Project Statement:
Assistive Robotic Arm

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Statement of Need

Hampton Elementary School has requested that a controllable mobility device, resembling a third limb, be created to provide greater independence to a disabled child within any academic setting. This device will be created for an exceptionally bright ten year-old boy who suffers from Cerebral Palsy. Cerebral Palsy is a debilitating condition that affects thousands of children annually. The disease itself affects the cerebral cortex of the brain and thus impairs much motor muscle control within the human body. While no one is completely sure as to how this condition is fully obtained, enough information is known to discern that the disease is caused by damage to the brain during the early developmental stages of life. The client’s specific form of Cerebral Palsy can be classified as Athetoid Quadriplegia. This type of Cerebral Palsy affects the entire body including the trunk, neck, and all four limbs due to weak muscle density. The nature of this type of Cerebral Palsy makes it difficult for the client to perform any actions that require fine muscle control such as grasping and speaking.

In the classroom, the client’s academic abilities far exceed his peers. He is academically astute, having knowledge of English, math, and grammar that is well beyond his years. Unfortunately, due to very limited muscle control from the Cerebral Palsy, the client is confined to a wheelchair and can only communicate through a voice box. While the client mentally understands all that is being taught within the integrated classroom, the client takes more time to complete assignments that involve fine motor control and coordination such as writing and typing. This places the client at a disadvantage and is forced to fall behind the other students when completing assignments. This requires the client to come in early and stay late after school in order to complete all his school work in a timely manner. The client is also incapable of feeding himself and is required to have a personal assistant with him throughout the school day. Since the client is mentally intelligent, he is eager to be independent; especially in regards to class work. Unfortunately, if the client’s personal assistant is not around when he arrives at school, the client cannot begin his schoolwork until someone is available to open his laptop for him. This again places the client at an academic disadvantage. It is essential that the client be provided with an assistive limb so that the client’s academic journey and potential will not be hindered any longer.

Basic Preliminary Requirements:

- The device must contain a motor.
- The device must run off of rechargeable batteries so that the client can use the device wherever desired.
- The device must be compact enough so that it does not over take the client’s wheelchair tray or interfere with the client’s joy stick.
- The device must be operated by a push button since the client only has control over his right index finger.
• The device must be placed on the right side of the wheelchair since that is the client’s dominant side.

• The device must provide the client with a new found sense of independence and freedom.

• The device must be able to perform elementary mobility actions of the lower arm. These actions include feeding oneself, opening one’s own laptop, grabbing basic objects of necessity, typing, and turning pages in a book.

• The device must also provide a full range of 360 degree movement so that the client can reach his own backpack.

• The device must not be ostentatious since the client refuses to use anything that appears to unique for his condition.

• The device must exist on a base that is capable of rotating 360 degrees.

• The device must also have two areas of attachment that resemble a hinge joint; one at the elbow and one at the wrist. The two hinges should also allow for circumduction, pronation, and supination about the X, Y, and Z axes. The points of movement about the wrist and elbow should be controlled by two separate buttons.

• The elbow and wrist joints must be strong enough to withstand the lifting of an everyday object.

Currently, a non motorized “assistive grabber” already exists on the market today. It is a detachable device that allows individuals who are confined to a wheelchair to grab objects of varying sizes, geometry, and orientations. Unfortunately, this device is not geared for individuals with limited mobility. The device requires much precision and muscle control by the user. Recently, research at the University of New Jersey’s, Department of Rehabilitation Engineering has been conducted in hopes to develop a device that will aid patients with limited mobility in the near future. The device is currently in the developmental stages is titled the “Haptic Master”. The device will be geared specifically towards children with Cerebral Palsy. The engineers involved with this project are looking to produce small robots mounted on wheelchairs, interactive video games, and a robotic arm that can be programmed to guide and aid human motion. The robotic arm would be programmed for intense finger motion and would aid in the rehabilitation of the individual’s finger muscles.
Basic Limitations:

The client is completely nonverbal and communicates via a wireless laptop in his classroom and uses a “DynaVox” communication device when he is out of the classroom. The right side of the client’s body would be considered his dominant side. The client uses his right hand to type and write. When writing, a pencil must be placed between the client’s pointer and middle fingers by his aid. The grip of the client’s pencil is weak due the uniqueness of his grasp. The client does not enjoy writing because he can not convey the depth of his thoughts in a fast enough manner. His arm also becomes easily fatigued from the nature of his inverted position. When the client types on the computer he uses his middle and ring fingers with very gross hand movements. Since the client types with both fingers near the keyboard, he often accidentally types unwanted letters. This also hinders his communication process. Due to the client’s lack of fine motor control, he is forced to type in an aggressive manner, pressing each key very hard. This causes the client to hold each key longer than needed. Since each key is sustained, multiples of each letter often appear on the screen. The client is then required to go back and revise the string of redundant letters. Overall, the client is accepted at his school and his request is to be provided with a device that can make him independent but also look very normal since he wants to fit in with the rest of his classmates.

Another limitation concern is the safety of the client and his peers. The gripping device must have a safety release mechanism incase it were to become attached upon the client or another child. Finally, the motor being used in this device cannot become too hot. This is for the protection of the client, his peers, and his wheelchair. Also, a patent already exists for an “assistive non-motorized grabber”. The group must be cautious not to create a device that is similar in nature.

Other Data:

The clients for this project include the 10 year old boy named Sam, who suffers from Cerebral Palsy, and his supporting staff at the Hampton Elementary School. The supporting staff includes the principal, the client’s fifth grade teacher, his aid, the occupational therapist, the physical therapist, the special education teacher, and the speech pathologist. Each of the staff members were supportive of this project and offered help in any way possible. The client’s location is at the Hampton Elementary School in Hampton, Connecticut. The school is only comprised of one floor. The area surrounding the elementary school is comprised of an upper level, where the playground is located, and a lower level containing grass fields. The school is planning on adding ramp to connect these two levels so that the client will have the ability to access the lower fields. Also, located in the lower level fields is the classroom garden.

The client’s supporting staff would like to find a solution to the client’s confinement. Due to the client’s limited mobility, his aid is required to feed him. Currently, the client’s aid also pushes his wheel chair when ever he needs to move from one location to the next. The latter of the two issues will be resolved since the client will be getting a new power wheel chair in November. His fifth grade teacher envisioned a device that could aid the client in opening his laptop and also working in the garden. The occupational therapist also suggested that the same device also provide a way for the client to take his backpack from the back of his wheelchair. The occupational and physical therapists also recommended that this new device be incorporated into his daily
occupational and physical therapy routines so he would feel comfortable using it especially if it required new motor skills.

In November the client will be receiving a new wheelchair. The new chair is classified as a Permobilite wheelchair and is specifically the C400 Stander Junior model. This wheelchair allows for sitting, standing, or lying. The operator has the option to drive the chair while either in the standing or sitting position. The wheelchair also has the ability to maneuver around advanced obstacles, climbing capabilities and has a rugged, advanced suspension system. Some technical specifications are as follows: length 44 in, width 24-28.5 in, backrest angle is adjustable (90-175 degrees), leg rest angle is adjustable (90-180 degrees), the maximum speed is 4 mph, and it has a 4 pole motor with 2GR24 batteries which have a charging time of 8 hours.

Questions:
- How will the robotic arm be controlled if the client can not operate a joy stick?
- Should there be two separate controls for the arm and wrist or should there be a switch that changes from one to the other?
- How will the device be mounted onto the wheelchair?
- Will it be able to pick things off of the ground?
- What should the outer layer be made out of in order to be safe for the client and others around him?
- How is a safety cut-off for the grips made?
- Will there be different grips for different tasks?
- Should one grip have a magnetic feature? Is that possible?
- How many fingers will the gripping device have?
- How do we program it to move in the x, y and z planes?
- Will the client take the device home or will it just accompany him at school?
- What type of batteries should it be powered by?
- How will the grips work so the device can pick up a variety of things, all being different sizes?