



June 12, 2016

To Whom It May Concern

Review of Thomas Dlask's Bachelor Thesis: Submarine Behaviour Model for Monte Carlo Simulations

I am the superintendent of the U.S. Naval Research Laboratory's Marine Meteorology Division. The U.S. Naval Research Laboratory is the U.S. Navy's corporate research laboratory, and the Marine Meteorology Division conducts a research and development program designed to improve the basic understanding of atmospheric processes and the atmosphere's interaction with the ocean, land, and cryosphere; develop and implement automated analysis, prediction, and weather interpretation systems for U.S. Department of Defense users; and study the effect of the atmosphere on Naval weapon systems.

I have direct experience with the development and use of behavioral models of adversarial assets and of optimal path planning, having developed and operationalized the U.S. Navy's Pirate Attack Risk Surface system and its Automated Optimal Track Ship Routing system. My expertise is in the realm of applying, integrating, and operationalizing techniques such as those described by Mr. Dlask; my comments should not be viewed as an expert in stochastic path planning. Given that background and those caveats, I support Mr. Dlask's thesis with a grade of A.

Given Mr. Dlask's position as a student at the Czech Technical University in Prague, he did an admirable job setting the operational scene for the need for submarine behavior models. I greatly appreciated the background, description, and pseudo-code he provided for the selection of algorithms he chose to consider. Acknowledging that Mr. Dlask's thesis was a focus on stochastic approaches to this problem, my single complaint was his choice not to normalize results using any well-known, deterministic path planning algorithms (such as A*). His work did an excellent job allowing me to gauge the relative merits of RRT, RRT*, and PRM, but the merits of those approaches relative to the deterministic methods typically applied in my community is unexplored. I appreciate that such additional work is likely considered beyond the scope of a Bachelor Thesis. My concern should not detract from the impressive body work that Mr. Dlask completed, but rather be indicative of my level of engagement and my appreciation of what he accomplished.

General comments:

- Mr. Dlask took great care with the gridding of the geophysical domain. It is easy (and typical) for practitioners outside of my community to neglect the implications of gridding in a spherical domain.
- The BANDIT approach to submarine motion provided a great deal of useful functionality. I especially appreciated BANDIT's ability to wait at nodes for more favorable conditions to develop.
- The use of the diagnostic information provided by debug output greatly facilitated my ability to understand and appreciate output from the system. It allowed me to not only better understand why the optimal route was chosen, but also understand why other routes were not chosen. In our experience as application developers in this domain, information about *why* is critical to helping users trust the guidance being provided.
- The sensitivity studies and case studies provided in the Evaluation chapter were excellent. They addressed many of the questions that I scribbled in the margins of the thesis in earlier chapters. The experiments with time varying threats with depth varying threats were especially interesting.
- I would encourage Mr. Dlask (or a follow-on researcher) to explore parallelization opportunities with this system.

I am thankful for the opportunity to review Mr. Dlask's work. I (selfishly) feel that both he and his advisors should be commended crafting a study and generating a thesis of such operational relevance. Perhaps the greatest praise I can provide is to express my desire to find ways to bring the results of this work into the U.S. Navy research community for further exploration and development.

Regards,

Dr. Jim Hansen
Superintendent, Marine Meteorology Division
Naval Research Laboratory
7 Grace Hopper Ave
Monterey, CA 93943
(831) 656-4721
jim.hansen@nrlmry.navy.mil