Design and Development of Motorized Height Adjustable Walking Crutch with Enhanced Stability

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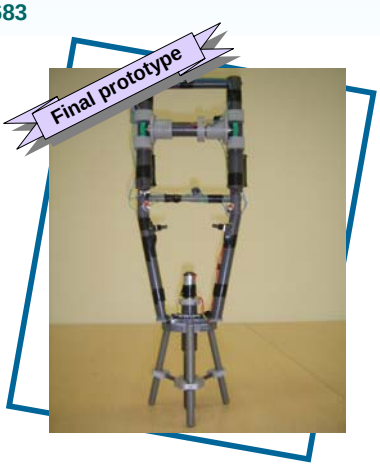
Introduction:

- Two crucial problems faced by walking crutch users:
  - Difficult to manually adjust the height of crutch to the desired position
  - Lack of stability when user stands and/or walks on slippery ground
- Walking crutches: Research work and Commercially available
  - Height of crutch is pre-set and manually adjustable
    => Not easy, neither convenient and nor accurate to adjust to desired position
  - Innovative shock-absorbing gel system (Thomas Fetterman) to increase ground grabbing stability
    => Cannot stand independently and does not enlarge the contact areas much
- Proposed motorized height adjustable walking crutch with enhanced stability
  - To resolve the two crucial problems – height adjustment and stability
  - With the aid of electric motors, gearings and lead screw mechanism



Materials and methods:

- Procedure for the design and development of the prototype of the proposed walking crutch
  1) Draw out a scaled down drawing of a commercially available walking crutch for visualizing the crutch
  2) Construct a paper model of the scaled down walking crutch for better understanding of the crutch
  3) Design and develop the proposed scaled down walking crutch using PVC solid and hollow piping materials
  4) Connect the electrical control and drives circuitries to automate height adjustment and stability
- #1: **Height adjustment of crutch**
  - Manual height adjustment: Turn the axel → Gear rotates → Move up/down
  - Automated height adjustment: Close the circuit → Motors rotate → Shafts turn the gears → Generates linear up/down movement

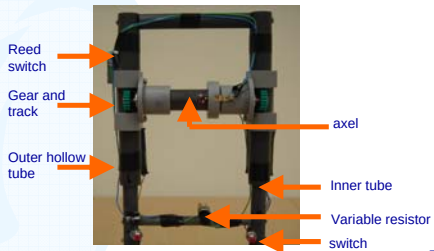


Figure 1: Photograph of top part of walking crutch

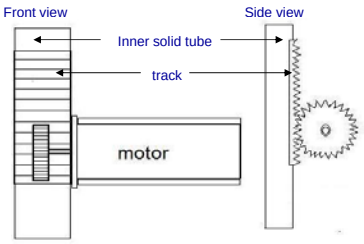


Figure 2: Sketch of front and side view of motor, gearing, gear track and inner solid PVC tube

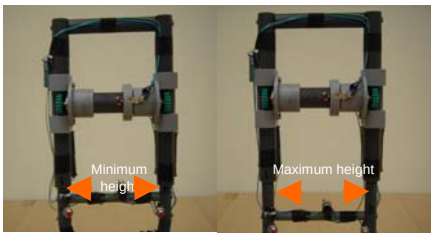


Figure 3: Walking crutch at its minimum height (left) and maximum height (right)

- #2: **Enhanced stability of crutch by extending extra legs**

  1) Inner wall of the main leg were taped
  2) A lead screw is attached to the motor shaft
  3) Lead screw is fixed in place and experiences rotational motion
  4) Main leg acts as a "lead screw nut"
  5) Rotational motion is converted to a linear one
  6) Main leg moves up/down linearly
  7) Causes the extra legs to stretch out or pull back

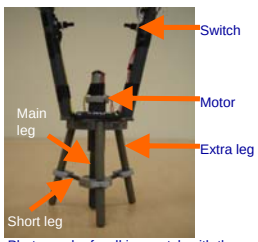


Figure 4: Photograph of walking crutch with three addition legs extended

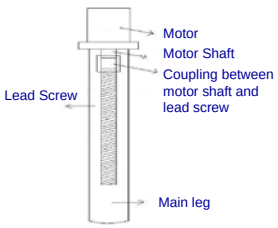


Figure 5: Sketch diagram of cross sectional view of the main leg of crutch

Experimental results:

3V AAA Battery Capacity (1250 mAh)	Maximum motion speed (cm/s)	Power consumed (watt)	Continuous operation time based on a 3 V battery supply (hours)	Intermittent operation time based on 5 mins usage per day
Adjustment of height upwards	0.89	0.96	3.9	1.5 months
Adjustment of height downwards	2.16	0.48	7.8	3.1 months
Extension of main leg upwards	0.051	0.24	15.6	6.2 months
Extension of main leg downwards	0.056	0.32	11.7	4.6 months

Discussions:

- Motorized height adjustment and enhanced stability of walking crutch is achieved through motor drives and additional mechanisms
- Turning function is not implemented because the function provides more cons than pros
- It is found that the use of three extra legs to enhance the stability is more stable than two legs
- Improvement areas for consideration
  - When someone falls down, the person may not be fast enough to activate the extra legs to provide stability
    => Add a fall detection sensing system to reduce enhance the reaction time.
  - Speed control is not precise with simple analog circuit
    => Add a digital microcontroller system to control the position and speed of the height adjustment
  - Replace bulky and heavy alkaline/rechargeable batteries with thin-film batteries which provide higher energy density

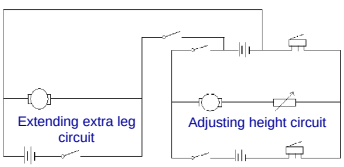


Figure 6: Electrical circuit diagram of walking crutch

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