Intelligent routing and surveillance algorithms for chart based navigation in archipelago-like environments

(DRAFT RESEARCH PLAN)

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Abstract

Electronic Chart Display and Information Systems (ECDIS) have widely substituted for the paper charts in merchant shipping. The same trend is common with leisure boats, too, as people are increasingly investing in build-up when making sailing easier and safer. However, navigators for leisure boats are more just display systems with no intelligence in interpreting the content of the charts. Humans are meant to plan and monitor the boat's motion along the routes with the aid of the chart display. Nowadays, route planning in coastal and archipelago-like environments is using the sea lanes as a planning base. The navigators are not able to take into account the obstacles or wind directions in archipelago navigation. The goal of the proposed research project is to develop path planning and obstacle surveillance algorithms for sailing boats. The algorithms will be evaluated in laboratory and real environment with a "leisure boat ECDIS" developed in the project. We will concentrate on archipelago-like environments defined by nautical charts. In our context the archipelago-like means a space where obstacles to be avoided are defined in charts as shallow waters, rocks, navigation marks and the like. Wind variation and drift are among the most important dynamic aspects to be taken into account. This involves the need of real time calculation and updating of paths and safety observations. The path planning problem is solved in two phases: first the free space will be defined and then the paths will be computed and optimized in this space. The outer bounds of the free space on the vector chart will be sketched by using the start and goal points, possible sea lanes available, wind information and boat characteristics as main parameters. The obstacles inside the outer bounds will expand on the free space. We will focus on two basic ideas of defining the possible paths in the free space. The first of them is named "Modified Direction Weighted Visibility Graph–method". The graph will be generated by taking the start point as the first vertex. The next vertex is the point of the obstacle visible in the sail boat's most efficient sailing direction. Typically there are two possible next vertexes as the sailboat can take either starboard or port course. Those points are new start points for the search. This will be continued towards the goal until it will be reached. During the search of visible points "bays" (concave edges) generate dead ends. They can be avoided by backtracking the visibility ray and thus finding a new route out of the dead end. Dijkstra's algorithm will be used on the generated graph to find the most efficient path (fastest or shortest). The second idea applies the well known cell decomposition technique. The cells will be defined by sweeping the free space by straight lines parallel to the port and starboard laylines of the sailboat. The cells will be connected as graph defining simple cell paths from start to goal. The cell graph defines a set of coarse paths for the sail boat and can be used for more refined path planning inside each of the cells. Once again, Dijkstra will be used to find the most efficient path. A stepwise refinement will be used in both of the methods sketched above. This might be necessary because of the computational complexity of the problem. First, a very rough free space with highly generalized chart information will be generated and first path candidates defined. During the sailing the refinements will be continuously computed in real time. Proximity information to the most dangerous obstacles will be used to monitor the sailing inside some predefined safety area. Real time proximity evaluation arises the need for sophisticated methods in restricting the search of chart data.

Key words - path planning, visibility, cell decomposition, sail boat navigation

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