

# A Path Planning Algorithm for an AUV Guided with Homotopy Classes Demo Storyboard

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## Abstract

This document presents a demo storyboard for an accepted paper in the ICAPS 2011. The paper presents a method that builds a topological environment based on the workspace to compute homotopy classes, which topologically describe how paths go through the obstacles in the workspace. Then, the homotopy classes are sorted according to an heuristic estimation of their lower bound. Only those with smaller lower bound are used to guide a planner based on the Rapidly-exploring Random Tree (RRT), called *Homotopic RRT* (HRRT), to compute the path in the workspace. The demo consist of a short presentation where the theoretical concepts of our paper are explained and an execution of an application that applies the whole method in bitmap scenarios<sup>1</sup>.

## Introduction

This storyboard presents the practical part of a paper accepted in the ICAPS 2011 (Hernández, Carreras, and Ridao 2011). The paper presents an extension of the method to generate homotopy classes that can be followed in any 2D workspace. Two paths that share the start and the end points belong to the same homotopy class if one can be deformed into the other without encroaching any obstacle. The homotopy classes generated are sorted according their quality given by a lower bound estimator. In order to maximize the number of homotopy classes that can be explored, we propose a path planner based on the RRT, called *Homotopic RRT* (HRRT), to generate paths in the workspace. The HRRT algorithm starts looking for a path in the homotopy class that has a high probability of containing the optimal solution. Our method has been tested in several scenarios and this demo will show up all the execution steps during these tests.

The demo consists of two steps. First, there will be a small presentation to introduce the goal of our research work, the theoretical concepts of homotopy classes and how are they generated in 2D workspaces. Then, there will be an application to run the tests proposed in the paper and see how our method overcomes each step of the process.

<sup>1</sup>The full paper describing this system appears in the ICAPS-2011 Proceedings at pages 82-89.

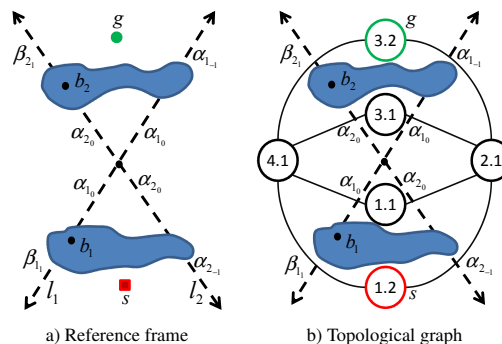


Figure 1: Example of a reference frame and its correspondent topological graph in a workspace with two obstacles.

## Demo Presentation

We will briefly present in few slides the theoretical concepts of the paper: the process of turning a metric space into a topological graph (Figure 1), the generation of the homotopy classes and computation of their lower bound, and the fundamentals of the HRRT path planning algorithm. The presentation will also include a slide with the goal of our method: its application to an Autonomous Underwater Vehicle (AUV).

## Demo Application

The execution of the demo application will allow the user to see all the steps of the method we propose to compute paths following homotopy classes. The user will be able to select a scenario among a set of bitmaps, to select the start point and goal point through a GUI, and to run the application.

The execution steps are these follows: Given a workspace, our method computes the reference and its topological graph. Both of them are shown in Figure 2 and in Figure 3 to easily understand how a metric environment can be turned into a topological one. Using the topological graph and knowing where the start and goal vertexes are (through the location of the start and goal points in the workspace), a set of homotopy classes will be computed. The computed homotopy classes, shown in Table 1, change according to the scenario and/or the start and goal points locations. Then, the application will compute the lower bound for each ho-

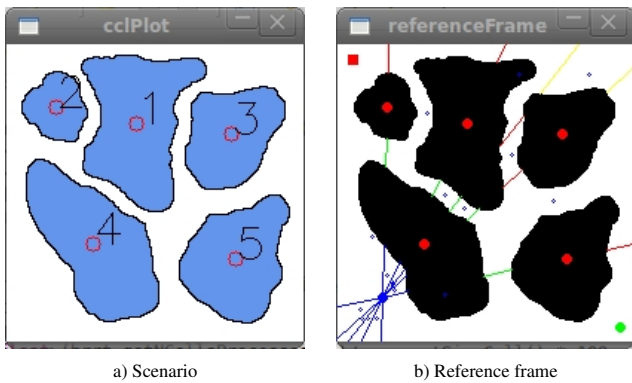


Figure 2: An environment where the obstacles have been identified and its corresponding reference frame.

Index	Homotopy class	Lower bound (pixels)
1	A5,0 A3,0 A4,0 A1,0 A2,0	295.658
2	A2,1 A1,1 B4,1 A3,1 A5,1	262.768
3	A2,1 A1,1 B4,1 A3,1 B5,2	280.403
4	A2,1 B1,2 B4,2 A3,2 A5,1	373.653
5	A2,1 B1,2 B4,2 A3,2 B5,2	357.347
6	A2,1 B1,2 B4,3 B3,3 A5,1	447.938
7	A2,1 B1,2 B4,3 B3,3 B5,2	386.538
8	B2,2 A1,1 B4,1 A3,1 A5,1	266.443
9	B2,2 A1,1 B4,1 A3,1 B5,2	283.623
10	B2,2 B1,2 B4,2 A3,2 A5,1	320.942
11	B2,2 B1,2 B4,2 A3,2 B5,2	304.636
12	B2,2 B1,2 B4,3 B3,3 A5,1	395.227
13	B2,2 B1,2 B4,3 B3,3 B5,2	333.827

Table 1: Homotopy classes of the scenario with with their index and lower bound. Notice that the  $\alpha_{k,s} / \beta_{k,s}$  notation of the paper is represented as  $Ak, s / Bk, s$  in the demo application.

motopy class. The lower bound is used to set up a preference order when computing the homotopy classes path in the workspace. Finally, the user will see the execution of the HRRT algorithm we propose in the paper. This part will show the construction of the tree and the path found (Figure 4).

### Acknowledgments

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### References

Hernández, E.; Carreras, M.; and Ridao, P. 2011. A path planning algorithm for an AUV guided with homotopy classes. In *Proceedings of the 21st International Conference on Automated Planning and Scheduling (ICAPS)*.

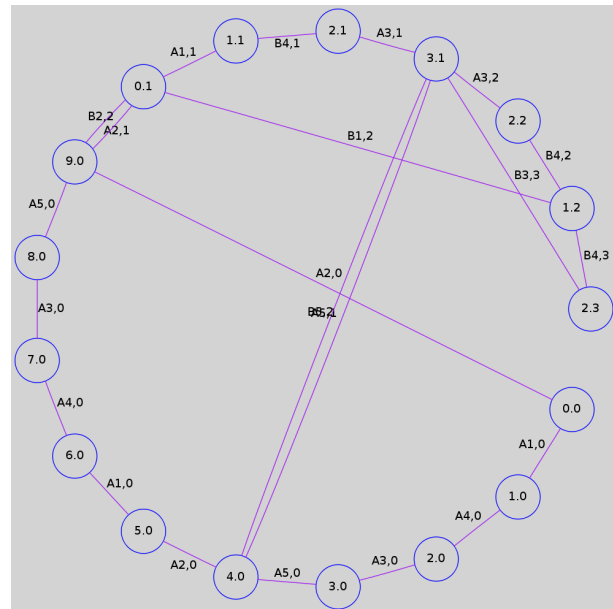


Figure 3: Topological graph of the scenario generated with Graphviz software.

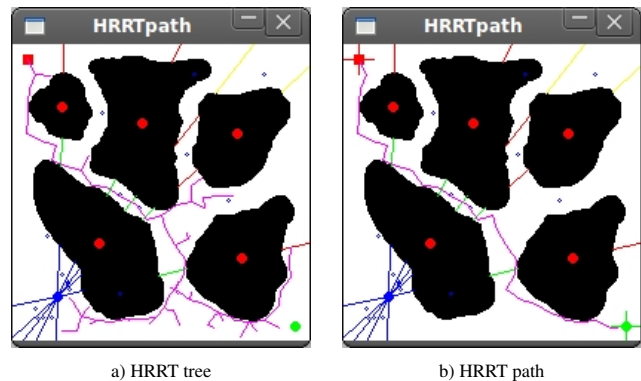


Figure 4: Tree and path computed with the HRRT algorithm for the homotopy class in Table 1 with the best lower bound (index 2).