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Editorial

Special issue "Autonomous Grasping"

This special issue of Robotics and Autonomous Systems is dedicated to recent developments on *Autonomous Grasping*. It is becoming clear that one keystone for the realization of robots carrying out accurate and intelligent tasks is their ability to handle autonomously all sorts of objects. Despite this topic being addressed periodically in robotics research over the last two decades, it remains a very challenging problem. Work in this field involves grasp planning and manipulation capabilities. The ease with which people skillfully handle objects to perform useful tasks has inspired recent developments of grasp planning and manipulation learning by demonstration algorithms, which this workshop aims at assessing.

This issue on *Autonomous Grasping* is the result from two previous workshops on *Grasp and Task Learning by imitation* organized by the authors at 2008 and 2010 editions of IEEE/RSJ International Conference on Intelligent RObots and Systems (IROS). The primary goal of these workshops was to bring together researchers working on integrating manipulation and learning, and also researchers from other disciplines interested in this subject. Both workshops gather robotic researchers working in robotic manipulation, task learning and replication of human grasping skills. These workshops were events for large audience to make them aware of the existing work and to make the techniques available for use in the wide field of potential applications. This special issue extends these previous initiatives and collects in a single place a set of advanced, high-quality papers that address the topic in robotics autonomous manipulation in many of its different perspectives — from geometric planning to totally bio-mimetic perspectives (see Table 1).

The first paper of this special issue, *An Overview of 3D Object Grasp Synthesis Algorithms,* by *Sahbani et al.,* presents a synthetic view of the current state of the art in grasping algorithm. Survey papers in grasping are already available in the literature but date back about ten years, since then an important progress has been made toward applying learning techniques to the grasping problem. This paper considers both analytical and learning approaches. The bibliography includes 72 entries, which is a valuable resource, especially for novel researchers in the field.

The following paper entitled *On the Manipulability Ellipsoids of Underactuated Robotic Hands with Compliance, by Prattichizzo et al.*, analyzes the human hand kinematic model using the force manipulability analyses of underactuated robotic hands from the view point of postural hand synergies. Postural hand synergies reduce the number of actuated joints to be controlled in a desired task. Indexes for evaluating the manipulability of robotics hands are proposed and validated through two examples.

The paper entitled *Efficient Models for Grasp Planning With A Multi-fingered Hand*, by *Saut & Sidobre*, presents a method for computing grasping poses for a human-like hand to grasp a rigid object using random sampling and feasibility testing. Various pre-computations, in particular regarding the workspace of the fingers, are used to accelerate the process.

In their paper *A 3D Shape Segmentation Approach for Robot Grasping by Parts, Aleotti & Caselli*, address the problem of grasp planning driven by a shape segmentation approach, which divides objects in different parts using the Reeb-graph technique. The main idea is that the equivalent parts grasp objects with the same topological structure. Experiments performed in a simulated environment on a reasonably large dataset show the potential of topological segmentation to highlight candidate parts suitable for grasping.

In the fifth paper of this special issue, entitled *A Toolbox for Box-based Approximation, Decomposition and Grasping, Kai Huebner* presents the BADGr toolbox developed in the framework of The European project PACO-PLUS. The main idea is to formalize and learn relation between objects and actions. The BADGr integrates specific software modules used in solving different aspects of high-level task-related grasp planning. Problems related to shape approximation, object recognition, grasp hypotheses, representation and control of gripper can be solved using BADGr. Simulation experiments are performed on a CAD model to illustrate the various steps of the proposed approach.

The paper entitled *A Real-time Strategy for Dexterous manipulation: Fingertips Motion Planning, Force Sensing and Grasp Stability, by Daoud* et al., presents a description of control and sensing implementations for an anthropomorphic robot hand. The originality of this approach is mainly the use of neural networks for planning the required grasping and re-grasping actions. Solving the problem of grasp synthesis, and specifically forces computation, through this new approach has conducted to real-time results.

In their paper *Autonomous Grasp and Manipulation Planning using a ToF Camera, Xue et al.* propose a novel approach combining range sensors and impedance control to cope with grasping and manipulation problems. The motion of a robotic arm and fingers is planned through information provided by a time-of-flight camera placed above the robot workspace. Different applications are presented showing the effectiveness of the proposed method.

Faria et al., in their paper entitled *Extracting data from human manipulation of objects toward improving autonomous robotic grasping*, consider the problem of how humans manipulate daily object, and construct a probabilistic representation model for the task and the objects. The experimental results show that

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Table 1
RAS – special issue "Autonomous Grasping" table of contents.

Paper order	ID	Title	Authors
1.	ROBOT-D-11-00052R1	An Overview of 3D Object Grasp Synthesis Algorithms	A. Sahbani, S. El-Khoury, P. Bidaud
2.	ROBOT-D-11-00063R1	On the Manipulability Ellipsoids of Underactuated Robotic Hands with Compliance	D. Prattichizzo, M. Malvezzi, M. Gabiccini, A. Bicchi
3.	ROBOT-D-11-00046R1	Efficient Models for Grasp Planning With A Multi-fingered Hand	J.-P. Saut, D. Sidobre
4.	ROBOT-D-11-00044R1	A 3D Shape Segmentation Approach for Robot Grasping by Parts	J. Aleotti, S. Caselli
5.	ROBOT-D-11-00035R1	BADGr — A Toolbox for Box-based Approximation, Decomposition and Grasping	K. Huebner
6.	ROBOT-D-11-00034R1	A Real-Time Strategy for Dexterous Manipulation: fingertips motion planning, force sensing and grasp stability	D. Nael, J.-P. Gazeau, S. Zeghloul, M. Arsicault
7.	ROBOT-D-11-00064R1	Autonomous Grasp and Manipulation Planning using a ToF Camera	Z. Xue, S. Ruehl, A. Hermann, T. Kerscher, R. Dillman
8.	ROBOT-D-11-00054R1	Extracting Data From Human Manipulation of Objects Towards Improving Autonomous Robotic Grasping	D.R. Faria, R. Martins, J. Lobo, J.M. Dias
9.	ROBOT-D-11-00056R1	Templates for Pre-grasp Sliding Interactions	D. Kappler, L. Chang, N.S. Pollard, T. Asfour, R. Dillman
10.	ROBOT-D-11-00053R1	Coupled Dynamical System Based Arm-Hand Grasping Model for Learning Fast Grasping Strategies	A. Shukla, A. Billard
11.	ROBOT-D-11-00028R1	Robotic Grasping and Manipulation Through Human Visuomotor Learning	B. Moore, E. Oztop
12.	ROBOT-D-11-00055R1	Active Learning of Visual Descriptors for Grasping Using Non-Parametric Smoothed Beta Distributions	L. Montesano, M. Lopes
13.	ROBOT-D-11-00050R1	Visual Programming by Demonstration of Grasping Skills in the context of a mobile service robot using 1D-Topology based Self-Organizing-Maps	M. Hušer, J. Zhang
14.	ROBOT-D-11-00045R1	A biomimetic reach and grasp approach for mechanical hands	F. Touvet, N. Daoud, J.-P. Gazeau, S. Zeghloul; M.A. Maier, S.T. Eskiizmirliler

manipulation tasks may be presented at the trajectory level by motion patterns using a feature-based approach. They also demonstrate that a sensor based volumetric map of the object can be a useful framework to estimate candidate points for stable grasps.

In the paper entitled *Templates for pre-grasp sliding interactions, Kappler et al.* present a framework for representing and synthesizing examples of pre-grasp interaction. This interaction can improve grasping success by making desired grasps reachable. In this article the authors present a framework for synthesizing pre-grasp interactions for high-dimensional anthropomorphic manipulators. The motion planning became simpler since information from pre-grasp manipulation examples reduces the search space to promising hand poses and shapes. The template information allows focusing search based on the object features to template poses and decreasing the planning time.

In the tenth paper *Coupled dynamical system based arm-hand grasping model for learning fast grasping strategies, Shukla & Billard* propose a novel approach for learning the grasping and reaching motions from human demonstrations. The authors perform Gaussian mixture models on the training data and use them for inference. The proposed method is presented at a general level and quantitatively evaluated in simulation and on a real iCub robot.

Moore & Oztop, in their paper entitled *Robotic Grasping and Manipulation Through Human Visuomotor Learning*, consider the problem of transmitting skills from humans to robots. In the first part the authors evaluate the time it takes for the human to learn how to interact and guide the robot. The second part is dedicated to the evaluation of the fact that the human through his/her training will teach implicitly some particular means to solve task.

The following paper entitled *Active Learning of Visual Descriptors for Grasping using Non-Parametric Smoothed Beta Distributions*, by *Montesano & Lopes, proposes an algorithm for actively learning a probabilistic grasp model.* The algorithm combines Binomial-Beta distributions and a non-parametric kernel approach to provide the full distribution for the probability of grasping. It is evaluated using synthetic dataset and real data obtained with a humanoid robot.

Hüser & Zhang, in their paper entitled *Visual Programming by Demonstration of Grasping Skills in the context of a mobile service robot using 1D-Topology based Self-Organizing-Maps*, consider the problem of Learning skills from demonstration. They propose an original approach of visual programming by demonstration of grasping skills where a mobile service robot is taught by a human instructor how to grasp specific objects. A Self-Organizing-Map with a one-dimensional topology is used to compensate tracking errors and instructor's demonstration inaccuracy. The approach is evaluated on the TASER robot using both synthetic and real world data.

In the last paper, *A biomimetic Reach and Grasp Approach for Mechanical Hands, Touvet et al.* consider the anthropomorphic concepts in the development of planners and controllers rather then at the mechanical design level. The authors propose architecture based on Matching Units (MU) to implement the reach and grasp task. The functions developed by the MUs are inspired from different models of the central nervous system (CNS). The authors claim that the MUs are able to relate sensory and motor information in an analogous way as the CNS. The proposal is implemented in a robotic system composed by a 6 dofs arm and a 16 dofs robotic hand.

Acknowledgments

The collection of papers from this special edition is consequence of a workshop on "Grasp Planning and Task Learning by Imitation". The IEEE International Conference Robotics and Systems (IROS 2010) in October 18, 2010 included this workshop in the program and a selected set of revised and extended papers were invited for this special issue.

The present Special Issue is the result from a review process on 17 submissions originated from the workshop and from invited submissions from of which, 13 were accepted after a two-stage reviewing process. The review process was supported by a guest editorial board, whose members are as given below.

The dedicated work of these colleagues was crucial in selecting the best submissions and in interacting with the authors to improve their submissions. The editors of this issue would like to give their sincere thanks to all of them.

The Guest Editors wish to express their gratitude to Rüdiger Dillman, The *RAS* Editor in chief, for his strong support for this special issue. They would also like to thank Salai Kulamani Birlasekar, Jing Xu and Christine Brand, for their fantastic timely support on many fronts. They are also grateful to the member of the organizing committee and guest editorial board for their effort in managing the review process of the papers that appear in this special issue.

Guest editors
Jorge Dias
Institute of Systems and Robotics, University of Coimbra, Portugal

Anis Sahbani *
Institute of Intelligent Systems and Robotics,
Pierre and Marie Curie University, France
E-mail address: anis.sahbani@upmc.fr.

Lakmal Seneviratne
Centre for Robotics Research, King's College London, United Kingdom

Said Zeghloul
Institute P', Poitiers University, France

Jianwei Zhang
Technical Aspects of Multimodal Systems Institute,
University of Hamburg, Germany

* Corresponding editor.