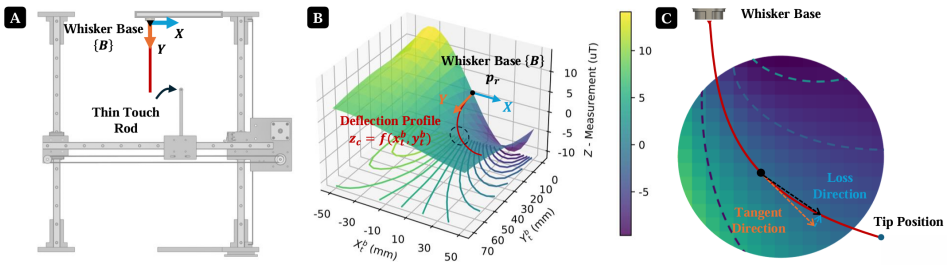
Dynamic contact estimate along a whisker-inspired tactile sensor

Description

An intriguing common feature among rodents are their whiskers, which they can actively move to sense the contact around their environment. These whiskers serve various functions such as extracting contour from object, providing location estimate for robot, recognizing textural feature, and actively avoiding collisions. Basically, it offers a non-intrusive tactile-based perception for robots with low computation cost, particularly beneficial in unstructured, cluttered, and visually impaired environments. Achieving a real-time passive contact estimates and ensuring a robust mechanical design are vital for such a sensor. Previous approaches have often relied on 6-axis force/torque sensors [1], piezo resistors [2], or other force-related sensors. However, these solutions are typically either bulky and challenging to scale down. In contrast, a magnetically transduced whiskers [3] offers a more compact and easily integratable solution, capable of forming arrays with parallel whiskers. Nonetheless, accurately modeling contact movement and localizing it along the whisker shaft based on magnetic flux changes around the root rely heavily on a robust design. We have already build a method to produce tip contact estimate, yet the current method based on state estimation for tangential contact still suffers from a dynamic error [4] due to the lack of prior knowledge on object's shape.



Tasks

In this project, you will further improve a magnetic transduced whisker sensor and develop a tangential contact estimation method. Then implement it on a robot arm platform or our biomimetic rodent robot, as an approach of perception and self-estimate. Specifically, your tasks will include: **1.** further improve our current sensor design and fabrication process to ensure its robustness and give a full evaluation on its performance; **2.** build solution to compensate the dynamic error of a tangential contact estimate method based on real-time state estimation; **3.** (optional) adopt this perception on robot arm to perform an active exploration and recognition within an unknown 2D plane.

[1] Tactile sensing with whiskers of various shapes: Determining the three-dimensional location of object contact based on mechanical signals at the whisker base[J]. Soft robotics, 2017; [2] A small-scale, rat-inspired whisker sensor for the perception of a biomimetic robot: Design, fabrication, modeling, and experimental characterization[J]. IEEE Robotics Automation Magazine, 2022; [3] A magnetically transduced whisker for angular displacement and moment sensing[C]. 2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS); [4] Whisker-inspired tactile sensing for contact localization on robot manipulators[C]. 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS).

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Type:
MA,SA

Research area:
tactile sensor, biomimetic rodent, robotics, non-intrusive perception

Programming language:
C++ or Python

Requirements:
High self-motivation and passion for robots; At least six-month working time; ROS, Python and C++ (optional) programming experiences; Familiar with real-time state estimation and experience on mechanical structure design.

Language:
English

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