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 of networked, robotic furniture integrated into existing living environments: an Assistive, Robotic Table [ART]. ART is the hybrid of a typical nightstand and the over-the-bed table found in hospital rooms, comprised of a novel “continuum robotic” table surface that gently folds, extends, and reconfigures to support work and leisure activities; a smart storage volume that physically manages and delivers personal effects; and an accessorized headboard. These components of ART recognize, communicate with, and partly remember each other in interaction with human users and with other components of the suite.

The key deliverable is the full-scale, working ART prototype performing “going-to-bed” and “awaking” scenarios for three target groups. Our trans-disciplinary team is developing this complex physical-digital artifact by way of iterative design and evaluation activities that recognize engineering design, 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 our intelligent “architectural robotic” 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 user and ART move to assisted care facilities.
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 therapy surface movements:

- Wrist Flexion • Arm Cupping
- Wrist Extension • Arm Cupping
- Wrist Flexion

**Therapeutic Surface**

**Post-Stroke Rehabilitation Surface**

ART features a novel continuum-robotic surface. While the traditional approach to provide movement in both robotics and architectural design relies on rigid structures (e.g., links, axes, 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.

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

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

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.

NVC Loop

In Concept

Emergent Robot Responses to Gesture

Current + Future Work


Nonverbal Robot Communication

Current + Future Work