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## Research Statement

My research interests mainly lies in applying Artificial Intelligence approaches in Robotics Engineering for solving demand challenges. Below is a discussion of my previous and current research as well as future research interests.

### Previous Research:

I began my study of Robotics Engineering as a M.Sc. graduate student, under the guidance of Dr. Mohamed Abdellatif and Prof. Samy Assal in Egypt-Japan University of Science and Technology (E-JUST). The research topic was developing an efficient heuristic exploration technique for mobile robots to save both time and energy. The proposed algorithm combined the both well-known exploration techniques: the Sensor-based Random Tree (SRT) and the A\* algorithms to explore unknown environment. In addition, a quantitative metric is proposed to assess the complexity of the exploration task of a certain environment.

In my Ph.D. study, under supervision of Prof. Samy Assal in E-JUST, I switched my work towards Human-Robot Interaction (HRI). The key point was to develop an intuitive shared control dexterous teleoperation scheme depending on the two modalities: the hand movements and the gaze-point detection. In the thesis, a novel cognitive grasp mapping strategy is proposed to tackle the dexterous grasp challenges. On the results of the developed intention recognition based cognitive grasp mapping technique using the two modalities, a higher accuracy is achieved by recognizing the intention from the eye-gaze compared to that of the hand movements. Besides, the Inverse Reinforcement Learning (IRL) technique is used to study the reach-to-grasp behavior and to find the objective function underlying this behavior. This helps in recognizing the intention of the human from his/her hand motions.

During my Postdoctoral fellowship in Korea University of Technology and Education, I worked in a collaborative project with CHARM Lab., Stanford University. The key challenge in this project was to develop a soft growing vine-like robot that can access narrow and tight environments with flexibility. Our duty was to propose an intuitive interface to tele-operate that kind of vine-like robot. We have proposed a soft interface for soft robot, where a flexible rod is used to give commands to steer and grow the vine-like robot. In this research, my knowledge in the kinematics of continuum robots helped me in reconstructing the flexible interface shape in terms of its curvature and the angle of curvature. The dynamics of the vine-robot have been also obtained to construct a physical simulation for the robot with its surrounding environment.

## **Present Research**

Even though I came back to Egypt, I am still working in collaboration with KOREATECH and Stanford Univ. in the plant-like growing robot. Currently, I am planning to make the proposed flexible interface active with haptic feedback to give the operator the sense of surrounding environment.

During my Postdoctoral fellowship in South Korea, I was interested in continuum robots. This motivates me to begin advising a Ph.D. student (Ibrahim Sleem) in E-JUST during his research. This research is mainly to tackle to motion planning challenge in continuum and soft robot. We are proposing a Learning-by-Demonstration approach to teach the robot how to plan for its point-point spatial motions. In addition, we are planning to apply the Inverse Reinforcement Learning approach to generalize for the given demonstration and to learn the objective function while the human tries to reach a certain point.

In my home faculty, I am currently working with a M.Sc. student (Rana Adel) who is working on developing an assistive robot that can safely help elder people in their daily life activities. The robot is proposed to be soft and flexible to solve the safety issue when working in collaboration with human.

## **Future Research Interests**

In future, I am interesting in applying Deep Learning techniques in robotics. Especially in soft robots, deep learning approaches could help tackling the issue of having a mathematical model for the robot. In addition, I am interesting in working with surgical robots and Origami-like robots that draw my attention during IROS'18 in Madrid.