Preface

Industrial robots carry out simple tasks in customized environments for which it is typical that nearly all effector movements can be planned during an off-line phase. A continual control based on sensory feedback is at most necessary at effector positions near target locations utilizing torque or haptic sensors. It is desirable to develop new-generation robots showing higher degrees of autonomy for solving high-level deliberate tasks in natural and dynamic environments. Obviously, camera-equipped robot systems, which take and process images and make use of the visual data, can solve more sophisticated robotic tasks. The development of a (semi-) autonomous camera-equipped robot must be grounded on an infrastructure, based on which the system can acquire and/or adapt task-relevant competences autonomously. This infrastructure consists of technical equipment to support the presentation of real world training samples, various learning mechanisms for automatically acquiring function approximations, and testing methods for evaluating the quality of the learned functions. Accordingly, to develop autonomous camera-equipped robot systems one must first demonstrate relevant objects, critical situations, and purposive situation-action pairs in an experimental phase prior to the application phase. Secondly, the learning mechanisms are responsible for acquiring image operators and mechanisms of visual feedback control based on supervised experiences in the task-relevant, real environment.

This paradigm of learning-based development leads to the concepts of compatibilities and manifolds. Compatibilities are general constraints on the process of image formation which hold more or less under task-relevant or accidental variations of the imaging conditions. Based on learned degrees of compatibilities, one can choose those image operators together with parametrizations, which are expected to be most adequate for treating the underlying task. On the other hand, significant variations of image features are represented as manifolds. They may originate from changes in the spatial relation among robot effectors, cameras, and environmental objects. Learned manifolds are the basis for acquiring image operators for task-relevant object or situation recognition. The image operators are constituents of task-specific, behavioral modules which integrate deliberate strategies and visual feedback control. The guiding line for system development is that the resulting behaviors should meet requirements such as task-relevance, robustness, flexibility, time limitation, *etc.* simultaneously. All principles to be presented in the work are based on real scenes of man-made objects and a multi-component robot system consisting of robot arm, head, and vehicle. A high-level application is presented that includes sub-tasks such as localizing, approaching, grasping, and carrying objects.

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