Optimized Bristle Design for Robotic Vacuum Cleaner

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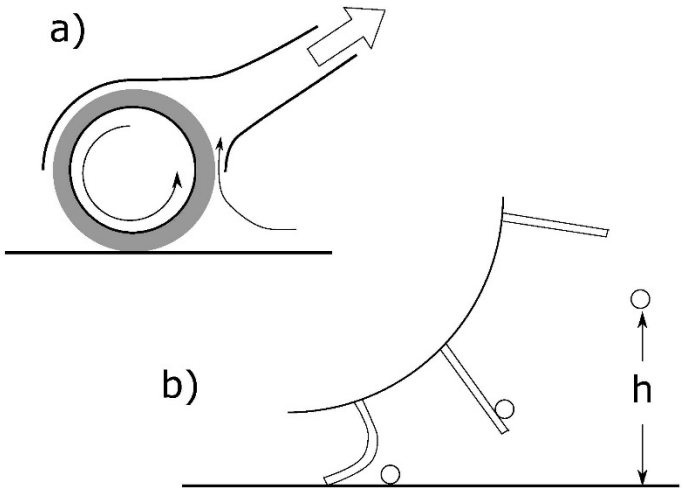
Maidbot Inc. is developing a battery powered vacuum cleaner robot for the hospitality industry. Size and weight constraints limit the available power, making design optimization imperative. One area that has received little attention in conventional vacuum cleaner design is optimization of the bristles on the rotating brush.



Part (a) of the figure is a generic sketch of a vacuum cleaner brush. Air is sucked between the brush and the housing to entrain dirt particles which are then carried to the filter. The bristles, here indicated by shading, agitate the dirt and lift it into the air stream.

Part (b) of the figure focuses on a single bristle and a single dirt particle as an idealization of the brush action. The bristle bends as it is rotated across the floor, then contacts a particle and carries that particle away from the floor. Ideally the particle will be driven to some height h above the floor where air flow can entrain it.

If the bristles are too flexible, they may ride over the dirt and not entrain it. If too stiff, they might damage floors or carpets. Electrostatic forces tend to attach the particle to the bristle which helps lift it from the floor or carpet but too strong an attachment will prevent entrainment in the air flow. Given the system dimensions, roller rotation rate, and particle charge, possible measures of effectiveness are the detachment of the particle from the fiber and the height h which a detached particle achieves in stagnant air. The larger h is, the greater the likelihood that the particle will be successfully entrained when air flow is present.

We are interested in determining the material characteristics of the bristles that are likely to lead to optimal operation. We expect that elasticity, plasticity, surface charge, and surface nanostructure are among the factors that will prove important.

Project activities should include a literature and patent search to establish the state of the art, followed by experiment and analysis to determine the most important factors and estimate an optimal design.