

SOCIAL ROBOTICS II

Social Interactivity Mentor for Youth with Autism using the NAO Robot (SIMYAN)

Andrew Nguyen, Bryce George, Colton Homuth, William Ross

Sponsor: Dr. Adham Atyabi

Faculty Sponsor: Mr. Bill Michael

December 4, 2020

1

TEAM ORGANIZATION

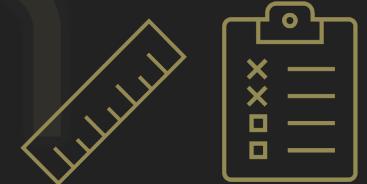
Project Manager:
Bryce George



Communication & Logistics Managers:
Colton Homuth & William Ross



Standards & Test Manager:
Andrew Nguyen



PROBLEM OVERVIEW

- ASD impairs social interactions
- Even more important to learn these skills while young
- Social interactions are critical for future success
- Robotics may be a key solution to developing these social skills

PROBLEM BACKGROUND

- We are developing the functionality for the robot to have social interactions with humans
- Limited in our knowledge of literature on best approaches for social development in children with ASD - specific therapeutics are out of scope
- Our work is more general in scope and guided by our sponsor's prior research and guidance

PROJECT SCENARIO



5

CONSTRAINTS

Social

- Testing will not be able to be done with ASD individuals

Ethical

- When dealing with ASD children, they must always be treated with respect
- Must make sure to focus on social development

Health and Safety

- Must make sure NAO programming doesn't prompt it to do anything dangerous
- COVID-19

6

CONSTRAINTS

Economics

- Constraint would be budget in this case
- Don't need many outside supplies, won't be a huge factor

Manufacturability

- Since project is adding software to existing hardware, we are only limited by the hardware provided and the software we write

Sustainability

- Project will be sustainable as long as no changes are made to the NAO robot that we are running it on, and we stay consistent with Python version

7

LITERATURE SEARCH

Using social robots to work with ASD individuals is an emerging research field...

Commercial Robots for ASD Research and Therapy						
Robot	Made By	Height (cm)	Ambulatory	Programmable	Degrees of Freedom	Features
Milo	Robokind	~58	Yes	Yes	21	<ul style="list-style-type: none">• Humanoid
NAO	SoftBank Robotics	58	Yes	Yes	25	<ul style="list-style-type: none">• High degrees of freedom allows body language expression
Pepper	SoftBank Robotics	120	No (wheels)	Yes	20	<ul style="list-style-type: none">• Emotive verbal expression
QTrobot	LuxAI	63	No (stationary)	Yes	17	

8

LITERATURE SEARCH

Used for teaching social skills

- Body Language Cognition
- Emotional Intelligence
- Social Customs/Standards
- Language Development
- Self Expression

Used in:

- Classrooms
- Treatment Facilities
- Research Facilities

Facilitate researchers, educators, and therapists

- ASD children more likely to interact with adult, asking questions to learn how to operate a robot
- ASD individuals are calmer when interacting with robot than with person
- Consistency of robot speech, movement, and interaction is comforting
- Fewer distracting body language cues than a human

PROJECT SCOPE

Outside Scope

- Not aiming to produce diagnostic test
- Not aiming to create therapeutic experience
- Not aiming to design or conduct a particular research experiment

** No testing will be performed with individuals who have ASD during this project*

Within Scope

- Create a framework to aid the development and implementation of advanced behaviors to support diagnostic and therapeutic applications
- Develop behavior components for a specific scenario as a POC
 - Interactive drawing exercise with a human subject

STANDARDS DISCUSSION

Coding Standards

- Python PEP 8 formatting style
- Use 4 spaces instead of tabs
- Comments
 - Describe all functions and their parameters
 - References/links to supporting documentation
- (Optional) Custom utilities should provide a command line or GUI interface

Documentation Standards (GitHub)

- Committed to UCCS-Social-Robotics/docs
- Must include a Wiki page or markdown for each module
- Include author(s) GitHub username and date information at the top of documentation files and wiki pages

Safety Standards

- Subscribe to IEC 60601 technical standards

11

REQUIREMENTS ANALYSIS: ENVIRONMENT SURVEY

- Frontier customer in emerging field
- Limited existing research to draw upon
- Using NAO robots provided by UCCS
- Existing NAO Framework base
 - Basic robot operation
 - Support for some advanced behaviors
 - Extensible via custom modules
- Relatively small community using NAO
 - Limited community contributions
 - Less likely to find useful utilities already implemented



Image 1

12

REQUIREMENTS ANALYSIS: CUSTOMER NEEDS & WANTS

Needs

- Extension of existing NAO framework
- Advanced behaviors
 - Cognition
 - Speech
 - Vision
 - Mobility & Motor Control
- Provide “play” experience
- Opportunity to learn social cues and concepts
- Human mannerisms and social characteristics

Wants

- Relative autonomy
 - Intelligence
 - Adaptability
- Natural interaction experience
 - Intuitive
 - Instructive
 - Comfortable
- Solution extensibility
- Solution reusability

13

REQUIREMENTS ANALYSIS: CONSIDERATIONS

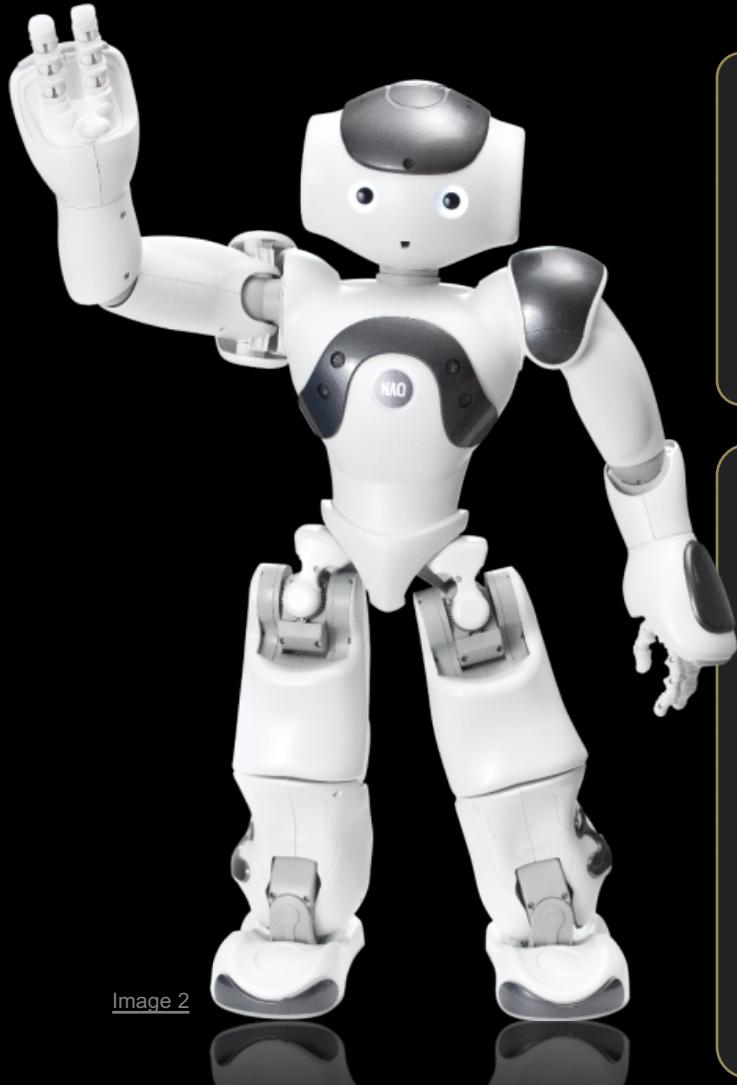


Image 2

Complexity of human social environments

- Natural language processing
- Contextual reference
- Unexpected disruptions/interruptions
- Multiple human interactors

Environmental awareness

- Measuring 3D distance and depth in environment
- Recognizing obstacles and resources
- Mapping environment and moving to different locations
- Understanding of object properties
 - Scale
 - Orientation
 - Color

REQUIREMENTS ANALYSIS: CONSIDERATIONS

Deep Learning & AI

- Model development and training
 - Accuracy
 - Training Time
 - Computational resources
- Model application
 - Collecting necessary data
 - Collecting sufficient data
 - Processing data within acceptable timeframe

Reasoning and Situational Analysis

- Situational Prediction
- Situational Responsiveness
- Data integration and interpretation

REQUIREMENTS SPECIFICATIONS

#	Use Case	Functional Requirements	Quality of Service Requirements
1	Load Master Module	<ol style="list-style-type: none">1. Allocate all necessary resources and load the Activities Master Module2. Detect subject within 5m of starting position	<ol style="list-style-type: none">1. Performed on robot startup2. Verbal notification of completion
2	Initialize Activities Master Module	<ol style="list-style-type: none">1. Verbally greet subject2. Orient face to look at subject (+/- 5°)3. Allocate/initialize all master level subroutines	<ol style="list-style-type: none">1. Greet subject < 1s after detection

REQUIREMENTS SPECIFICATIONS

#	Use Case	Functional Requirements	Quality of Service Requirements
3	Start Activity	<ol style="list-style-type: none">1. Verbally explain operation instructions2. Verify valid verbal activity selections3. Notify of invalid activity selections and re-prompt4. Discover all available activity modules5. Load and initialize selected activity module	<ol style="list-style-type: none">1. Verify and acknowledge selections <= 1s after heard

REQUIREMENTS SPECIFICATIONS

#	Use Case	Functional Requirements	Quality of Service Requirements
4	Select Object to Draw	<ol style="list-style-type: none">1. Verbally explain drawing activity2. Verbally list drawable objects3. Prompt for object selection4. Verify object selection5. Notify of invalid object selections and re-prompt	<ol style="list-style-type: none">1. Verify and acknowledge selections <= 1s after heard

REQUIREMENTS SPECIFICATIONS

#	Use Case	Functional Requirements	Quality of Service Requirements
5	Obtain Writing Implement	<ol style="list-style-type: none">1. Determine if already holding writing implement2. Ask whether to continue using current writing implement3. Drop writing implement4. Verify and acknowledge choice to use current writing implement5. Verbally instruct subject to provide new writing implement	<ol style="list-style-type: none">1. Verify and acknowledge selections <=1s after heard

REQUIREMENTS SPECIFICATIONS

#	Use Case	Functional Requirements	Quality of Service Requirements
5	Obtain Writing Implement <i>(continued)</i>	<ul style="list-style-type: none">6. Detect when to close hand to grip writing implement7. Close hand to grip writing implement8. Evaluate writing implement orientation9. Notify invalid orientation and instruct how to fix10. Evaluate if cap still on11. Notify cap still on and instruct subject to remove it	<ul style="list-style-type: none">2. Detect writing implement in hand in ≤ 1s after it is placed there3. Identify marker orientation < 2s after closing grip4. Identify if cap is still on in < 2s

REQUIREMENTS SPECIFICATIONS

#	Use Case	Functional Requirements	Quality of Service Requirements
5	Obtain Writing Implement <i>(continued)</i>	12. Notify cap still on and instruct subject to remove it 13. Determine writing implement color (black, blue, red, green, brown, purple, or yellow)	

REQUIREMENTS SPECIFICATIONS

#	Use Case	Functional Requirements	Quality of Service Requirements
6	Draw Object	<ol style="list-style-type: none">1. Locate/detect drawing surface within 5m of position2. Notify of no drawing surface found and prompt for next action3. Detect drawing surface boundaries4. Notify inaccessible drawing surface conditions and instruct how to position correctly	<ol style="list-style-type: none">1. Detect drawing surface in <= 3s2. Identify drawing surface boundaries in <= 1s

REQUIREMENTS SPECIFICATIONS

#	Use Case	Functional Requirements	Quality of Service Requirements
6	Draw Object <i>(continued)</i>	<ol style="list-style-type: none">6. Load necessary hand/arm motor control module(s)7. Locate object drawing instructions8. Execute drawing instructions to draw the object on the drawing surface9. Able to draw square<ol style="list-style-type: none">a. Four angles within +/- 1° of 90°b. Four sides same length to within +/- 5mm	

REQUIREMENTS SPECIFICATIONS

#	Use Case	Functional Requirements	Quality of Service Requirements
6	Draw Object <i>(continued)</i>	<p>10. Able to draw rectangle</p> <ul style="list-style-type: none">a. Four angles within +/- 1° of 90°b. Two sets of sides same length to within +/- 5mm <p>11. Able to draw circle</p> <ul style="list-style-type: none">a. No segment of circumference varies by more than +/- 5% of radius length in distance from the center	

REQUIREMENTS SPECIFICATIONS

#	Use Case	Functional Requirements	Quality of Service Requirements
6	Draw Object <i>(continued)</i>	<p>13. Able to draw right triangle</p> <ul style="list-style-type: none">a. One angle $+/- 1^\circ$ of 90°b. Two angles $+/- 1^\circ$ of 45°c. Length of sides adjacent to 90° angle are same length within $+/- 5\text{mm}$	

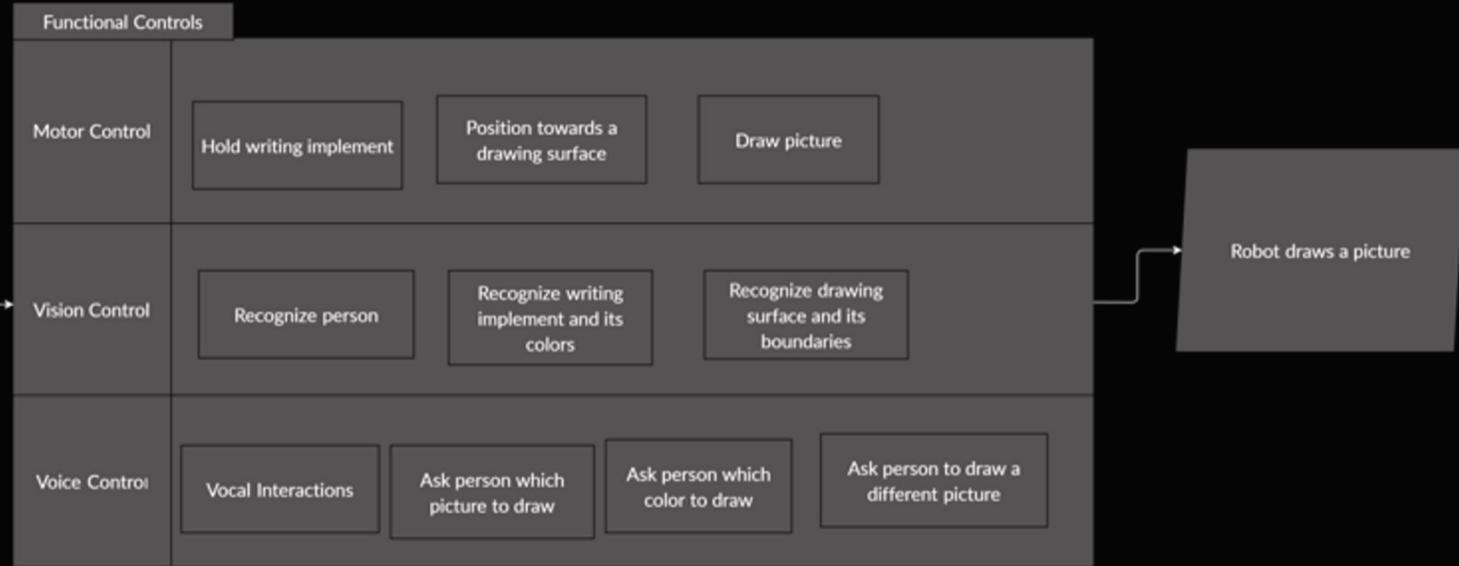
REQUIREMENTS SPECIFICATIONS

#	Use Case	Functional Requirements	Quality of Service Requirements
7	Interact with Subject	<ol style="list-style-type: none">1. Select an appropriate user interaction statement2. Speak interaction statement to subject3. Listen for verbal response to an interrogative statement4. Evaluate response statement	<ol style="list-style-type: none">1. Select or generate an interaction statement in $\leq 3s$2. Evaluate a response statement in $\leq 3s$

REQUIREMENTS SPECIFICATIONS

#	Use Case	Functional Requirements	Quality of Service Requirements
8	Complete Activity	<ol style="list-style-type: none">1. Evaluate whether activity can be repeated2. Ask whether to repeat activity or exit activity3. Verify and verbally acknowledge choice to repeat or exit the activity4. Re-initialize activity module5. Exit an unload activity module	<ol style="list-style-type: none">1. Verify and acknowledge selections <= 1s after heard

BLOCK DIAGRAM



SYSTEM DESIGN EXPECTATIONS

- Design will entail programming the NAO robot to draw with another person
- Must supplement existing NAOqi API to perform more detailed tasks
 - Handling a writing implement
 - Recognizing a writing surface
 - Intricate joint movement
 - Social interaction
- Since project is going to be implemented using NAO...
- Majority of time will be spent developing/testing various algorithms
- Most anticipated problems are standard problems with software development
 - System integration
 - Lots of tasks working simultaneously

29

ISSUES

- Minimal robotics experience
- Minimal Python experience
- Limited knowledge of Neural Networks and Machine Learning
- Proprietary NAO Framework
- Limited knowledge of ASD social behavior and therapies
- COVID-19 closures and limitations

TIMELINE

2020

2021

Requirements
Analysis
Report

Project
Proposal
Presentation

Development

Design Review
Presentation

Start
Integration
Testing

4

4 || 19

29

1

26

9

12

7

SDK Design

Begin
Development

Finish
Development

Final
Presentation

Design

Testing

DEC

JAN

FEB

MAR

APR

MAY

31

TIMELINE: UPCOMING TASKS

Task	Assigned To	Start	Complete By
Setup Robot Remote Access	Setup – Bryce, Andrew Materials – Will, Colton	Begin	Before end of semester
Requirements Analysis Report	Full Team	Begin	12/4/2020
Test NAO's ability to hold marker	Will	ASAP	First week of Spring semester
Research Depth Sensors	Xbox Kinect – Bryce, Andrew LIDAR - Will, Colton	12/4/2020	1/29/2021
SDK Design	High Level – Bryce Focus Areas – To Be Assigned	1/19/2021	2/26/2021
Prepare Proposal Presentation	Full Team	1/22/2021	1/29/2021
Deliver Proposal Presentation	Full Team	1/29/2021	32

DRAFT BUDGET

Items:

- Jetson Nano GPU
- Remote access equipment: Camera, “play pen” fence, padding
- 3D printed materials: utensil holder, backpack (for GPU)
- Depth Sensor (Lidar/Infrared)

Cost allocation:

- Jetson Nano GPU - free, borrowed from advisor Bill Michael
- Depth Sensor (\$300 maximum)
- Remaining materials (\$100 maximum)

Funds will be acquired from department allowance of \$100 per person (total \$400)

CONCLUSION

- Extend the existing NAO Framework to support advanced social behaviors
 - Cognition
 - Speech
 - Vision
 - Mobility & Motor Control
- Provide advanced social behaviors in order to promote interaction and social learning for ASD youth
- Fulfill specific Social Interactive Drawing scenario
- Create documented SDK for future application development

REFERENCES

Images:

1. https://www.eduporium.com/media/catalog/product/cache/c687aa7517cf01e65c009f6943c2b1e9/n/a/nao-print_03_4.png
2. https://www.eduporium.com/media/catalog/product/cache/c687aa7517cf01e65c009f6943c2b1e9/n/a/nao-print_06_4.png

Diehl, J., Schmitt, L., Villano, M., & Crowell, C. (2012, January). The Clinical Use of Robots for Individuals with Autism Spectrum Disorders: A Critical Review. Retrieved November 28, 2020, from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3223958/>

NAO⁶. (n.d.). Retrieved Fall, 2020, from <https://developer.softbankrobotics.com/nao6>

Waltz, E. (n.d.). Therapy Robot Teaches Social Skills to Children With Autism. Retrieved November 28, 2020, from <https://spectrum.ieee.org/the-human-os/biomedical/devices/robot-therapy-for-autism>

Zhang, Y., Song, W., Tan, Z., Zhu, H., Wang, Y., Lam, C., . . . Yi, L. (2019, April 09). Could social robots facilitate children with autism spectrum disorders in learning distrust and deception? Retrieved November 28, 2020, from <https://www.sciencedirect.com/science/article/pii/S0747563219301487>

ANY QUESTIONS?

SOCIAL-ROBOTICS II

TEAM ORGANIZATION

PROBLEM OVERVIEW

PROBLEM BACKGROUND

CONSTRAINTS

LITERATURE SEARCH

PROJECT SCOPE

STANDARDS DISCUSSION

REQUIREMENTS ANALYSIS

REQUIREMENTS ANALYSIS: GOALS & WANTS

REQUIREMENTS ANALYSIS: CONSIDERATIONS

REQUIREMENTS ANALYSIS: REQUIREMENTS

REQUIREMENTS SPECIFICATIONS

REQUIREMENTS SPECIFICATIONS

REQUIREMENTS SPECIFICATIONS

REQUIREMENTS SPECIFICATIONS

REQUIREMENTS SPECIFICATIONS

REQUIREMENTS SPECIFICATIONS

SYSTEM DESIGN EXPECTATIONS

ISSUES

TIMELINE

TIMELINE: UPCOMING TASKS

DRAFT BUDGET

CONCLUSION

REFERENCES

Index:

Title

Team Organization

Problem Overview

Problem Background

Constraints

Literature Search

Project Scope

Standards Discussion

Requirements Analysis:

- [Environment Survey](#)
- [Customer Needs & Wants](#)
- [Considerations](#)

Requirements Specifications:

- [Use Case 1: Load Master Module](#)
- [Use Case 2: Initialize Activities Master Module](#)
- [Use Case 3: Start Activity](#)
- [Use Case 4: Select Object to Draw](#)
- [Use Case 5: Obtain Writing Implement](#)
- [Use Case 6: Draw Object](#)
- [Use Case 7: Interact with Subject](#)
- [Use Case 8: Complete Activity](#)

Block Diagram

System Design Expectations

Issues

Timeline

➤ Upcoming Tasks

Draft Budget

Conclusion

References