Robot Navigation

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Thousands of robots of all kinds are now deployed in hazardous environments ranging from war zones to the deep sea to other planets. Yet by and large, deployed robots do not navigate themselves – they are controlled through a tight feedback loop. Data from robot sensors is transmitted over radio, and shown on a monitor to an operator holding a joystick. The operator moves the joystick, which is converted into a command sent back over radio to the robot that moves as it has been directed. These tele-operated vehicles keep their operators out of harm's way and have saved lives. What happened, though, to the idea of autonomous robots doing our dull, dirty and dangerous work for us – without our constant intervention? For decades, science fiction has presented a vision of robots that clean house, take the kids to school, and navigate freely among people. Are we anywhere near these visions of the future? Have we made a progress towards these visions?

Unlike many other high tech devices – phones, computers, stereos, etc. – robots go out and physically navigate or even affect the world around them. We formulate the robot navigation as a problem of connecting states or points in a high dimensional configuration space with an unobstructed, connected path. We then evaluate and compare candidate paths with cost metrics. As these robots increasingly have the capability to go out and affect things in their environment, they run the risk of doing damage to people or their environment. Thus, in the future robots are increasingly going to evaluate these risks and the trades between them. Whereas today, the worst damage that a robotic vacuum cleaner can do is eat a sock – about $2 of damage, tomorrow, vehicles will be on our roads driving us around autonomously – a much greater level of risk. In fact, recently, a large company secretly put robotic vehicles on streets, roads and highways, and let them drive themselves hundreds of miles, all autonomously. Can we measure the state of robot technology by how much we are willing to gamble with a robot?

In my talk, I will examine the interplay between societal acceptance of autonomy and the forcing functions that may incentivize further adoption of autonomy. I will show how alternatives to teleoperation allow operators to supervise a UGV using operator following behaviors and a gesture and speech interface, which lowers operators' mental fatigue and increases their situational awareness. We have also made progress in autonomous manipulation, so that today robots more dexterously manipulate objects with less human supervision. In addition, I will show how we are crossing a threshold, where it soon will be more efficient to perform advanced sensor processing onboard a robot than it will be to transmit it for processing elsewhere – thus enabling smarter behaviors. I will also discuss some of the gaps and open problems in autonomy and robot navigation, and the enablers that are accelerating progress in robotics.