Robotica (2000) volume 18, pp. 1–2. Printed in the United Kingdom © 2000 Cambridge University Press

INTRODUCTION TO THE SPECIAL MILLENNIUM ISSUE ON GRASPING AND MANIPULATING

Sugaru Arimoto

Department of Robotics, Ritsumeikan University, 1-1-1 Nojihigashi, Kusatsu, Shiga, 525–77 (Japan)

At the end of the 20th century robot technology became well established as a reliable and economic source in industrial automation. On the other hand, it is claimed that even a general six or seven degree of freedom robot arm or a multifingered robot hand designed carefully and manufactured with very high precision lacks versatility in its use in a variety of tasks that must be done instead of a human. The lack of versatility or the clumsiness of present industrial robots is not due to the fine mechanism of such robots. Rather, the clumsiness shows a lack of our knowledge of everyday physics, in particular, a lack of knowledge of physics involving grasping and handling of various kinds of things and manipulating them with certain dexterity, in which tactile and vision sensings must be well coordinated.

The aim of this special issue is to collect challenging research papers that reflect the state of the art of "grasping and manipulation" at the beginning of the new millennium. It consists of eight invited papers:

1. S. Hirai and T. Wada, "Indirect Simultaneous Positioning of Deformable Objects with Multi Fingers Based on an Uncertain Model".

   A novel control law for indirect simultaneous positioning of a deformable object is proposed, where multiple points on the object should be guided simultaneously. It is found that its modeling is indispensable in positioning but an uncertain, roughly identified model is applicable due to the robustness of the proposed control law.

2. S. Kawamura, H. Kino and C. Won, "High Speed Manipulation by Using Parallel Wire Driven Robots".

   A new type of parallel wire driven robot proposed for realizing high speed manipulation and motion stability of robots is analyzed by using a Lyapunov function. The paper reports that ultra-high speed with more than 40g (g: gravitational acceleration) can be attained by using relatively small actuators.

3. A. Bicchi and D. Prattichizzo, "Analysis and Optimization of Tendinous Actuation for Biomorphically Designed Robotic Systems".

   A general framework for modeling a class of mechanical systems for robotic manipulation is presented, which consist of articulated limbs with redundant tendinous and unilateral constraints. The previous analysis of force distribution in multiple whole-limb manipulation is generalized to provide a basis for the control of co-contraction and internal forces that guarantee a proper operation of the system.

4. H. Kawarazaki, T. Hasegawa and K. Nishihara, "A Heuristic Approach to Grasp Planning for a Multi-Fingered Hand-Arm Robot Based on the Structure of Empty Space".

   Grasp planning for a multi-fingered hand-arm robot in the presence of obstacles is proposed. In addition to a proposal of two methods called "hand-configuration method" (HCM) and "arm-configuration method" (ACM), several heuristics are used in order to generate the grasp configuration rapidly.

5. Y. Yamada, H. Morita and Y. Umetani, "Slip Phase Isolating: Impulsive Signal Generating Vibrotactile Sensor and its Application to Real-Time Object Regrip Control".

   A vibrotactile sensor capable of generating high-frequency signals is developed for exclusively distinguishing a slip phase from various other contact phases. A slip phase isolating the function of the sensor is verified and an object regrip control in real-time is demonstrated.

6. D. Ding and Y.H. Liu, "The Synthesis of 3-D Form-Clousure Grasps".

   A new formulation of computing three-dimensional form-closure grasps of into robotic fingers is presented. A recursive reduction technique to transform the complicated problem in 6-D space into a simpler 3-D one is proposed and then, according to the linear inequality theory, the problem is transformed into searching for a set of points which ensure the inconsistency of each of the two linear inequality systems.

7. M.M. Svinin, K. Ueda and M. Kaneko, "On the Liapunov Stability of Multi-Finger Grasps".

   The paper deals with the stability of a rigid body under multiple contact forces. By considering the problem at the force planning level, the stability of a force distribution is defined and the stability conditions are established in an analytical form in terms of so-called L-S-V coefficients. The paper also shows how to obtain these conditions for the feedback stabilization.

8. S. Arimoto, P.T.A. Nguyen, H.Y. Han and Z. Doulgeri, "Dynamics and Control of a Set of Dual Fingers with Soft Tips".

   Dynamics of a mechanical hand composed of dual fingers with soft and deformable tips are derived and a

https://doi.org/10.1017/S0263574799002416 Published online by Cambridge University Press

passivity analysis of the dynamics is presented. Design problems of control for dynamics stable grasping and enhancing dexterity in manipulating things are discussed together with a list of future research subjects on dexterous manipulation by soft fingers.

To sum up, it may be seen from the papers selected for this special millennial issue that there are still vast research regions related to everyday physics, such as grasping and manipulation of objects, that remain unexplored by scientists and engineers.

https://doi.org/10.1017/S0263574799002416 Published online by Cambridge University Press