基于水下机器人研究的学术论文分析报告(英文)

Research papers based on research of underwater robots

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arXiv:1709.08945

[pdf, other] cs.HC

Gesture-based Human-robot Interaction for Field Programmable Autonomous Underwater Robots

Authors: Pei Xu

Abstract: The uncertainty and variability of underwater environment propose the request to control underwater robots in real time and dynamically, especially in the scenarios where human and robots need to work collaboratively in the field. However, the underwater environment imposes harsh restrictions on the application of typical control and communication methods. Considering that gestures are a natural and efficient interactive way for human, we, utilizing convolution neural

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network, implement a real-time gesture-based recognition system, who can recognize 50 kinds of gestures from images captured by one normal monocular camera, and apply this recognition system in human and underwater robot interaction. We design A Flexible and Extendable Interaction Scheme (AFEIS) through which underwater robots can be programmed in situ underwater by human operators using customized gesture-based sign language. This paper elaborates the design of gesture recognition system and AFEIS, and presents our field trial results when applying this system and scheme on underwater robots. △ Less

Submitted 26 September, 2017; originally announced September 2017.

Comments: 7 pages, 12 figures, 2 tables

arXiv:1706.07204

[pdf] cs.RO

Context Reasoning in Underwater Robots Using MEBN

Authors: Xin Li, José-Fernán Martínez, Gregorio Rubio, David Gómez

Abstract: This paper presents ongoing research in the SWARMs project towards facilitating context awareness in underwater robots. In particular, the focus of this paper is put on the context reasoning part. The underwater environment introduces uncertainties in context data which lead to difficulties in the context reasoning phase. As probability is the best well-known formalism for computational scientific reasoning under uncertainties, the emerging and effective probabilistic reasoning method, namely, Multi-Entity Bayesian Network (MEBN), is explored for its feasibility to reason under uncertainties in the SWARMs project. A simple use case for oil spill monitoring is used to verify the usefulness of MEBN. The results show that the MEBN is a promising approach to reason about context in the presence of uncertainties in the underwater robot field. △ Less

Submitted 22 June, 2017; originally announced June 2017.

Comments: Presented at the Third International Conference

on Cloud and Robotics (ICCR 2016), 2016 (arXiv:1706.05424)

Report number: ICCR/2016/02

arXiv:1709.08292

[pdf, other] cs.RO

Underwater Multi-Robot Convoying using Visual Tracking by Detection

Authors: Florian Shkurti, Wei-Di Chang, Peter Henderson, Md Jahidul Islam, Juan Camilo Gamboa Higuera, Jimmy Li, Travis Manderson, Anqi Xu, Gregory Dudek, Junaed Sattar

Abstract: We present a robust multi-robot convoying approach that relies on visual detection of the leading agent, thus enabling target following in unstructured 3-D environments. Our method is based on the idea of tracking-by-detection, which interleaves efficient model-based object detection with temporal filtering of image-based bounding box estimation. This approach has the important advantage of mitigating tracking drift (i.e.

drifting away from the target object), which is a common symptom of model-free trackers and is detrimental to sustained convoying in practice. To illustrate our solution, we collected extensive footage of an underwater robot in ocean settings, and hand-annotated its location in each frame. Based on this dataset, we present an empirical comparison of multiple tracker variants, including the use of several convolutional neural networks, both with and without recurrent connections, as well as frequency-based model-free trackers. We also demonstrate the practicality of this tracking-by-detection strategy in real-world scenarios by successfully controlling a legged underwater robot in five degrees of freedom to follow another robot's independent motion. △ Less

Submitted 24 September, 2017; originally announced September 2017.

Comments: Accepted to IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2017

arXiv:1804.02479

[pdf, other] cs.RO

Understanding Human Motion and Gestures for Underwater Human-Robot Collaboration

Authors: Md Jahidul Islam

Abstract: In this paper, we present a number of robust methodologies for an underwater robot to visually detect, follow, and interact with a diver for collaborative task execution. We design and develop two autonomous diver-following algorithms, the first of which utilizes both spatial- and frequency-domain features pertaining to human swimming patterns in order to visually track a diver. The second algorithm uses a convolutional neural network-based model for robust tracking-by-detection. In addition, we propose a hand gesture-based human-robot communication framework that is syntactically simpler and computationally more efficient than the existing grammar-based frameworks. In the proposed interaction framework, deep visual detectors are used to provide accurate hand gesture recognition; subsequently, a finite-state machine performs robust and efficient gesture-to-instruction mapping. The distinguishing feature of

this framework is that it can be easily adopted by divers for communicating with underwater robots without using artificial markers or requiring memorization of complex language rules. Furthermore, we validate the performance and effectiveness of the proposed methodologies through extensive field experiments in closed- and open-water environments. Finally, we perform a user interaction study to demonstrate the usability benefits of our proposed interaction framework compared to existing methods. △ Less

Submitted 6 April, 2018; originally announced April 2018.

Comments: arXiv admin note: text overlap with arXiv:1709.08772

arXiv:1707.06564

[pdf, other] cs.RO

A Customisable Underwater Robot

Authors: Guido Schillaci, Fabio Schillaci, Verena V. Hafner

Abstract: We present a model of a configurable underwater drone, whose parts are optimised for 3D printing processes. We show how - through the use of printable adapters - several thrusters and ballast configurations can be implemented, allowing different maneuvering possibilities. After introducing the model and illustrating a set of possible configurations, we present a functional prototype based on open source hardware and software solutions. The prototype has been successfully tested in several dives in rivers and lakes around Berlin. The reliability of the printed models has been tested only in relatively shallow waters. However, we strongly believe that their availability as freely downloadable models will motivate the general public to build and to test underwater drones, thus speeding up the development of innovative solutions and applications. The models and their documentation will be available for download at the following link: https://adapt.informatik.hu-berlin.de/schillaci/underwater.html. △ Less

Submitted 20 July, 2017; originally announced July 2017.

arXiv:1712.01341

[pdf, other] cs.RO

Proving the existence of loops in robot trajectories

Authors: Simon Rohou, Peter Franek, Clement Aubry, Luc Jaulin

Abstract: This paper presents a reliable method to verify the existence of loops along the uncertain trajectory of a robot, based on proprioceptive measurements only, within a bounded-error context. The loop closure detection is one of the key points in SLAM methods, especially in homogeneous environments with difficult scenes recognitions. The proposed approach is generic and could be coupled with conventional SLAM algorithms to reliably reduce their computing burden, thus improving the localization and mapping processes in the most challenging environments such as unexplored underwater extents. To prove that a robot performed a loop whatever the uncertainties in its evolution, we employ the notion of topological degree that originates in the field of differential topology. We show that a verification tool based on the

topological degree is an optimal method for proving robot loops. This is demonstrated both on datasets from real missions involving autonomous underwater vehicles, and by a mathematical discussion. △ Less

Submitted 4 December, 2017; originally announced December 2017.

ACM Class: I.2.9; G.1.5

arXiv:1509.06110

[pdf, other] cs.RO

Design, Modeling and Control of A Novel Amphibious Robot with Dual-swing-legs Propulsion Mechanism

Authors: Yang Yi, Zhou Geng, Zhang Jianqing, Cheng Siyuan, Fu Mengyin

Abstract: This paper describes a novel amphibious robot, which adopts a dual-swing-legs propulsion mechanism, proposing a new locomotion mode. The robot is called FroBot, since its

structure and locomotion are similar to frogs. Our inspiration comes from the frog scooter and breaststroke. Based on its swing leg mechanism, an unusual universal wheel structure is used to generate propulsion on land, while a pair of flexible caudal fins functions like the foot flippers of a frog to generate similar propulsion underwater. On the basis of the prototype design and the dynamic model of the robot, some locomotion control simulations and experiments were conducted for the purpose of adjusting the parameters that affect the propulsion of the robot. Finally, a series of underwater experiments were performed to verify the design feasibility of FroBot and the rationality of the control algorithm. △ Less

Submitted 21 September, 2015; originally announced September 2015.

Comments: 8 pages

arXiv:1801.05790

physics.app-ph

Exploring Hidden Acoustic Spin Underwater

Authors: Yang Long, Jie Ren, Hong Chen

Abstract: Investigating wave propagation in fluid enables a variety of important applications in underwater communications, object detections and unmanned robot control. Conventionally, momentum and spin reveal fundamental physical properties about propagating waves. Yet, vast previous research focused on the orbital angular momentum of acoustics without thinking about the existence possibility of spin due to the longitudinal wave nature. Here, we show that underwater acoustic wave processes the non-trivial spin angular momentum intrinsically, which is associated with its special spin-orbital coupling relation for longitudinal waves. Furthermore, we demonstrate that this intrinsic spin, although unobservable in plane wave form, can be detected by four approaches: wave interference, Gaussian exponential decay form, boundary evanescent wave, and waveguide mode. We further show that the strong spin-orbital coupling can be exploited to achieve unidirectional excitation and backscattering immune transport. We hope the present results can improve the geometric and topological understanding about underwater

acoustic wave and pave the way on the spin-related underwater applications. △ Less

Submitted 6 February, 2018; v1 submitted 17 January, 2018; originally announced January 2018.

Comments: To be combined to an experimental work. We have withdrawn the current theoretical version, and a new version will be born by joining this theoretical paper to an experimental one

arXiv:1308.4294

[pdf] cs.RO

Expanding the Knowledge Horizon in Underwater Robot Swarms

Authors: Enzo Fioriti, Stefano Chiesa, Fabio Fratichini

Abstract: In this paper we study the time delays affecting the diffusion of information in an underwater heterogeneous robot swarm, considering a time-sensitive environment. In many situations each member of the swarm must update its knowledge

about the environment as soon as possible, thus every effort to expand the knowledge horizon is useful. Otherwise critical information may not reach nodes far from the source causing dangerous misbehaviour of the swarm. We consider two extreme situations. In the first scenario we have an unique probabilistic delay distribution. In the second scenario, each agent is subject to a different truncated gaussian distribution, meaning local conditions are significantly different from link to link. We study how several swarm topologies react to the two scenarios and how to allocate the more efficient transmission resources in order to expand the horizon. Results show that significant time savings under a gossip-like protocol are possible properly allocating the resources. Moreover, methods to determine the fastest swarm topologies and the most important nodes are suggested. △ Less

Submitted 19 August, 2013; originally announced August 2013.

arXiv:1512.01789

[pdf, other] cs.CV

The Next Best Underwater View

Authors: Mark Sheinin, Yoav Y. Schechner

Abstract: To image in high resolution large and occlusion-prone scenes, a camera must move above and around. Degradation of visibility due to geometric occlusions and distances is exacerbated by scattering, when the scene is in a participating medium. Moreover, underwater and in other media, artificial lighting is needed. Overall, data quality depends on the observed surface, medium and the time-varying poses of the camera and light source. This work proposes to optimize camera/light poses as they move, so that the surface is scanned efficiently and the descattered recovery has the highest quality. The work generalizes the next best view concept of robot vision to scattering media and cooperative movable lighting. It also extends descattering to platforms that move optimally. The optimization criterion is information gain, taken from information theory. We exploit the existence of a prior rough 3D model, since underwater such a model is routinely obtained using sonar. We demonstrate this principle in a scaled-down setup. △ Less

Submitted 6 December, 2015; originally announced December 2015.

arXiv:1509.07975

[pdf, other] cs.RO

doi

10.1007/s10514-015-9500-x

Modeling Curiosity in a Mobile Robot for Long-Term Autonomous Exploration and Monitoring

Authors: Yogesh Girdhar, Gregory Dudek

Abstract: This paper presents a novel approach to modeling curiosity in a mobile robot, which is useful for monitoring and adaptive data collection tasks, especially in the context of long term autonomous missions where pre-programmed missions are likely to have limited utility. We use a realtime topic modeling technique to build a semantic perception model of the environment, using which, we plan a path through the locations in the world with high semantic information content. The

life-long learning behavior of the proposed perception model makes it suitable for long-term exploration missions. We validate the approach using simulated exploration experiments using aerial and underwater data, and demonstrate an implementation on the Aqua underwater robot in a variety of scenarios. We find that the proposed exploration paths that are biased towards locations with high topic perplexity, produce better terrain models with high discriminative power. Moreover, we show that the proposed algorithm implemented on Aqua robot is able to do tasks such as coral reef inspection, diver following, and sea floor exploration, without any prior training or preparation. △ Less

Submitted 26 September, 2015; originally announced September 2015.

Comments: 20 pages, in-press, Autonomous Robots, 2015. arXiv admin note: substantial text overlap with arXiv:1310.6767

arXiv:1804.00762

[pdf, other] cs.RO

Stress-Based Navigation for Microscopic Robots in Viscous Fluids

Authors: Tad Hogg

Abstract: Objects moving in fluids experience patterns of stress on their surfaces determined by their motion and the geometry of nearby boundaries. Fish and underwater robots can use these patterns for navigation. This paper extends this stress-based navigation to microscopic robots in tiny vessels, where robots can exploit the physics of fluids at low Reynolds number. This applies, for instance, in vessels with sizes and flow speeds comparable to those of capillaries in biological tissues. We describe how a robot can use simple computations to estimate its motion, orientation and distance to nearby vessel walls from fluid-induced stresses on its surface. Numerically evaluating these estimates for a variety of vessel sizes and robot positions shows they are most accurate when robots are close to vessel walls. △ Less

Submitted 2 April, 2018; originally announced April 2018.

arXiv:1803.08202

[pdf, other] cs.RO

Person Following by Autonomous Robots: A Categorical Overview

Authors: Md Jahidul Islam, Jungseok Hong, Junaed Sattar

Abstract: A wide range of human-robot collaborative applications in industry, search and rescue operations, healthcare, and social interactions require an autonomous robot to follow its human companion. Different operating mediums and applications pose diverse challenges by adding constraints on the choice of sensors, the degree of autonomy, and dynamics of the person following robot. Researchers have addressed these challenges in many ways and contributed to the development of a large body of literature. This paper provides a comprehensive overview of the literature by categorizing different aspects of person-following by autonomous robots. Also, the corresponding operational challenges are identified based on various design choices for ground, underwater, and

aerial scenarios. In addition, state-of-the-art methods for perception, planning, control, and interaction are elaborately discussed, and their feasibilities are evaluated in terms of standard operational and performance metrics. Furthermore, several prospective application areas are identified, and open problems are highlighted for future research. △ Less

Submitted 21 March, 2018; originally announced March 2018.

arXiv:1006.5263

[pdf] cs.MA

Design specifications of the Human Robotic interface for the biomimetic underwater robot "yellow submarine project"

Authors: Anil Bheemaiah

Abstract: This paper describes the design of a web based multi agent design for a collision avoidance auto navigation biomimetic submarine for submarine hydroelectricity. The paper describes the nature of the map - topology interface for river bodies and the design of interactive agents for the control of

the robotic submarine. The agents are migratory on the web and are designed in XML/html interface with both interactive capabilities and visibility on a map. The paper describes mathematically the user interface and the map definition languages used for the multi agent description △ Less

Submitted 28 June, 2010; originally announced June 2010.

Comments: conference

arXiv:1804.08692

[pdf] physics.app-ph

Switchable Adhesion Actuator for Amphibious Climbing Soft Robot

Authors: Yichao Tang, Qiuting Zhang, Gaojian Lin, Jie Yin

Abstract: Climbing soft robots are of tremendous interest in both science and engineering due to their potential applications in intelligent surveillance, inspection, maintenance, and detection under environments away from the

ground. The challenge lies in the design of a fast, robust, switchable adhesion actuator to easily attach and detach the vertical surfaces. Here, we propose a new design of pneumatic-actuated bioinspired soft adhesion actuator working both on ground and under water. It is composed of extremely soft bilayer structures with an embedded spiral pneumatic channel resting on top of a base layer with a cavity. Rather than the traditional way of directly pumping air out of the cavity for suction in hard polymer-based adhesion actuator, we inflate air into the top spiral channel to deform into a stable 3D domed shape for achieving negative pressure in the cavity. The characterization of the maximum shear adhesion force of the proposed soft adhesion actuator shows strong and rapid reversible adhesion on multiple types of smooth and semi-smooth surfaces. Based on the switchable adhesion actuator, we design and fabricate a novel load-carrying amphibious climbing soft robot (ACSR) by combining with a soft bending actuator. We demonstrate that it can operate on a wide range of foreign horizontal and vertical surfaces including dry, wet, slippery, smooth, and semi-smooth ones on ground and also under water with certain load-carrying capability. We show that the vertical climbing speed can reach about 286 mm/min (1.6 body length/min)

while carrying over 200g object (over 5 times the weight of ACSR itself) during climbing on ground and under water. This research could largely push the boundaries of soft robot capabilities and multifunctionality in window cleaning and underwater inspection under harsh environment. △ Less

Submitted 22 March, 2018; originally announced April 2018.

arXiv:1511.09067

[pdf, other] cs.CV

Sparse Coral Classification Using Deep Convolutional Neural Networks

Authors: Mohamed Elawady

Abstract: Autonomous repair of deep-sea coral reefs is a recent proposed idea to support the oceans ecosystem in which is vital for commercial fishing, tourism and other species. This idea can be operated through using many small autonomous underwater vehicles (AUVs) and swarm intelligence techniques to locate and replace chunks of coral which have been broken

off, thus enabling re-growth and maintaining the habitat. The aim of this project is developing machine vision algorithms to enable an underwater robot to locate a coral reef and a chunk of coral on the seabed and prompt the robot to pick it up. Although there is no literature on this particular problem, related work on fish counting may give some insight into the problem. The technical challenges are principally due to the potential lack of clarity of the water and platform stabilization as well as spurious artifacts (rocks, fish, and crabs). We present an efficient sparse classification for coral species using supervised deep learning method called Convolutional Neural Networks (CNNs). We compute Weber Local Descriptor (WLD), Phase Congruency (PC), and Zero Component Analysis (ZCA) Whitening to extract shape and texture feature descriptors, which are employed to be supplementary channels (feature-based maps) besides basic spatial color channels (spatial-based maps) of coral input image, we also experiment state-of-art preprocessing underwater algorithms for image enhancement and color normalization and color conversion adjustment. Our proposed coral classification method is developed under MATLAB platform, and evaluated by two different coral datasets (University of California San Diego's Moorea

Labeled Corals, and Heriot-Watt University's Atlantic Deep Sea). △ Less

Submitted 29 November, 2015; originally announced November 2015.

Comments: Thesis Submitted for the Degree of MSc Erasmus Mundus in Vision and Robotics (VIBOT 2014)

arXiv:1509.07979

[pdf, other] cs.CV

Anomaly Detection in Unstructured Environments using Bayesian Nonparametric Scene Modeling

Authors: Yogesh Girdhar, Walter Cho, Matthew Campbell, Jesus Pineda, Elizabeth Clarke, Hanumant Singh

Abstract: This paper explores the use of a Bayesian non-parametric topic modeling technique for the purpose of anomaly detection in video data. We present results from two experiments. The first experiment shows that the proposed

technique is automatically able characterize the underlying terrain, and detect anomalous flora in image data collected by an underwater robot. The second experiment shows that the same technique can be used on images from a static camera in a dynamic unstructured environment. In the second dataset, consisting of video data from a static seafloor camera capturing images of a busy coral reef, the proposed technique was able to detect all three instances of an underwater vehicle passing in front of the camera, amongst many other observations of fishes, debris, lighting changes due to surface waves, and benthic flora. △ Less

Submitted 15 February, 2016; v1 submitted 26 September, 2015; originally announced September 2015.

Comments: 6 pages, ICRA 2016

arXiv:1310.6767

[pdf, other] cs.RO

doi

10.1109/ICRA.2014.6906913

Curiosity Based Exploration for Learning Terrain Models

Authors: Yogesh Girdhar, David Whitney, Gregory Dudek

Abstract: We present a robotic exploration technique in which the goal is to learn to a visual model and be able to distinguish between different terrains and other visual components in an unknown environment. We use ROST, a realtime online spatiotemporal topic modeling framework to model these terrains using the observations made by the robot, and then use an information theoretic path planning technique to define the exploration path. We conduct experiments with aerial view and underwater datasets with millions of observations and varying path lengths, and find that paths that are biased towards locations with high topic perplexity produce better terrain models with high discriminative power, especially with paths of length close to the diameter of the world. △ Less

Submitted 24 October, 2013; originally announced October 2013.

Comments: 7 pages, 5 figures, submitted to ICRA 2014

arXiv:1605.01018

[pdf, other] cs.RO

A Solution to Time-Varying Markov Decision Processes

Authors: Lantao Liu, Gaurav S. Sukhatme

Abstract: We consider a decision-making problem where the environment varies both in space and time. Such problems arise naturally when considering e.g., the navigation of an underwater robot amidst ocean currents or the navigation of an aerial vehicle in wind. To model such spatiotemporal variation, we extend the standard Markov Decision Process (MDP) to a new framework called the Time-Varying Markov Decision Process (TVMDP). The TVMDP has a time-varying state transition model and transforms the standard MDP that considers only immediate and static uncertainty descriptions of state transitions, to a framework that is able to adapt to future time-varying transition dynamics over some horizon. We show how to solve a TVMDP via a redesign of the MDP value propagation mechanisms by incorporating the introduced dynamics along the temporal

dimension. We validate our framework in a marine robotics navigation setting using spatiotemporal ocean data and show that it outperforms prior efforts. △ Less

Submitted 25 January, 2018; v1 submitted 3 May, 2016; originally announced May 2016.

arXiv:1702.01848

[pdf, other] cs.RO

Data-Driven Learning and Planning for Environmental Sampling

Authors: Kai-Chieh Ma, Lantao Liu, Hordur K. Heidarsson, Gaurav S. Sukhatme

Abstract: Robots such as autonomous underwater vehicles (AUVs) and autonomous surface vehicles (ASVs) have been used for sensing and monitoring aquatic environments such as oceans and lakes. Environmental sampling is a challenging task because the environmental attributes to be observed can vary both spatially and temporally, and the target environment is usually

a large and continuous domain whereas the sampling data is typically sparse and limited. The challenges require that the sampling method must be informative and efficient enough to catch up with the environmental dynamics. In this paper we present a planning and learning method that enables a sampling robot to perform persistent monitoring tasks by learning and refining a dynamic "data map" that models a spatiotemporal environment attribute such as ocean salinity content. Our environmental sampling framework consists of two components: to maximize the information collected, we propose an informative planning component that efficiently generates sampling waypoints that contain the maximal information; To alleviate the computational bottleneck caused by large-scale data accumulated, we develop a component based on a sparse Gaussian Process whose hyperparameters are learned online by taking advantage of only a subset of data that provides the greatest contribution. We validate our method with both simulations running on real ocean data and field trials with an ASV in a lake environment. Our experiments show that the proposed framework is both accurate in learning the environmental data map and efficient in catching up with the dynamic environmental changes. △ Less

Submitted 28 March, 2018; v1 submitted 6 February, 2017; originally announced February 2017.

Comments: arXiv admin note: substantial text overlap with arXiv:1609.07560