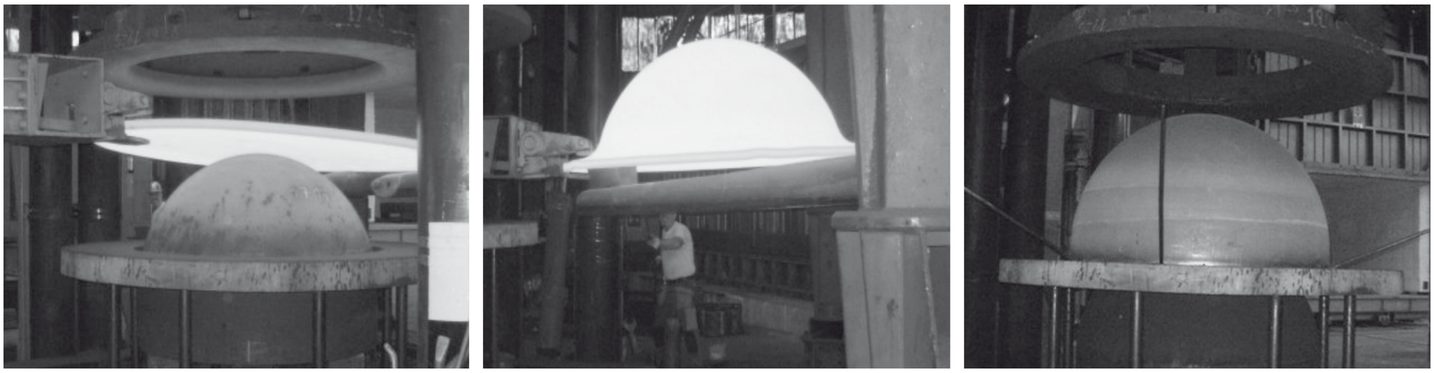

Fig. 2. Deep drawing of one hemispherical dished head

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ANT COLONY OPTIMIZED PLANNING FOR UNMANNED SURFACE MARINE VEHICLES

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THE PROBLEM:

This paper presents some results achieved from a preliminary study on the use of the Ant Colony Algorithm to plan feasible optimal or suboptimal trajectories for an autonomous ship manoeuvring. The scenario, for this preliminary work, comprises only open sea manoeuvres. The goal involves obtaining the least time consuming ship trajectory between to points, departing from the start point with arbitrary initial speed and attitude values and arriving to the end point with predefined speed and attitude values.

The specific dynamic of the ship imposes typical restrictions to its manoeuvrability. In the present case, the non-holonomicity, the rate speed/turn radius, and the imposed forward-only propulsion of the ship make up the main restrictions to the ship movement. For long distances, the problem could be tackled as a classical navigation problem, in which, for the most part of the ship trajectory, techniques such inertial navigation should be enough. The problem arises at short distances when it becomes a manoeuvring problem. In this case to obtain a optimal, --in some cases just a feasible--, trajectory could be a difficult problem.

A WAY OF SOLUTION:

In recent years, several innovative optimisation techniques, based on heuristic search methods have been developed and proved in very different scenarios. Among them, the so called bioinspired algorithms, such the Ant Colony Optimisation or the Artificial Bee Colony Algorithm result particularly attractive by their capacity to solve complex optimisation problems in which, other classical techniques are unfeasible or difficult to implement.

The aim of the present work is to prove the viability of one of these techniques to obtain the trajectory of an autonomous ship in the manoeuvring scenario described above. To accomplish this goal, a simplified dynamical model of a ship, considering only three degrees of freedom (surge, sway and yaw) was employed. The propulsion was modelled as a trimable waterjet system, which plays also the role of the rudder. Both, speed and course are controlled by a classical PID system, which stabilizes the course and speed, according to preset values of the PID constants. A more complete description of this model will be provided in the full paper.

Ant Colony Optimisation algorithms are based in the way in which ants are capable of finding the shortest path from a food source to their nest. Ants deposit a certain amount of pheromone while walking. When any ant searches a path to follow in its search for food, it prefers, in a probabilistic sense, the trails rich on pheromona. As far as shorter paths can be followed faster, the shorter the path the larger the number of ants that cover it by unit time. As a result, the shortest (optimum) path becomes more and richer on pheromona, and more a more ants follow it. Although the process tends to converge with time to the best way found by the ants, the probabilistic nature of the ants path election, makes easier to avoid get trapped in local minima far from the optimal solution and it allows, once the algorithm has found a feasible solution, to improved it towards the optimum.

In the robotics context it is usual to divide the problem of robot motions into two steps: first to get an optimal path (path planning), according with certain cost criteria, and then making the robot follow the path (path following). It may be difficult for the robot to follow the path, due to the dynamic characteristics and restrictions of the robot itself.

In our case we propose to solve the motion problem in one step, so the path planning includes the robot dynamics and restrictions.

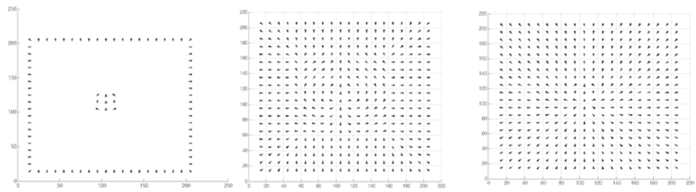
Now, the original ant colony algorithm doesn't consider any particular dynamics for the ants' movements. It just assigns an elapsed time proportional to the length covered by the ant in its movement towards the goal. Our contribution here is to add dynamics -the dynamics of the ship- and restrictions to the algorithm. In this way the trajectories obtained are feasible. The ants behave as ships.

In the original algorithm, the ant colony is composed by an arbitrary number of ants. They are sent from the nest, which represent the starting point of the quest, in random directions. The ants follow straight paths until they reach an obstacle, then a new random direction is selected. When any ant reaches the goal, it marks the track followed from the nest to the goal.

CELLULAR AUTOMATA FOLLOWED BY ANT COLONY:

Due to the nature of the manoeuvring problem, the space of search is really large to find not only the optimal but also a feasible solution, following a whole random search. Therefore we propose a way to guide the search. The idea is to use cellular automata.

To apply cellular automata the manoeuvring area is divided into square cells. Each cell is assigned a motion direction (an arrow). Each cell is an automaton. The 2-dimensional set of automata is represented as a matrix. A goal is marked. The automata have transition rules, so after iterations of matrix multiplications the automata draw flow "potential" lines towards the goal. The paper will explain in detail this part of the proposed procedure. Let us put a sequence of figures, following the evolution of the computations:



start ***in the middle*** ***final***

On the same grid used by the cellular automata we put now the ants.

In each cell the heading marked by the cellular automata is taken as the centre of a probability distribution. When an ant reaches a cell, it throws a dice with the probability distribution given by the cell to select its new motion heading. And so on from cell to cell. The ant could eventually reach the target, or not. If no, when the distance to the target is really far the ant is killed. If the ant gets the target with correct attitude, the ant is also killed and the centre of the probability distribution in every cell is shifted towards the successful heading.

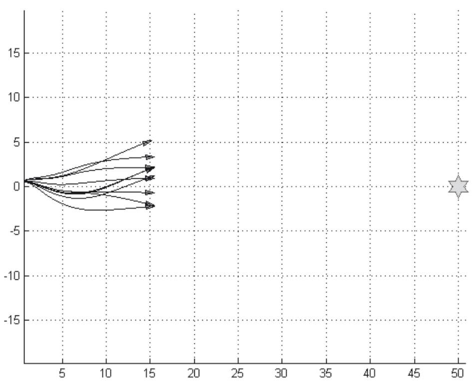


Fig. 2 Initial phase of the search. The ants are going to pass two cells (the cell occupy 4 squares in the Matlab grid).

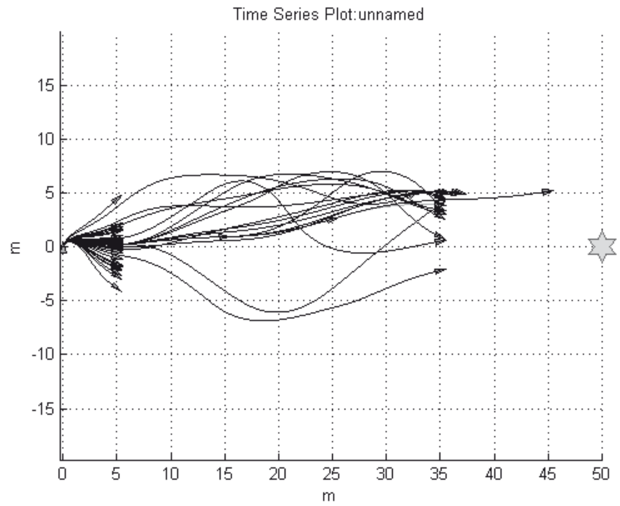


Fig. 3 Shows two consecutive generations of ants.

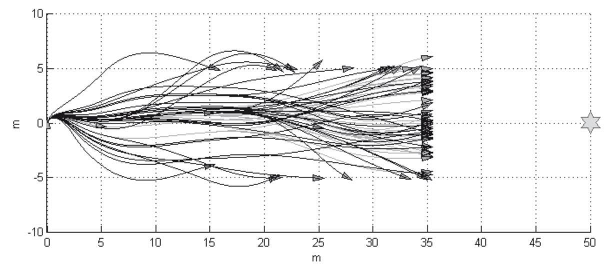
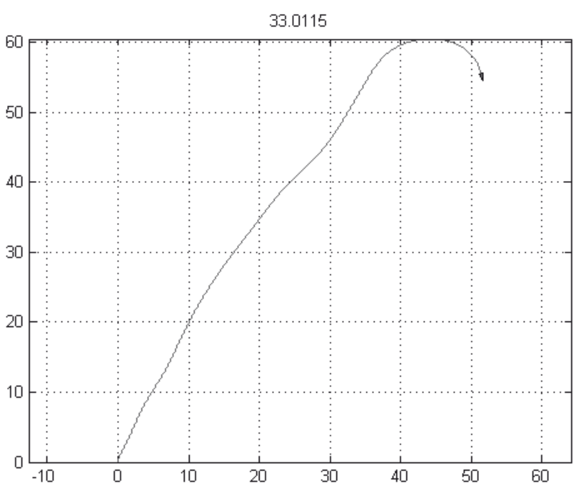


Fig. 4 Shows another more advanced stage of the search.



CONCLUSION

The paper introduces a path planning method with guaranteed feasible manoeuvring trajectories for ships. The new procedure has two steps: first with cellular automata and second with ant colony optimization.

The results obtained thus far are encouraging. In the next future we plan to add shallow waters to include a kind of corridor restrictions to the problem.

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