Session Overview
Field Robotics

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Field robots do not operate in factories or other controlled settings, but rather operate outdoors, underwater, underground, or even on other planets. They are characterized by a focus on real applications, and on operation in complex terrain. Field robots are often large vehicles, and often have forceful interactions with their workspace. Given their complex setting and complex (and often dangerous) tasks, most field robots are not fully autonomous: a great deal of effort goes into the user interface, providing mixed modes of human and robot interaction.

Field Roboticsis a branch of robotics characterized by its domain: the applications of robotics in the unstructured world to perform useful tasks. The papers in this session illustrate well the breadth of concerns addressed in building field robots. Some of earliest field robots were configured only for mobility and data gathering to perform such missions as exploration and mapping. Today, systems have been fielded which interact forcefully with the environment in such applications as excavation, mining and sampling. Many field robots are characterized by large scales (big machines, long distances covered); forceful interaction (either with large loads or with difficult terrain); complex machines (robots with many degrees of freedom); and complex environments (moving objects, soft and uneven terrain); and difficult operating environments (limited bandwidth, large distances between operator and machine).

Many of the applications that field robotics aspires to automate take place outdoors, in fairly unstructured environments, because we would like to give our robots the worst jobs; those that are difficult, dirty, and dangerous. Outdoor environments are complex due to their lack of predictable structure, uncontrolled weather conditions, and the pervasiveness of hazards. Often, the surface over which the robot moves is soft, or uneven, or difficult to sense. Such complexity often leads us to either choose more benign environments or to reduce the level of autonomy and involve humans: mixed-mode control, with varying degrees of control shared between a human and a robot, is an active area of field robotics research. Nonetheless, there are situations where higher levels of autonomy can still be argued to be prudent. In particular, being productive outdoors is a dangerous business, for robots as for humans. This session includes three papers which exploit autonomy to address extremes, respectively, in environmental complexity, remoteness, and danger to humans.

Some rich environments are characterized by complicated topology and many spatially-distributed degrees of mobility hazard. In these environments, perception must often make up for characteristically inadequate prior information. Yet, perception is only half the problem. Once something unexpected is perceived, a new mobility plan must be generated, and it must be generated in real-time if the vehicle is to move continuously during the process. The first paper Field D*: An Interpolation Based Path Planner and Replannerdescribes a version of the D* real-time replanning algorithm which is designed for such environments. Field Dstar uses interpolation to remove the discretized heading constraint under which most discrete motion planners operate. This leads to smoother plans which can be superior to those generated by optimal discrete planners.

Due to the well-known difficulties of teleoperation, many situations persist where autonomy is the only effective option. Extraterrestrial environments are so extremely remote that even the speed of light is a limitation. The Mars Exploration Rovers named Spirit and Opportunity have recently achieved a landmark in field robotics history. Kilometers of terrain on another planet have now been successfully traversed under autonomous control. The second paper in this session Tradeoffs Between Directed and Autonomous Driving on The MER Roversdescribes the issues associated with controlling the rovers and the graduated autonomy levels that arose to address them. The logistics of communicating only twice daily with the rovers, combined with the need to move quickly to the next science target, leads to the judicious use of autonomy in order to optimize productivity while managing risk to the rover.

Many terrestrial applications also present a plain tradeoff between risk and productivity and robotics can, of course, be used to redefine that tradeoff. Among commercial applications, mining is well-known to challenge our capacity to remove risk while simultaneously addressing the need to get a job done quickly and well. The third paper in this session is Surface Mining: Challenges and Main Research Issues for Autonomous Operations. It surveys the reasons for our present successes in mining automation as well as the remaining challenges to be addressed in order to increase the impact of field robots on mining in the future.