Assistive Robotic Device

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Project Goals

- To assist a fifth grade child with athetoid cerebral palsy in the classroom, a robotic assistive arm device will be designed and mounted on his wheelchair.

- This device will be utilized to help him accomplish routine tasks in the classroom without the use of an aide.

- The assistive robotic arm will act as a third limb for the client, translating his gross motor movements into fine motions.
Project Goals

- It will assist in
  - Eating
  - Reaching
  - Typing
  - Writing
  - Opening Doors

- While he has an aide who helps him in class he feels a lack of independence which affects his self esteem.
Client Background

- Hampton Elementary School

- For an 11 year old boy named Sam.
  - He uses an electric wheelchair

- Diagnosed with Cerebral Palsy since Birth.
  - Athetoid Cerebral Palsy

- Wants to be more independent.
Cerebral Palsy

- Cerebral Palsy is a non progressive disease that causes physical disability in human development.

- Our patient is diagnosed with Athetoid Cerebral Palsy. Athetoid Cerebral Palsy occurs due to damage in the basal ganglia and extrapyramidal motor system.

- This disorder makes fine motor motions very difficult. It is a great challenge for the client to hold objects stationary or maintain posture.
Other Products

The Assistive Robotic Manipulator (ARM) can perform functions of an arm and hand, including grasping objects with its gripper. The maximum spread between the gripper's fingers is 3.5 inches. It's speed is 25 centimeters per second. Its velocity, position, and acceleration (force) are continuously monitored, and visual and acoustic warnings of any unsafe situation are provided.
Tasks which can be carried out using the ARM are:
• Eating and drinking
• Preparing meals and drinks, e.g. using microwave and coffee maker
• Taking medicines
• Personal hygiene, such as electrical shaving, brushing teeth,
• Housekeeping, such as doing the dishes, cleaning up a room
• Leisure activities, such as playing chess, painting and turning a page of a book
• Picking-up objects from a shelf or the floor
• Opening doors, a closet or a drawer
“The Outreach Reaching Aid”

This NSF Project is developed to be more versatile and stronger than current reachers by giving the user the strength and functionality of a fixed length reacher combined with the portability of a folding reacher. This reaching aid allows the user full control of its length from a 12 inch to 30 inch range, while still being affordable at a suggested retail price of $45.
Proposed Design

- Elevator control in z-direction
- Step motors and microprocessors utilized to coordinate “elbow” and “shoulder” joints
- Pressure sensor in grip mechanism
- Composed of aluminum and PVC skeleton

Side View (not to scale)  
Top View (not to scale)
Input

- System will utilize digital joystick similar to that used on client’s wheelchair to control x/y location of grabbing hand
- Large buttons will control height of arm and tilt of hand
- Additional button will engage grab mechanism.
Microprocessor Control

- In order to enhance ease of use for client system will be controlled in x/y directions instead of individual joint control.
- Microprocessor will output pulse train to step motors to coordinate motion.
Angles to Cartesian Coordinate Conversion

- Coordinates $x_0$, $y_0$ are calculated trigonometrically.
- Coordinates then shifted by an angle $\beta$ utilizing a linear transform.

- $X=A\cos(\beta)-B\cos(\alpha-\beta)$  
- $Y=A\sin(\beta)-B\sin(\beta-\alpha)$
## Budget

<table>
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<tr>
<th>Material</th>
<th>Cost</th>
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<tbody>
<tr>
<td>2 Step Motors</td>
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<td>2 Step Motor Drivers</td>
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<tr>
<td>Microcontroller</td>
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<td>Screws</td>
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<td><strong>Total</strong></td>
<td><strong>$689.00</strong></td>
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</table>
Challenges

- Smooth operation of step motors
- Inconspicuous appearance/noise
- Client and classmate safety
- Budgetary constraints
- Reliable power source
- Water/spill protection
Conclusions

- Assistive robotic arm will allow client to achieve a new level of independence
- Novel microprocessor controlled joint coordination will reduce client frustration
- Assistive robotic arm will be a significantly cheaper alternative to current products
**Derivation**

\[ x_0 = A + B \cos(180 - \alpha) \]
\[ y_0 = B \sin(180 - \alpha) \]

Linear Rotation Transformation:

\[
\begin{bmatrix}
x' \\
y'
\end{bmatrix} =
\begin{bmatrix}
\cos \theta & -\sin \theta \\
\sin \theta & \cos \theta
\end{bmatrix}
\begin{bmatrix}
x \\
y
\end{bmatrix}
\]

Carrying out the matrix multiplication and changing terms we get the two equations:

\[ X = x_0 \cos(\beta) - y_0 \sin(\beta) \]
\[ Y = x_0 \sin(\beta) + y_0 \cos(\beta) \]

Using the previously derived definitions of \( x_0 \) and \( y_0 \) we then get the equations:

\[ X = [A + B \cos(180 - \alpha)] \cos(\beta) - B \sin(180 - \alpha) \sin(\beta) \]
\[ Y = [A + B \cos(180 - \alpha)] \sin(\beta) + B \sin(180 - \alpha) \cos(\beta) \]

These equations can be further simplified utilizing trigonometric identities as follows:

\[ X = A \cos(\beta) - B \cos(\alpha) \cos(\beta) - B \sin(180 - \alpha) \sin(\beta) \]
\[ X = A \cos(\beta) - B \cos(\alpha) \cos(\beta) - B \sin(\alpha) \sin(\beta) \]
\[ X = A \cos(\beta) - B \cos(\alpha - \beta) \]

**\[ X = A \cos(\beta) - B \cos(\alpha - \beta) \]**

\[ Y = A \sin(\beta) - B \cos(\alpha) \sin(\beta) + B \sin(180 - \alpha) \cos(\beta) \]
\[ Y = A \sin(\beta) - B \cos(\alpha) \sin(\beta) + B \sin(\alpha) \cos(\beta) \]
\[ Y = A \sin(\beta) - B \left[ \cos(\alpha) \sin(\beta) - \sin(\alpha) \cos(\beta) \right] \]

**\[ Y = A \sin(\beta) - B \sin(\beta - \alpha) \]**