

Master/Bachelor Thesis - Semester Project

Safe Robotic Manipulation Control with TENG Sensor and Control Barrier function Based on Machine Learning

Background

Perception algorithms based on radar or depth cameras have emerged as a salient focal point in the field of robotics. However, within the context of robots operating amid dynamic obstacles, there exist limitations in the capacity of cameras and radar to capture environmental information around the end-effector of robotic manipulators without blind spots. Simultaneously, the implications of utilizing multiple sensors, particularly in terms of cost and data processing, present considerable challenges and are not overly promising.

Recent advancements in sensing technologies have introduced new possibilities for enhancing the safety and performance of robotic manipulators. One such promising technology is the Triboelectric Nanogenerators (TENGs), which are composed of flexible thin film materials and convert mechanical energy into electrical energy by exploiting the triboelectric effect and electrostatic induction [1]. Furthermore, recent works propose the use of control barrier functions (CBFs) to enforce safety and control Lyapunov functions (CLFs) to ensure convergence to desired states [2]. Thus, it becomes significantly meaningful to construct a safe control for robots based on CBF and TENG sensors, utilizing machine learning as a bridge [3].

Your Tasks

In this thesis, your task will be learning state-of-the-art knowledge of machine learning and control barrier function and then developing more advanced algorithms with TENG sensors for robotic manipulators. To be specific:

1. You will first learn basic knowledge of machine learning and control barrier function. Online materials are recommended, such as [Stanford CS 229](#).
2. You will reproduce the results of state-of-the-art representation algorithms and other related research results. By doing this, you will have a deep understanding of related knowledge and then learn how to use the TENG sensor.
3. You will propose a novel algorithm for safe robotic manipulation control with TENG sensor and control barrier function based on machine learning.

Requirement

- High self-motivation.
- Six months working time;
- Experiences or knowledge from related courses
- Programming skills in Python or C++(must have);
- Familiar with PyBullet, Mujoco, Gazebo, or Omniverse.

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- [1] C. Wu, A. C. Wang, W. Ding, H. Guo, and Z. L. Wang, "Triboelectric nanogenerator: a foundation of the energy for the new era," *Advanced Energy Materials*, vol. 9, no. 1, p. 1802906, 2019.
- [2] Q. Nguyen and K. Sreenath, "Exponential control barrier functions for enforcing high relative-degree safety-critical constraints," in *Proc. Amer. Control Conf.*, 2016, pp. 322–328.
- [3] Mizuta K, Hirohata Y, Yamauchi J, et al. Safe Persistent Coverage Control with Control Barrier Functions Based on Sparse Bayesian Learning[C]/2022 IEEE Conference on Control Technology and Applications (CTA). IEEE, 2022: 311-318.

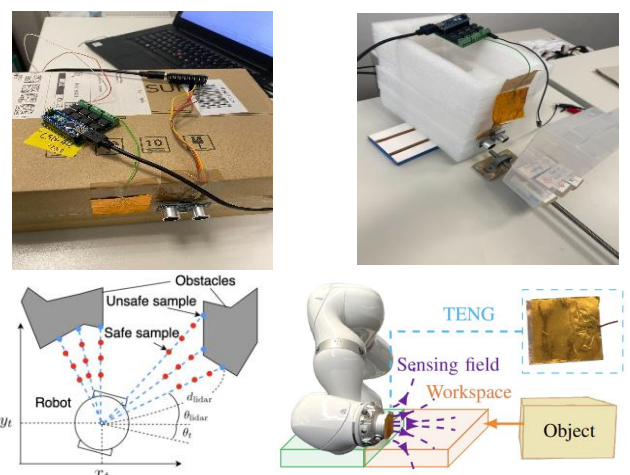


Figure 1. TENG sensor and its applications on robot manipulator