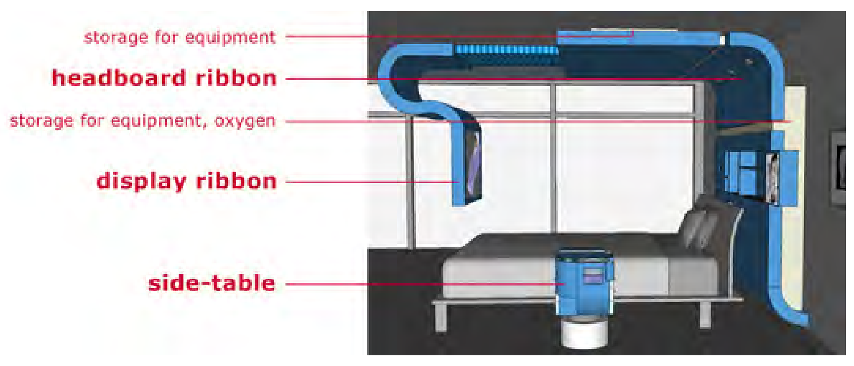
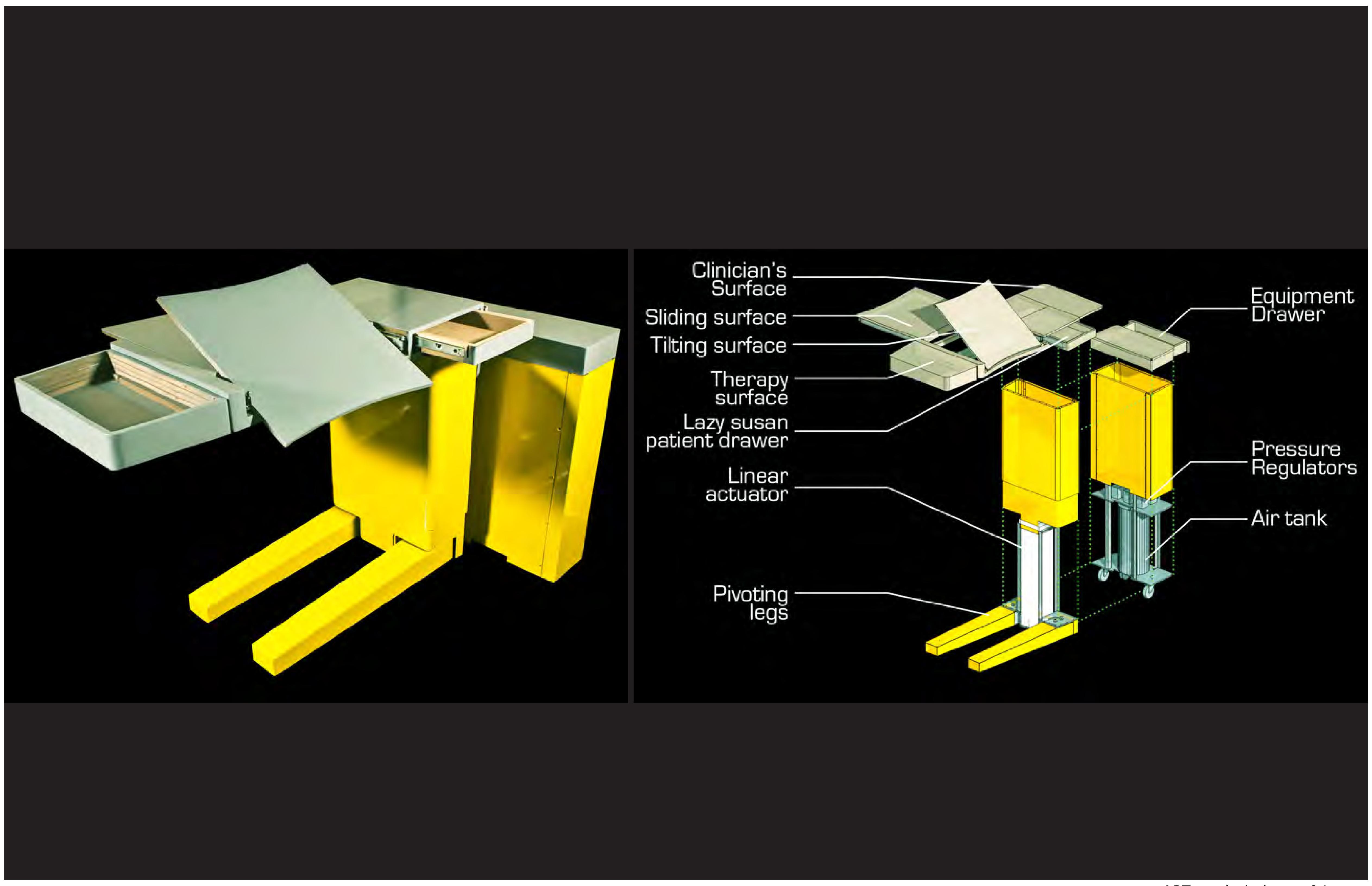
The home+ Vision

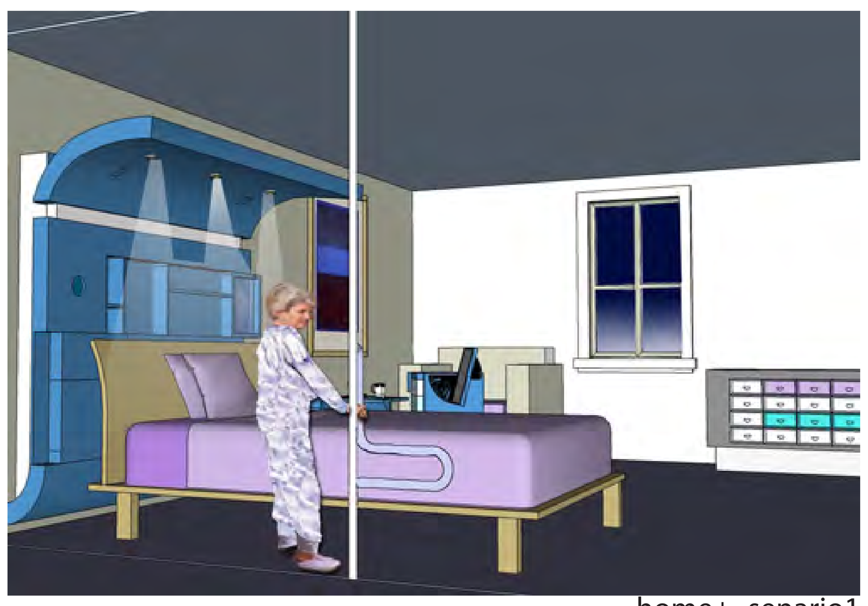


A suite of networked, distributed "robotic furnishings" integrated into existing domestic environments and healthcare facilities.

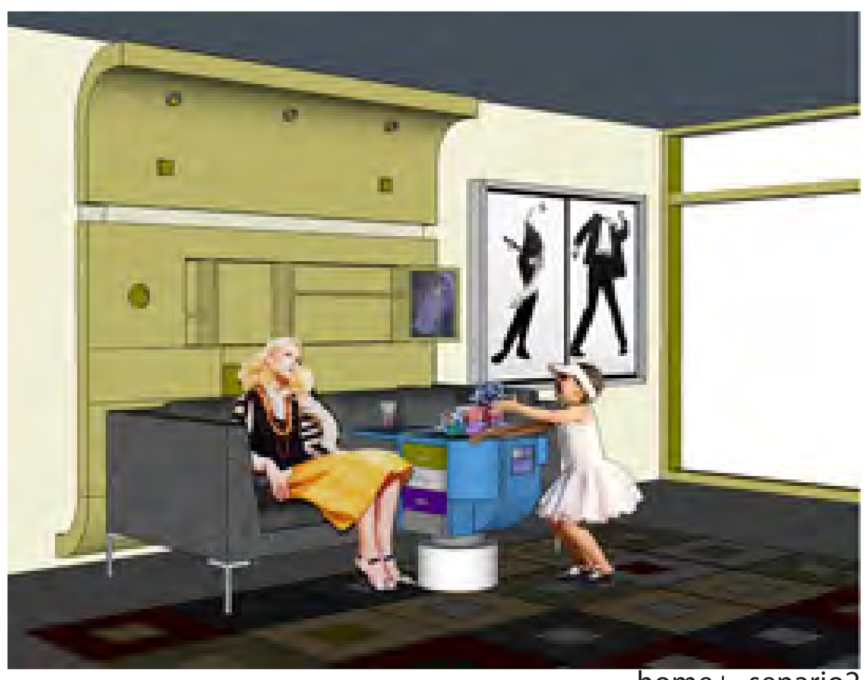


ART_exploded axon & image

home+_senario1



home+_senario1



home+_senario2

Reference: Threatt, A. L., Merino, J., Green, K.E., Walker, I.D., Brooks, J. O. et. al. A Vision of the Patient Room as an Architectural Robotic Ecosystem. Video (IEEE archival) inThreatt,Proceedings of IROS 2012, Vilamoura, Algarve, Portugal, October 2012

Reference: K.E.Green, I.D. Walker, J. O Brooks and W.C. Logan, Jr. comforTABLE: A Robotic Environment for Aging in Place, late-breaking paper, HRI'09, March 11–13, 2009, La Jolla, California.

[ART]

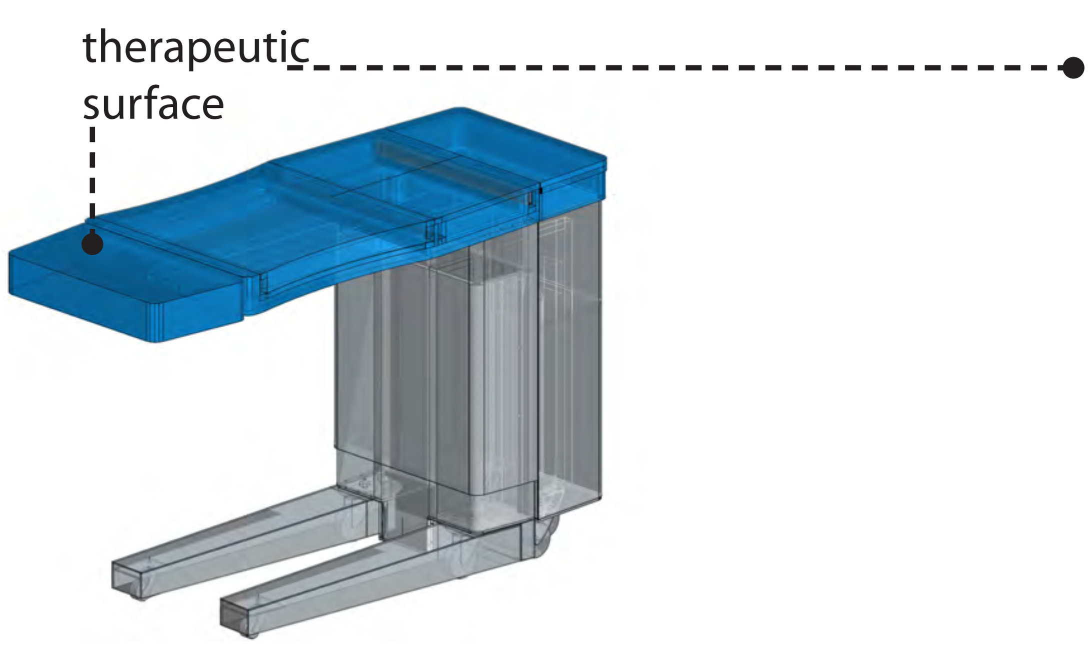
Assistive Robotic Table

Promoting Independent Living

In hospitals, technology has become pervasive and indispensable during medical crises. At home, technology proliferates as computerized health monitoring systems and, perhaps in the future, as assistive "humanoid" robots. Meanwhile, our everyday environments remain essentially conventional: low-tech and ill-adaptive to dramatic life changes. This social condition places strain on healthcare and family support systems, and represents a failure of scientists, engineers and architects to support independent living.

How can our everyday environments be outfitted with intelligent hardware promoting independent living? We focus on a discrete component of an envisioned suite ("home+") of networked, robotic furniture integrated into existing living environments: an Assistive, Robotic Table [ART]. ART is the hybrid of a typical nightstand found in homes, and the over-the-bed table found in hospital rooms; it features a plug-in "continuum robotic" surface that supports rehabilitation. We envision that ART and the other components of the home+ suite recognize, communicate with, and partly remember each other in interaction with human users.

The key deliverable of the SHB award is the full-scale, working ART prototype. Our trans-disciplinary team has developed this complex, physical-digital artifact by way of iterative design and evaluation activities that recognize engineering, architectural design and human-centered design as inseparable. Key outcomes of the research are the "continuum robotic" surface as well as an innovative approach to human mobility and its metrics for intelligent, physical artifacts. The key broader impact of the research is ART, empowering people to remain in their homes for as long as possible, even as their physical capabilities alter over time; and, in more grave circumstances, affording people some semblance of feeling "at home" as users and ART move to assisted care facilities.



A continuum-robotic 2D surface actuated byMcKibben, pneumatic muscles.

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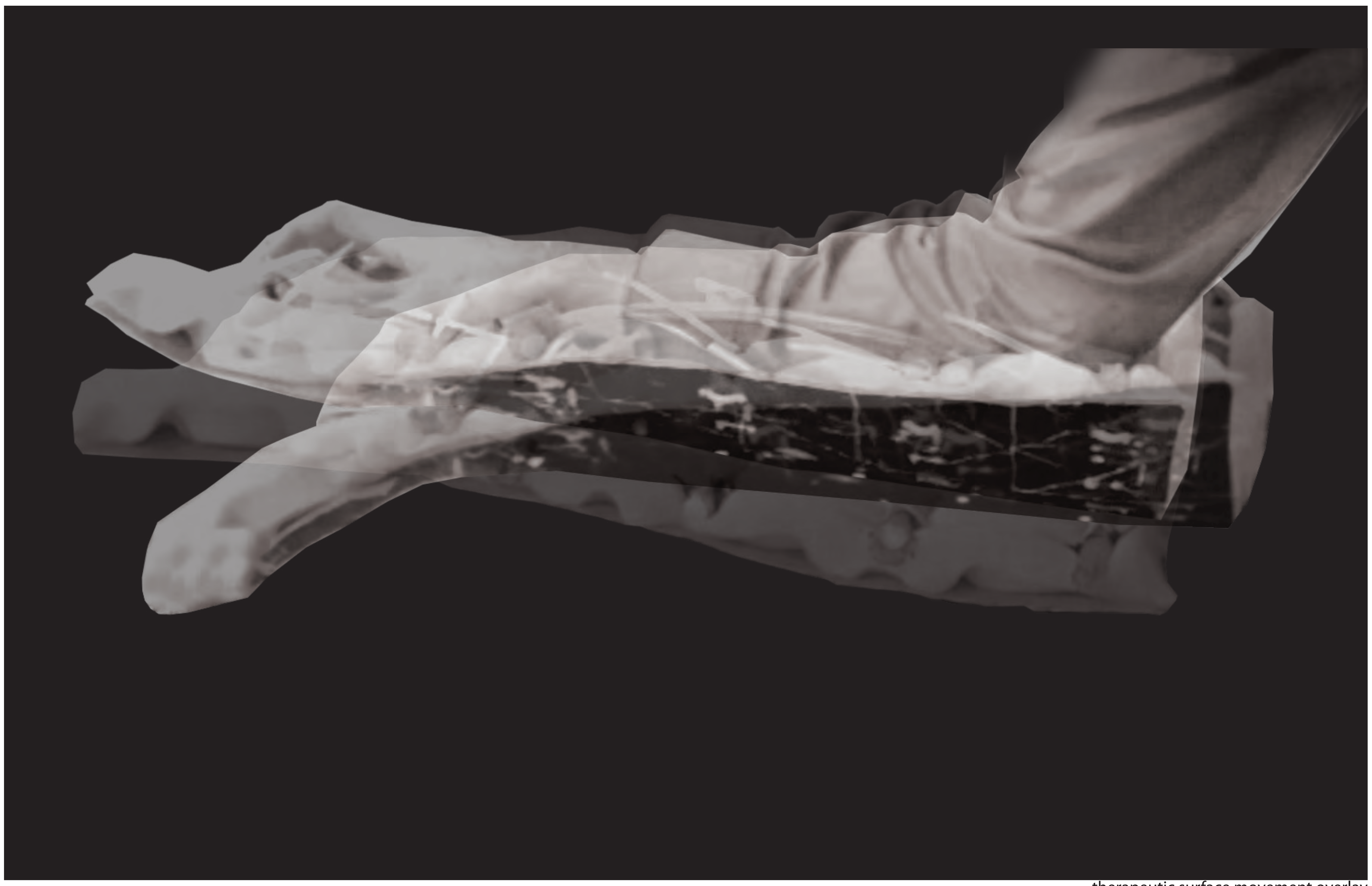
The patient's arm is guided by the continuum-robotic surface, helping stroke patients regain mobility in clinic and at-home. We designed for 5 movements:

- Wrist Flexion
- Arm Cupping + Wrist Flexion
- Wrist Extension
- Arm Cupping
- Arm Cupping + Wrist Flexion



therapeutic surface movement overlay

[Therapeutic Surface]

Post-Stroke Rehabilitation Surface

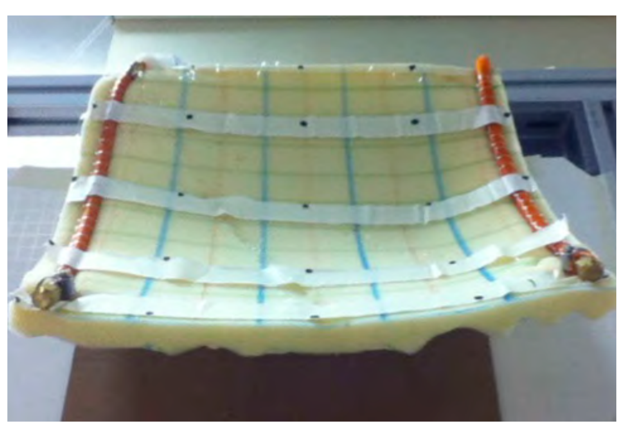
ART features a novel, continuum-robotic surface. While the traditional approach to providing movement in both robotics and architectural design relies on rigid structures (e.g. links, axis, doors, and windows) along, or about one-dimensional surfaces (i.e. lines and axes), we argue for an alternative design approach based on a flexible, continuous, two-dimensional surface actuated by pneumatic muscles - a new and emerging technology for assistive robotics. Such a compliant surface promises to achieve the simultaneous flexibility and load capacity required for ART, and meets its design constraints while ensuring that users are safe and comfortable with, and accepting of the technology.

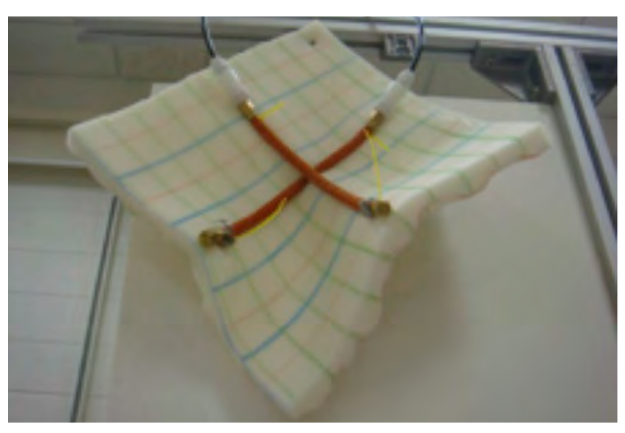
Arm Cupping+ Wrist Extension

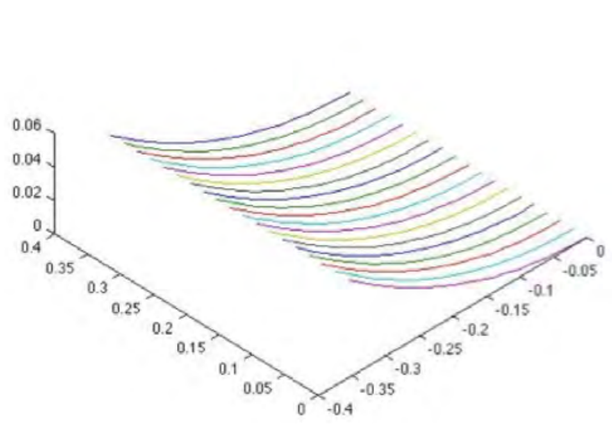
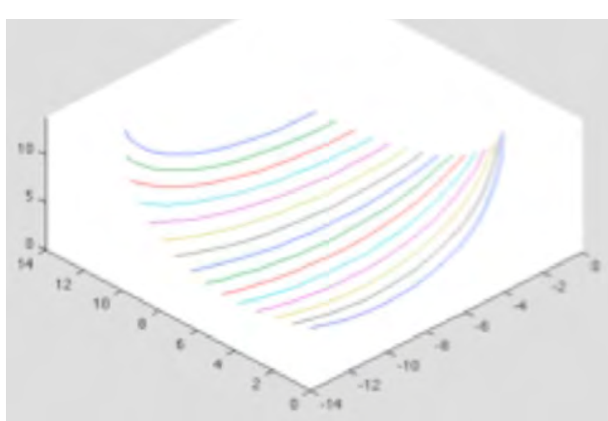
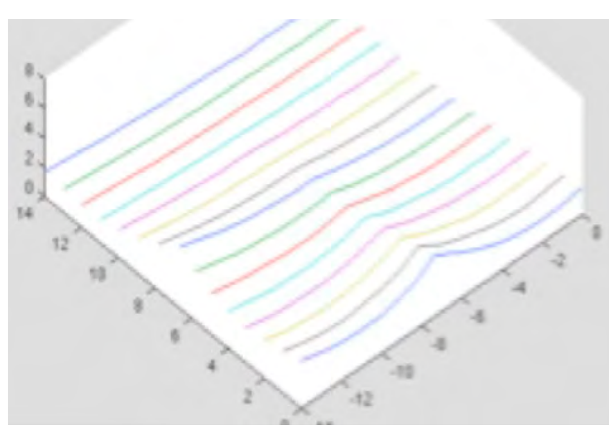
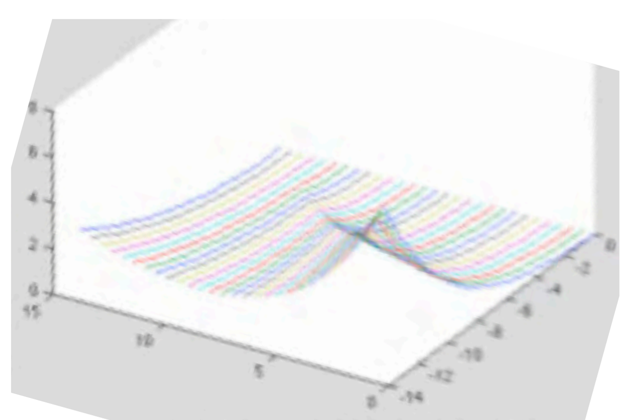
Arm Cupping+ Wrist Flexion

 +  + 

A woven-polyester surface, designed by us, and produced by the Institut für Textiltechnik der RWTH Aachen U., actuated by digitally-controlled pneumatic muscles





The shape of the surface matches the mathematical model of the surface

Reference: Merino, J., Threatt, A. L., Walker, I.D. and Green, K.E. "Forward Kinematic Model for Continuum Robotic Surfaces." Proceedings of IROS 2012: the 2012 IEEE/RSJ International Conference on Intelligent Robots and Systems, Vilamoura, Algarve, Portugal, October 2012.

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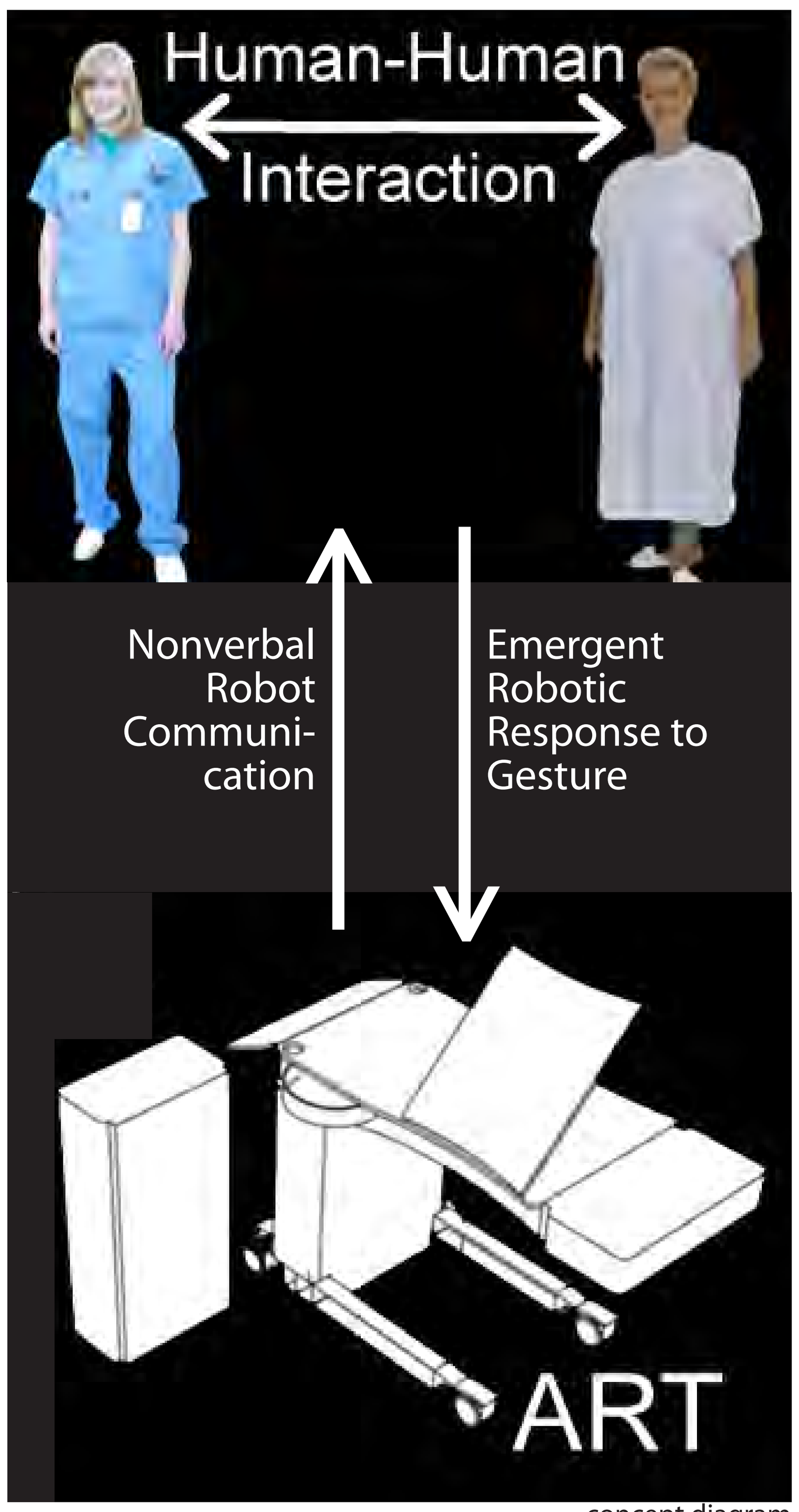
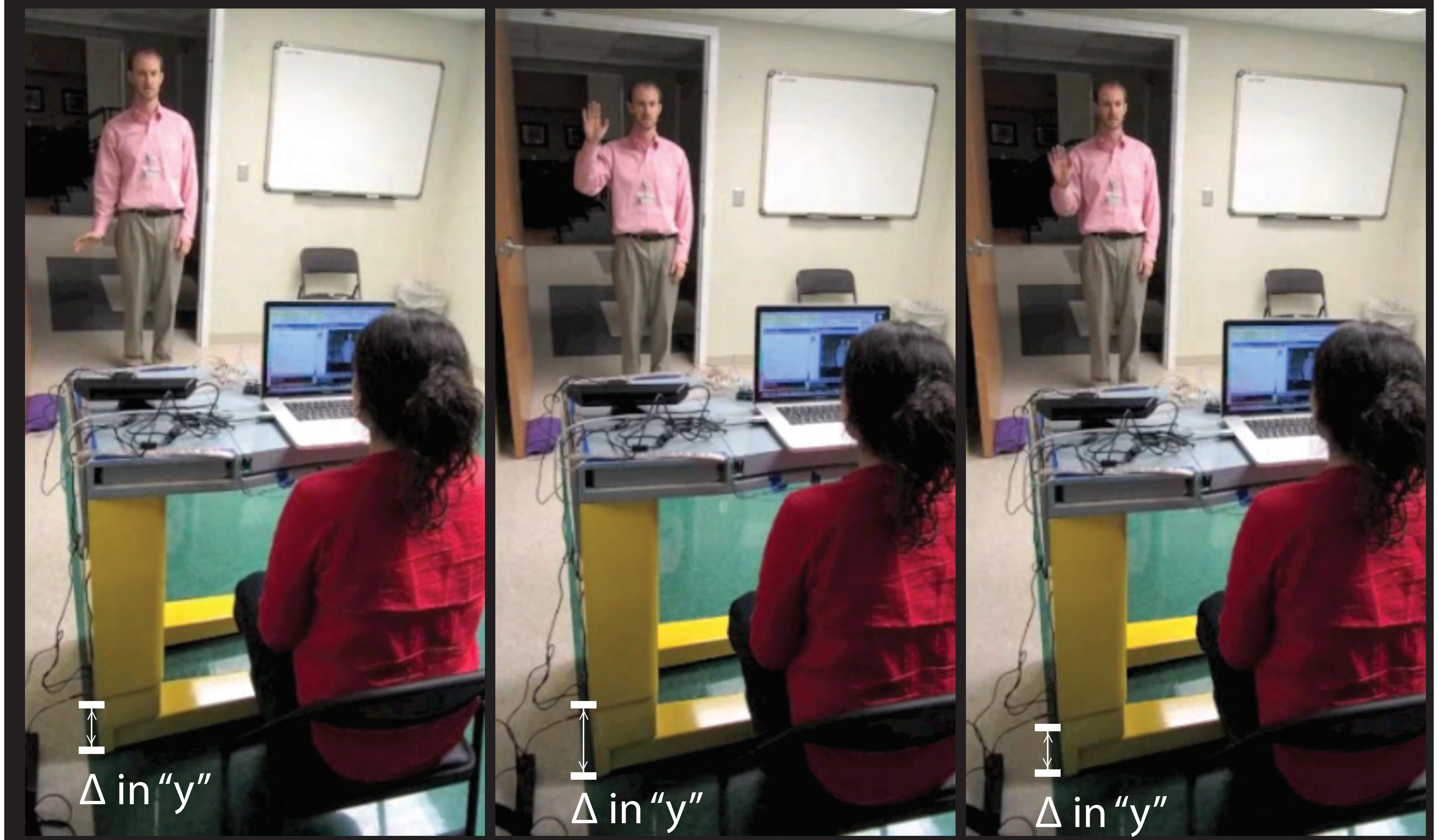
Typically, gesture recognition takes the form of template matching in which the human participant is expected to emulate a choreographed motion as prescribed by the researchers. A corresponding robotic action is then a one-to-one mapping of the template classification to a library of distinct responses. But we cannot count on rehabilitating post-stroke users to perform gestures to the liking of robots. We explore, instead, a recognition scheme based on the Growing Neural Gas (GNG) algorithm which places no initial constraints on the user to perform gestures in a specific way. Skeletal depth data are clustered by GNG and mapped directly to a robotic response that is refined through reinforcement learning. A simple good/bad reward signal is provided by the user. Early experimental outcomes are promising.

Our NVC Loop, in concept



concept diagram

Inevitably, assistive robotics will become integral to our everyday lives. How will we communicate with such robots, and how will they communicate with us? We make the case for a relatively "artificial" mode of nonverbal human-robot communication [NVC] to avoid unnecessary distraction for people, busily conducting their lives via human-human, natural communication. We propose that this NVC be conveyed by familiar lights and sounds. We conducted early experiments with our NVC platform in a rehabilitation hospital. Our NVC platform was perceived by medical staff as a desirable and expedient communication mode for human-robot interaction in clinical settings, suggesting great promise for our mode of human-robot communication.

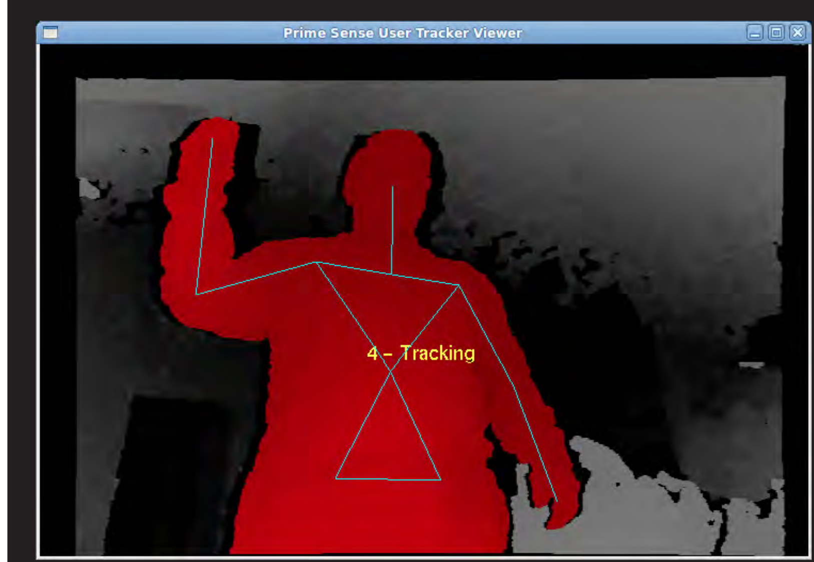


robot response & movement photos

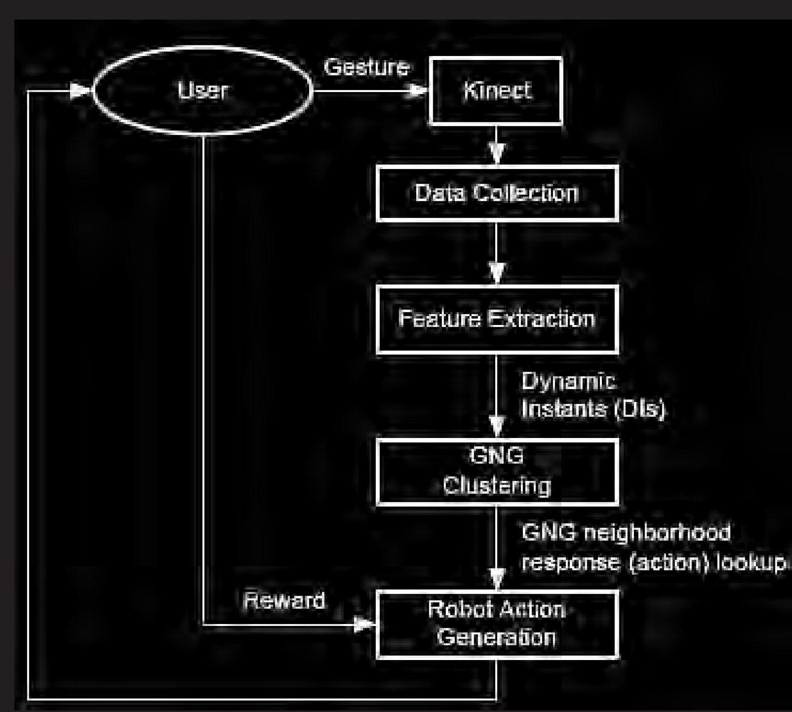
[Emergent Robot Respones to Gesture]

Current+Future Work

Reference: Threatt, A. L., Green, K. E., Brooks, J. O., Merino, J. and Walker, I. D. "Design and Evaluation of a Nonverbal Communication Platform for Human-Robot Interaction." Proceedings of the HCI International 2013 Conference, Las Vegas.



Growing Neural Gas (GNG) algorithm places no initial constraints on the user to perform gestures in a specific way.



The response of the robot converges upon the user-defined gesture by taking user-feedback into account.

The Kinect collects skeletal depth data.

[Nonverbal Robot Communication]

Current+Future Work

Reference: Yanik, P.M., Manganelli, J., Merino, J. Threatt, A.L., Brooks, J.O., Green, K.E. and Walker. I.D. "Use of Kinect Depth Data and Growing Neural Gas for Gesture Based Robot Control." Proc. of the 6th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth 2012), pages 283-290, La Jolla, CA, 2012.

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