Solium remote systems

Project Proposal

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Problem Statement

Teachers of the severely handicapped will find great benefit in the ability to control the wheelchair of a child who is unable to control it themselves. Caretakers for immobile handicapped and non-handicapped children will find great benefit in the ability to control a wheelchair of a child who is unable to control it themselves.

The problem can be solved with appropriate safety measures, spatial sensing and determination, perhaps sensors in the walls to lay out safe routes, hardware control at the chair and input processing from the remote steering unit. The chair will include a camera, and the remote controller will include a video image.

Possible Applications

Remote operation

Caretakers can use the remote operation control to move the user of the chair around, if needed, without pushing the motorized chair, or having to use the chairs onboard control stick. With the video feed from the chair, and integrated safety, the remote operator can even move the user from beyond line of sight if needed.

Driver Ed

The system could then be applied as a driver education system for the user of the chair. In this mode, the chair is controlled primarily by the student, except can be guided by the teachers remote controls.

Follow the leader

Due to the lack of control, users of wheelchairs are noted as being uncomfortable when pushed along from behind. With this mode of travel for the chair, the chair will automatically follow the person in possession of the remote controller. Along with the on board safety measures, this would allow the chair user to travel along with somebody without having to be pushed.

Automatic travel

The chair could be given a predetermined route to move from one location to another. For example, a student could be sent from a classroom, along a safe path, to the library in a building.

Chair Retrieval

Users who are more self sufficient have the option of using the remote control's video feedback feature to retrieve the chair from another area. This could be used when they are in bed and need to go elsewhere, and can do it without help if needed.

Safety features

The chair will be equipped with an array of safety features due to the increased risk of remote operation. The remote operator will have a restricted view of the chair's path and the safety of the rider must be considered.

Sensors to detect proximity to obstacles, an emergency stop feature, as well as an intercom should be included. Some of the safety feature could also be used as stand alone systems to enhance the safety of currently owned wheelchairs.

History and Current Research

History

Electric wheelchairs were originally developed to assist injured veterans of World War II. Before this, manual wheelchairs had to either be pushed by a caretaker or by the user pushing on hand-rims that were attached to the wheels. If the user didn't have use of both arms, it would be impossible for them to propel the wheelchair by themselves.

The control system is able to amplify whatever action the user is able to do into movement of the electric wheelchair. The most common control is a single joystick, which allows users with the control of at least one hand to operate the wheelchair. Other possible controls include a chin joystick and a puff/sip sensor.

Most development since the appearance of the electric wheelchair has been to increase the mobility, ruggedness, and endurance of the wheelchair, or to create new control systems that allow people with varying disabilities to be mobile. Remote control systems have not been seriously developed into commercial products that can be easily integrated into existing wheelchairs.

Research

Luleå University of Technology

Researcher Sven Rönnbäck developed an advanced wheelchair as part of his doctorate thesis. The wheelchair was developed to assist people with extremely severe disabilities, leaving them with with highlt limited motor control. Through the use of an array of sophisticated sensors, the chair is able to drive autonomously, moving towards goals while avoiding obstacles that may injure the user.

The wheelchair has many control methods that can be used depending on the situation. For users with normal motor control, a manual joystick can be used to drive the wheelchair. If the caretaker wishes to do so, a remote control can also be used. The

wheelchair can be driven via a wirless network connection, with the driver receiving video images from a camera mounted on the top of wheelchair.

The main focus of the research, however, is an autonomous mode that can navigate the wheelchair safely. The primary sensor for this mode is a SICK laser measurement system (also known as LIDAR), that uses a scanning infrared laser to detect objects in an 180 degree sweep at ranges of over 50 meters. Using navigation software, the wheelchair can move while avoiding obstacles such as walls and chairs in addition to preventing dangerous operations such as driving down stairs.

Ryerson University

A team of researchers developed an upgrade kit for wheelchairs that would add useful functionality. The kit allowed for a camera to be mounted on the wheelchair with the video being read by a laptop computer. The laptop would then use wireless communication to stream the video to the internet, where a remote care provider would be able to view the area around the wheelchair. From that remote location, the care provider would then be able to drive the wheelchair. The upgrade kit would be compatible with existing wheelchairs, which would decrease the overall cost of the system.

Current Solutions

ReHabTeQ, a British company, developed a wheelchair named the Rolteq, whose features include a remote control and a hydraulic lift, in addition to others. The remote allows a care provider to move the wheelchair and also control the life. In addition to this example, there are several other patents for remote control wheelchairs. One such example is a European patent, EP1845921, which describes a wheelchair that can be fetched remotely by the user. This chair is mainly used for patients to operate their own wheelchairs rather than for use by the caretaker.

Deficiencies in Current Solutions

While operating a standard electric wheelchair, the patient may become uncomfortable when the wheelchair is being operated by a caretaker. In addition

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caretakers may not trust children to be able to control their own wheelchairs, fearing that they may drive into a hazard.

The ReHabTeQ Rolteq wheelchair remote isn't wireless, giving it a very short effective range. The wheelchair itself is proprietary, meaning that remote can't be used with other manufacturer's wheelchairs. ReHabTeQ is also not a very widely known company, so its technology has not been widely adopted.

ReHabTeQ remote

The university research wheelchairs also suffer from several deficiencies. The one being developed by the Luleå University of Technology, while being very advanced, is very expensive due to the many sophisticated pieces of equipment needed for its operation. The LIDAR unit alone costs $5000, making the wheelchair impractical for most applications. The equipment also requires more power usage and a large size wheelchair, decreasing its usefulness is some endurance or mobility applications.

The Ryerson University upgrade kit is primarily targeted to control over the internet, neglecting a useful local control. It also suffers from several safety issues, being that the wheelchair experienced several crashes while testing.

Functional Requirements

Local equipment

Power Chair

The system is based on an electric powered wheelchair. The main difference will be the method in which the chair is controlled. The wheelchair will be equipped with a custom chair control system. The system will handle input primarily from a joystick, to be used in the same manner as most power chairs, as well as input from the remote controller. To use the joystick to move the user will push up to go forward, down to go reverse, and left or right to turn. If the joystick is pushed slightly, the chair moves more slowly.

Due to the remote nature of the chair, it will have a camera to view in front of the chair. The video feed will be transmitted to the remote controller when the wheelchair is remotely controlled. The chair will also have several sensors to detect impassable objects to prevent collisions, as well as to avoid voids such as stairs.

The chair controller will also handle all signal processing and video transmission. For this application, a laptop would be suitable, since it is small and can be easily maintained.

For use with follow the leader mode, the chair will have an integrated sensor to determine which direction to travel

Remote equipment

To remotely control the wheelchair, a touchscreen device with networking ability will be required. It will also have to be capable of the displaying video, playing sounds such as an alert, and transmitting sound for the intercom.

To control the chair, the remote will display the view from the chairs camera. The screen will display a control that would then react in the same manner as if the same gestures were applied to the chair's joystick. The remote control can be set up to override or disable the chair's local joystick. The remote will also have an emergency stop button for safety.

If the connection between the chair and the remote is broken during control, the chair stops moving.

Modes of operation

Normal operation

During normal operation, the wheelchair is used no different than most other powered wheelchairs. The rider of the chair is in control of the chair. The main interface is the joystick on board. From the remote, all that can be done is to stop the chair and communicate with the intercom. Also the onboard safety measures would not allow the chair to collide with an obstacle or drop down stairs.

Complete remote control

During complete remote control the chairs local joystick is disabled. This would give the caretake complete control of the wheelchair. The only exception to the control from the remote would be if the emergency stop button was pressed on the chair or remote. This would stop the chair. Also the onboard safety measures would not allow the chair to collide with an obstacle or drop down stairs.

Split control

During split control, both the chairs joystick and the remote controller can give input to the chair. Typically the remote would be set up to override the commands of the joystick. This would be useful to guide the user of the chair along if they have poor motor control. It could also be used as a driver education mode to teach people how to drive a powered wheelchair more safely.

Follow the leader

In the follow the leader or puppy dog mode, the wheel chair will automatically follow the holder of the remote controller. This would be used so the caretaker would not have to focus on driving the wheelchair.

The chair would have to detect the range from the chair to the controller, not to exceed a maximum safety distance. If the chair loses its bearing to the remote the chair will stop. It the distance is too great, the chair will stop.

Line rider

To move the chair from one area to another automatically, the chair will have sensors to follow a line on the floor. For example, this could be used to move a student from the classroom to the library in a building. The teacher who sends the student to another room can keep track with the video feed. The alarm on the remote could be tripped if a problem occurred such as an obstacle in the path or the emergency stop button was pressed.

Chair retrieval

For more independent users, the remote could be used to retrieve the empty chair to where they need it. For example, the chair is on the other side of their bedroom, or even another room, and they need to use it. The user could use the video on the remote to drive the chair to where they are.

Safety Features

Proximity detection

Since the chair will be capable of remote controlled motion, with a limited view, extra measures need to be taken to ensure the safety of the user. When the chair is in motion, either remotely or with local controls, obstacles that could impair the safety of the user must be avoided. Thus, the chair needs to be equipped with the necessary sensors to detect the presence of obstacles in the path of the chair. When the sensors detect a problem area, the chair is to be halted, and then not allowed to move in a direction that would travel into the problem area or obstacle. The chair should however, be capable of moving into a safe direction after stopping.

Proximity detection could be equipped as a standalone system to increase the safety of standard power wheelchairs.

Obstacles to be avoided

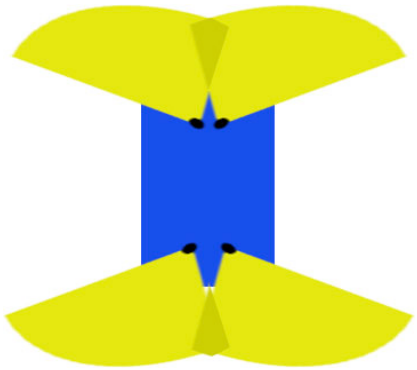
Some examples of obstacles to be detected are any objects taller than the ground clearance of the chair such as walls, boxes, furniture, people, pets, or any other object that one would not want to strike with the chair.

Drop-offs in the path of the chair should also be avoided. If something like a staircase is encountered, the chair should be unable to drive over the ledge. However, in the case of something like an elevator, the small gap between the floor of the building and the elevator is not a danger, and therefore should not trigger the chair to stop.

Pattern of detection

The sensors should detect obstacles in any direction the chair is capable of moving. The chair will be stopped only when an obstacle is in the path of motion. For example, an object behind the chair would not halt the chair, or the chair can drive along a wall. In the

figure below, four sensors are used to check forward, reverse, as well as turns. Blue is the chair, yellow the sensor range, and dark yellow sensor overlap.



There are also sensors to check down; this would stop the chair if a staircase was met.

Proximity detection alert

When an obstacle is detected, the chair should alert the rider with a buzzer and/or light. At the same time the remote controller should be notified that an obstacle was met with. Since something like an iPhone or blackberry will be the platform of the remote, the vibrate feature and speaker can be triggered.

Emergency stop button

The chair should be equipped with an emergency stop feature. When the button is pushed the chair or the remote, the chair will immediately stop.

Local stop button

The chair will have a local button that the user can press to stop the chair. The button is to be large enough so that a person with poor motor control will be able to easily press it. It should also be brightly colored.

Remote stop button

The remote control device should be equipped with a parallel emergency stop button. It should be a larger area on the interface or a physical button on the device so that it can be pressed without looking.

Remote Calling/Intercom

The chair have a communications system between the remote and the chair. This could be used to call for help if needed.

Local intercom use

The user of the wheelchair, through the use of a button, can activate the intercom. This action would then set off an alarm on the remote control. A speaker and microphone will need to be added to the chair. For those who are not able to speak, they could press the button as a means to communicate, (e.g.: press once for yes, twice for no) and the remote will make a sound for successive button presses until the intercom is reset.

Remote intercom use

The remote can be used to call the chair if needed by pressing a button. During the conversation, the remote can be used just like a telephone. The alarm on the remote will be audio as well as tactile.

Objectives and Goals

The overall goal of the remote control wheelchair is aid those in need of mobility. The product should be affordable, easy to use, convenient, and user friendly. It should serve multiple purposes and be safe.

Improve Quality of Life

Those who find themselves wheelchair bound, weather if be for a short period of time or a lifetime, often comment on how uncomfortable it can be to have another person in control of their wheelchair. Eliminating the necessity for the person in control of the chair to be behind the wheelchair can help to increase the comfort of the person sitting.

Increase mobility for those who find themselves challenged

A remote controlled wheelchair can give mobility and increase mobility for a variety of people. For those who use a wheelchair for every day movement, they may find having a remote control that can be personally used or passed off to a second person would be beneficial to them. There are also those who are not able to physically control a wheelchair. For those who are unable to use their hands to control a wheelchair, having a remote control that someone else can use might be the only option.

Teaching aid

Controlling a wheelchair can be a different experience for everyone. Allowing another person to control the movement of the wheelchair can help to teach someone how to use the wheelchair safely and efficiently. This could be effective in teaching a young child who is learning to use a wheelchair for the first time. It could also be used to teach someone who is newly handicapped how to get around and perform everyday routine.

An affordable product/ attachment

Ideally this should be something that is affordable to the everyday person. It should be something that is cost effective.

Increase Safety

The addition of sensors should increase the safety of the wheelchair. Ideally it will prevent someone from falling down a flight of stairs or hitting an obstacle.

Users

There are two categories of wheelchair users:

1) People who will use a wheelchair short-term due to an injury or other happening that leaves them immobile for a short time

2) People who will use a wheelchair long period of time or their entire life.

Short Term Users

First, let us define a short-term user as an individual that will not permanently require the use of a wheelchair. Also, in this situation, the user probably has never used a wheelchair before the injury that has immobilized them. So, with their lack of knowledge of an electric wheelchair, it may be unsafe for them to just be given a chair and be left alone, especially if it is a young child.

The driver education feature could be a useful tool to teach the user on how to operate the wheelchair safely. This use would probably be deployed to wheelchair rental facilities and hospitals. So in this case the wheelchair rental facility or hospital would buy the kit to add on to the wheelchair.

The user's caretaker would also benefit greatly from remote control. This is especially the case if the caretaker was older and physically unable to move the person, such as a grandparent.

The follow the leader mode would also come in handy if the caretaker and the user wanted to go for a walk. The caretaker did not want to have to worry about pushing the user or have to keep their thoughts on driving carefully with a remote control.

Long Term Users

Immobile with no other disability

This can be treated much the same way as the short-term disability category. This user would be someone who is able to use their hands but not able to walk. Also, even it the user was not able to use their hands, a system could be implemented for them. There are some slight differences in which the wheel would be deployed. Firstly, the chair would not be available from a wheelchair rental company. The user and their family would buy the wheelchair and then buy the kit to use the remote control function. Otherwise, the use would be the same.

Slight disability

This type of user would be quite different. They may be able to move the chair and make decisions, however, not all decisions are correct, and the user must be monitored while using the wheelchair

For deployment of the product the family would have a wheelchair already, and then they would buy the add-on to enable the remote control wheelchair function. In this case, caretakers of the user will use the driver education function. If the user starts driving towards stairs for example, the caretaker can take control and stop an accident from occurring.

Again, caretakers can use the follow the leader mode when walking along with the chair, making it easy to have a normal walk with the user of the wheelchair. Now, when the user goes to class or is put in a care taking facility, the teacher or caretakers will also require the use of the device in case the user tries to leave the classroom or go somewhere they should not.

Another way that the chair can help the caretaker or teacher is the autonomous mode. For example in the home, if the mother of the user is in the kitchen cooking, and wants the user to go into the living with their father but can't leave the kitchen. A simple follow the line command could be given and the chair will automatically take the user into the next room. A line must be set up though in order for the functionality to work. This

would also work well for a teacher, who needs the user to move to another room while watching other students.

Severe disability

The final type of user is someone who has no control of his or her movement. For example, if the user is not able to move the chair under his or her own power. In this case, the caretaker will handle the movement of the wheelchair. The remote mode will never be turned off so the caretaker makes sure they are always in control of the user. Follow the leader mode will again be helpful to the caretaker when wanting to take the user on a walk.

The same applies to the with the autonomous mode, family, caretakers, and teachers can set a predetermined path that will let the user essentially move on his own so they can keep there focus on other activities.

Constraints

Technical Constraints

This product will need to be controlled by very accurate and sensitive spatial sensors. It cannot afford to have any mistakes at all. The type of person who will be using this wheelchair will not be able to control themselves in even a small collision. Many would also not anticipate what was about to happen. If it an accident did happen, the may have no capacity to brace themselves. Simply put, there would be no room for error with this product. Luckily, there are reliable sensors already on the market, so this will not be a big issue.

The camera will not need to be one of high quality. It will just need to give an idea of the view from the wheelchair. A lower quality camera would possibly be preferable, as the bandwidth of the wireless connection to the remote would be more reliable. Any delay or hiccup in the connection with the remote could have serious consequences.

In case these measures fail, we will need to include enhanced restraining devices. Most restraining devices are not designed to hold a person in a collision that occurs without an aide nearby.

The add-ons that we include will need to be universally applicable. Presumably the standard joystick would be replaced with the connection unit to the remote control. This way all of the motor considerations are already addressed by the manufacturer. All that is needed to be addressed is replacing the input device.

The remote control itself will need a type of analog input, to control the variable speed and direction of the wheelchair. There will also need to be an emergency stop feature, one that will not simply slam on the brakes and possibly eject the rider. It will need to stop quickly but not abruptly, in case something is discovered to be in the way, either by the camera or the sensors.

Budget Constraints

This wheelchair will be infinitely more useful if it can be covered by insurance. It would then be available to many people that could not afford this product otherwise. It can be considered an accessory to an already covered power wheelchair:

Durable Medical Equipment consists of items, usually "hardware", that is used at home. It must be able to stand up to repeat use, used in the home environment, and be medically useful (that is, its first use must be medical, something a healthy person wouldn't ordinarily need).

"Wheelchair accessories and options are considered any modifications or additions made to an existing wheelchair due to medical necessity or recreational purposes and are not sold as part of the original chair... While all are optional, reimbursement for coverage will depend on the item as well as the individual's needs.", (http://www.wheelchairnet.org/WCN_WCU/Research/StakeholderDocs/PDFs/wpf_wheelchairsummary_doc.pdf)

However, as often with insurance companies, there is much more to consider. First, the DME must be necessary and reasonable either in the treatment of an injury or illness, or in improving the function of an impaired body part. Second the DME must be for use in the individual's home.

The necessary part of the first requirement is met by obtaining a doctor's prescription that includes the diagnosis and prognosis for the individual, the reasons behind prescribing the DME, and the length of time that the DME will be needed. The requirement for reasonableness is much more complex.

The guidelines the Part B carrier can use in determining reasonableness include weighing the expense against the anticipated therapeutic benefits, investigating less costly alternatives, and determining if the DME will serve the same purpose as equipment readily available to the individual. If the DME fails the reasonableness test, reimbursement in full is usually denied.
(http://www.amcbaltimore.com/Funding/Funding_-_Power_Wheelchairs/funding_-_power_wheelchairs.html)

Medicare requirements

As this excerpt shows, this wheelchair add-on would need to first be shown to be necessary to the user. If the user has no way to control their own wheelchair, this will not be difficult to show. This product would increase the chances of receiving reimbursement for a power wheelchair.

Motorized/Power Wheelchair

Medicare has two parts. Part B is the medical insurance part of Medicare that pays for Durable Medical Equipment (DME). In order for Part B carriers to be reimbursed for DME, two conditions must be met. Medicare Coverage Criteria

A power wheelchair is covered when all of the following criteria are met:

1. The patient's condition is such that without the use of a wheelchair the patient would otherwise be bed or chair confined; and,

2. The patient's condition is such that a wheelchair is medically necessary and the patient is unable to operate a wheelchair manually; and,

3. The patient is capable of safely operating the controls for the power wheelchair.

The intended user of this product would fit the first two qualifications, but would fall short on the third, therefore likely being denied a power wheelchair. With this add-on, the third requirement would no longer be an issue.

So far we have established the product to be necessary, but to be ‘reasonable’, we will need to keep the expense of the product down. There will be many therapeutic benefits and it will obviously be much better than the current user-controlled wheelchairs. However, we will need to justify those benefits to the insurance companies as reasonable expenses, which is much easier if this is an inexpensive system.

Schedule Constraints

For this product, there is no immediate restricting schedule. This would be a huge benefit to both the users and the teachers once it is available, but there is no pressing schedule for its need. Obviously, the sooner technology like this is available, the better, but it would be more beneficial to properly design and implement this product over trying to quickly squeeze out ineffective technology.

Deliverables

The items to be delivered with a complete system are as follows.

Remote controller

A mobile controller with touch screen capabilities for use by a remote operator, such as an iPhone.

Power wheelchair

A power wheelchair with all safety equipment installed will be required. The chair will include the cameras for the remote view, the chairs native controls for local use with a parallel remote processor, and the intercom with a microphone and a speaker. All necessary sensors for following and safety will be built in the chair.

Computer controller

A laptop will be included to process remote requests as well as transmit the video and intercom data. Alternate packages could include a chair with only the safety features installed and no remote capability.

Documentation

A user manual will be packaged with the chair to explain the use and the the safety features. For teachers using the driver education system, a specialized training manual will be available.

Future Plans and Expandability

Not only is it important to design products that can be useful to users in the present, it is also important to design products that can be expanded upon for future customers. The world of technology is one that is always changing, thereby making improvements to older products easier.

The Solium remote controlled wheelchair has several features that can be added or expanded upon in the future, to make the chair an even more useful product to customers. The features that can be added in the future include, but are not limited to, the ability to monitor the vital signs of a person in the chair, a call for help button that is directly linked to the remote control, and global positioning for the chair and user in it.

Explanation of features

Vital Signs

Since the system is based around the idea of being remote controlled, it is implied that the person who is controlling the system may not be next to the chair at all times. In order to add extra peace of mind and security to the person controlling the chair, this feature will be added.

Heart rate and oxygen level measuring machines will be added to the system and linked into the already existing computer. The computer will measure the levels constantly and stream the results to the remote. When the levels change drastically or go below a certain “safe” level, the remote will alert the controller so that they can come and see what exactly is wrong.

Call for help enhancement

It is reasonable to think that since a person is in a wheel chair, they may not be able to call for help, however you cannot assume that this is the case for everyone. It is possible that some users just may not have the strength to move themselves in the chair, but still have the ability to press buttons, hence the call feature. This feature is very straight forward, and it is a direct line, similar to the vital sign feature, that will inform the controller when the user needs help.

However, the chair might be enhanced to automatically call for help even if the vital signs are not out of tolerance. If the chair has not moved for some limited time deemed too long, or if their is a weight change such as if the user were to fall out of the chair, the remote should be notified

Tracking system on chair

As the system becomes more efficient, and as users begin to trust it more, it would make sense that controllers would trust the system more. This trust would translate into feeling more comfortable being further away from the chair. A tracking system would become appropriate because as users begin to trust the system, they may spend more time away from the chair itself.

The tracking system will consist of a GPS or radio signal that will transmit the chair's location to the remote. The controller will be able to view the location of the chair via the video screen that is already on the remote. Any changes in the chair's position will alert the controller of the chair, and if such situation arises, the controller will be able to override any commands and put on the brakes.