Marine Robot Autonomy

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Editor

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Preface

This book provides an update to select underwater autonomy areas. It is intended for researchers and engineers who are new to the field of marine robot autonomy, at the same time, appealing to those with more experience. This book was inspired by: (1) quite a few researchers looking for a reference for graduate courses in marine autonomous robotics with emphasis on autonomy and (2) researchers and engineers who are new to the area with little or no formal training or experience in the area. It is hoped that the extensive references deliberately compiled by each chapter author provide a valuable starting point for further study.

The introductory chapter sets the background and provides definitions for subsequent chapters. It starts with a motivation for why autonomy is necessary and timely for marine robots. Then, it briefly reviews existing metrics and standards for marine autonomy and the components that exist in many intelligent autonomy architectures. The autonomy requirements of military and oceanographic users are touched upon and briefly contrasted to give the reader an appreciation for two different users of marine robots. Then, the fundamentals of what limits marine autonomy specifically, the underwater medium, underwater navigation, and critical enablers like energy are introduced. In-depth exploration is left to subsequent chapters; however, tie-ins and developments related to the following chapters are noted.

To start, two different intelligent autonomy architectures are highlighted, the behaviour-based MOOS-IvP (Benjamin et al., Chap. 2) and the deliberative T-REX (Rajan et al., Chap. 3). These architectures are implemented on actual systems and have received a fair amount of interest from the military and scientific users.

One of the basic functionalities of an intelligent autonomy architecture (for all environments) is motion or path planning. This occurs once a map of the environment exists. Plans optimized around constraints have to be generated. For reactive applications as in obstacle avoidance, plans are generated in near real time. For more deliberative search applications where a detailed digital map of the area exists this can take longer. Path planning is discussed in Chap. 4 (Paull et al.).

UUVs on long deployment require fault tolerance as the UUV itself will change if the mission is long enough. When unexpected hardware failures occur, the intelligent autonomy should allow the UUV to reconfigure itself to use alternative combinations of the remaining functioning resources (Lane et al., Chap. 5). This has been termed “autonomous embedded recoverability.” Chapter 5 describes work on a declarative goal-based solution for adaptive mission planning that builds in the ability to adapt and recover from failures.

The ability to scan or sense a wider area and to work cooperatively has the potential to vastly improve the efficiency and effectiveness of mission operations. However, given the complexity and difficulty of the underwater environment, cooperation between underwater vehicles faces many challenges. This is covered in Chap. 6 (Redfield).

In the very dynamic ocean environment where operators work with little or no a priori information the value of machine learning emerges. Reinforcement learning is a methodology in robot learning where a scalar evaluation (reward) of the performance of the algorithm is available from interaction with the environment. The objective in reinforcement learning is to maximize the expected reward through adjusting a value function. The role of machine learning in an intelligent autonomy architecture is highlighted in Chap. 7 (Carreras et al.).

SLAM is an example of a truly autonomous capability with little or no human intervention. With SLAM, a spatial map of the UUV’s environment is built for navigation purposes. The UUV uses its sensors (sonars, bathymetric sensors, etc.) to perceive the environment. The sensors are modelled as real with errors and finite ranges. The sensor measurements are assembled to create the map. There is no a priori environment information for the UUV to work with. With SLAM, beacons and networks do not have to be deployed or used making the technique useful in GPS-denied, underwater, or under-ice environments. Chapter 8 showcases this capability through three case studies.

I would like to acknowledge the efforts of the many reviewers who have given generously their time. Each chapter was meticulously peer reviewed. Lastly, I would like to thank all the authors who have contributed to this book. They are among the researchers who are expanding the envelope on the state of the art in autonomy for marine robots.

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