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

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Hi, my name is TritonBot.

https://youtu.be/yxHTb1IILAc
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

Low battery and not charging?

- Yes
  - Dock
  - Is Charging?
    - Yes
    - Some other control logic
    - No
      - Retried 5 times?
        - Yes
        - Some other control logic
        - No
          - Dock

- No
  - Dock
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) Im(10) '\w+'<name>
'\w+'<name>(.1) '\w+'<name2>(.1) "my(10) name(10) is '\w+'<name> '\w+'<name2>"
```
Speech Interaction

• Rule-based method gives us a good starting point

- Questions (e.g. Where does the president of the US live?)
  - Correct Answer (e.g. White House / Washington DC) 224 (73%)
  - Wrong Answer (e.g. California, or no match.) 47 (15%)
  - Don’t Know (e.g. I don’t know) 21 (7%)
  - Silence 15 (5%)

- Total 307
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

- **Head Camera** → **Face Detection** → **Face Embedding** → **Face Lookup** → **Face Database** → **Face Training**

128-d vector

- **CMU/OpenFace**
- **ColorFERET Dataset**

- **Threshold: 0.5**

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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