UC San Diego
JACOBS SCHOOL OF ENGINEERING
Computer Science and Engineering

CONTEXTUAL ROBOTICS INSTITUTE

TritonBot: First Lessons Learned from Deployment of A Long-term Autonomy Tour Guide Robot

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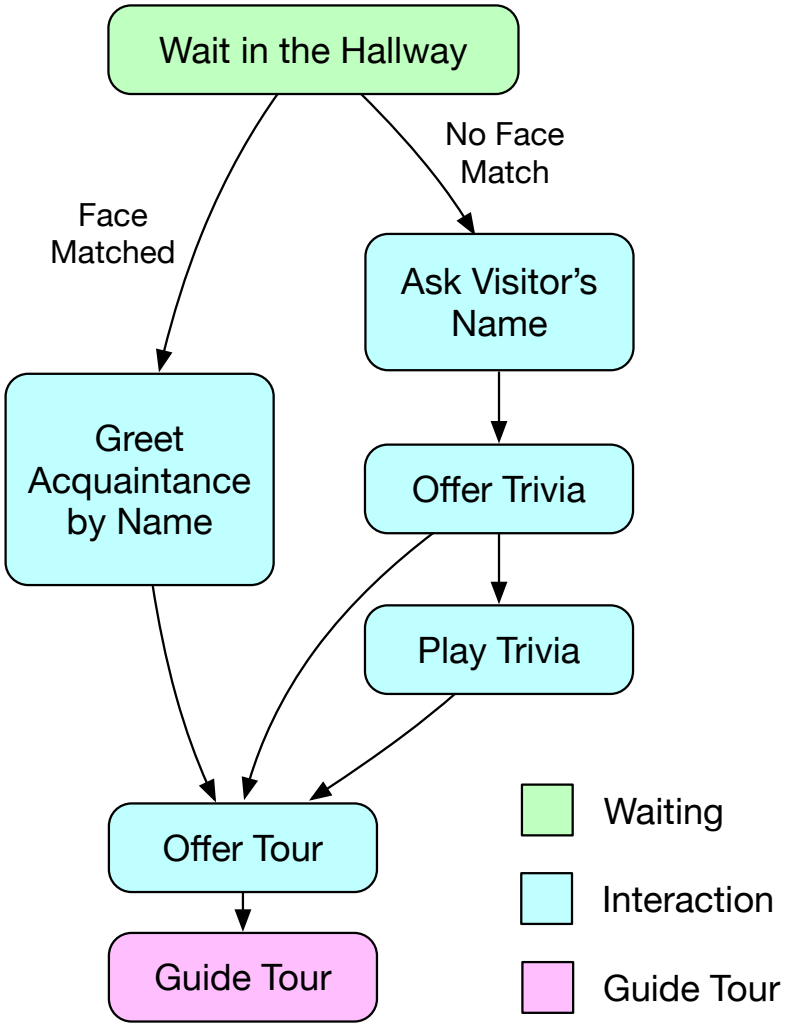
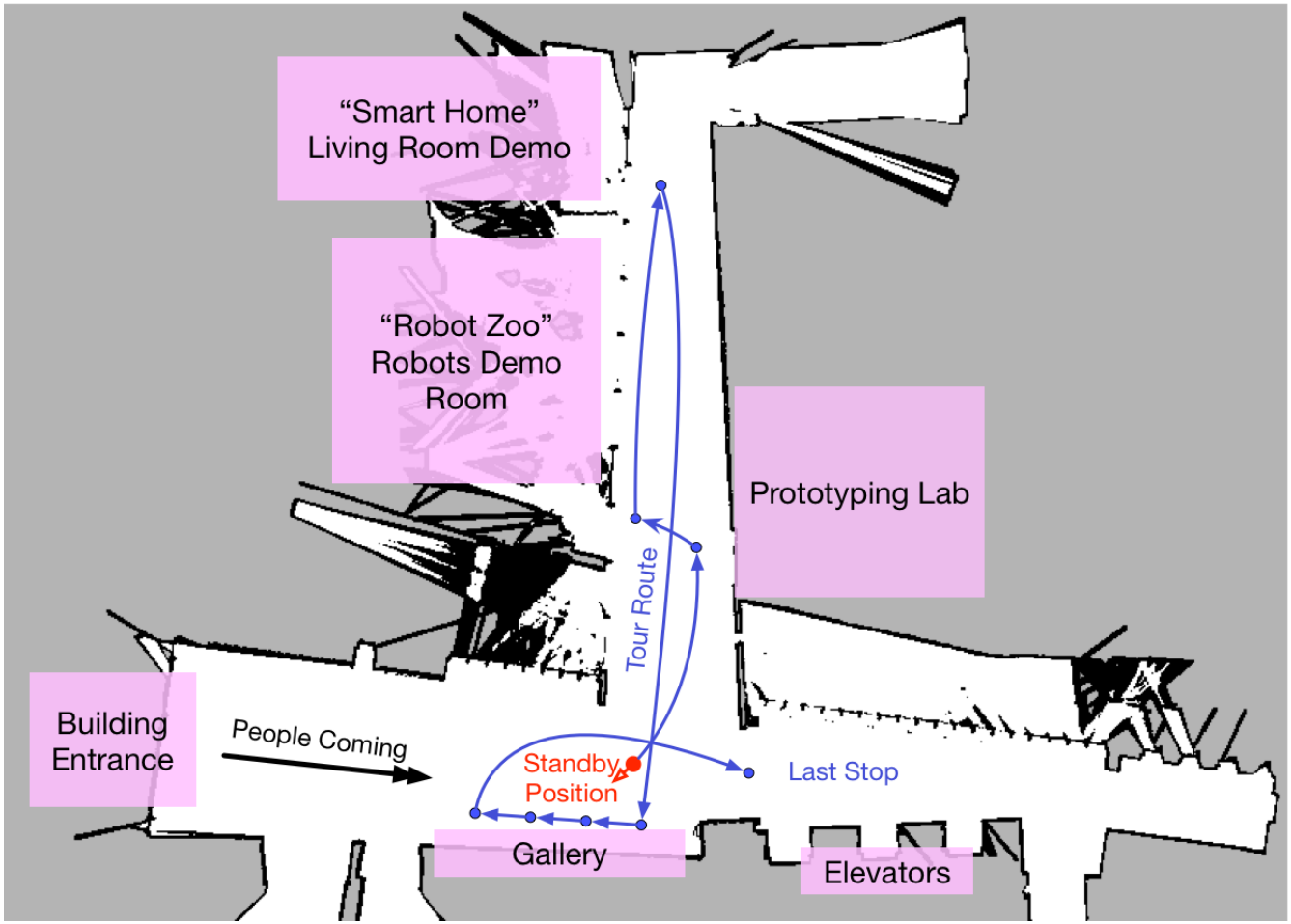
https://youtu.be/yxHTb1IlLAc

The Goal of TritonBot

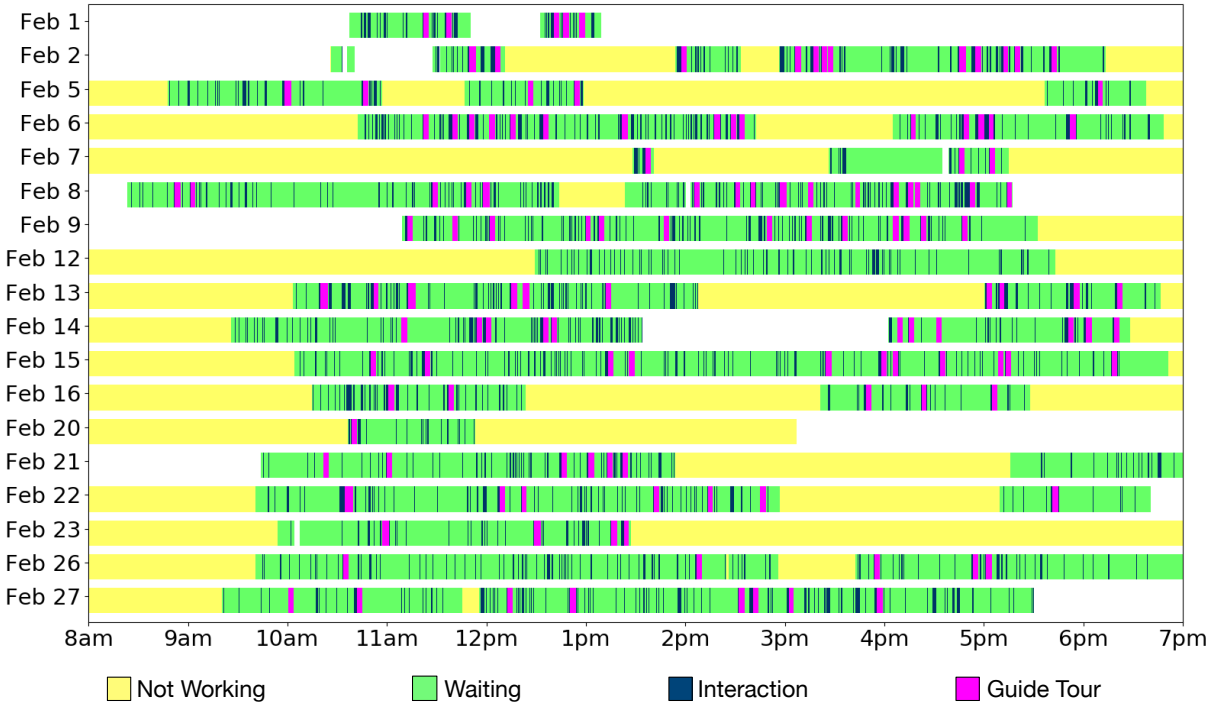
- Service robots often fail in long-term deployment
- TritonBot: A realistic example to study long-term autonomy
  - Face detection + recognition
  - Voice recognition + intent extraction
  - Localization + navigation
- Learn lessons in long-term autonomy
  - Reliability, Scalability, and Learning



The Goal of TritonBot



TritonBot Deployment Time



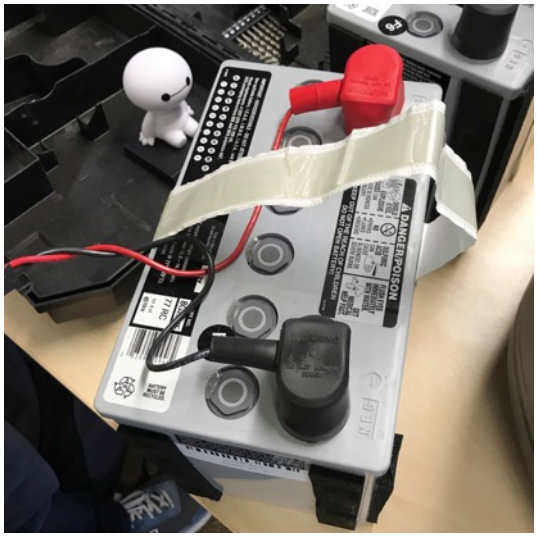
- Deployment
  - 108.7 hours
- Interaction
  - 22.1 hours
- Listen + Speak
  - L: 4.0 hours
  - S: 10.7 hours
- Tour Guide
  - 150 tours
  - 9.9 km

Lessons Learned from TritonBot

- Hardware Failures
- Unstable Internet
- Software Failures
- Software Deployment
- Navigation
- Speech and Dialogue
- Face Recognition
- Logging
- Safety

HARDWARE FAILURES

Hardware Failures

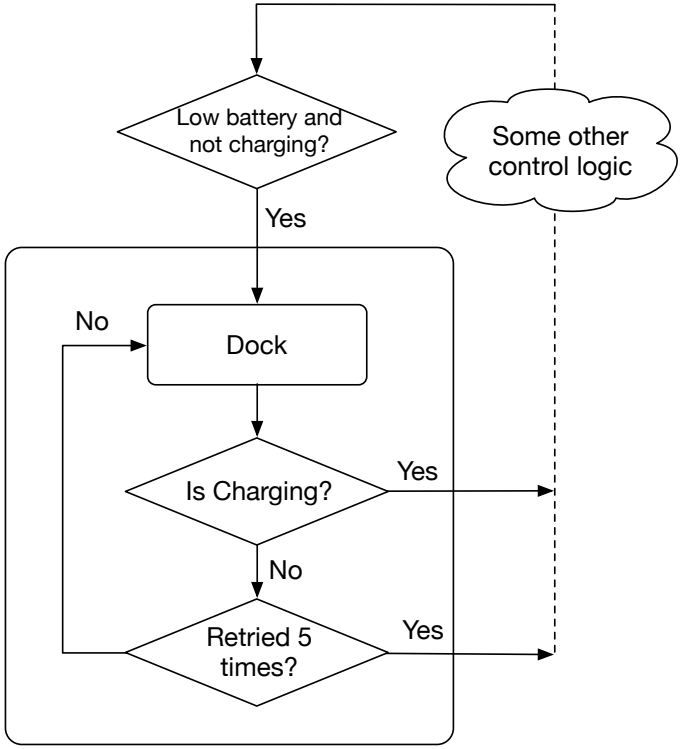


Battery
Over-discharge

Electrical
Connector Failure

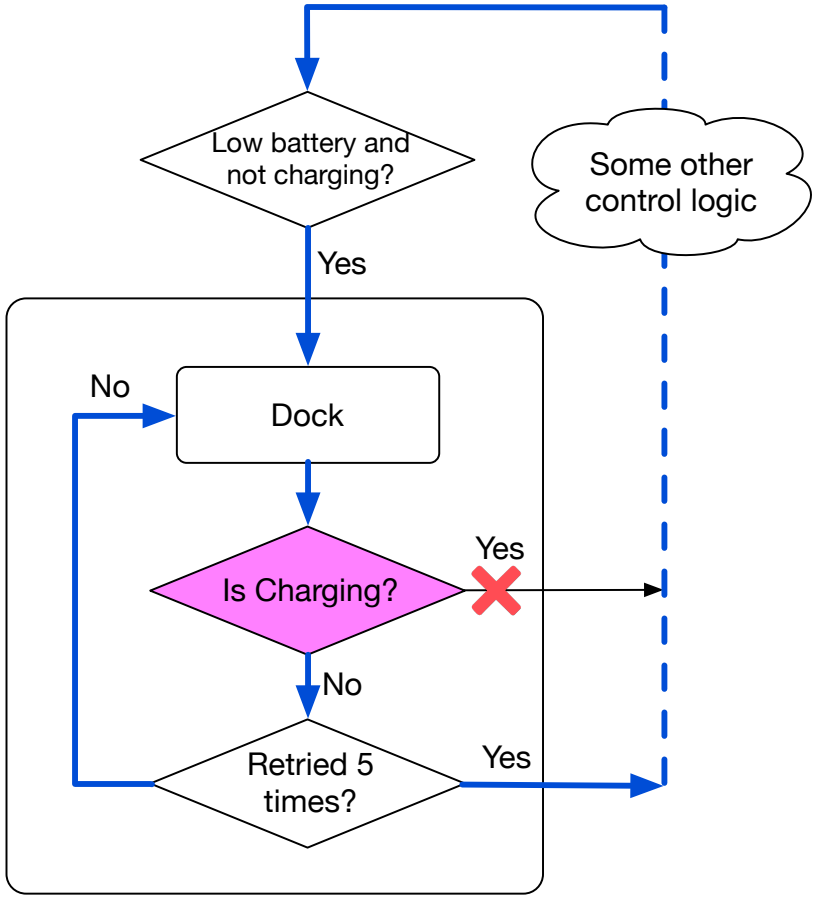
Mechanical
Wear and Tear

Hardware Failures



Hardware Failures

- Robot is not prepared for failures
- The need for testing methods
- Fault-injection for service robots (in progress)



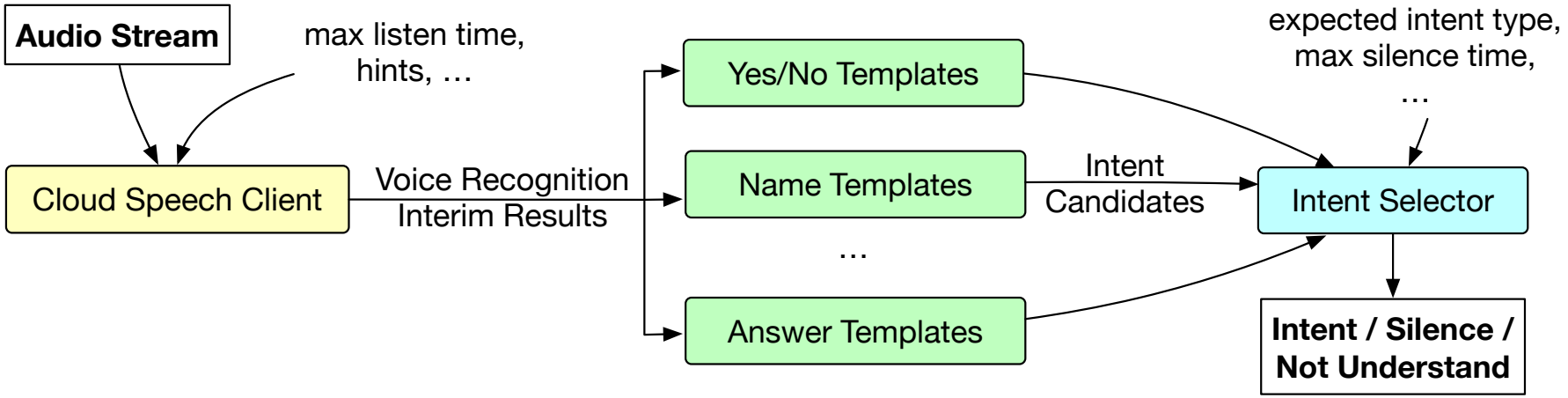
SPEECH INTERACTION

Speech Interaction

- Challenge
  - Realtime recognition
  - Intent extraction

Speech Interaction

- Solution
  - Google Cloud Speech API
  - Rule-based: template matching

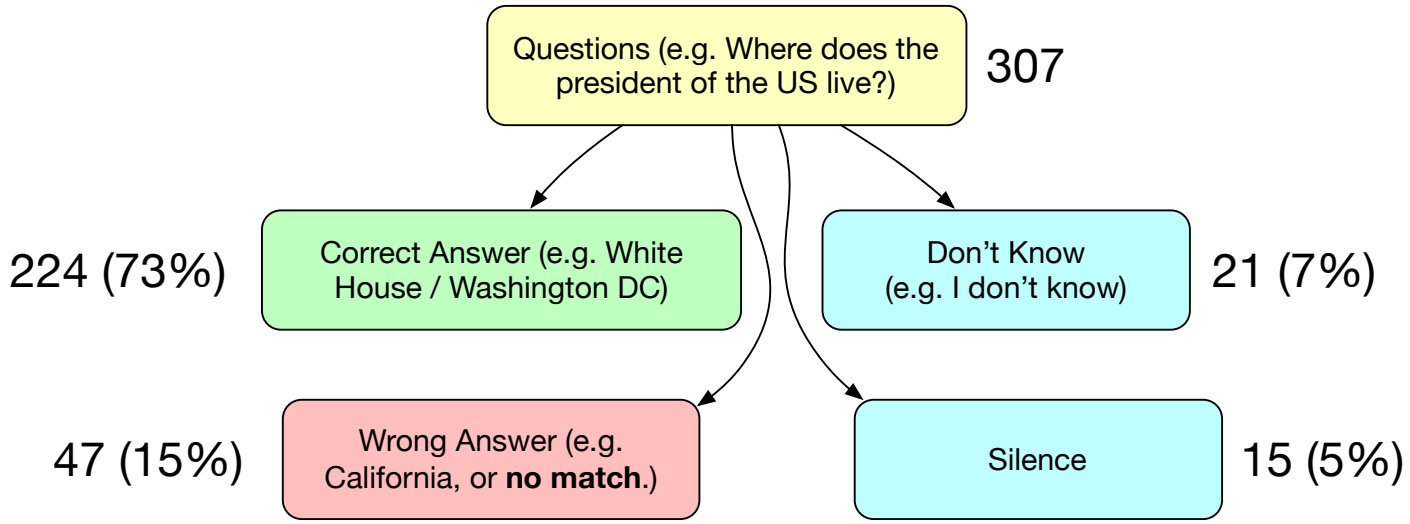



```
my(10) name(10) is '\w+'<name>
'\w+'<name>(.1)
'\w+'<name>(.1) '\w+'<name2>(.1)
```

```
name(10) is '\w+'<name>
Im(10) '\w+'<name>
"my(10) name(10) is '\w+'<name> '\w+'<name2>"
```

Speech Interaction

- Rule-based method gives us a good starting point

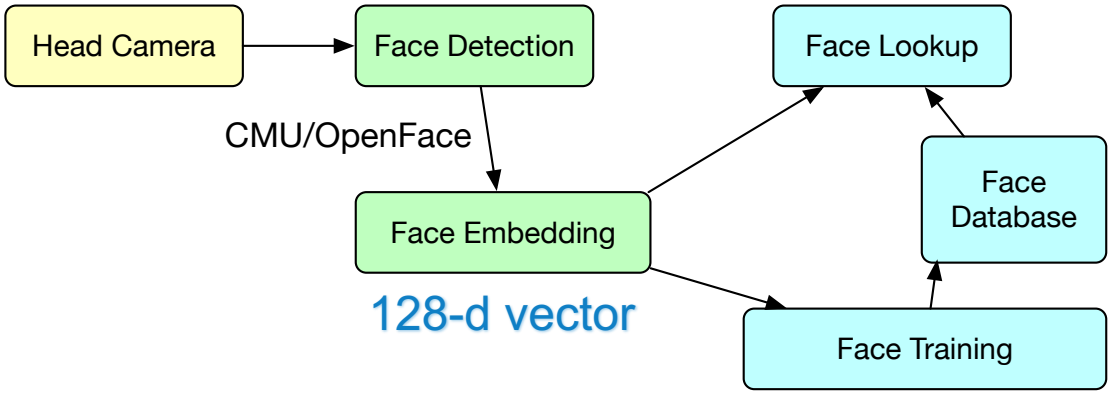


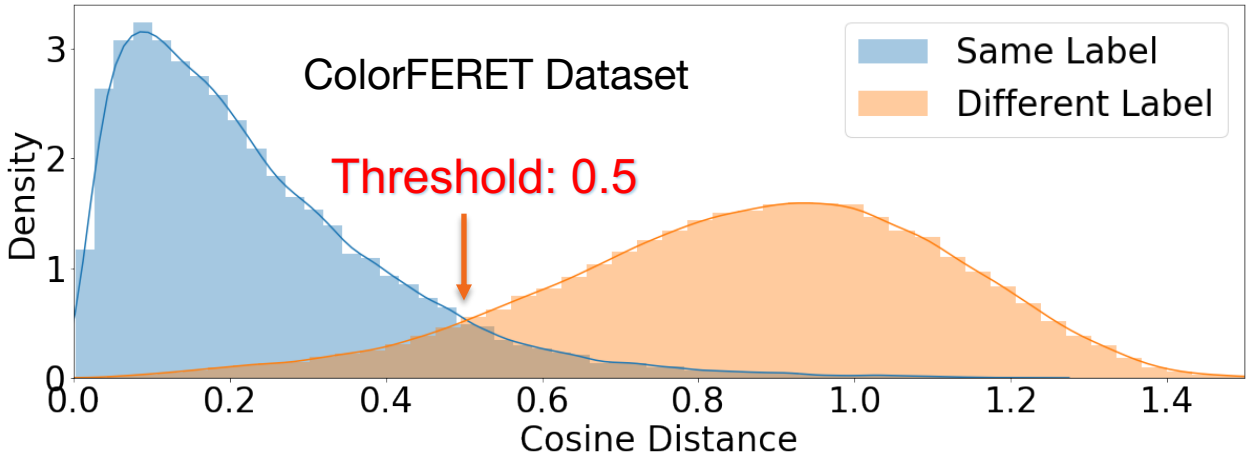
Speech Interaction

- Rule-based method gives us a good starting point
  - Asked 307 quizzes, 80%+ valid responses
- Cloud voice recognition service performs better than we expected: sub-second latency

FACE RECOGNITION

Face Recognition

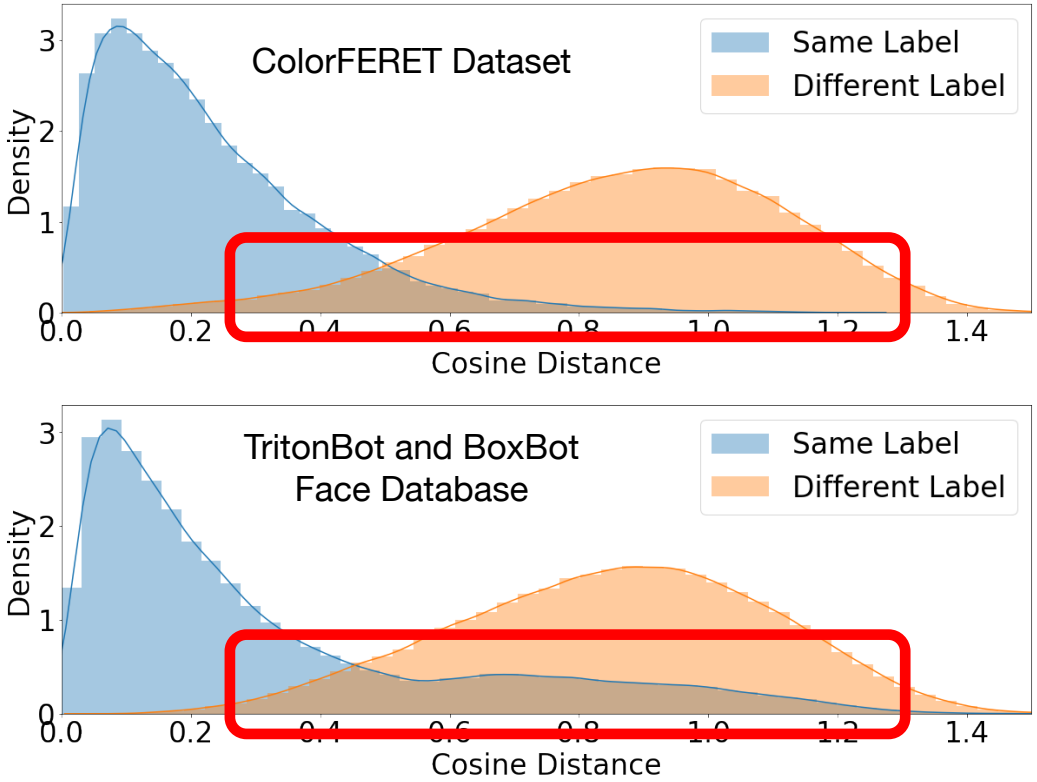




- B. Amos, B. Ludwiczuk, and M. Satyanarayanan, “Openface: A general-purpose face recognition library with mobile applications,” CMU-CS-16-118, CMU School of Computer Science, Tech. Rep., 2016.
- National Institute of Standards and Technology. ColorFERET database.

Face Recognition

- Multiple faces in the view



Face Recognition

- Multiple faces in the view
- Database becomes larger overtime
  - False positives

SOFTWARE DEPLOYMENT

Software in Long-term Autonomy

- TritonBot Software Statistics
  - Customized code: 130,000 lines
  - Third-party software
    - Google Cartographer, CMU OpenFace, Google Cloud Speech API, etc.
  - Version updates: 126 times in 6 months
  - Configuration update: 71 times in 6 months

Robot Software Deployment

- Challenge
  - Many software components: 65 ROS nodes
  - Libraries: dependency hell
  - Configuration files are hard to manage

Robot Software Deployment

- Solution
  - Use Linux containers (Docker)
    - Pack software into self-contained container images
    - Run software in isolated environment
  - Collect configuration in a Git Repository
    - Map directories into the Docker containers
    - Keep the full history of robot software configuration

Conclusion

- TritonBot gives us a real-world experience of a long-term autonomous robot.
- Biggest challenge: human beings.
- TritonBot is also a platform for HRI studies.
- TritonBot is open-source at

https://tritonbot.github.io