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Comment

Learning in robotic manipulation: The role of dimensionality reduction in policy search methods
Comment on "Hand synergies: Integration of robotics and neuroscience for understanding the control of biological and artificial hands" by Marco Santello et al.

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A question that often arises, among researchers working on artificial hands and robotic manipulation, concerns the real meaning of synergies. Namely, are they a realistic representation of the central nervous system control of manipulation activities at different levels and of the sensory-motor manipulation apparatus of the human being, or do they constitute just a theoretical framework exploiting analytical methods to simplify the representation of grasping and manipulation activities? Apparently, this is not a simple question to answer and, in this regard, many minds from the field of neuroscience and robotics are addressing the issue [1]. The interest of robotics is definitely oriented towards the adoption of synergies to tackle the control problem of devices with high number of degrees of freedom (DoFs) which are required to achieve motor and learning skills comparable to those of humans. The synergy concept is useful for innovative underactuated design of anthropomorphic hands [2], while the resulting dimensionality reduction simplifies the control of biomedical devices such as myoelectric hand prostheses [3]. Synergies might also be useful in conjunction with the learning process [4]. This aspect is less explored since few works on synergy-based learning have been realized in robotics. In learning new tasks through trial-and-error, physical interaction is important. On the other hand, advanced mechanical designs such as tendon-driven actuation, underactuated compliant mechanisms and hyper-redundant/continuum robots might exhibit enhanced capabilities of adapting to changing environments and learning from exploration. In particular, high DoFs and compliance increase the complexity of modelling and control of these devices. An analytical approach to manipulation planning requires a precise model of the object, an accurate description of the task, and an evaluation of the object affordance, which all make the process rather time consuming. The integration of learning into control naturally leads to relaxing the above requirements through the adoption of coordinated motion patterns and sensory-motor synergies as useful tools leading to a problem of reduced dimension. To this purpose, model-based control strategies relying on synergistic models of manipulation

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activities learned from human experience can be integrated with real-time learning from actions strategies [5]. In [6] a classification of learning strategies for robotics is provided, while the difference between imitation learning and reinforcement learning (RL) is highlighted in [7]. From recent research in the field [8,9], it seems that RL represents the future toward autonomous and intelligent robots since it provides learning capabilities as those of humans, i.e. based on exploration and trial-and-error policies. In this context, suitable policy search methods to be implemented in a synergy-based framework are to be sought in order to reduce the search space dimension while guaranteeing the convergence and efficiency of the learning algorithm.

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References

[1] Santello M, Bianchi M, Gabiccini M, Ricciardi E, Salvietti G, et al. Hand synergies: integration of robotics and neuroscience for understanding the control of biological and artificial hands. Phys Life Rev 2016;17:1–23 [in this issue].
[2] Catalano MG, Grioli G, Farnioli E, Serio A, Piazza C, Bicchi A. Adaptive synergies for the design and control of the Pisa/IIT SoftHand. Int J Robot Res 2014;33:768–82.
[3] Ison M, Artemiadis PK. Proportional myoelectric control of robots: muscle synergy development drives performance enhancement, retainment, and generalization. IEEE Trans Robot 2015;31:259–68.
[4] Ficuciello F, Palli G, Melchiorri C, Siciliano B. Postural synergies and neural network for autonomous grasping: a tool for dexterous prosthetic and robotic hands. In: Pons J, et al., editors. Converging clinical and engineering research on neurorehabilitation, biosystems & biorobotics. Heidelberg: Springer; 2013. p. 467–80.
[5] Schaal S, Atkeson C. Learning control in robotics. IEEE Robot Autom Mag 2010;17(2):20–9.
[6] Sahbania A, El-Khouryc S, Bidaud P. An overview of 3D object grasp synthesis algorithms. Robot Auton Syst 2012;60(3):326–36.
[7] Kormushev P, Calinon S, Caldwell D. Reinforcement learning in robotics: applications and real-world challenges. Robotics 2013;2:122–48.
[8] Tsagarakis NG, Metta G, Sandini G, Vernon D, Beira R, Becchi F, et al. iCub: the design and realization of an open humanoid platform for cognitive and neuroscience research. Adv Robot 2007;21:1151–75.
[9] Kormushev P, Calinon S, Caldwell D. Robot motor skill coordination with EM-based reinforcement learning. In: Proc. IEEE/RSJ international conference on intelligent robotics systems. 2010. p. 3232–7.