United States Department of Commerce
Home Lift, Position and Rehabilitation Chair

The HLPR chair is a testbed for developing assistive mobility technology concepts for wheelchair-dependent people. A prototype design has been developed that offers much greater independence in safely transferring from the chair to other locations.

Lead agency:

National Institute of Standards and Technology (Department of Commerce)

Agency Mission:

To promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.

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Partner agency:

University of Delaware (through a National Science Foundation Grant)

General Description:

Engineers at the National Institute of Standards and Technology (NIST) have developed a robotic system that may offer

wheelchair-dependent people independent, powered mobility and the ability, depending on patient status, to move to and from beds, chairs and toilets without assistance.

The lifting ability of the system, which is called the "HLPR Chair" (for Home Lift, Position and Rehabilitation), also should significantly reduce caregiver and patient injuries.

The HLPR chair draws on mobile robotic technology developed at NIST for manufacturing and defense applications. It is built on an off-the-shelf forklift with a U-frame base on wheel-like casters and a rectangular vertical frame. The frame is small enough to pass through the typical residential bathroom. The user drives the chair using a joystick and other simple controls.

The HLPR chair's drive, steering motors, batteries and control electronics are positioned to keep its center of gravity—even when carrying a patient—within the wheelbase. This allows a person weighing up to 300 pounds, to rotate out, from the inner chair frame, over a toilet, chair or bed while

supported by torso lifts. The torso lifts lower the patient safely into the new position. The chair frame can even remain in position to continue supporting the patient from potential side, back or front falls.

In addition, the proof-of-concept prototype HLPR Chair would allow stroke victims and others to keep their legs active without supporting their entire body weight. Retractable seat and foot rests, padded torso lifts for under arms (that, when raised, act like crutches) and an open frame at the bottom of the chair facilitate leg exercises. The patient, once lifted and supported by the torso lifts, can walk as the HLPR Chair moves forward at a slow pace. The current maximum speed is 27 inches per second (0.7m/s).

Future research possibilities include defining the sensing and control requirements that would enable the HLPR to autonomously dock with toilets, provide voice-activation capability so patients can call the HLPR from another location, and provide dial-in leg loading to limit leg forces during rehabilitation.

Excellence: What makes this project exceptional?

Significance: How is this research relevant to older persons, populations, and/or an aging society?

Effectiveness: What is the impact and/or application of this research to older persons?

Innovativeness: Why is this research exciting or newsworthy?

There has been an increasing need for wheelchairs over time. Independent mobility is fundamental to health, social integration and individual well-being of humans. Hence, mobility must be viewed as being essential to the outcome of the rehabilitation process of wheelchair-dependent persons and to their successful (re-)integration into society and to a productive and active life. The quality of the wheelchair, the individual work capacity, the functionality of the wheelchair/user combination, and the effectiveness of the rehabilitation program do indeed determine the freedom of mobility.

Just as important as wheelchairs are the lift devices and people who lift patients into wheelchairs and other seats, beds, automobiles, etc. The need for patient lift devices will also increase as generations get older. Beyond providing the patient greater indepence, lift devices can prevent numerous injuries to both the patient and their care-givers. Example statistics are: one in three nurses becomes injured while moving non-ambulatory patients and one in two non-ambulatory patients are injured from falls while being transferred between a bed and a wheelchair.

Based on a survey of patient lift and mobility devices, NIST researchers discovered a need for technology that includes mobility devices that can lift and maneuver patients to other seats and technology that can provide for rehabilitation to help the patient become independent of the wheelchair. Their study also determined there are no standards nor performance metrics for such devices should they become available in the commercial sector. Nursing home caregivers will develop back injuries totaling 200,000 incidents this year alone from transferring patients and cost the US $2 Billion. Based on these compelling needs, NIST designed a HLPR Chair testbed to investigate patient transfer including specific areas of mobility, lift and rehabilitation toward safety standards, performance measurements of such devices, and advanced autonomous controls.

The HLPR Chair testbeds are based on a manual, inexpensive, off-the-shelf, sturdy forklift. The forklift includes a U-frame base with casters in the front and rear and a rectangular vertical

frame. The lift and chair frame's dimensions allow it to pass through even the smallest, typically 61 cm (24 in) wide x 203 cm (80 in) high, residential bathroom doors.

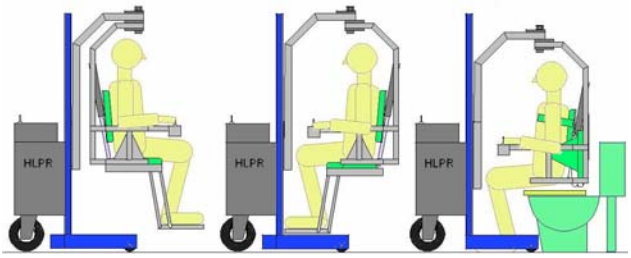

Figure 1: Graphic showing concept of placing patient onto a toilet or other chair with the HLPR chair.

Figure 2: Rehabilitation configuration of the HLPR chair

The HLPR chair design is innovative in several ways. It is designed to explore key challenges in wheelchair-bound mobility, transfer to other surfaces, ability to reach high objects, rehabilitation, and autonomous assistive navigation for wheelchairs. The HLPR chair provides a seat/stand mechanism that provides lift and rotation to the patient allowing transfer to other chairs, beds, or toilets while maintaining safety by having the center of gravity remain within the wheelbase even if the patient is outside of it. See Figure 1 for a graphic illustrating a transfer. To place a HLPR Chair user on another seat, they can drive to for example, a toilet, seat, or bed. Once there, the HLPR Chair rotates the footrest up and beneath the seat and the patients feet are placed on the floor personally or by a caregiver. The HLPR Chair inner L-frame can then be rotated manually with respect to the chair frame allowing the patient to be above the toilet. Padded torso lifts then lift the patient from beneath his/her arm joints similar to crutches. The seat, with the footrest beneath, then rotates from horizontal to vertical behind the patients back clearing the area beneath the patient to be placed on the toilet, seat, bed, etc.
Patient lift is designed into the HLPR Chair to allow user access to high shelves or other tall objects while seated. The HLPR Chairs' patient lift is approximately 1 m (36 in), equivalent to the reach of a standing 2 m (6 ft) tall person. This is a distinct advantage over marketed chairs and other concepts. The additional height comes at no additional cost of frame and only minimally for actuator cost.

The HLPR Chair enhances patient rehabilitation through a load sensor and control on the lift actuator. The researchers designed rehabilitation into the HLPR Chair, as shown in Figure 2, to allow, for example, stroke patients to keep their legs active without supporting the entire load of the patients body weight. The patient, once lifted, could walk while supported by the HLPR Chair driving at a slow walking pace towards regaining leg control and eliminating the need for a wheelchair.

Autonomous mobility control using a sophisticated control architecture and advanced 3D imagers is nearly complete through a teaming arrangement with the University of Delaware. Commercialization is now being considered by the healthcare industry.