Arbitrary Task Execution through System Dynamics Identification

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The Problem: Development of techniques to identify both stationary and dynamic objects in a scene, to learn their dynamics and to manipulate them.

Motivation: Ideally, robots should be able to recognize a dynamical system and learn how to control it, independently of its complexity. This framework might then be applied to functional object recognition, i.e. the identification of objects by their function.

Previous Work: Previous research on systems modelling for robotic manipulation focused on learning the model given the order of the dynamical system. Different strategies are usually applied according to the problem to be solved, [1]. Since the robot has to be set-up for each new task, the overall process is not automated. For the recovery of an object’s motion, previous work focused on mapping 3D segments reconstructed using stereo [3].

Approach: Our approach, instead of separating the object recognition and model dynamics learning problems, focuses on a common framework for both of them.

Objects can be recognized by function - Functional object recognition - which is being implemented by first applying tuned frequency filters, that segment objects in the image with the frequency content of the optical flow concentrated on a local area of the frequency spectrum. In addition, we are also applying wavelets to the optical flow map, since wavelets provide information in both time and frequency domains. Thus, the tuned frequency filters strategy can be extended for the detection of events in time. The dynamics of a linear system can be completely recovered from the frequency and phase shift of the output, by applying a finite number of sinusoidal inputs to the actuator (for example the robotic arm). The actuator is detected using skin detection, or by selecting the regions of the image tuned to a specific frequency.

We are applying locally affine models to learn the non-linear dynamics of cog’s arm (six degrees of freedom). We are controlling the arm using a sliding-modes controller (low level control), and using the same learning scheme to model the dynamics of the controlled system (after kinematics identification). The high level control is implemented by an optimal controller. Other possible approach consists of learning some model characteristics, and then turning the problem into a classification scheme.

Figure 1: The humanoid robot Cog manipulating an object (left) and object segmented using frequency tuned filters (right).
We are also investigating the usefulness of wavelets \cite{2} for integrating oscillatory and non-oscillatory tasks, or mixtures of both, so that tasks can be communicated to the robot with simultaneous frequency and spatial desired contents.

**Impact:** The execution of complex tasks often requires coordinating smaller tasks, and the flexibility thus achieved will extend largely the range of applications to which robotics is currently applied.

**Future Work:** We plan to develop the algorithms to impose the rigidity and kinematic constraints, and then implement the model learning scheme.

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**References:**

