User-Centric Optimal Planning for Robots in Non-trivial Terrains

Howie Choset, Carnegie Mellon University

http://voronoi.sbp.ri.cmu.edu

People excel at determining what is important to optimize. Computers efficiently perform optimization calculations. This work proposes a method that enables a person and a computer to play to each other's strengths. The work will provide algorithms to generate optimal paths based on the user's preference and environmental conditions. Personnel can take robots to completely different localities, and by switching in a different terrain model, this approach will seamlessly find optimal paths in the new arenas. The work derives its strength from the fact that it is both human-centric and based on rigorous mathematical foundations.

Based on the commander's input the approach will generate an initial path, (in actuality a set of initial paths), and a means to optimize each path subject to a numerically expressed cost function. Such a cost function could be time-to-completion, terrain negotiability, path safety, or covertness. This approach will also optimize weighted combinations of cost functions. For example, in some scenarios the user decides that it is three times more important that the robot(s) (or any agent(s) for that manner) be covert than arriving at the target as quickly as possible, in which case the function .75 x covertness + .25 x time-to-completion is optimized. Since people excel at determining what is important, it makes sense to have them set the weighting factors for the proposed optimization routines. In other words, a person will set the agenda for the optimization scheme but then the computer will actually perform the optimization itself. Simply put, this work seeks to develop a framework for optimizing a cost function, or combination of cost functions, to produce optimal paths based on user input.

Ultimately, this work will come in the form of software that allows the user gets to dial in weighting factors for the relative importance of criteria to be optimized and then outputs the optimal path based on these criteria. The user can then look at the path and decide if it is desirable. If not, the user can reset or tweak the optimization weights until a desired path is achieved. Or, the user can drag parts of the path on a display to a fine-tuned desired result. Here, we are making a clear separation between what people do well and what computers do well.

Finally, the results of the proposed work can be used to determine optimal paths for any type of agent, not just robots,. Therefore, this optimization approach can assist human-guided vehicles where it is nearly *impossible* for a person to simultaneously optimize several variables for many vehicles. These enhanced capabilities rely on developing new fundamental results in homotopy theory, a branch of applied mathematics, and then verifying and refining these results in experiment.