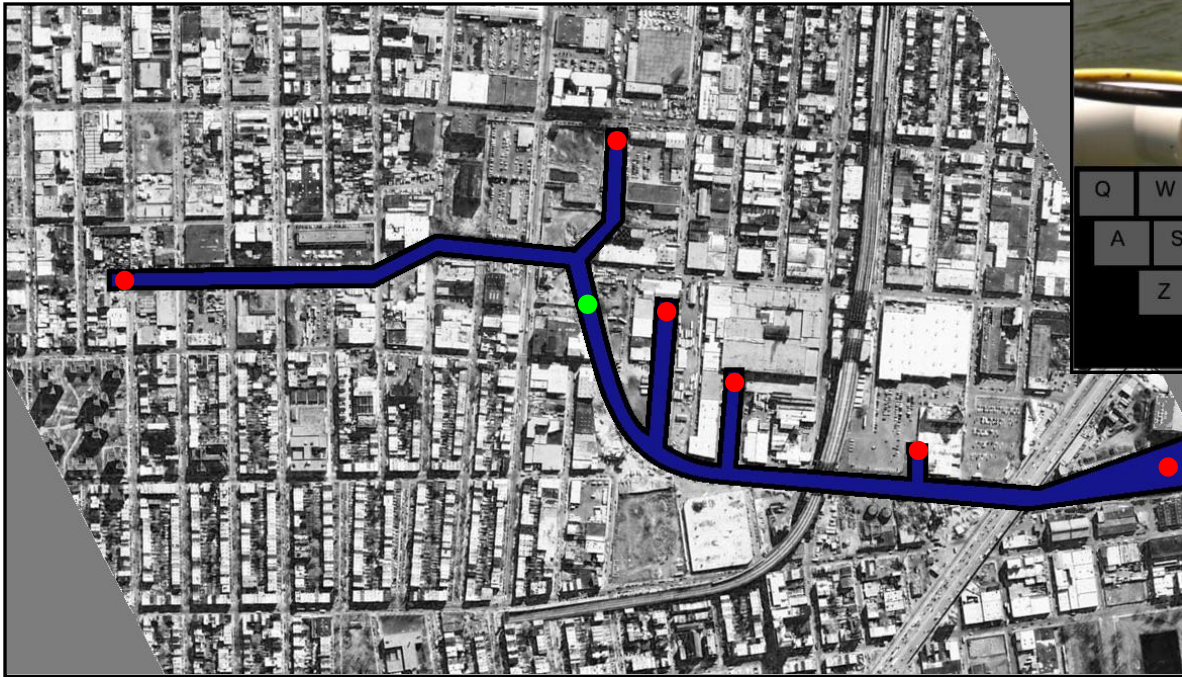
- Repetitive tasks have been shown to be effective in regaining motor function
- Robotic devices have been identified as effective tools in rehabilitation

Citizen science & rehab: Brooklyn Atlantis

Test the effect of including scientific tasks in rehabilitation exercises
on patient engagement



- System operates in tagging mode and map mode
- Force feedback is applied to the participant
- Performance data is gathered from the joystick



Two populations were tested

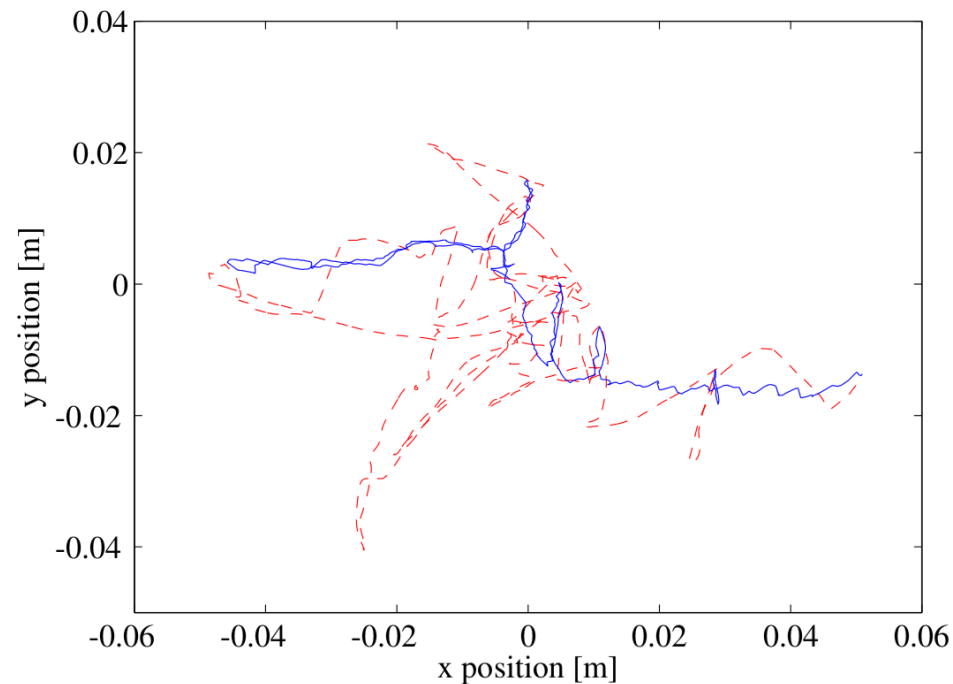
- 30 healthy subjects (control group)
- 30 patients undergoing rehabilitation treatment at a hospital

Citizen science tasks increase engagement in rehabilitation exercises

- Both groups indicate a preference for the task with citizen science
- No perceived increase in difficulty for the task with citizen science

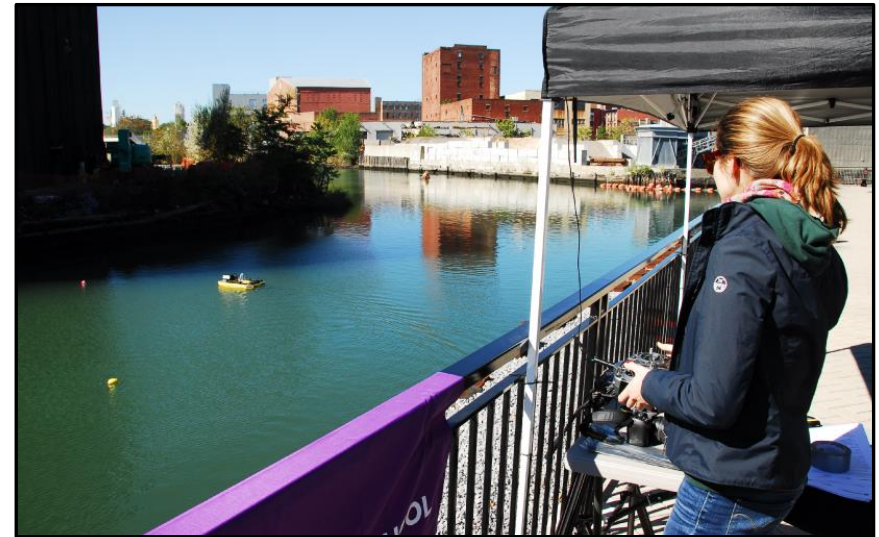
The low-cost device can be used to accurately measure performance

- Performance indices based on sensor data demonstrate better performance by the group of healthy subjects



Direct, in-person interaction with researchers can increase engagement

- 86 Citizen-scientists were recruited and participated first-hand in data collection
- Brooklyn Atlantis research team was on-site to engage participants
- Pre- and post-surveys administered before and after the experience



After the experience, overall levels of motivation were found to increase significantly, including:

- Norm oriented and collective motives (increased social awareness)
- Reputation (findings will be shared through the project website)
- Identification with scientific aim (increased environmental awareness)
- Intrinsic motivations (likely due to enjoyment of the task)

Implementing formal rewards to increase participation

- 90 Citizen scientists used the web-based interface in one of three experimental conditions:
 - No reward
 - Monetary reward (\$1)
 - Social media reward
- Survey instruments used to assess impact on engagement and enjoyment



Reward mechanisms were found to be effective

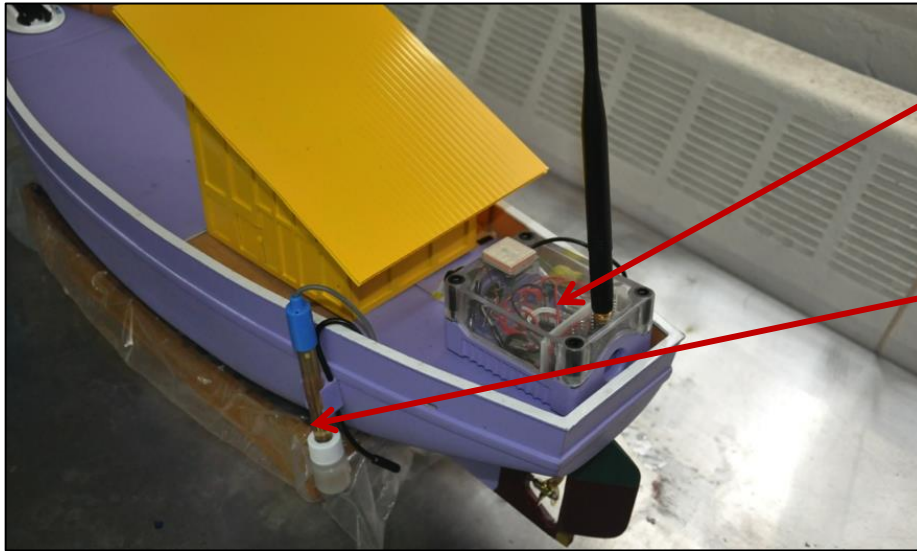
- Both monetary and social media rewards significantly increase contribution (nearly twice as many images tagged)
- Both reward mechanisms also significantly increase levels of engagement and enjoyment

Annual one-day event for on-site participation

- Four remotely controlled boats fitted with sensors
- Citizens piloted the boats using conventional remotes and iPods
- As the boats move, their GPS position and corresponding water quality sensor data are transmitted back for plotting
- Over 150 citizen scientists educated on environmental monitoring



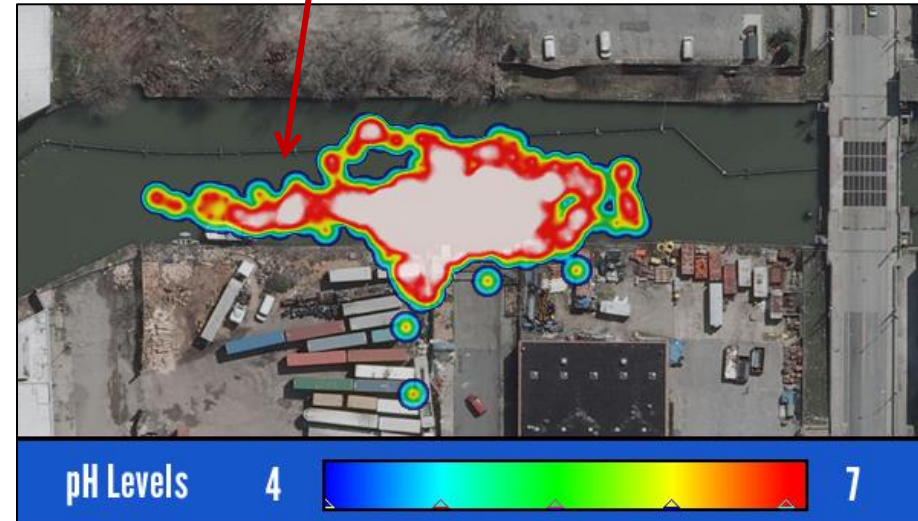
Gowanus Voyage: Data



Control unit, consisting of an Arduino Pro Mini, GPS module, and Xbee radio

Water quality sensor; either pH, conductivity, dissolved oxygen, or temperature

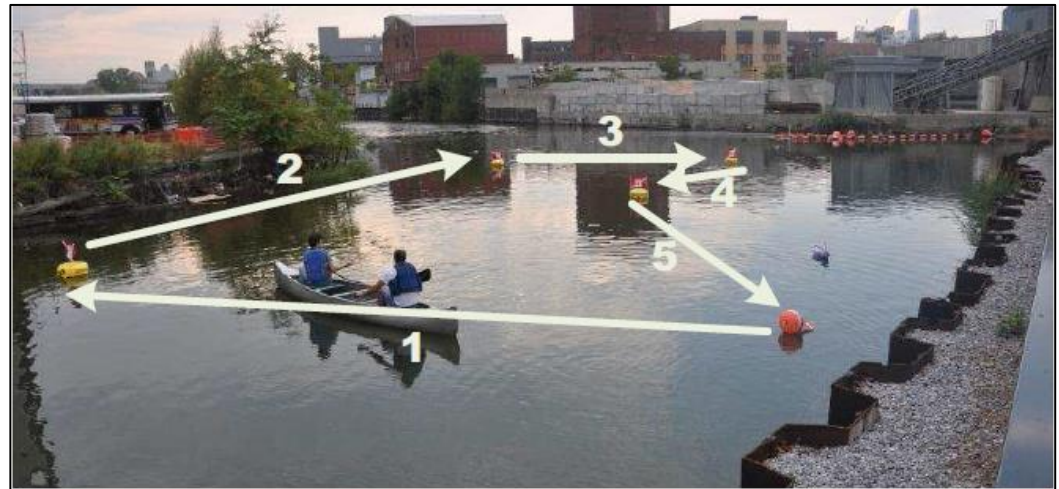
Data-map created on-site by citizen scientists



Gowanus Voyage: Using a Kinect

A rehabilitation task was designed around the event

- Participant input was captured using a Microsoft Kinect
- Using arm gestures, participants were tasked with controlling the boats along a path
- Performance metrics were developed for quantifying sensorimotor performance



Thank you!



Department of Mechanical and Aerospace Engineering
New York University Tandon School of Engineering
Brooklyn, NY, USA

<http://faculty.poly.edu/~mporfiri/index.htm>
mporfiri@nyu.edu