Chapter 10 summarizes the DDT Project. The authors list the most important points for all of the different types of robots and the contributions of the DDT Project. This large and varied project helped to establish the field of rescue robots. They also point toward the importance of integrating industry, government, and research together to provide the best potential for lessening the toll a disaster will wreak on human life and well-being. With explicit diagrams, photographs, and graphs to fill out the clearly written descriptions, this book is an important resource for anyone working in this vital area.

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Introduction to Autonomous Manipulation: Case Study with an Underwater Robot, SAUVIM

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London, England,
2014, 174 pages.

One of the most important aspects of disaster robotics is the ability to act in an unstructured environment, possibly without intervention from a human operator. *Introduction to Autonomous Manipulation* delves into this challenging topic, presenting solutions through a careful case study in underwater robotics, a project called *the semiautonomous underwater vehicle for intervention missions* (*SAUVIM*).

Chapter 1 provides an introduction to autonomous manipulation on a moving base such as an underwater robotic vehicle. It discusses the motivation for having the option to move away from high-bandwidth, human-supervised manipulation in some situations but not in others. It gives a good overview of what has been done in this area, especially from a project-based perspective. The authors present their opinion about what the most important sensors are for autonomous manipulation.

Chapter 2 details an overview of the basis in the kinematics, dynamics, and geometry of multibody systems. The authors begin with basic mathematical operations and proceed to present coordinate system representations, operations, and methods of describing a robotic structure, its kinematics, and its dynamics. The authors do an excellent job of presenting what is needed as an overview, without getting bogged down in too much detail (which exists elsewhere in numerous texts). However, they provide references for the interested reader to go beyond what is presented here. The authors opt to provide a sparse reference section at the end of this chapter to avoid overly distracting the reader. Some of the reference sections are more extensive as needed.

Chapter 3 covers kinematic control. The human operator should be able to control the manipulation process with only high-level commands. The robot determines what joint trajectories need to be followed for successfully achieving goals. The authors discuss task-oriented control and the natural exploitation of a hierarchical control structure being useful for high-level commands versus low-level control processes. They present some caveats, such as singularities, where manipulators can orient in ways that unique solutions to matrix problems do not exist, and how to avoid them. Additionally, successfully addressing multiple tasks of varying priorities is derived mathematically. The key in their methodology lies in avoiding singular configurations with shape functions that keep the system some defined distance away from such problem states. The conservativeness of the distance can be adjusted parametrically (and simply), making this a very practical approach. One thing that the authors do an excellent job of in this chapter is the definition of measures. It is key in manipulation to have measures from which to generate useful motions. The final section of this chapter discusses the results from the application to the control of the underwater—the Manipolatore Antropomorfo per Interventi Sottomarini 7080.

Chapter 4 discusses the modeling of the SAUVIM vehicle-manipulator system. For any robot that will act in uncertain environments, it is important to have a good model of the system to build a useful control system. They discuss automation of the problem, that high-dimensional problems require automation of the procedures to generate the kinematic and dynamic equations of motion. The identification of relevant parameters is performed in real time with an extended Kalman filter. The results from a successful simulation and implementation are presented.

Chapter 5 lays out a strategy for target localization using dual frequency identification sonar and other sensors. The merging of heterogeneous sensor data for different object distances is a useful aspect to the techniques presented in this chapter. At close range, camera, laser, and motion tracking technologies can augment sonar. Cameras and lasers have disadvantages in terms of low visibility at ocean depths and the need for a light source, whereas motion tracking technologies have advantages if the target can be coupled with a motion-tracking marker of some type by human intervention. This semiautonomous manipulation strategy can be very effective. Video processing is also discussed, along with a successful practical application example.

Chapter 6 presents the SAUVIM main software framework that allows the authors to run all the applications. It consists of a front seat/back seat

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paradigm for real-time control. Basically this amounts to a low-level, real-time, hardware-based control and a high-level control that is not guaranteed to be real time. They follow the same approach as in the National Aeronautics and Space Administration/National Bureau of Standards Standard Reference Model Telerobot Control System architecture, breaking the problem down into six basic elements: 1) actuators, 2) sensors, 3) sensory processing, 4) world modeling, 5) behavior generation, and 6) value judgment. These are integrated into a multilevel hierarchical structure. Finally, the authors describe an underwater object recovery mission application demonstration of their system. Each phase was successfully completed with no human intervention.

The conclusion of this book describes the careful addressing of issues that appear repeatedly in autonomous robotic manipulation (of all areas). These are target area navigation, vehicle positioning, and arm control systems.

Although there are many open issues for fully autonomous robots capable of handling unstructured environments and missions, this book provides an insightful big-picture approach that could be applied to many problems. Robotic systems capable of operating autonomously in disasters and emergencies will need this type of complete solution strategy. This book is a step in the right direction toward addressing this increasingly pressing need.

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FROM THE GUEST EDITORS *(continued from p. 20)*

prosthesis to achieve biologically accurate kinematics and kinetics across different walking speeds, without the need for speed- or patient-specific tuning. Results from walking experiments are reported to show the effectiveness of the proposed control approach.

There are many ongoing initiatives dedicated to wearable robotics, including conferences, special issues, and international workshops. All of them demonstrate the growing interest in the topic. Overcoming the physical limits of the body, whether natural, age-induced, or caused by diseases or traumatic events, with temporary or permanent effects, is an actual societal need. Finally, considering its highly inter- and transdisciplinary nature, the value of wearable robotics for the education of young engineers should not be overlooked.

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References

[1] R. K. Aaron, H. M. Herr, D. M. Ciombor, L. R. Hochberg, J. P. Donoghue, C. L. Briant, J. R. Morgan, and M. G. Ehrlich, "Horizons in prosthesis development for the restoration of limb function," *J. Amer. Acad. Orthopaedic Surgeons*, vol. 14, no. 10, pp. S198–S204, 2006.

[2] B. Dellon and Y. Matsuoka, "Prosthetics, exoskeletons, and rehabilitation [Grand Challenges of Robotics]," *IEEE Robot. Autom. Mag.*, vol. 14, no. 1, pp. 30–34, 2007.

[3] A. M. Dollar and H. Herr, "Lower extremity exoskeletons and active orthoses: Challenges and state-of-the-art," *IEEE Trans. Robot.*, vol. 24, no. 1, pp. 144–158, 2008.

[4] H. Herr, "Exoskeletons and orthoses: Classification, design challenges and future directions," *J. NeuroEng. Rehab.*, vol. 6, no. 21, pp. 1–9, 2009.

[5] H. Kazerooni, "Exoskeletons for human performance augmentation," in *Springer Handbook of Robotics*, B. Siciliano and O. Khatib, Eds. New York: Springer, 2008, pp. 773–794.

[6] M. Bergamasco, B. Allotta, L. Bosio, L. Ferretti, G. Parrini, G. M. Prisco, F. Salsedo, and G. Sartini, "An arm exoskeleton system for teleoperation and virtual environments applications," in *Proc. IEEE Int. Conf. Robotics Automation*, May 8–13, 1994, vol. 2, pp. 1449–1454.

[7] H. Herr and A. Wilkenfeld, "User-adaptive control of a magnetorheological prosthetic knee," *Ind. Robot: Int. J.*, vol. 30, no. 1, pp. 42–55, 2003.

[8] J. E. Pratt, B. T. Krupp, C. J. Morse, and S. H. Collins, "The RoboKnee: An exoskeleton for enhancing strength and endurance during walking," in *Proc. IEEE Int. Conf. Robotics Automation*, 26 Apr.–1 May 2004, vol. 3, pp. 2430–2435.

[9] H. Kazerooni, J.-L. Racine, L. Huang, and R. Steger, "On the control of the berkeley lower extremity exoskeleton (BLEEX)," in *Proc. IEEE Int. Conf. Robot. Autom.*, Apr. 18–22, 2005, pp. 4353–4360.

[10] F. Sup, A. Bohara, and M. Goldfarb, "Design and control of a powered transfemoral prosthesis," *Int. J. Robot. Res.*, vol. 27, no. 2, pp. 263–273, 2008.

[11] L. Zollo, S. Roccella, E. Guglielmelli, M. C. Carrozza, and P. Dario, "Biomechatronic design and control of an anthropomorphic artificial hand for prosthetic and robotic applications," *IEEE/ASME Trans. Mechatron.*, vol. 12, no. 4, pp. 418–429, 2007.

[12] C.-J. Yang, J.-F. Zhang, Y. Chen, Y.-M. Dong, and Y. Zhang, "A review of exoskeleton-type systems and their key technologies," in *Proc. Inst. Mech. Eng., Part C: J. Mech. Eng. Sci.*, vol. 222, no. 8, pp. 1599–1612, 2008.

[13] H. S. Lo and S. Q. Xie, "Exoskeleton robots for upper-limb rehabilitation: State of the art and future prospects," *Med. Eng. phys.*, vol. 34, no. 3, pp. 261–268, 2012.

[14] R. Bogue, "Exoskeletons and robotic prosthetics: a review of recent developments," *Ind. Robot: Int. J.*, vol. 36, no. 5, pp. 421–427, 2009.

[15] F. Jabr, "Mind-controlled prosthetics to help amputees," *New Scientist*, vol. 210, no. 2810, p. 11, Apr. 30, 2011.

[16] H. Thomson, "Get your move on," *New Scientist*, vol. 218, no. 2920, p. 19, June 8, 2013.

[17] C. Barras, "Man controls new prosthetic leg using thought alone," *New Scientist*, vol. 220, no. 2937, p. 14, Oct. 5, 2013.

[18] H. Hodson, "Lifting big," *New Scientist*, vol. 223, no. 2980, p. 1, Aug. 2, 2014.