SafePath™

by

GeckoSystems International Corporation

Third party confirmation of the need for SafePath™ robotically assisted navigation and how it would increase the safety and mobility of disabled people world wide.

GECKO™ SYSTEMS

Controlling a wheelchair is not a simple matter. No matter what control device is selected (joystick, head motion, sip and puff) it has to be delicately adjusted for each user. Factors such as tremor and spasticity have to be compensated for. Speed must be limited for safety and speed limiters slow things down even when the environment is safe for a higher speed. Different running surfaces such as carpet vs tile also affect chair performance. Door thresholds can be serious obstacles.

SafePath, the GeckoSystems suite of sensors and artificial intelligence deals with these issues. The end result is more freedom and productivity and a better quality of life for the wheelchair user.

The Need

The need for GeckoSystems' "collision proof wheelchair" is real. It is a fact firmly supported by third party studies.:

Department of Health and Human Services, office of the Inspector General

Power Wheelchairs in the Medicare Program:
Supplier Acquisition Costs and Services

"Medicare allowed an average of $11,507 for complex rehabilitation power wheelchair packages that cost suppliers an average of $5,880 in the first half of 2007."
http://oig.hhs.gov/oei/reports/oei-04-07-00400.pdf

Surely those who pay $9-12000 for a wheel chair will pay a reasonable price for an upgrade that will actually let clients use the chair safely and efficiently in everyday life. In the US, payers include Medicare, the V. A. and Insurance companies. These institutions are at risk to pay even more if someone can't control a power chair and becomes seriously injured. Inability to control is the reason why many patients are refused power chairs.

Fifty Academic Papers on the Collision Proof Wheelchair
and none of them are commercially viable.

Here's a bibliography compiled by the V. A. It lists 50 wheelchair research papers published as early as 1986:

http://www.rehab.research.va.gov/jour/05/42/4/pdf/simpson-append.pdf

Below find information on a study done by the V. A . in 2000:

"**Abstract —** The extreme difficulty with which persons with severe disabilities have been taught to maneuver a power wheelchair has been described in case studies, and anecdotal evidence suggests the existence of a patient population for whom mobility is severely limited if not impossible given currently available power wheelchair control interfaces. Since our review of the literature provided little evidence either in support or refutation of the adequacy of existing power wheelchair control interfaces, we surveyed 200 practicing clinicians, asking them to provide information about their patients and to give their impressions of the potential usefulness of a new power wheelchair navigation technology. Significant survey results were:

- Clinicians indicated that 9 to 10 percent of patients who receive power wheelchair training find it extremely difficult or impossible to use the wheelchair for activities of daily living.
- When asked specifically about steering and maneuvering tasks, the percentage of patients reported to find these difficult or impossible jumped to 40%.
- Eighty-five percent of responding clinicians reported seeing some number of patients each year who cannot use a power wheelchair because they lack the requisite motor skills, strength, or visual acuity. Of these clinicians, 32% (27% of all respondents) reported seeing at least as many patients who cannot use a power wheelchair as who can.
- Nearly half of patients unable to control a power wheelchair by conventional methods would benefit from an automated navigation system, according to the clinicians who treat them.

We believe these results indicate a need, not for more innovation in steering interfaces, but for entirely new technologies for supervised autonomous navigation."

http://www.rehab.research.va.gov/jour/00/37/3/fehr.htm

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Over 200,000 people in the United States use electric-powered wheelchairs (EPWs) as their primary means of mobility [1, 2]. EPWs provide functional mobility for people with both lower and upper extremity impairments. Great advances have been made in the design of electric powered wheelchairs over the past 20 years, yet the control algorithms for these wheelchairs have improved comparatively little since the early 1980's. Electric-powered wheelchair driving could become safer, more effective in a broader array of environments, and functional for more people with the application of advanced control systems [3, 4].

Control systems research has achieved broad application in other areas, such as telecommunications, robotics, automation, and medicine. The simple proportional-integral (PI) controller used on most EPWs today for velocity control does not perform well when subjected to disturbances, sensor uncertainties and load variation [5, 6]. In addition, wheelchair users may encounter different environments and road conditions when driving indoors or outdoors. Incidence of loss of control and injury are far too frequent among EPW users [3], [5]. A substantial fraction of EPW accidents can be directly attributed to the control system and design features of EPWs [3–6]. Persons with severe and complex disabilities might find it difficult to steer an EPW in a confined environment or under adverse conditions such as slippery or uneven terrain or obstacles. Sometimes, even experienced users may lose control of their chairs under such driving conditions. Especially problematic are the actions of negotiating a slope-transition and crossing the threshold of a doorway. These complex actions require hand-eye coordination and fine motor control that for some individuals with high-level spinal cord injury, multiple sclerosis or brain injury that may be exceedingly challenging. For some of these people, learning how to safely and effectively use an EPW can take hours or weeks. Fehr et al reported that 18%– 26% of their patients that used a manual wheelchair could not safely operate an EPW. Their study concluded that no independent mobility options for these patients existed at the time of assessment [7]. Furthermore, a report using data from the United States emergency departments stated that in 2003 over 100,000 wheelchairs related accidents were treated with 65–80 percent of the accidents being tips and falls [8].

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2811532/

From the same paper- GeckoMotorController™ functions are clearly described:

Some research has been conducted on simulation and control of EPWs. Brown et al. [9] applied optimal control theory to the design and development of a control system for an EPW. They developed a PID controller with self-adaptive gains. The controller did not consider robustness in terms of external disturbance rejection. Shung et al. [10] described a computer model of an EPW and its motor control circuitry. In their later work [11], they presented an EPW velocity feedback controller based on the rear wheel drive EPW model and motor control circuitry developed in [10]. A computer simulation study showed that the velocity controller made the EPW easier to drive under varying surface conditions. No driving experiments were reported to verify the practical use of the proposed controller. Another issue identified by EPW user's is wheel slip, which frequently occurs when driving over low-traction terrain, deformable terrain, steep hills, or during collisions with obstacles, and can frequently result in wheelchair loss of control or immobilization. The wheelchair should quickly detect the stalled state in order to let the user or control-system take appropriate action, such as planning an alternate route away from the low-traction terrain region or implementing a traction control algorithm [12]. For most automobiles, wheel slip can be accurately estimated through the use of encoders by comparing the speed of driven wheels to that of the coasting wheels [13]; however this does not apply for all-wheel drive vehicles or those without redundant encoders such as most EPWs. Ding and Cooper reviewed the past researches on EPW and stated that "control algorithms for these [EPW] wheelchairs have not improved substantially since the early 1980s."[5]

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2811532/

Information on how GeckoMotorController™ contributes to the SafePath™ Navigation solution can be found here:

http://www.geckosystems.com/low_level/geckomotor.php

Market Evaluation for Colchester Catalyst on the use of Robotic Wheelchairs

Excerpts below, but reading of the entire report is recommended.

1.1 Reason for Market Research

This market research was conducted at the request of Colchester Catalyst. Colchester Catalyst is a charity organisation established in the 1990s. Its main aim is making life easy for disabled people and providing support to their carers. This includes short term loan of disability equipment such as wheelchairs to those that have lower or upper body impairments [1]. Due to various user needs and advancement in technology, robotics research into wheelchairs has been increasing steadily, especially in the past decade. This involves applying mobile robotics techniques unto standard electric powered wheelchairs to aid wheelchair users during their everyday living activities. Such technology refines their joystick control commands so that they are less likely to collide with objects and people in the environment. As a result, this report was requested in order to access the possibility and feasibility of acquiring such novel wheelchairs into the existing wheelchair fleet of Colchester Catalyst.

1.4 Robotic Wheelchair Market Drivers

Due to the continuous advancement in medicine, people are bound to live longer all over the world. However, as people grow older, their agility and mobility reduces resulting in the need for mobility devices. Japan has one of the best national health service in the world resulting in an increase in the ageing population. Due to this ageing problem, the Japanese government is spending money on different types of robotic devices to either aid mobility or entertain the ageing population. In Europe however, the market driver is mainly the amount of young people in the 20-30 age gap that have been involved in accidents, born disable or are war veterans. Whereas in the United States, it is a combination of both factors that is an ageing population and an increase in disabled young people.

1.6 Robotic Wheelchair Market Opportunities and Forecast

From the above sections, the areas with the greatest opportunities of market growth are Japan, Europe and the USA. There seems to be a strong correlation between the ageing population in Japan and them being the largest researchers in service robotics and hence robotic wheelchairs. Most of the media coverage concerned with robotics or mobility has been from Japan in terms of famous robots such as Asimo by Honda, the robotic unicycle by Honda, the i-Real by Toyota and the bed that ”morphs” into a wheelchair by Panasonic among other products. However, none of these companies have been able to commercially produce these products mostly because of the lack of a viable business plan. In Europe and the USA, the main drivers is as a result of increasing injured young people either because of accidents or wars in addition to an ageing population. As a result, these three market regions could have the greatest market opportunities in the future with the global sales in service robotics excepted to reach 8.42 billion dollars by 2015.

The robotic wheelchair market is still very young and almost non existent with practically no commercialisation of the robotic wheelchair. An exception however is the UK company- Simile Rehab UkK. However, the market landscape is bound to change as an increasing number of wheelchair companies are investigating the possibility of using robotic technology on their wheelchairs. For example, IMASEN, a Japanese company, bought a robotic technology from GeckoSystems in March 2011. GeckoSystems is a leading developer of mobile service robot technology research company based in the Altanta, USA. With their technology, robots are equipped with the capability to perform collision free navigation in a cluttered room. As a result, of this collaboration, it is possible that in the next few years, we see an adult sized electric wheelchairs with robotic technology being mass produced. This would also introduce competition into this market niche encouraging the reduction in prices from their currently expensive price tags.

Market Evaluation for Colchester Catalyst.pdf

The Benefit

SafePath™ obviously makes mobility vehicles safer by collision avoidance, but there are additional benefits.

With SafePath™ the operator will be able to direct the chair more effectively as erratic signals from spasticity or poorly controlled body movements can be filtered out through interpretation of the direction through GeckoNav™ artificial intelligence.

Dynamic stability will be improved by GeckoMotorController™ and SafePath™. The speed of each wheel will be synchronized to compensate for discreet differences in the size of wheels , unevenness of terrain or traction, or any other factor which can mechanically create a deviation in course. Each wheel traverses the same distance, enabling any SafePath™ enabled vehicle to travel in a straight line without drifting or wandering.

GeckoMotorController™ also eliminates the snatch or jerking effect caused by the engagement of the motor, no sudden starts or stops except for “panic stop” or emergency mode. Speed will be optimized for the user with maximum speeds being achieved in an open environment and regulated down in loose crowds and environments with obstacles. Injuries do occur when joysticks are poorly manipulated and as a result of sudden stops and starts. There is a risk of falling, but rapid trunk displacement can also seriously aggravate a disability.

Maneuvering space will be optimized due to the precision of SafePath control creating safer movement in tight areas such as the home environment.

Rehabilitative control devices and joysticks can be engineered for simple installation through a SafePath™ interface. As advanced methods such as neural control are developed they can be standardized to operate in the same “plug and play” manner we are used to using with computers.

SafePath™ will provide unprecedented control, safety, and freedom for the disabled who need mobility assistance. GeckoSystems believes that with SafePath™ control the advantages of power mobility can be extended to a large number of people who could not otherwise control a powered wheelchair.

SafePath™ will help to avoid injuries -

SafePath™ adds another layer of control for the wheelchair user and control is a major safety factor. There is a large group of disabled peope who are unable to control a standard wheelchair or must subject themselves to high level of risk when doing so.

SafePath™ enhances the current technology on the market and greatly reduces the impact of the following risk factors.

Power Wheelchairs and User Safety (also MOTORIZED WHEELCHAIRS) by the National Institute for Rehabilitation Engineering

Wheelchair Control Methods are also very significant to safety. Most power wheelchairs are controlled solely by the user, without intervention by computers, terrain monitors gyroscopes or autopilots. These power wheelchair models require, for safety, that the user quickly sense, recognize and react to each and every situation, as it arises. The young, healthy paraplegic will usually meet these requirements most rapidly and effectively. The power wheelchair user with weak and/or slow-moving hand responses is more likely to have accidents and may be more severely injured.[b] An ALTERNATIVE is available in some more costly power wheelchair models. This is the addition of computer-controlled systems that constantly monitor and correct for: wheelchair position and attitude; forward terrain variations; up and own stairway variations; user commands; and overall wheelchair performance. In theory, these power wheelchairs are much safer to operate than those without computer oversight. In practice, however, these power wheelchairs are sometimes more dangerous than non-computer wheelchairs. Serious accidents sometimes result from sensing or computer system failures. The failures may be subtle ones not recognized by the wheelchair user. Or, they can be in the form of a sudden, unexpected total failure of the wheelchair computer system, which may result in an accident when occurring at a critical time. Disregarding cost factors and considering safety issues alone, it is difficult to recommend the use of power wheelchairs that have -or that lack- computer monitoring and control capabilities.[/b] This type decision is best made with advice, on an individual basis, by each patient's physician, therapist or mobility trainer. A "Dead-Man's" safety control to automatically stop and brake the wheelchair if the user should let go of the wheelchair control stick or slump in his seat, can protect against accidents due to sudden loss of manual control or due to fainting or seizure. This feature is highly recommended and was included in most power wheelchairs dispensed by this Institute.

USERS of Power Wheelchairs - DISABILITY CATEGORIES & SAFETY RISKS as summarized below, do not include the added hazards of navigating a power wheelchair with poor vision or with susceptibility to fainting or unexpected seizures. It is assumed that all wheelchair users are strapped in for safety. Two straps should be used: one, down, lap to chair - and the other higher up, securing the upper body to the backrest of the wheelchair. The power wheelchair user must be secured both ways for maximum safety.

A. **Paraplegics -** Healthy, Fit & Active are typically the safest users of manual, power-assisted, and fully powered wheelchairs. LOWEST RISK.

B. **Amputees -** Missing Legs and/or Arms but with active upper bodies are usually safe users of power wheelchairs, depending on the type of control devices used. If planned and implemented properly, then LOW RISK.

C. **People with Weak or Poorly Controlled Upper Bodies** using standard joystick to reliably control power wheelchairs. This category may include some people with Cerebral Palsy, some with Multiple Sclerosis, some with Parkinson Disease, and people with many other conditions. Some of these conditions may cause impaired eyesight, slowed reflexes and/or impaired judgment. All should be fully screened for such functional deficits just as for automobile driving safety. MODERATE RISK.

D. **People with Little or No Upper Body Movement,** using special quad controls such as mouth joystick, puff & sip breath control, or gyroscopic (inertial) wheelchair controls. HIGH RISK.

E. **Paralyzed Small People -** Children and "very small" Adults ...in special seats or carriers often need a power wheelchair, most of all when significantly paralyzed. Depending on mechanical implementations, individual conditions, and personalized mobility and safety training, these people are at HIGH RISK.

http://www.abledata.com/abledata_docs/PowerChair-Safety.htm

SafePath™ Will Help Adults

A power wheelchair helps many disabled people who lack the stamina to push a manual wheelchair. Other conditions that may require a power wheelchair include:

• Spinal curvature, such as from scoliosis
• Poor arm, leg or torso control
• Degenerative muscle disease, such as post-polio syndrome
• Repetitive motion injuries from pushing a manual wheelchair

Once nothing more than a manual wheelchair with an attached motor, battery and joystick, the power wheelchair has evolved into something much more sophisticated. Although they typically weigh more and are more prone to break down than manual wheelchairs, power wheelchairs let their riders enjoy many of the same activities they enjoyed on foot or in a manual wheelchair - and their power systems let them do some things manual wheelchairs cannot. Although power wheelchairs come in two basic configurations -- traditional and platform - specialized wheelchairs are available to meet specific needs of the user.
http://topics.info.com/Power-Wheelchair_1934

SafePath™ Will Help Teenagers

Power Wheelchairs Change the Lives of Medicare Beneficiaries

Information provided by American Association for Homecare - Published: 2010-11-02

Ten years ago, Keli Babcock faced a crisis. A medical condition was affecting her legs and her lungs, requiring that she use a ventilator. She couldn't walk or even maneuver a manual wheelchair. Mobility had become a difficult challenge.

But Keli wasn't about to give in; she aspired to accomplish much in life. The Medicare program provided the teenager with a power wheelchair, one that is powered by batteries and includes equipment that allows a ventilator to ride along with her.

Keli is supported by her loving family, but with the power wheelchair she was able to care for herself and not be dependent on others. She can get to the bathroom, prepare meals and perform other daily necessities of life in her home.

What transpired exemplifies the impact that a power wheelchair can have on someone with limited mobility: Medicare helped vastly improve Keli's quality of life. With the mobility issues mitigated, Keli went on to achieve many of her goals, as well as give back to her community. Keli finished high school, and then earned a Bachelor's Degree in Social Work from Weber State University.

"I wouldn't have been able to accomplish much without the power wheelchair," Keli says. "It has made a tremendous difference in my life. I can move around my home, I work, and I've been able to travel. None of those things would have happened if it weren't for the power wheelchair that Medicare provided."

Keli, now 27, works at the Tri-County Independent Living Center in Ogden, where she helps patients with mobility limitations overcome their challenges. "I tell people my story, and what I have had to overcome, and hope it will inspire them," says Keli, who a year ago was crowned Ms. Wheelchair Utah for 2010. Her winning platform was: "You are unique. Live it. Love it. Rock it!"

And Keli reiterates the importance of her power wheelchair: "My wheelchair has meant everything to me. It means so much when people are able to gain more freedom and independence from mobility assistance."

Disabled World - The Medicare mobility benefit has successfully allowed many people to overcome physical challenges that limit their mobility:

http://www.disabled-world.com/assistivedevices/mobility/wheelchairs/electric/power-Wheelchairs.php

SafePath™ Will Help Children

Functional, independent mobility in children with disabilities has been shown to improve cognitive and perceptual skills, reduce learned helplessness, increase confidence and increase participation with their peers in everyday activities. Provision of powered mobility has resulted in significant improvements in several social components e.g., expressive behavior, cooperation, interacting with family, in the quantity of motor activities, and in the quality of interactive and symbolic play. Newer therapeutical models focus on task performance, which often requires the use of a power wheelchair for children who otherwise can not perform their daily routine with similar efficiency to their non-disabled peers.

Manual wheelchairs do not provide adequate efficiency for children with fatigue, compromised respiratory capacity, limited coordination, or strength. A child's ability to drive a motorized wheelchair is not related to chronological age; rather, it is related to cognitive readiness. Age appropriate supervision is natural and may be required for safety and to enhance learning.

Not everyone who is incapable of walking or propelling a manual wheelchair effectively is a candidate for PM. Motivation, understanding of basic cause and effect, spatial relationships and problem solving concepts, attention, and physical ability to activate the access method consistently and purposefully are required to successfully operate a power wheelchair.

It is RESNA's position that age, limited vision or cognition, behavioral issues, the ability to walk or propel a manual wheelchair short distances should not, in and of themselves, be used as discriminatory factors against PM for children. RESNA recommends early utilization of Powered Mobility for the appropriate candidates as medically necessary, to promote psycho-social development, reduce learned helplessness, and to facilitate social and educational integration and Independence.

http://permobil.com/Global/USA/FUNDING/Documents/Funding/Research%20Articles/Resna_position_pwr_wc_pediatric_users.pdf

The Market

According to the Fehr study, also referenced on page three:

Independent Mobility Options for Persons with Severe Disabilities

In addition to assessing the adequacy of available control interfaces for regular power wheelchair users, our survey results also document the existence of a group of persons for whom no independent mobility options exist at this time. Eighty-five percent of responding clinicians reported seeing some number of patients each year for whom use of a power wheelchair is not an option because these patients lack the motor skills, strength, or visual acuity needed to control the chair. Twenty-seven percent of respondents reported evaluating at least as many patients who cannot use a power wheelchair as who can (i.e., the number reported for question I.5 was greater than or equal to the response to question I.2). It was estimated from survey responses that 18-26 percent of nonambulatory patients who cannot use a manual wheelchair are also unable to operate a power wheelchair (see Table 4). Clinicians indicated that nearly half their patients who are unable to operate a power wheelchair using conventional methods would benefit from a computer-controlled power wheelchair navigation system.

A secondary objective of our survey was to evaluate the perceived usefulness of an emerging technology whereby a computer controls the steering of a power wheelchair on behalf of its rider. As indicated above, clinicians reported that 44-49 percent of their patients who are unable to operate a power wheelchair would benefit from this technology. Persons with spinal cord injury and disorders such as MS, amyotrophic lateral sclerosis (ALS), and Parkinson's disease, alone or in combination with other disabilities, were the patient populations most frequently cited by clinicians as likely to benefit. Further, when asked to consider the possibility of enabling persons with cognitive disabilities to travel unassisted to specified locations within an institution at pre-programmed times (a potential future application of computer-controlled navigation), 91 percent believed such capability would be useful for at least a few patients, and 23 percent believed it would be useful for many.
http://www.rehab.research.va.gov/jour/00/37/3/fehr.htm

According to the 2010 United States Census figures there are 3.3 million wheelchair users age 15 or over. [1] According to a 2003 paper by Mitchell P. LaPlante entitled *Demographics of Wheeled Mobility Device Users*[2] approximately 17% of those users have powered mobility, nine per cent of those use wheelchairs, for an estimated number of three hundred thousand.

The 40% of those users who currently find “steering and maneuvering tasks… difficult or impossible” yields a backlog of 118,800 users who currently need upgrade kits. Using the information above GeckoSystems believes it is reasonable to believe that there would be another 150,000 users who are now unable to qualify for a power wheelchair but could qualify for a SafePath™ enhanced chair.

GeckoSystems believes this is a conservative number because the clinicians are seeing a pre-screened population which has been sent to them for the purpose of being equipped with a power wheelchair. They are not seeing many of the 83% who do not use powered mobility because through experience, the referring professional believes they would not be able to qualify for a powered wheelchair. SafePath navigation could easily double the number of disabled who could qualify for powered mobility assistance.

End Notes:

[1] 2010 Census figures

[2] *Demographics of Wheeled Mobility Device Users*[1] by Mitchell P. LaPlante

Our original prototype above.

Other chairs show how SafePath would appear on a final OEM application with depth cameras made to our specificatons.