Cyberphysical Systems with Virtual Reality and Robotics

MS ECE Final Project
August 14, 2020
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→ **Problem Statement**

Significance & Novelty

Project Design & Approach

Results & Discussion

Closing Thoughts

Problem Statement

- Explore possibility of connected world
  - Cyberphysical systems
  - Industry impact
- Project concepts
  - Human-machine interfaces
  - APIs
  - Blockchain
  - VR
  - Communication protocols
  - Authentication
  - Robotics

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Prior Work

- EC544 CE in Connected World semester project
- 2017 Undergraduate Senior Design project
- Full-time work experience in software engineering
- Augmented Reality Monopoly game
  - 2013 Senior Design project from advisor
- Literature
  - Cyberphysical systems in deterministic models
  - UC Berkeley highlighting difficulties
  - Cyberphysical systems & electrical power
  - IEEE Digital Library

Significance & Novelty

- Using blockchain transactions to power robot
- Decentraland SDK, Ethereum, AWS, DexterOS
  - Not a common stack
- Incorporating cloud technology in cyberphysical communication
- Applications for blockchain beyond bitcoin
  - Monitoring interactions as “triggers”
- Contribution to existing literature
  - Proof of concept that is inexpensive

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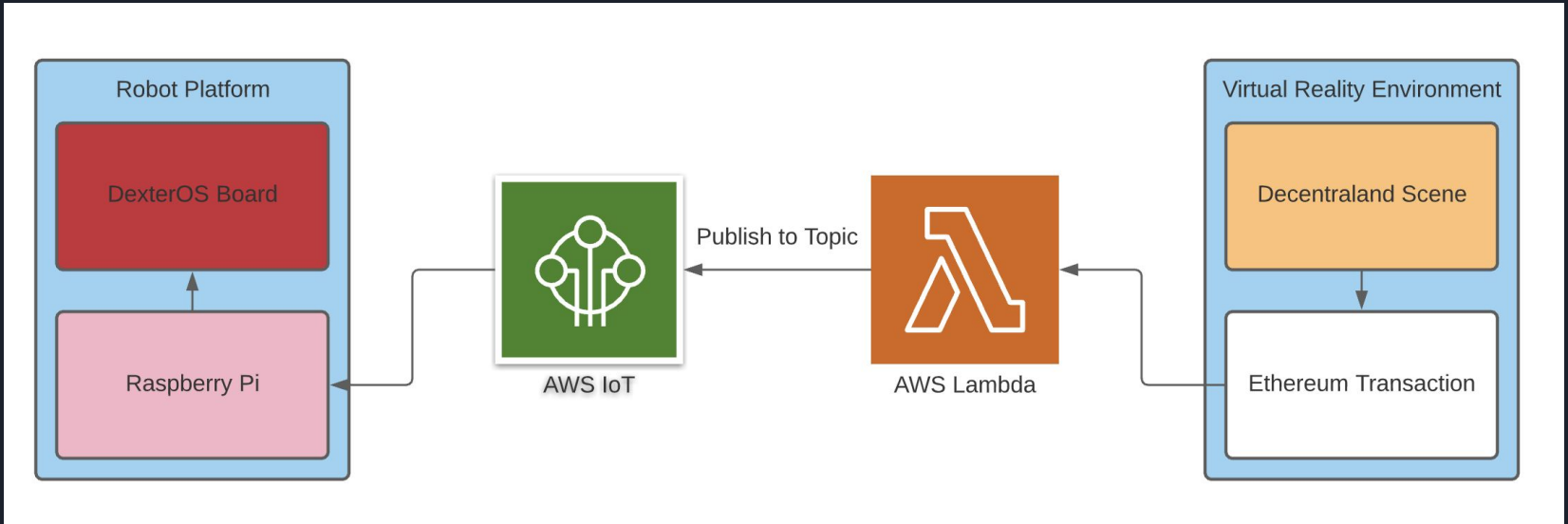
Original Project Approach

- Robot traverses VR Maze in real-time
  - Purchase and assemble robot
  - VR maze built with Decentraland SDK
  - Unity, VR Headset
- Robot rewarded with cryptocurrency when maze is solved in certain amount of time
  - Crypto wallet on a Raspberry Pi
  - Rewarded with ether
  - Blockchain & Ethereum

Modified Project Approach

- Robot moves forward when “fueled” in VR environment
  - Box in VR sends ether to robot
  - Ether “fuels” robot forward accordingly
- AWS Lambda, IoT
  - Communication with VR and robot
  - Observes blockchain transactions
  - Publishes message to topic

System Diagram



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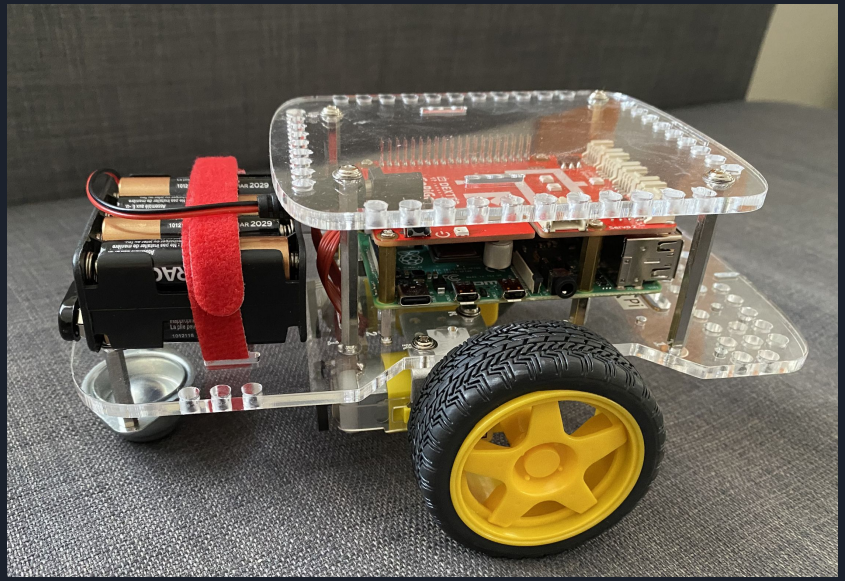
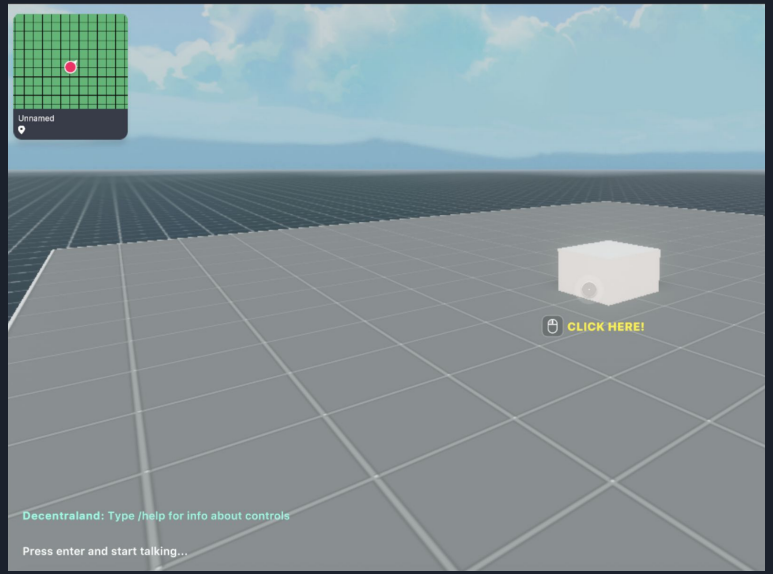
Physical System

- GoPiGo3
  - DexterOS
  - Basic movements
  - Motors, wheels, batteries
- Raspberry Pi 4
  - Raspbian OS
  - AWS IoT Device SDK



Virtual Reality

- Decentraland Scene
  - Button box with hover text
  - Map showing position
- Decentraland SDK
  - Written in Javascript
  - Button transaction
  - Render locally with CLI



Lambda Function

- Not in original project approach
- Included as part of the communication stack
- Written in Python, AWS Console
- Two Purposes
  - Monitor transactions on the blockchain
  - Publish message to IoT for commanding robot
- Appropriate roles, policies, permissions

Cryptocurrency & Blockchain

- Two MetaMask accounts created
  - One with ether, one without
- Infura account created
  - Interactions on blockchain
- JS Script sends ether from Account A to Account B
  - Signed transaction with Infura
  - Establish provider with Web3 JS
  - Gas, gas price, wei/ether conversion
  - Proper authentication

Discussion

- AWS Device SDK for C and Python
  - Shared library/API issues
- AWS IoT approach
  - SNS topic, python/typescript lambdas
  - AWS Greengrass vs SDKs
- Full & Light nodes
  - Not the best approach
  - Infura & MetaMask

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Challenges & Failures

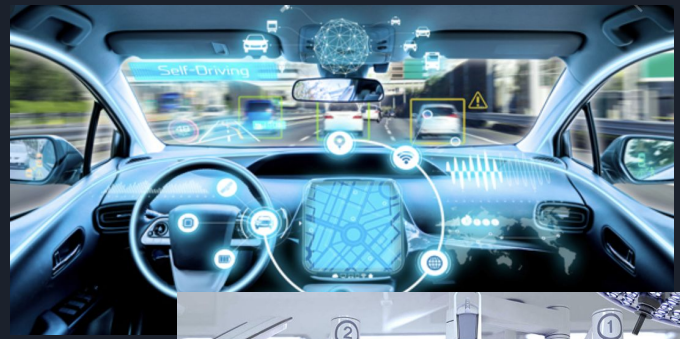
- COVID-19 Pandemic
  - Remote project & meetings
  - No access to on-campus resources
  - Personal stressors
- Time Management
- Issues with light node
- Communication Stack
  - Difficult documentation
  - Python & C
- Ether transactions

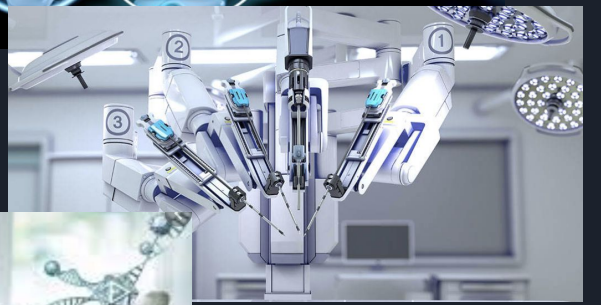
What I Learned

- GoPiGo3 and DexterOS
- AWS IoT Device SDKs
- Lambda with IoT
  - Publishing topic
  - Permissions
- Ether, Infura, MetaMask
  - Send/receive transactions
  - Blockchain
  - Gas & gas prices...

Potential Future Work

- Upgrade or customize physical system
- Add more elements to the Decentraland scene
  - Capability to receive MANA
  - Deploy LAND
- Sync/Async Lambda for transaction time
- Include more robot movements
- Different types of cryptocurrency
  - Dialog box





Questions?

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