

Research Description - Rishi Malhan

I work at the intersection of Robotics and Artificial Intelligence. Goal of my research is to innovate and develop highly impactful and scaleable Smart Robotic Systems that will assist humans with tedious, repetitive, laborious, and harmful manual tasks. Humans will then be able to focus more on supervisory or creative tasks which will improve our work and living standards. Specifically, I focus on systems that have robotic arms. Systems could be static where robots are fixed with respect to each other and the given task OR mobile where the arm is mounted on a platform that is mobile, also called mobile manipulators.

The robots have several joints that can move relative to one another which help them go from one location to other. Humans can manually program positions of each joint and move the robot small steps at a time but this is not practical and economical. I develop algorithms that would answer the most important question: How would the robot perceive the environment, understand the task, and then plan its motion from current location to the desired. Similar to how we move our limbs without colliding with stuff here and there. We would adjust our force, speed, etc depending on the task. But we take the process for granted as it is effortless. For a machine, it is very challenging and counter intuitive for us.

Motion planning is basically searching for right sequence of joint motions. Each step in the sequence is N values for robot. N is degree of freedom of robot, usually 6-7 for industrial robots and >9 for mobile manipulators. That is a hard problem which requires use of sophisticated mathematical frameworks like optimization, sampling, graph search, etc. to find the sequences. Imagine the number of combinations. For a robot with 6 joints and maybe 50 steps in its motion sequence, we could have 6^{50} possibilities of values. Even the fastest computer would fail. Hence smart algorithms are needed to search for sequences close to where our solution lies! And this needs to be done within 100-300 milliseconds for any practical use. Otherwise imagine commanding your robot and it takes 1 hour to process what you said.

The motions are of two types, moving from point A to B with no restrictions on the way. And path constrained like holding a wine glass upright. My research has made advances in both the fields. Mostly making older algorithms SMARTER for domains like composites, additive manufacturing, pick and place operations. All these areas are future of US innovation which strengths my case as well.

Lastly, while executing these motions the robots may make mistakes. Machine learning portion of my research helps learn what mistakes were made and perform the motions better. Additionally, environment could also change. Let's say some objects moved in the environment. So robot must learn this quickly and make course corrections. Overall

the research requires strong mechanical design (creativity), computer science, analytical, and a bit of electrical engineering related skills.