

A photograph of a grand, classical-style building with a series of tall, white columns and a wide set of stone steps leading up to the entrance. The building is made of red brick and has many windows. The sky is blue with some light clouds. The image is used as a background for the text.

Making Advanced Computing Concepts Accessible for High School Students

Brian Broll and Gordon Stein
Vanderbilt University

WHAT DO THESE HAVE IN COMMON?



NETFLIX

 **Office 365**

 **TikTok**

 **Spotify**

 **YouTube**

CALL OF DUTY®

ROBLOX

amazon
prime



FORTNITE

Google





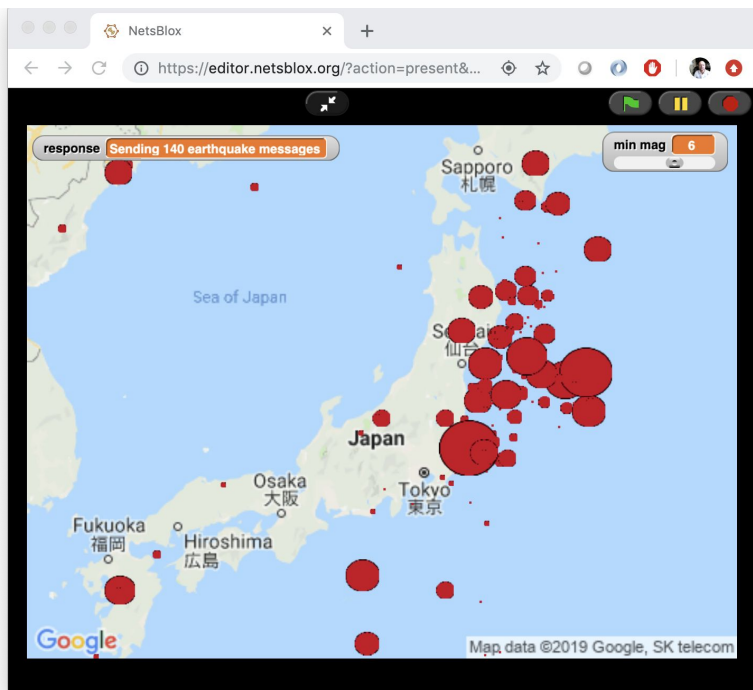
NETSBLOX

- A blocks-based programming environment designed for making distributed computing more accessible
- An extension of Snap!, a popular blocks-based programming environment from Berkeley
- Two main networking abstractions:
 - Remote Procedure Calls
 - Message Passing
- These also facilitate learning about many other advanced concepts such as:
 - Cybersecurity
 - Robotics
 - Internet of Things

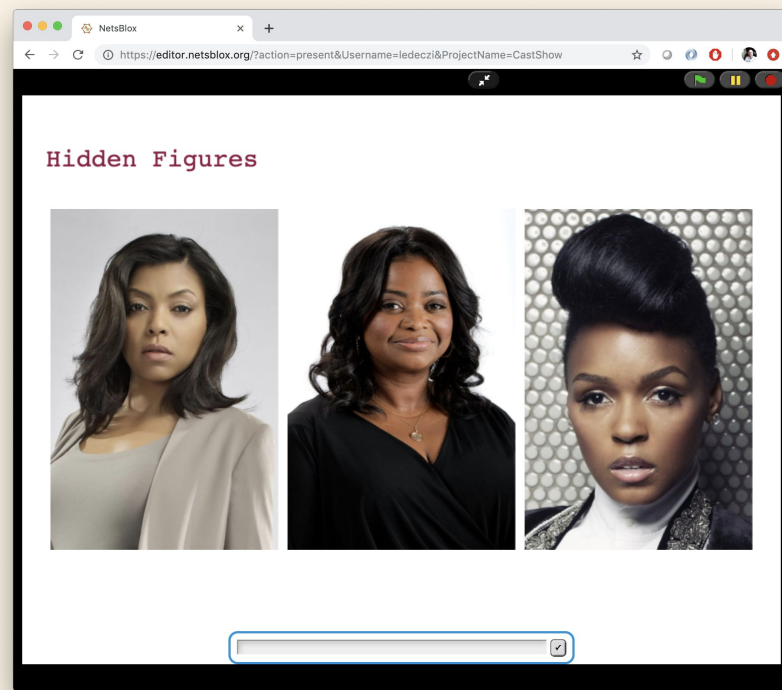




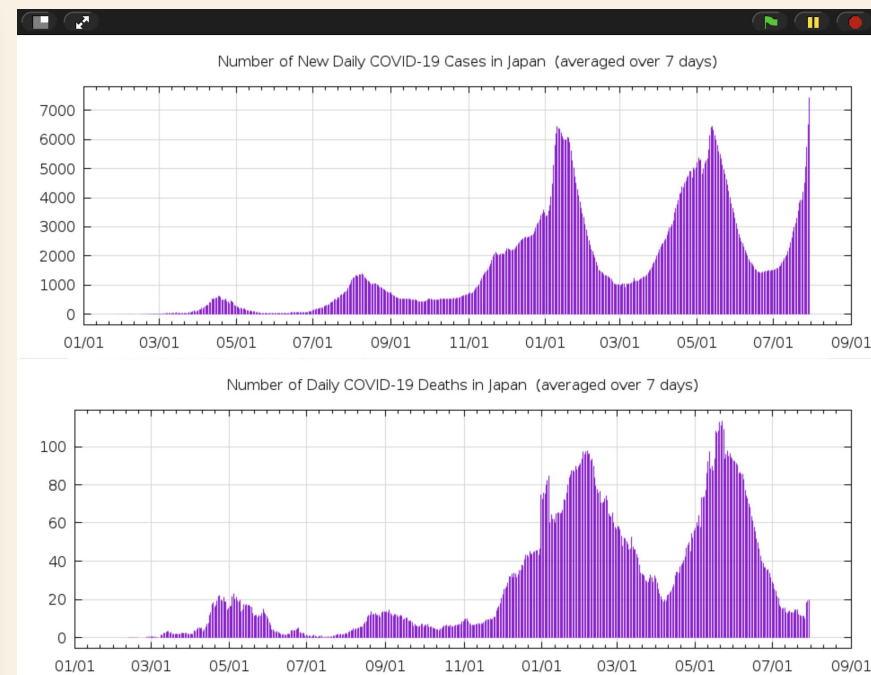
RPC DEMOS



Earthquake Visualization



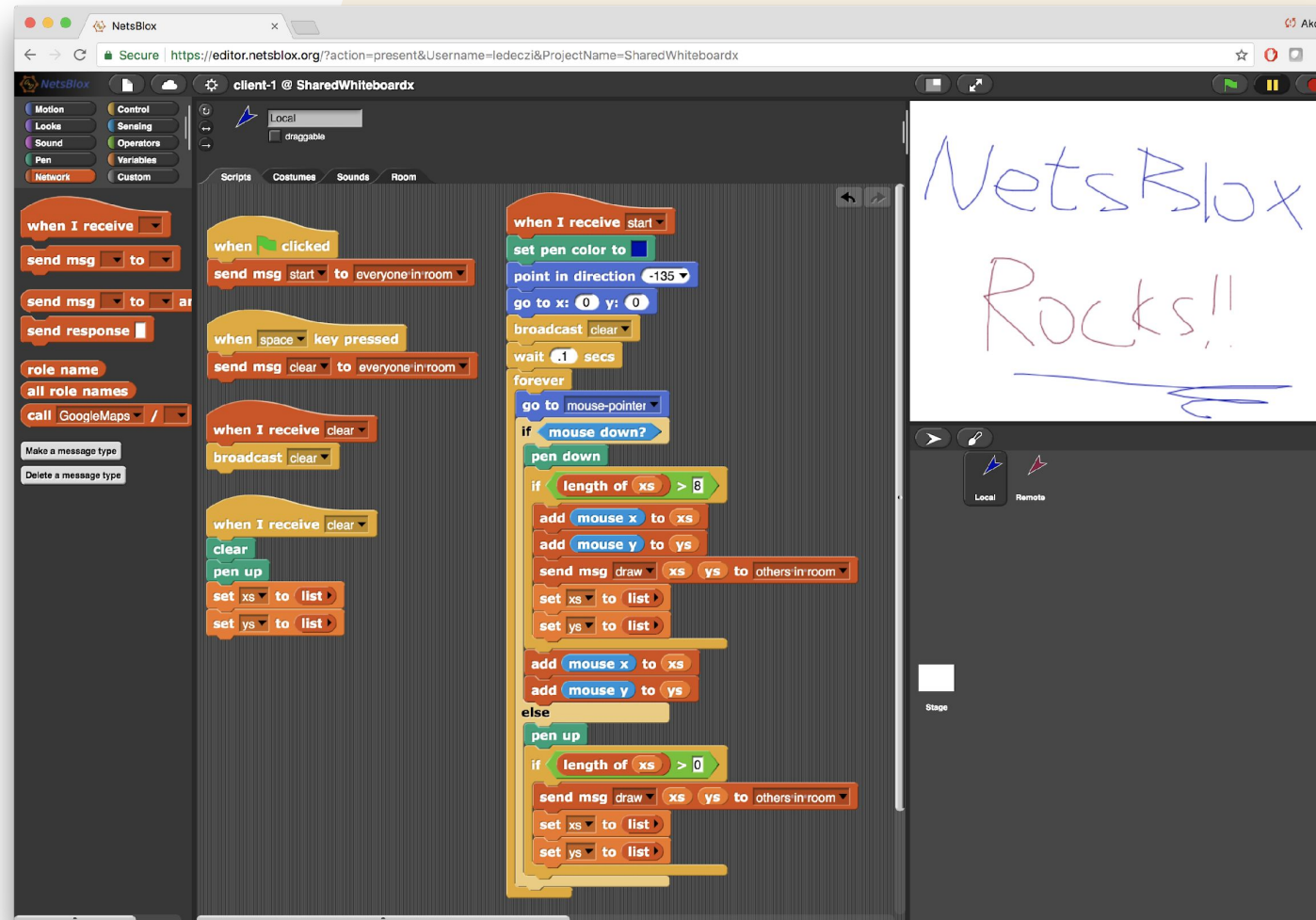
Cast of Any Movie



COVID-19 Data



MESSAGE PASSING DEMOS



2-User Shared Whiteboard

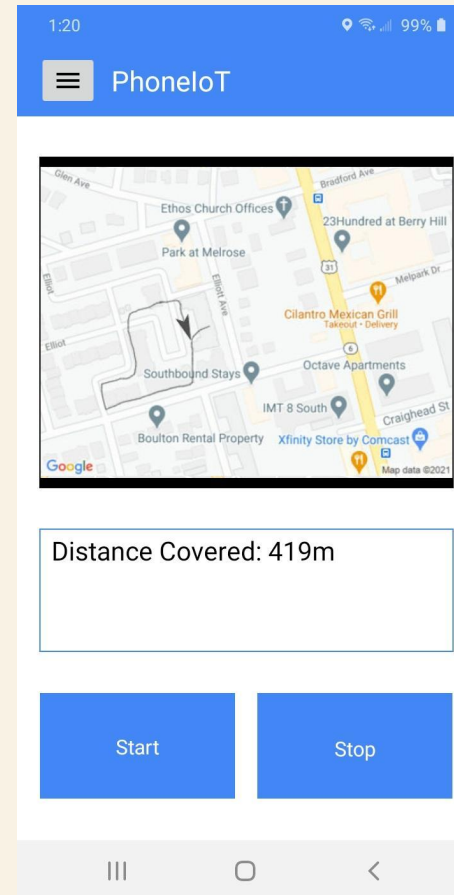
PhoneloT



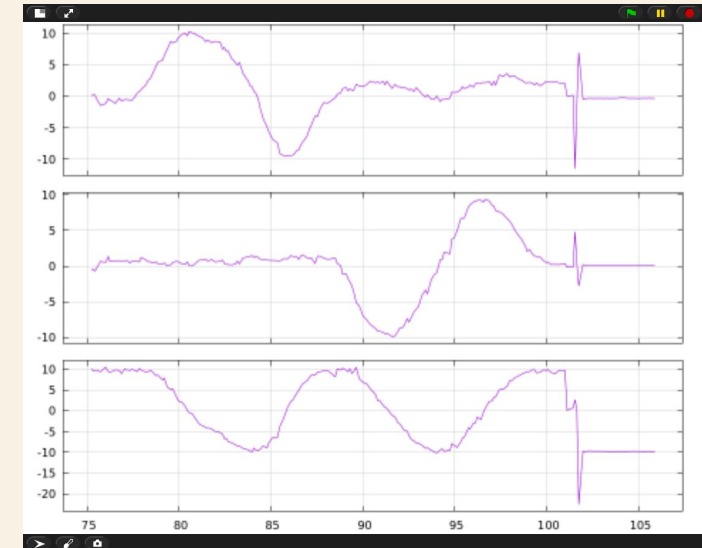
VANDERBILT
UNIVERSITY



- PhoneIoT, an iOS and Android app, provides access to all phone sensors for NetsBlox
- Get value (RPC) or turn on streaming (messages)
- NetsBlox programs can also place GUI widgets on the phone
- GUI events are NetsBlox messages
- Can be used to teach IoT and distributed computation
- Not a mobile app development environment!



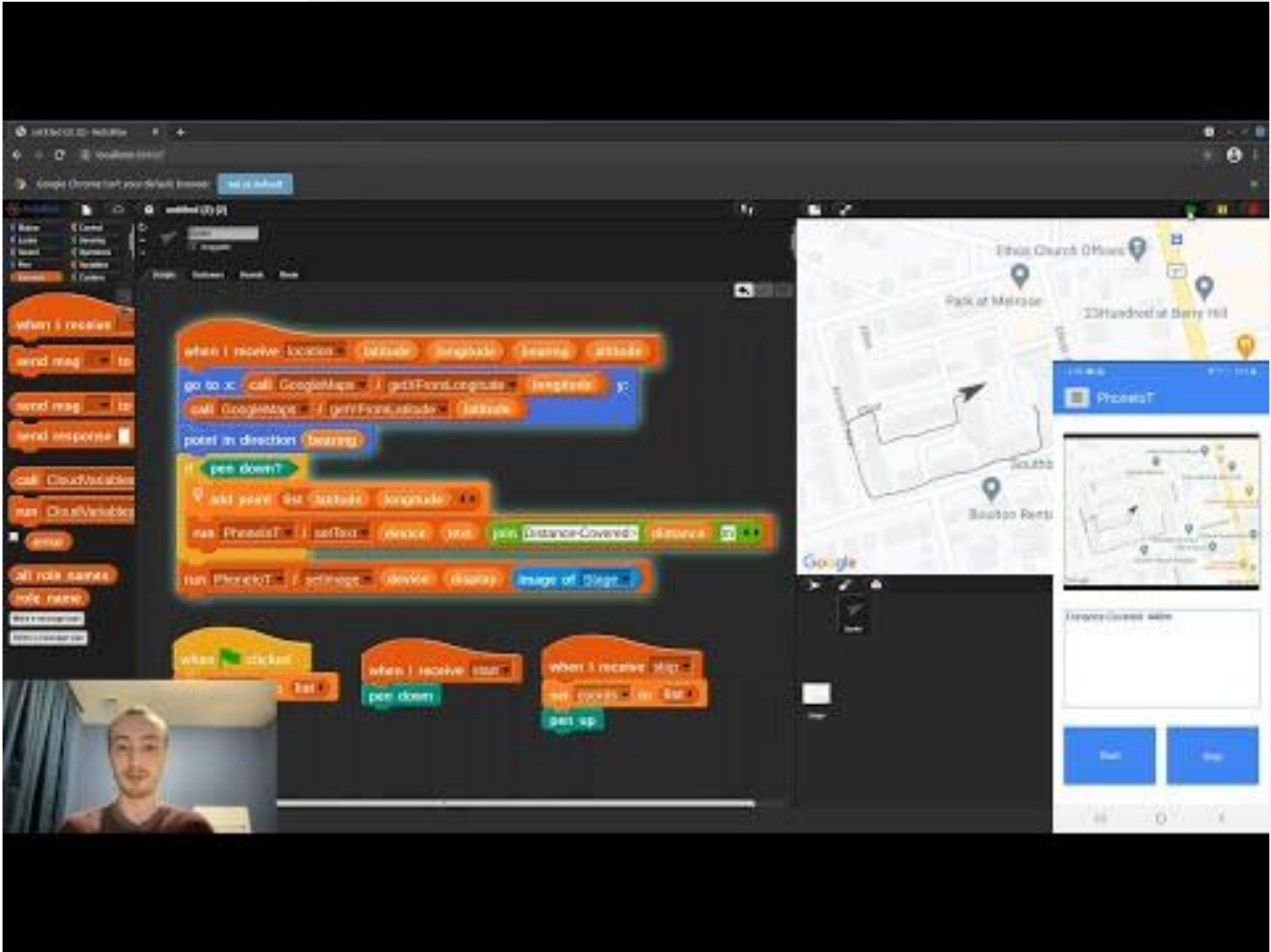
Exercise Tracker
(phone display)



Plot 3-axis acceleration
(stage)



DEMOS



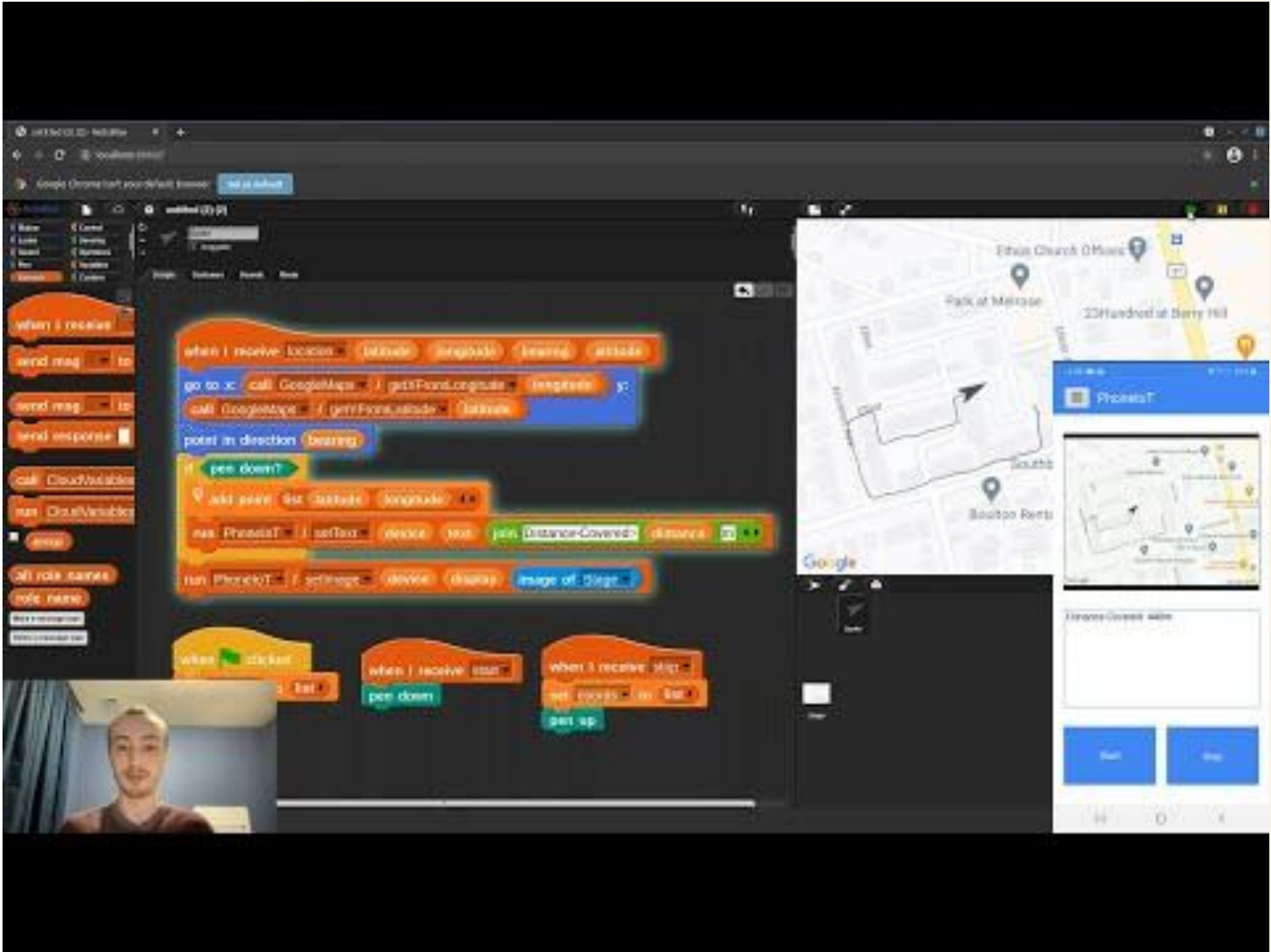
Devin Jean

For the full video, check out <https://tinyurl.com/phoneiot>





DEMOS



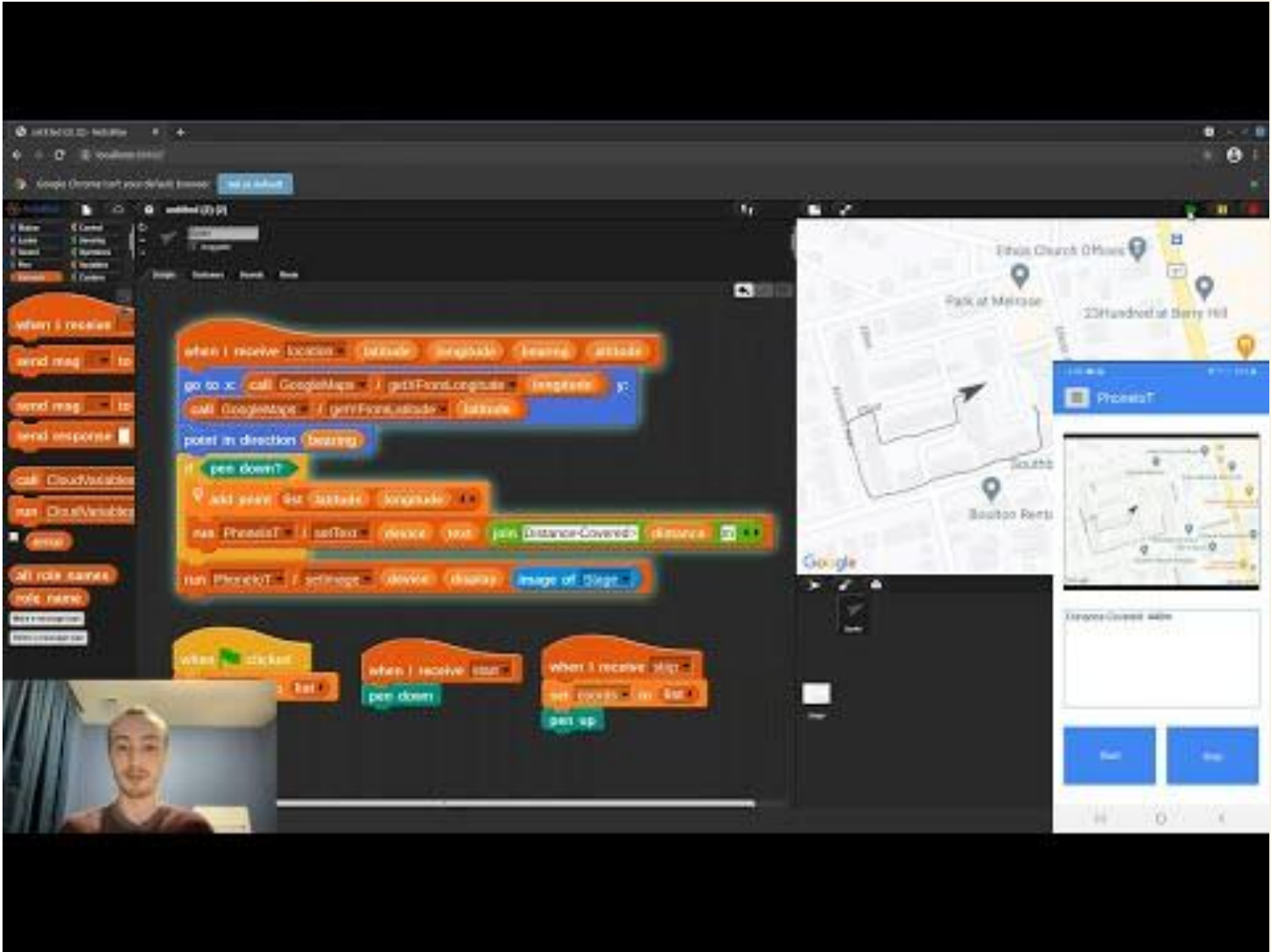
Devin Jean

For the full video, check out <https://tinyurl.com/phoneiot>





DEMOS



Devin Jean

For the full video, check out <https://tinyurl.com/phoneiot>



RoboScape



VANDERBILT
UNIVERSITY

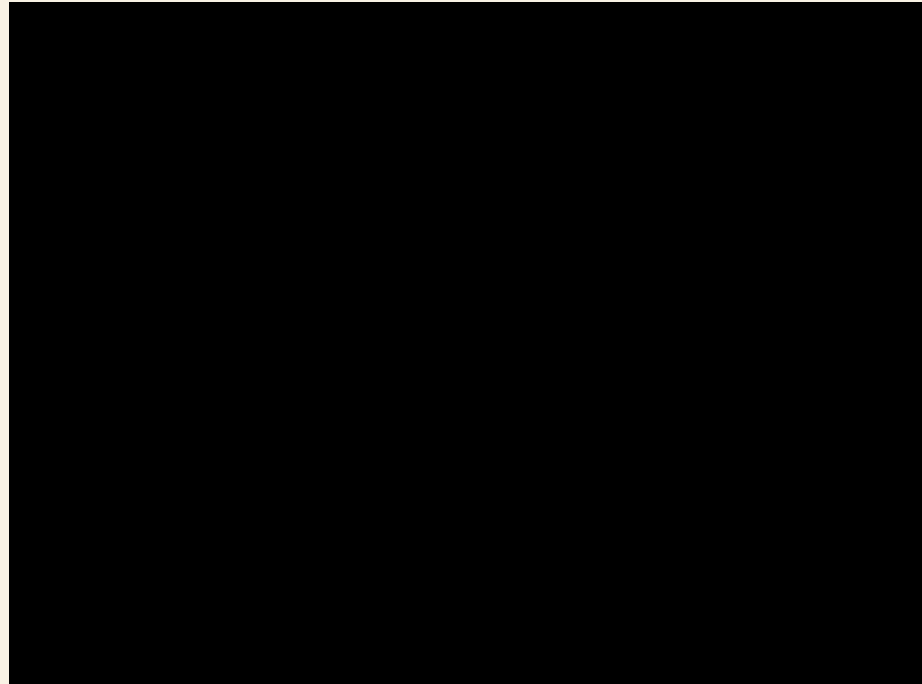
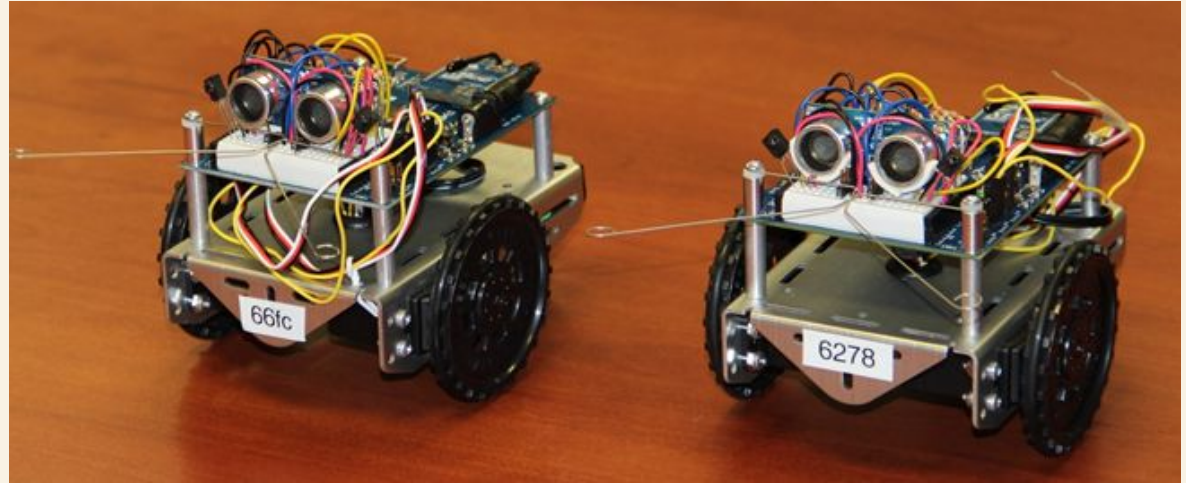


- RPCs and messages can be used to control WiFi-enabled robots
- Code runs in the browser (no wires, no downloads)
- Supports remote robotics out of the box



<https://stemforall2019.videohall.com/presentations/1343>

ROBOTICS WITH A TWIST





- Wireless communication can be intercepted by other students, motivating cybersecurity
- Has been used to teach robotics and cybersecurity
- Encryption, secure key exchange, denial of service attacks, replay attacks, etc.
- Able to add security features without a firmware update
- Multiple summer camps

<https://stemforall2019.videohall.com/presentations/1343>

ROBOTICS WITH A TWIST



RoboScape Online



VANDERBILT
UNIVERSITY



VIRTUAL ROBOTICS

- To enable remote learning, we have created a Unity-based 3D virtual robotics environment
- Same interface, same code as physical robots
- No hardware cost, no maintenance
- Students can remotely access shared space to collaborate or compete solving challenge problems



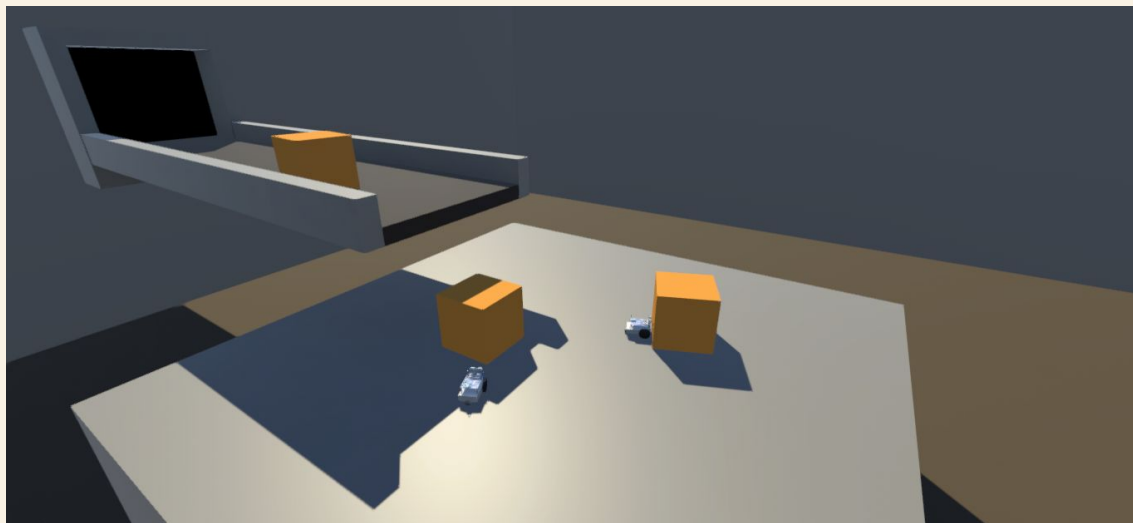
<https://tinyurl.com/bhkz2ed9>



- Can support a wide range of robots and environments
- Extends beyond robotics

<https://tinyurl.com/bhkz2ed9>

VIRTUAL ROBOTICS



Clear the table



Traffic light control



DEMOS

IPSN 2021

Demo: Distributed Virtual CPS Environment for K12

Gordon Stein
gordon.stein@vanderbilt.edu
Vanderbilt University
Nashville, Tennessee, USA

Devin Jean
devin.c.jean@vanderbilt.edu
Vanderbilt University
Nashville, Tennessee, USA

Ákos Lédeczi
akos.ledeczi@vanderbilt.edu
Vanderbilt University
Nashville, Tennessee, USA



Traffic light control

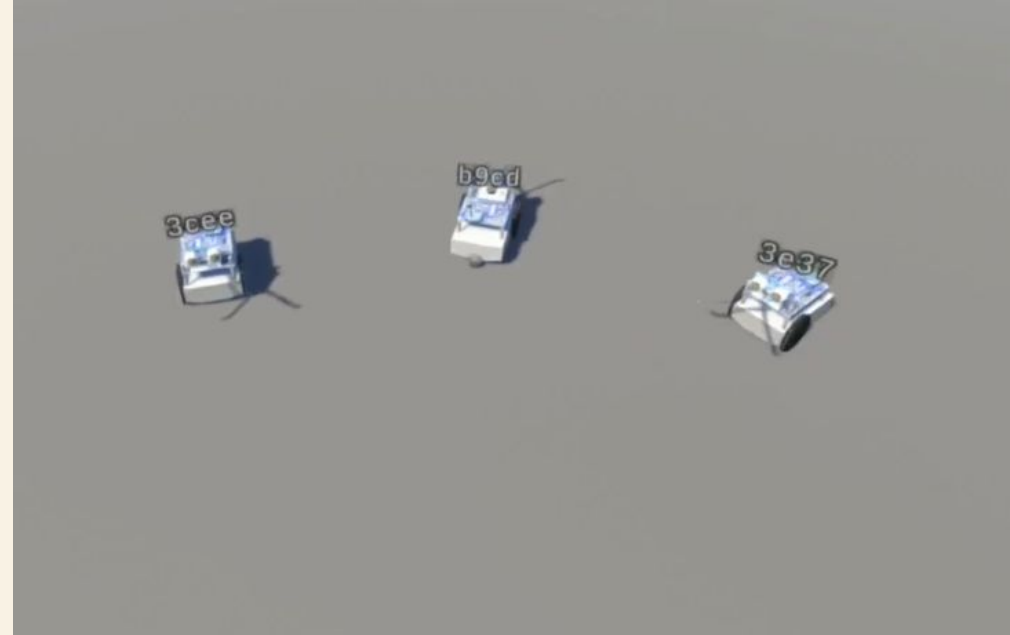
Gordon Stein





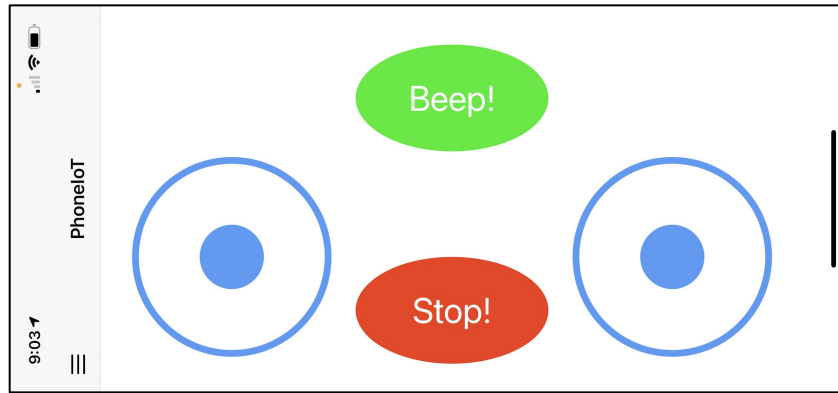
VIRTUAL ROBOTICS

- 3 Summer Camps in June 2021
- Final project: drive your robot with your phone

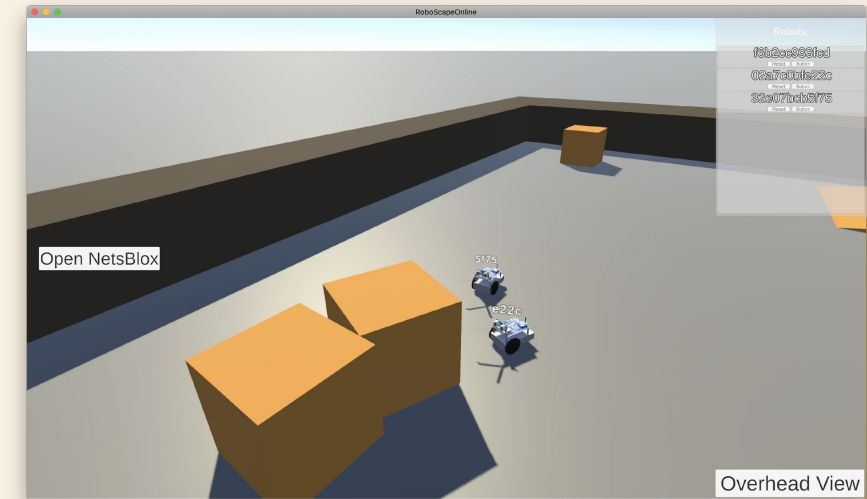
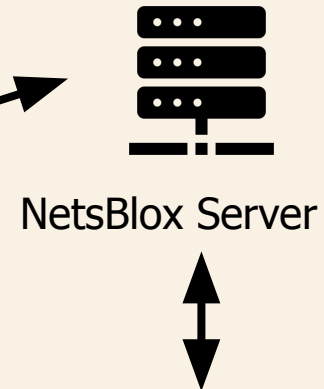


<https://tinyurl.com/bhkz2ed9>

PhoneIoT on Mobile Device



ROBOT CONTROL WITH PHONE



RoboScape Online Unity VR Environment in the Cloud

```
when clicked
  set robot to item 1 of call RoboScape / getRobots
  run RoboScape / send robot beep:500-500
  run RoboScape / listen robot
  set device to f612612b46e5
  run PhoneIoT / setCredentials device 0
  run PhoneIoT / listenToGUI device
  run PhoneIoT / clearControls device
  run PhoneIoT / addJoystick device 10 5 50
  list landscape true list event joy1
  run PhoneIoT / addJoystick device 10 67 50
  list landscape true list event joy2
  run PhoneIoT / addButton device 90 36 50 15 Beep!
  list landscape true list event beep list fontSize 2
  list style ellipse
  list color call PhoneIoT / getColor 17 237 17 alpha
  run PhoneIoT / addButton device 35 36 50 15 Stop!
  list landscape true list event stop list fontSize 2
  list style ellipse
  list color call PhoneIoT / getColor 237 31 17 alpha
  broadcast start
```

NetsBlox Client on Computer/Browser

```
when I receive joy1 x y
  set left to round y x 100

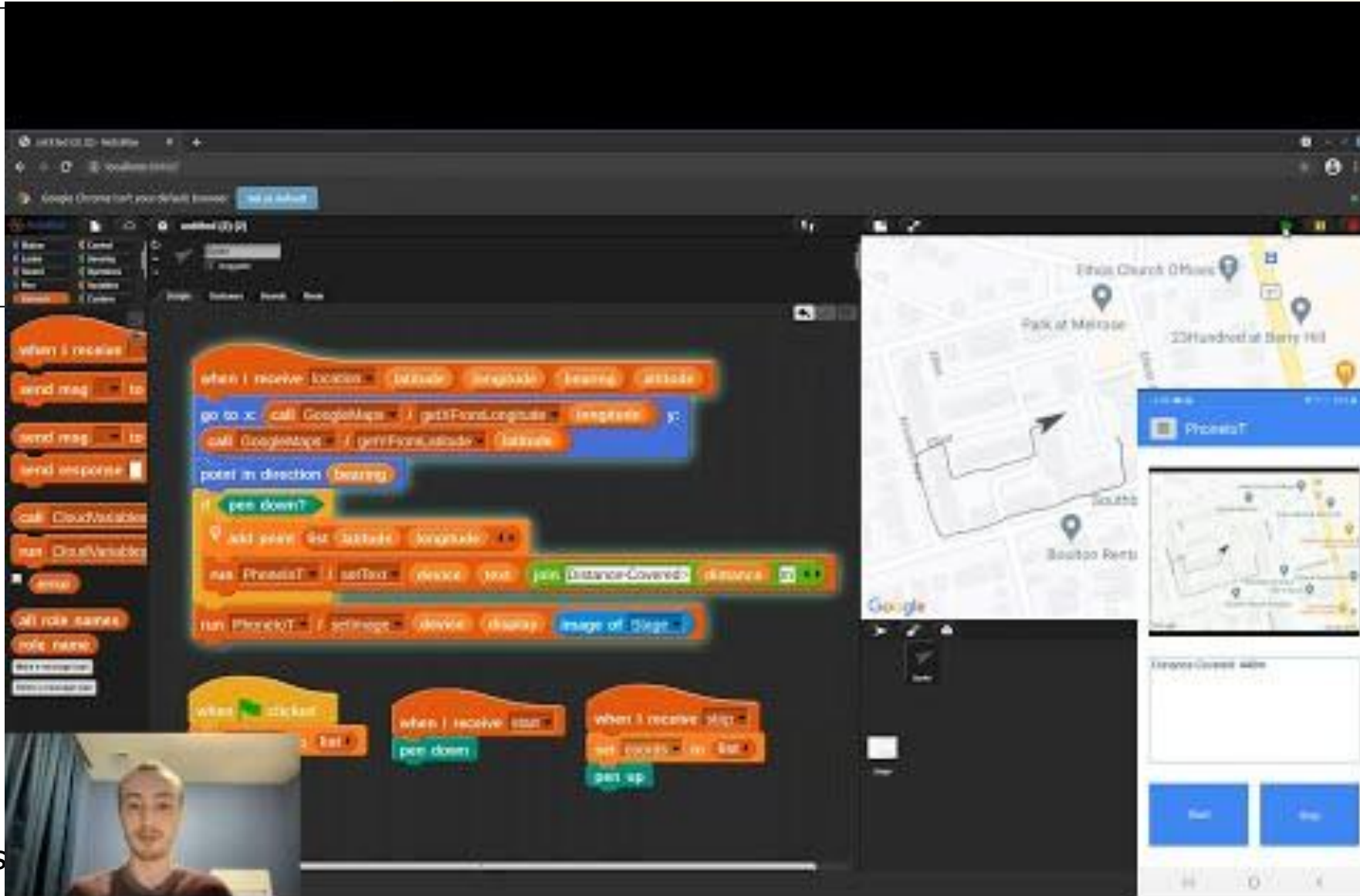
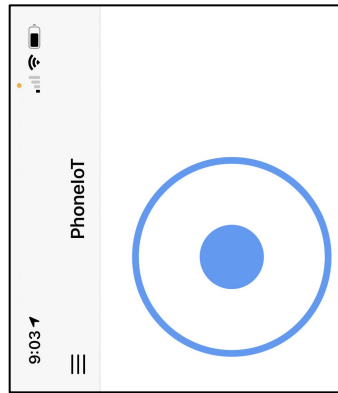
when I receive joy2 x y
  set right to round y x 100

when I receive beep
  run RoboScape / send robot join beep 400 800
  say Beep! for 1 secs

when I receive stop
  set right to 0
  set left to 0
  run RoboScape / send robot join set:speed 0 0

when I receive start
  script variables old left old right
  forever
    if not left = old left and right = old right
      run RoboScape / send robot join set:speed left right
      set old left to left
      set old right to right
  wait 2 secs
```

ROBOT CONTROL WITH PHONE



Online ent in the Cloud

Nets

Camps and Curriculum



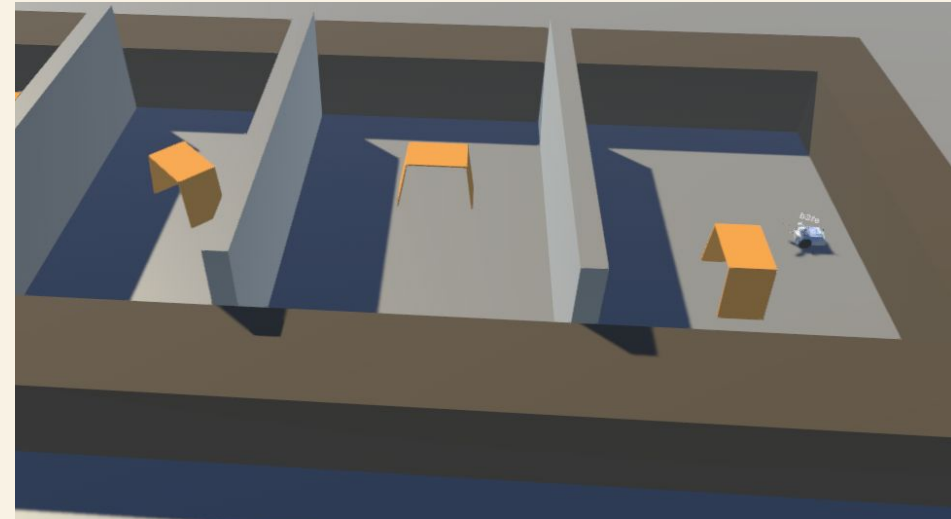
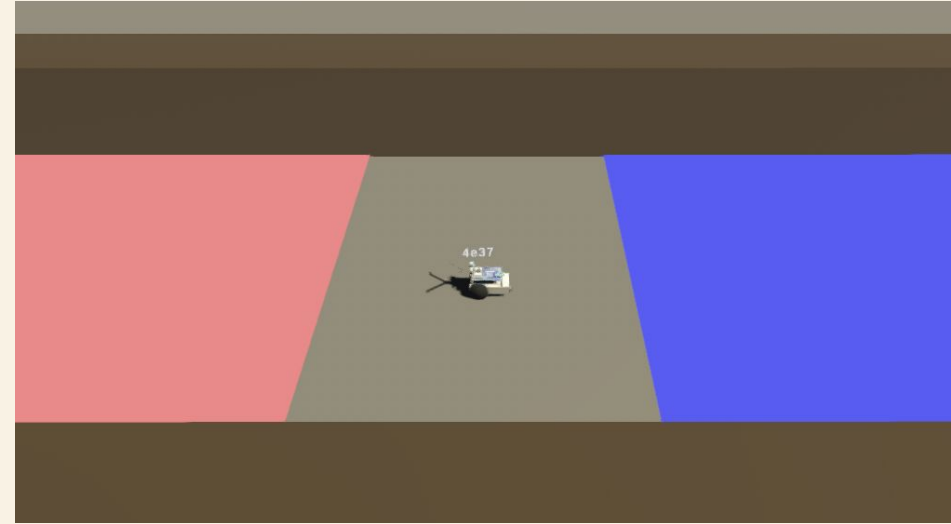
VANDERBILT
UNIVERSITY



- MLK High School Camp
 - 1 week long summer camp
 - Students learned basic programming concepts followed by robotics and cybersecurity activities
- Computer Science Frontiers
 - 1 week professional development with teachers followed by a 2 week summer camp with high school students
 - Teachers were learning the content in the first week and teaching it in the following 2 weeks
 - Students learned about distributed computing, cybersecurity, IoT, and robotics



SUMMER CAMPS





IN THE CLASSROOM

- Created a makerspace for MLK High School complete with laptops, VR headsets, and physical robots.
- Developing a course following AP CSP with a focus on:
 - Distributed Computing
 - Machine Learning
 - Internet of Things
 - Software Engineering
- We have begun the course approval for the state of Tennessee
- Planning to add the course for this coming Fall at MLK High School in Nashville





- Opening the internet creates a rich set of possibilities:
 - Access to online data and services
 - Distributed programs: social apps, multiplayer games, etc.
 - Support for a wide variety of devices including robots, phones and voice assistants
 - Real-time collaboration, remote learning
 - User extendibility
- Students can create projects that interests them and are relevant to their lives promoting engagement
- A small set of powerful abstractions supported by a handful of simple blocks keeps the learning curve gentle:
 - Adding support for phones or robots required no changes on the client and no new blocks!

CONCLUSIONS

Supported by



Computational
Thinking and Learning



CONTRIBUTORS

- Graduate students:
 - **Gordon Stein, Devin Jean, Hamid Zare, Ben Yett**
- Vanderbilt Faculty and Research Staff:
 - **Peter Volgyesi, Miklos Maroti, Janos Sallai, Corey Brady, Cliff Anderson, Ole Molvig, Chris Vanags, Gautam Biswas**
- Collaborators:
 - **Shuchi Grover, Tiffany Barnes, Veronica Catete, Marnie Hill, Dan Garcia, Jens Moenig**
- Countless undergraduate students, summer interns, high school teachers and students

Supported by



Computational
Thinking and Learning