Socially Aware, Expressive, and Personalized Mobile Remote Presence: Co-Robots as Gateways to Access to K-12 In-School Education

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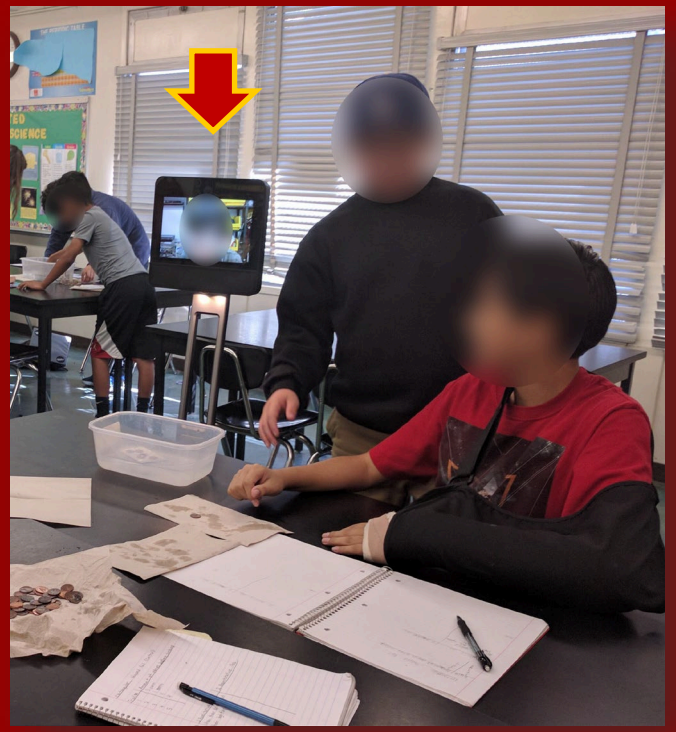
Study Coordinator: Rhianna Lee. High School Students: Drew Sevilla



Motivation and Goals

Each year, more than 6.5 million K-12 students in the US miss substantial portions of school, resulting in significant educational and social issues.

How can mobile remote presence (MRP) robots improve access to in-school learning and reduce the impact of extended school absence for K-12 students?

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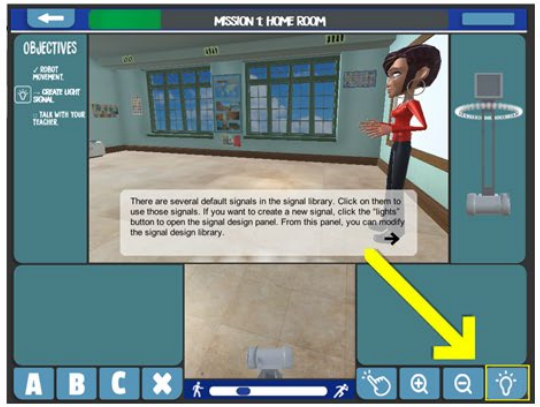
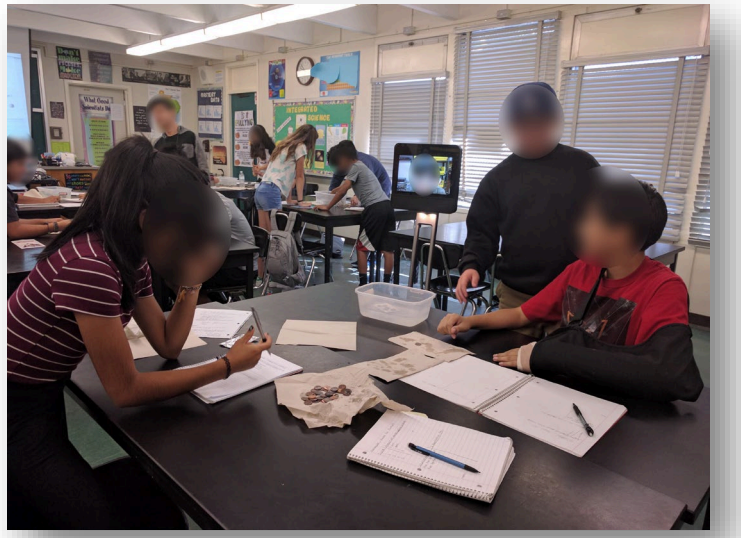
Exploratory Studies to Characterize User Needs [1,2]

Performed exploratory studies that identified key challenges and offered design recommendations for MRP platforms in the classroom [1].

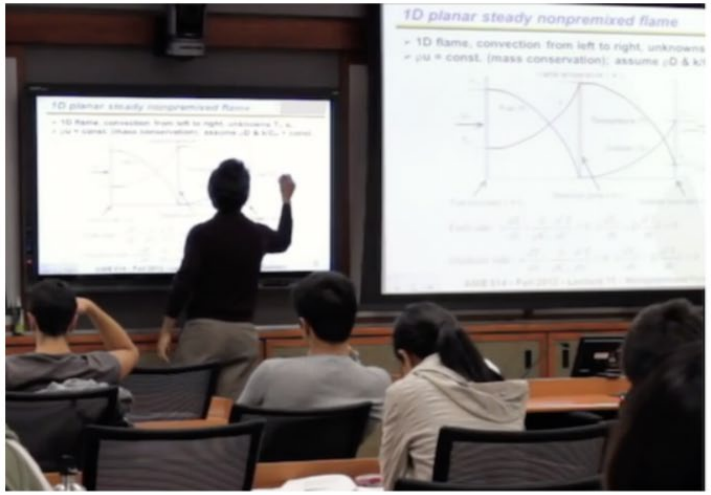


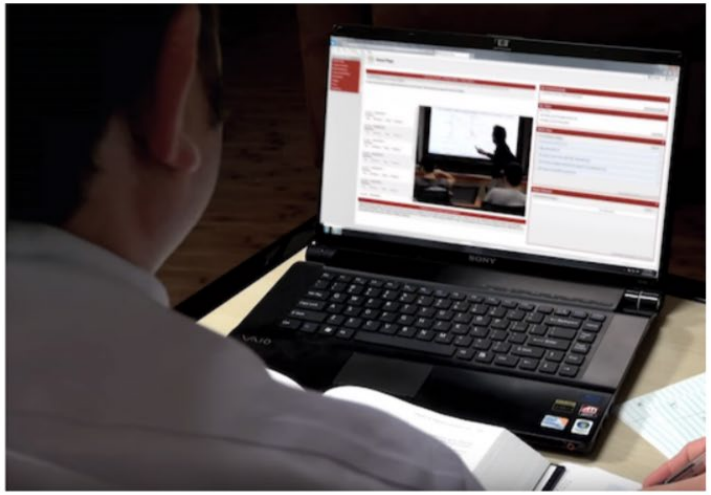


Developed a simulated classroom telepresence game to facilitate MRP research [2].

Assessing and Comparing Remote Learning Technologies [3,4]

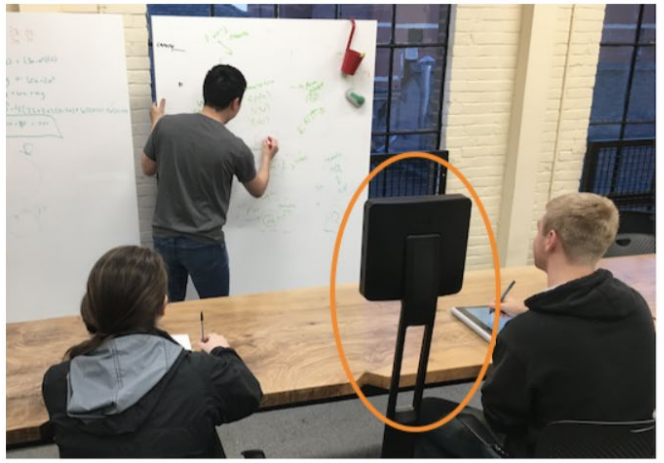
Distance learning technology

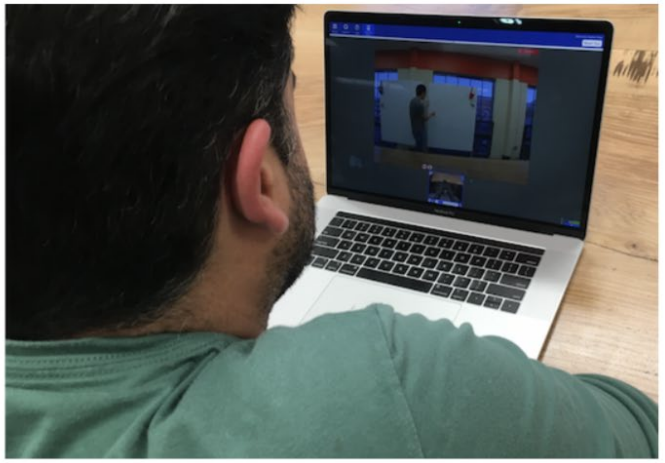




Found that students felt more present, self-aware, and expressive when using a mobile remote presence (MRP) robot than when using distance learning [3].

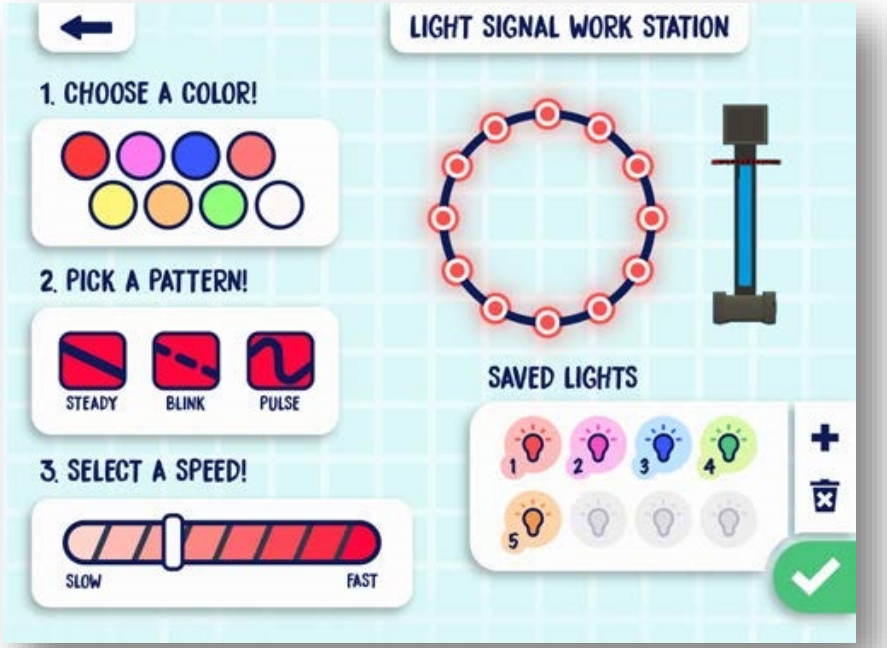
MRP





Signaling and Situational Awareness for Telepresence [5–13]

Developed **communicative MRP robot** hardware including user-controlled expressive light arrays and low-cost 3D-printable arms for gesturing [6,7,9,11].

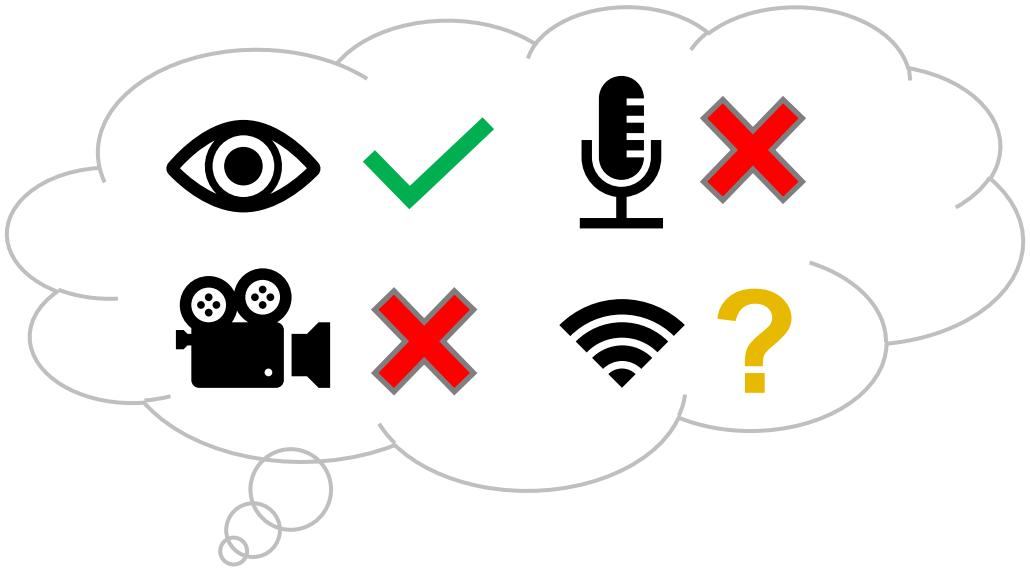


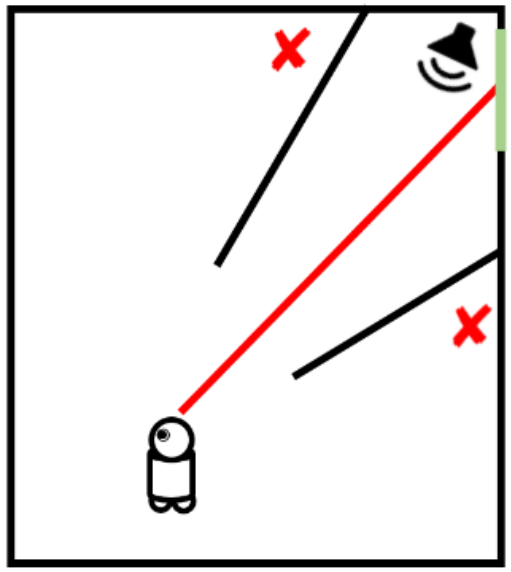
Personalizing Telepresence Robots [16,17,18]

Found that personalization of the MRP is perceived differently by robot operators and interlocutors [16].

Identified interpersonal closeness as a predictor of telepresence experience [17].

User Mental Models of Robot Capabilities [14,15]





Studied mental model formation about perceptual capabilities through a custom, web-based game played by over 200 participants [14,15].

Multi-Week Classroom Deployments with Homebound Students

	P1	P2	P3	P4
Duration	5 weeks	2 weeks	7 weeks	4 weeks
Classrooms	Spanish	History, English, Law	Intensive Studies	Math, Science, English, History, Lunch
Days Attended	10 days	7 days	21 days	7 days
Total Hours on Robot	12 hours	10 hours	14 hours	16 hours

Data Collected :: Overview

Variables Measured via Questionnaires

	Single Measure	Repeated Measures
Participants (i.e., Robot Operators)	• Temperament • Previous Experience with Video Chat and other Technologies	• Attitudes toward Technology • Attitude toward Class Subject • Presence • Self-Consciousness • Robot Usability • Attention and Inclusion
Classmates		• Presence • Attention and Inclusion • Robot Usability
Teachers	• Types of Classroom Activities • Use of Technology in the Classroom	• Engagement of participant • Presence • Attention and Inclusion • Robot Usability

Annotation of Audio+Video Data

1. Measures of Engagement:
   - Speaking
   - Moving the Robot
2. Speech Intelligibility Cues

Findings :: Homebound Students a High Variance Population

ID	Medical Context	Avg. Engagement	Beneficial MRP Features
P1	Speech and motor challenges	Spoke in **32%** of 5min windows	Mobility
P2	Mental health challenges	Spoke in **89%** of 5min windows	Limited field of view
P3	Speech and motor challenges	Spoke in **96%** of 5min windows	Ability to log in and out anytime
P4	Mental health and motor challenges	Spoke in **38%** of 5min windows	Visibility among school administrators

Findings :: How to Successfully Deploy an MRP in the Classroom

Successful deployment takes a team with good planning and communication

https://pisces.bbystatic.com/image2/BestBuy_US/images/products/9477/9477247_sa.jpg

At Home

the homebound student

parents

siblings

caregivers

— Supporting the Technology —

assistive technology specialists

MRP technical support

school district IT support

At School

teachers

school administrators

classmates, including “bot buddies”

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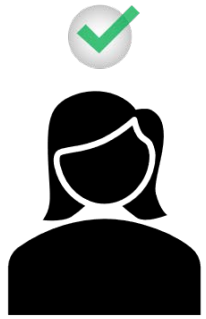
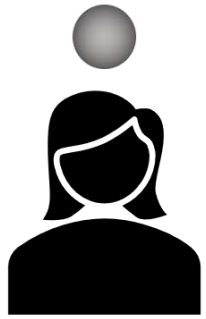
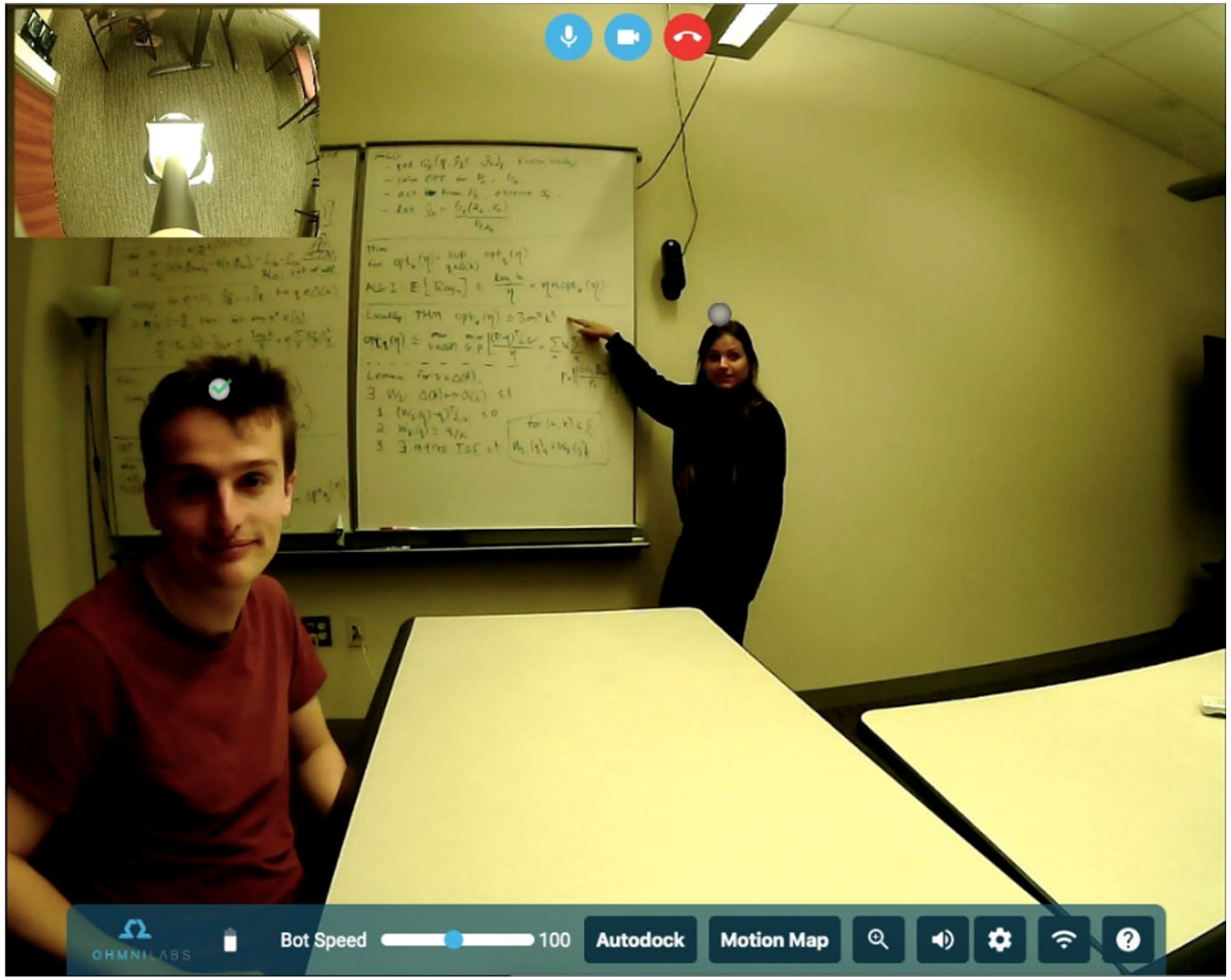
Model of Speech Intelligibility [19]



Operator's Speech is **Intelligible** to This Person



Operator's Speech is **Not Intelligible** to This Person



Our data-driven model estimated the intelligibility of the operator's speech given the distance to a listener and ambient noise level in the classroom [19].

An interface element displaying speech intelligibility estimates was tested with two of the four multi-week deployment participants.

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Toward Automatically Detecting Comprehension Cues

Cues that listeners understood the participant could be detected by future MRP systems and used to assist homebound students.

We found over 700 comprehension cues and identified which types were most common in our deployments.

These cue categories accounted for 75% of **positive cues** (i.e., indicating the cuer understood the participant):

- Continuations (50%)
- Correct/Appropriate Responses (16%)
- Direct Affirmations (16%)

These cue categories accounted for 75% of **negative cues** (i.e., indicating the cuer did not understand the participant):

- No Response (49%)
- Asking for Clarification (17%)
- Cuer Movement (8%)
- Inappropriate Response (7%)

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K-12 STEM Outreach

5 Robotics Open House events
(usually 1,000 – 2,000 visitors)

8 K-12 school assembly visits

7 other public demos

interviews

comedy shows

TV appearances

Acknowledgments

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High School Student: Drew Sevilla

PI Maja Matarić

Co-PI Gisele Ragusa

Publications (1 of 3)

NEEDS ASSESSMENT (EARLY EXPLORATION)

[1] Elizabeth Cha, Samantha Chen, and Maja J. Matarić. "Designing Telepresence for K-12 Education". In 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN '17), Lisbon, Portugal, Aug 28 - Sep 1, 2017. IEEE. (pdf)

[2] Elizabeth Cha, Jillian Greczek, Ao Song, and Maja J. Matarić. "My Classroom Robot: Exploring Telepresence for K-12 Education in a Virtual Environment". In 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN '17), Lisbon, Portugal, Aug 28 - Sep 1, 2017. IEEE. (pdf)

CLASSROOM TECH COMPARISONS

[3] Naomi T. Fitter, Nisha Raghunath, Elizabeth Cha, Christopher A. Sanchez, Leila Takayama and Maja J. Matarić. "Are We There Yet? Comparing Remote Learning Technologies in the University Classroom", In IEEE Robotics and Automation Letters, 5(2):2706-2713, Apr 2020. (pdf)

[4] Naomi T. Fitter, Elizabeth Cha, Leila Takayama. "Comparing remote learning technologies". In 2018 RSS Workshop on Fundamental Issues in Symbiotic Human-Robot Interaction at Robotics: Science and Systems (RSS 2018), Pittsburgh, PA, USA, June 26-30, 2018. (pdf)

SIGNALING AND COMMUNICATION (1 of 2)

[5] Elizabeth Cha, Emily Meschke, Terrence Fong and Maja J. Matarić. "A Probabilistic Approach to Human-Robot Communication", In the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2019), Macau, China, Nov 4-8, 2019.

[6] Naomi T. Fitter, Youngseok Joung, Marton Demeter, Zijian Hu and Maja J. Matarić. "Design and Evaluation of Expressive Turn-Taking Hardware for a Telepresence Robot", In 28th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN 2019), New Delhi, India, Oct 14-18, 2019. (pdf, video)

[7] Naomi T. Fitter, Youngseok Joung, Zijian Hu, Marton Demeter and Maja J. Matarić. "User Interface Tradeoffs for Remote Deictic Gesturing", In 28th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN 2019), New Delhi, India, Oct 14-18, 2019. (pdf)

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[8] Elizabeth Cha, Yunkyung Kim, Terrence Fong and Maja J. Matarić. "A Survey of Nonverbal Signaling Methods for Non-Humanoid Robots", In Foundations and Trends in Robotics, 6(4):211-323, 2018. (pdf)

[9] Elizabeth Cha, Naomi T. Fitter, Yunkyung Kim, Terrence Fong and Maja J. Matarić. "Generating Expressive Light Signals for Appearance-Constrained Robots", In 2018 International Symposium on Experimental Robotics (ISER), Buenos Aires, Argentina, Nov 5-8, 2018. (pdf)

[10] Elizabeth Cha, Naomi T. Fitter, Yunkyung Kim, Terrence Fong and Maja J. Matarić. "Effects of Robot Sound on Auditory Localization in Human-Robot Collaboration", In 13th ACM/IEEE International Conference on Human Robot Interaction (HRI), Chicago, IL, USA, Mar 5-8, 2018. (pdf)

[11] Elizabeth Cha, Tushar Trehon, Lancelot Wathieu, Christian Wagner, Anurag Shukla, and Maja J. Matarić. "ModLight: Designing a Modular Light Signaling Tool for Human-Robot Interaction". In 2017 IEEE International Conference on Robotics and Automation (ICRA '17), Singapore, May 29 - Jun 3, 2017. IEEE. (pdf)

[12] Elizabeth Cha and Maja J. Matarić. "Using Nonverbal Signals To Request Help During Human-Robot Collaboration". In 2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS '16) Daejeon, Korea, Oct 9-14, 2016. IEEE. (pdf)

SITUATIONAL AWARENESS

[13] Naomi T. Fitter and Maja J. Matarić. "Increasing Self-Awareness for Telepresence Robot Users", In Proceedings, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS-2018): Workshop on Assistance and Service Robotics in a Human Environment, Madrid, Spain, Oct-2018. (pdf)

Publications (3 of 3)

MENTAL MODELS OF PERCEPTUAL CAPABILITIES

[14] Matthew Rueben, Eitan Rothberg, Matthew Tang, and Maja J. Matarić. "Estimating and Influencing User Mental Models of a Robot's Perceptual Capabilities: Initial Development and Pilot Study", In Companion of the 15th ACM/IEEE International Conference on Human-Robot Interaction (HRI '20), Cambridge, UK, Mar 23-26, 2020. (pdf)

[15] Matthew Rueben, Matthew Tang, Eitan Rothberg, and Maja J. Matarić. "Helping Users Develop Accurate Mental Models of Robots' Perceptual Capabilities: A First Approach", In Workshop on Trust, Acceptance and Social Cues in Robot Interaction (SCRITA) at the 28th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN 2019), New Delhi, India, Oct 14-18, 2019. (pdf)

PERSONALIZATION

[16] Naomi T. Fitter, Megan Strait, Eloise Bisbee, Maja J. Matarić and Leila Takayama. "You're Wigging Me Out! Is Personalization of Telepresence Robots Strictly Positive?", In *2021 ACM/IEEE International Conference on Human-Robot Interaction (HRI '21)*, Mar-2021. (.pdf)(Details)

[17] Naomi T. Fitter, Luke M. Rush, Elizabeth Cha, Thomas R. Groechel, Maja J. Matarić, and Leila Takayama. "Closeness is Key over Long Distances: Effects of Interpersonal Closeness on Telepresence Experience", In the 15th ACM/IEEE International Conference on Human Robot Interaction (HRI '20), Cambridge, UK, Mar 23-26, 2020. (pdf)

[18] Naomi T. Fitter, Yasmin Chowdhury, Elizabeth Cha, Maja J. Matarić, Leila Takayama. "Evaluating the Effects of Personalization on Telepresence Robots for Education". Late-breaking Report in 13th ACM/IEEE International Conference on Human-Robot Interaction (HRI '18), Chicago, IL, USA, Mar 5-8, 2018. ACM/IEEE. (pdf)

SPEAKING VOLUME APPROPRIATENESS

[19] Matthew Rueben, Thomas R. Groechel, Yulun Zhang, Gisele Ragusa, and Maja J. Matarić. "Increasing Telepresence Robot Operator Awareness of Speaking Volume Appropriateness: Initial Model Development", In Companion of the 15th ACM/IEEE International Conference on Human-Robot Interaction (HRI '20), Cambridge, UK, Mar 23-26, 2020. (pdf)