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Using the art practice of play to communicate legged robotics research concepts

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Abstract
The art practice of play uses spontaneity and surprise to communicate meaningful content and inspire critical thinking (1-3). We describe three engineering education outreach efforts that use play to communicate legged robotics research concepts. In the first workshop, Penn engineering students were motivated to learn how to program a legged robot using the narrative of a "dance competition," with the winning dances to be showcased at the Philadelphia Science Festival. In the second workshop, Philadelphia School District high school students used a poseably programmable legged robot to tell a story by performing a series of behaviors in a set of their own design and documenting the story as a video artwork. Here, there were two narratives: One created by the workshop directors, communicating concepts about complex multi-legged behaviors and gaits, and the other created by the students using the robots to express their ideas. In the final workshop, middle school students created locomoting robots using motors, post-consumer materials, and basic art supplies. The concepts of energy and physical programming were demonstrated using working Trashbots and practiced during an introductory exercise making a vibrating motor from a spinning one. Participants then created a robot of their own design using iterative experimentation. We conclude from these three workshops that play can be used as a vehicle for scientific communication. (1) David Getsy, ed. *From diversion to subversion: Games, play, and twentieth-century art, Vol. 16* (Penn State Press, 2011). (2) Nato Thompson and Gregory Scholette, eds. *The interventionists: Users' manual for the creative disruption of everyday life* (MIT Press, 2004). (3) Diedra Krieger, 'Plastic Fantastic,' Gyre Exhibition, Anchorage Museum, Alaska, 2014.

For more information: Kod*lab.

Keywords
STEAM, STEM, robotics, art, legged robots

Disciplines
Electrical and Computer Engineering | Engineering | Systems Engineering

USING THE ART PRACTICE OF PLAY TO COMMUNICATE LEGGED ROBOTICS RESEARCH CONCEPTS

Penn Engineering | GRASP Laboratory
General Robotics, Automation, Sensing & Perception Lab

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SCIENCE THROUGH NARRATIVE
ENGAGING BROAD AUDIENCES

NSF

OVERVIEW

The art practice of play uses spontaneity and surprise to communicate meaningful content and inspire critical thinking (1-3). We describe three engineering education outreach efforts that use play to communicate legged robotics research concepts.

Strategies of play employed in the studies:
1. All participants engage in the same activity regardless of previous preparation.
2. Activities were structured but open-ended, encouraging creation of self-determined goals.
3. Aesthetic and theatrical artistic goals, unexpected in the context of robotics, encouraged the use of experimentation, learning and spontaneous, creative thinking to program visual gestures and behaviors.

Scientific & engineering concepts communicated the studies:
- center of mass, balance and the alternating tripod gait (STUDY 1)
- bioinspired robots - robot and animal gaits (cockroach in STUDY 1, horses in 2)
- physical programming, including both the use of physical setpoints to program actuator behavior and changes to a robot's chassis that alter its behavior (STUDY 2, 3)
- concepts of energy transmission (STUDY 3)
- experimentation and iterative processes (STUDY 1, 2, 3)

The three workshops described here provide preliminary support that play can be used as a vehicle for scientific communication. In the future, we plan to investigate the effectiveness of our scientific communications using pre/post interviews and surveys. We are in the early stages of exploring new combinations of the art practice of play and robotics research concepts, including gait design and robot morphology, to facilitate informal education with other GRASP Lab members.

(1) David Getsy, ed. From diversion to subversion: Games, play, and twentieth-century art, Vol. 16 (Penn State Press, 2011).
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View a playlist of videos from the studies with this QR code.

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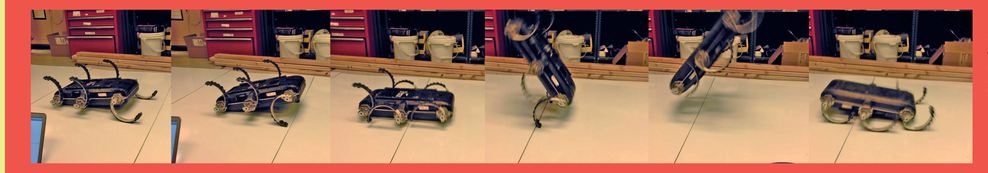
STUDY 1: CAN YOU MAKE A LEGGED RESEARCH ROBOT DANCE?

MAKING THE DANCES: Penn undergraduates and graduate students were invited to create a robot dance using a RHex family robot, with the winning three dances to be showcased at Discovery Day in Clark Park, Philadelphia, PA for the 2014 Philadelphia Science Festival. This "dance competition" replaced the annual "gait competition," a mandatory competition in which new lab members compete to program the fastest hexapedal gait on a RHex robot. With the change in the type of competition, four older PhD students out of seven, including one non-RHex user, chose to participate in the dance competition, whereas no older graduate students or non-RHex users had chosen to participate in the gait competition for at least the previous two years.

RHex performs a "shuffle" maneuver in a dance choreographed by Avik De and Sarah Costrell (PhD students)



Jeff Duperret, PhD student, gets RHex to flip to the song "I Like to Move It".

OUTREACH WITH DANCES: The dances were then displayed on a dance floor, constructed from donated white board painted Masonite from Home Depot, in Discovery Day. The dances facilitated conversation about legged robots with visitors. Through the exhibit, visitors learned about center of mass, balance, the alternating tripod gait, bioinspired robots and RHex's relationship to the common cockroach.

RHex performs a dance at the festival.

Kodlab members Jeff Duperret, PhD student, Shafag Idris, undergraduate, Ben Kramer, undergraduate, and Sonia Roberts, PhD student, pose with an instructional poster at Clark Park.

Ben Kramer, undergraduate, repositions RHex to perform another dance.

Jeff Duperret, PhD student, shows a local student how to command the robot to walk.

STUDY 2: CAN YOU MAKE A LEGGED ROBOT TELL A STORY?

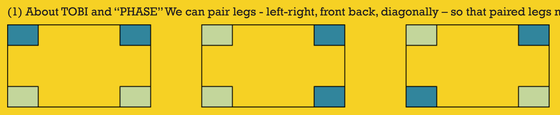
Image: Teaching Oriented BioInspired "TOBI" Robot, a four legged robot, used in the workshops for STUDY 2

Philadelphia School District high school students used a poseably programmable legged robot (TOBI) to tell a story by performing a series of behaviors in a set of their own design and documenting the story as a video art piece. Here, there were two narratives: One created by the workshop directors, communicating concepts about complex multi-legged behaviors and gaits, and the other created by the students using the robots to express their ideas. The workshops each with 9 participants were held at The Franklin Institute, Pennsylvania Academy of Fine Arts, Slought Foundation and the Department of Making + Doing, in the fall of 2014 and early spring 2015.

Students collaborated in groups of 3 to develop the narrative, create a set design and physically program the robot's performance. Workshop instructions:
1. TOBI's legs are set by manually rotating them and recording different positions.
2. You have to set the angle of TOBI's legs incrementally - each point in its movement is specific (like the stills Muybridge took, or stop-motion animation). You have complete control over the angle of each leg position.
3. You will be able to program 10 different positions for TOBI's legs.
4. Use the storyboarding worksheet to come up with a 30 second story or physical performance you'd like TOBI to accomplish.

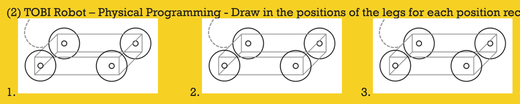
Handout selections:

(1) About TOBI and "PHASE" We can pair legs - left-right, front back, diagonally – so that paired legs move together.

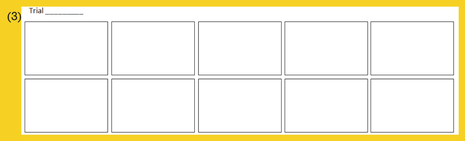


Phase is a comparison of the position of each leg to the other legs - how many degrees away they are from each other. We can think about how the legs are "in phase" (in similar positions) or "out of phase" (in dissimilar positions).

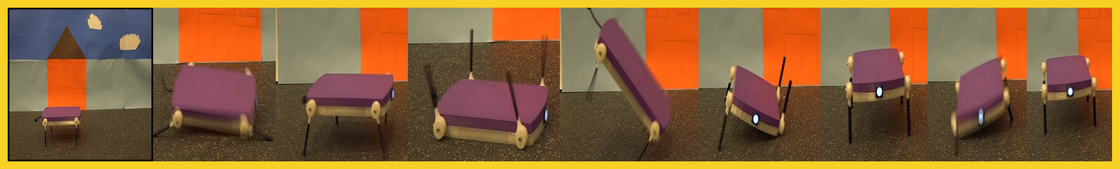
(2) TOBI Robot – Physical Programming - Draw in the positions of the legs for each position recorded

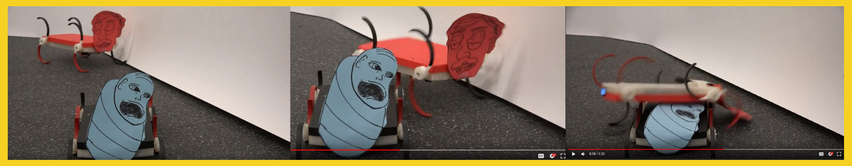


(3)



STUDENT SURVEY COMMENTS: "I LEARNED THAT IT TAKES A LOT OF TIME JUST TO MAKE A ROBOT, AND A LOT MORE TIME TO MAKE IT CONVEY EMOTIONS"



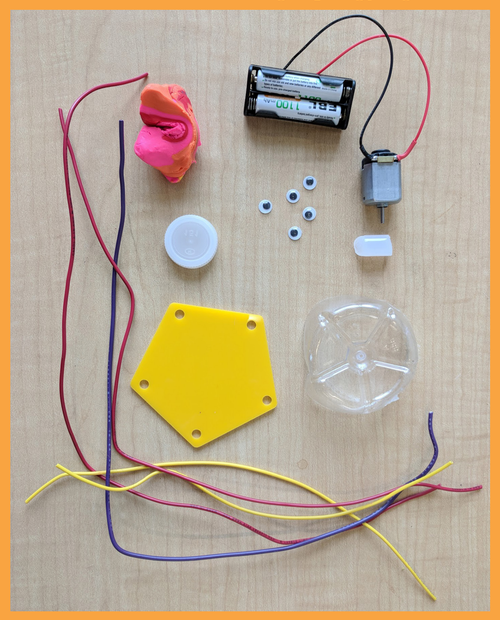


Student projects from TFI:
(above) "School's Out for Summer"

(left) "Edgar Allen Poe and His Baby Mama"

STUDY 3: CAN YOU CREATE A WALKING "TRASHBOT" ROBOT?

"Trashbots" are constructed primarily of post-consumer materials that locomote by transmitting energy from a vibrating motor that communicates ground reaction forces to the mass center through springy legs.

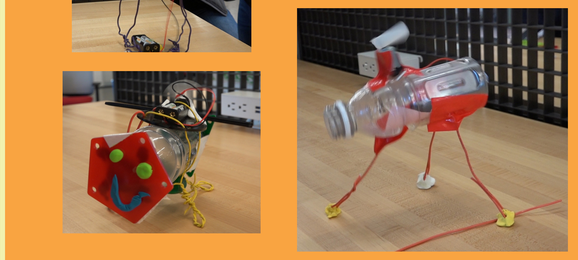


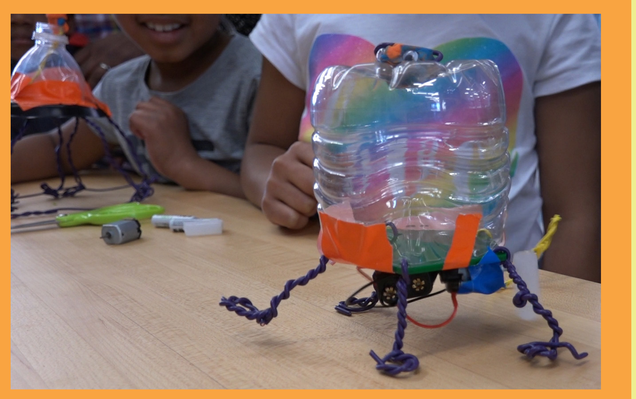
(above) Materials provided for Trashbots workshop: 18 gauge wire, post-consumer water bottles, plastic plates, laser-cut acrylic, 3V motor soldered to a AAA battery bay, batteries, Sculpy and googly eyes.

The concepts of energy and physical programming were demonstrated using working Trashbots and practiced during an introductory exercise in which students created a vibrating motor by pushing a chunk of hot glue onto the shaft of a servo motor.

K-8 students with their parents created a robot of their own design using iterative experimentation.

Selection of completed Trashbots produced at the workshops.





We led three workshops with a total of 45 Philadelphia-area K-8 students to make Trashbots during "Be a Pennovator," part of the "Be A Scientist For a Day!" program of events for the 2017 Philadelphia Science Festival at Pennovation Center. Participants could take their creation home with them.

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