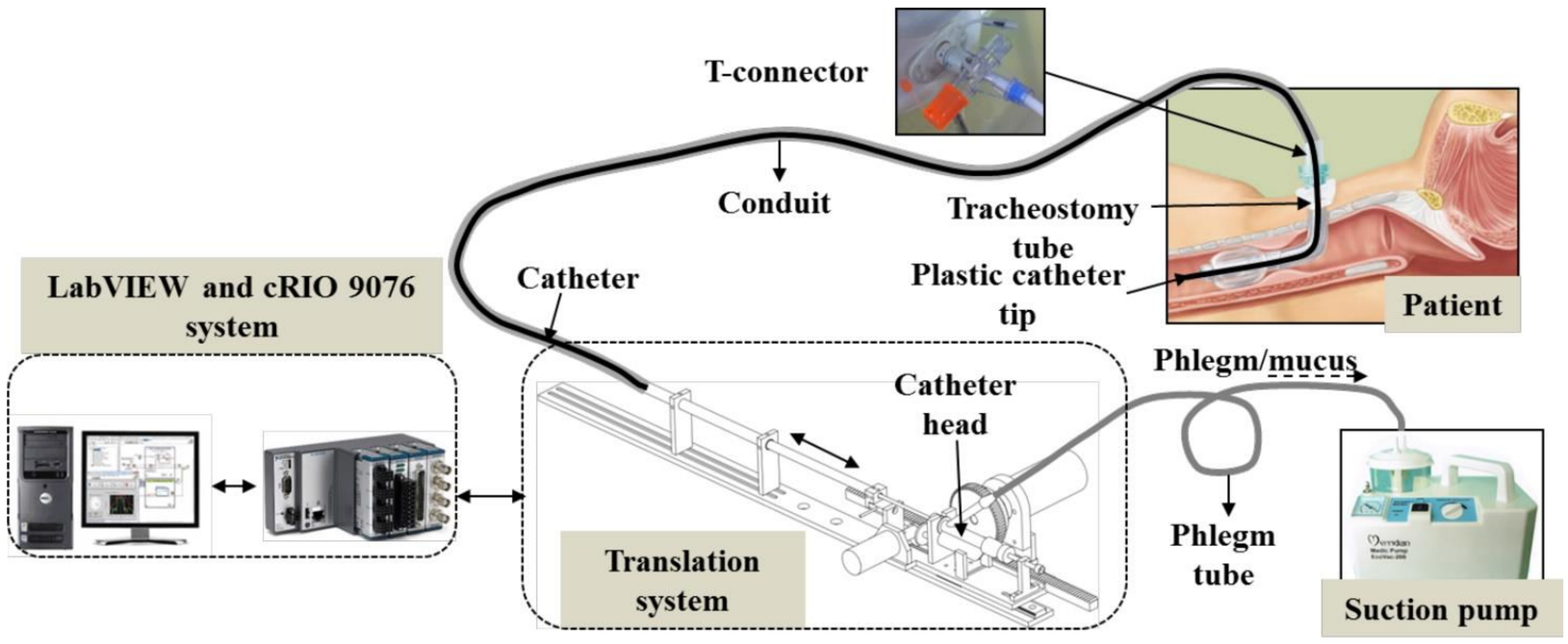
NANYANG TECHNOLOGICAL UNIVERSITY

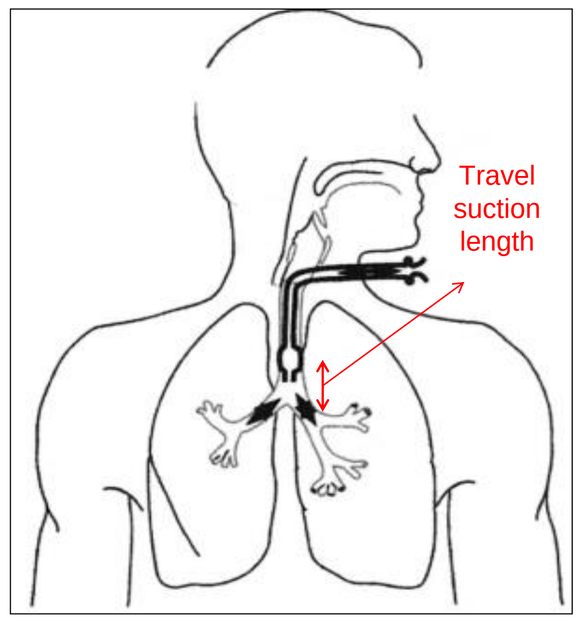
Robotics Research Centre

Development and Evaluation of a Novel Mechatronic Tracheostomy Tube for Automated Tracheal Sunctioning

Project Motivation & Objectives

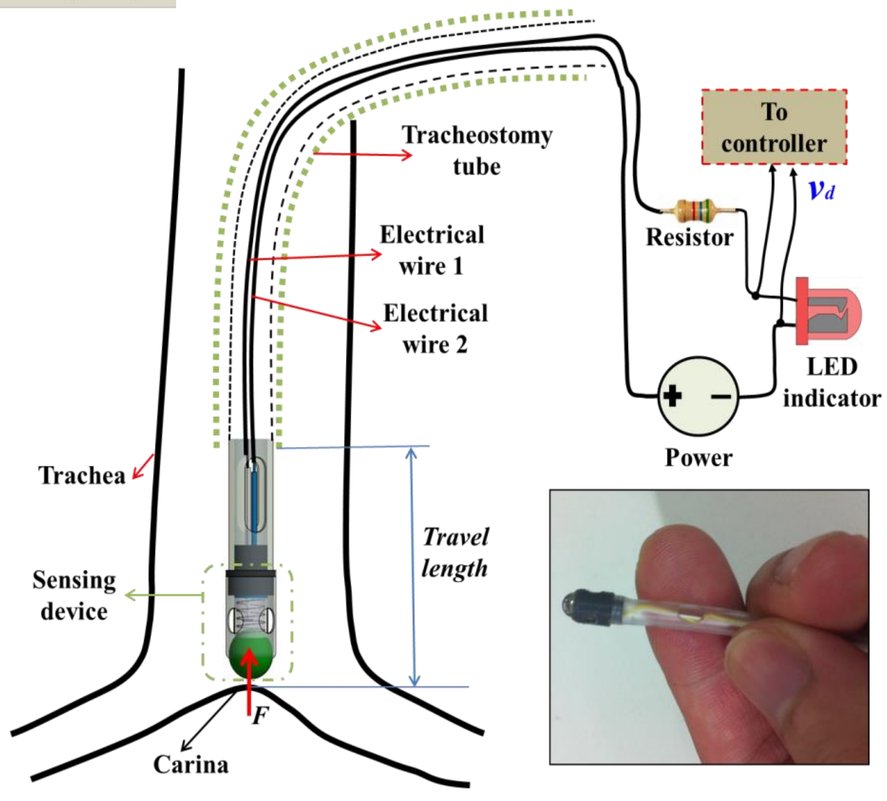
- Mechanical ventilation is required to aid patients with breathing difficulty. Currently, nurses spend millions of man-hours periodically removing mucosal secretions by inserting a tracheostomy tube through an opening in the patient's neck. A catheter is inserted into the trachea through the tube and suction is applied as it is being withdrawn. This cycle is repeated multiple times.
- The aim of this project is to create a portable automated suctioning system to reduce their workload and allow more patients to recover at home.
- Backlash-like hysteresis that arises from friction between the catheter and its conduit cause inaccuracies in positioning of the catheter tip, which could damage the delicate tissue lining of the trachea.
- It is thus necessary to increase the accuracy of the catheter tip through the application of feedback mechanisms and control algorithms.





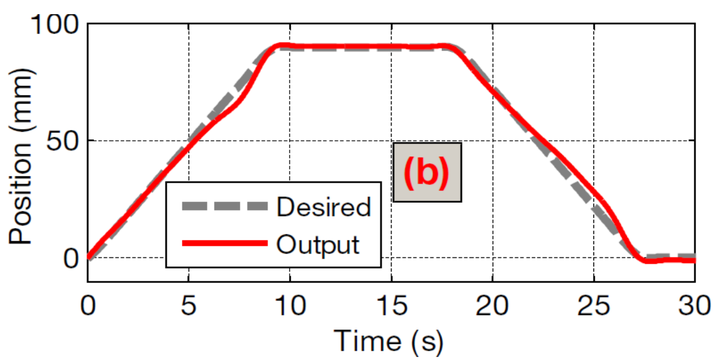
Methodology

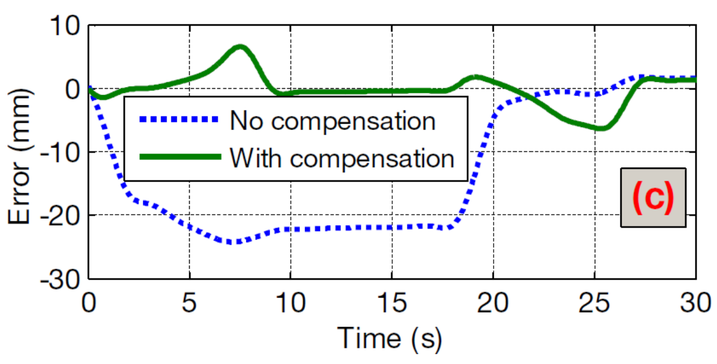
- The catheter was designed to have a length of 2.0 m versus the standard length of 0.4 m. This enables the patient to have more freedom of motion.
- A custom-fabricated compliant force sensor was fitted onto the tip of the catheter to provide feedback.
- The backlash-like hysteresis was quantified and compensated for using a modified version of the Dahl model. This modified model eliminates discontinuities in the hysteresis loop, allowing the direct inverse to be used in compensation thus reducing computational cost.



Results

- Without hysteresis compensation, the output position lags behind the desired trajectory. (a)
- When compensation is applied, the peak error is reduced from 23 mm to 7 mm. The root-mean-square error is reduced from 16 mm to 2.5 mm. (b) & (c)
- Upon collision with the carina, the force sensor terminates the insertion phase of the catheter and reduces the amplitude of subsequent cycles to prevent repeated collisions. Only 8g of force is needed to activate it.





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Funding Agency: Academic Research Fund Tier 1