How Industrial Robots Benefit from Affordances

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Abstract. In this paper we discuss the potential of Gibson's affordance concept in industrial robotics. Recent advances in robotics introduce more and more robots to collaborate with human co-workers in industrial environments, more ambitious development of using mobile manipulators in industrial environments has also received widespread attentions. We investigate how the conventional robotic affordance concept fits the pragmatic industrial robotic applications with the focuses on flexibility, re-purposing and safety.

1 Why Affordances

Majority of today's industrial robots operating in factories are attached to a fixed basement, operate on the various parts passing through a production line. Although they can be reprogrammed with a teach pendant, in many applications (particularly those in the automotive industry) they are programmed once and then fixed behind metal fences, where they repeat that exact same task for years. In recent years, however, collaborative robots have received more attention in manufacturing industry as they can safely work together with human workers in efficient new ways, e.g. to perform the task that requires a robot to do the physical labor while a person does quality-control inspections. High **complexity and uncertainty** of system caused by dealing with a large number of objects, requirement of **fast re-purposing and deployment** for new or swapped tasks and **safety** awareness are three major challenges that are consequent on the utilization of collaborative robots in industry.

The concept of affordances has been coined by J.J. Gibson [1] in his seminal work on the ecological approach to visual perception. Although there are several attempts to formalize the theoretical concept (see [2] for an overview), the idea of a relationship combining *perception*, *action* and *outcome* is innate to most approaches and first formalized in [3]. Mapping the concept of affordance into the domain of industrial robotics could

– reduce the uncertainty and complexity caused by a large number of objects and objects in arbitrary positions/poses in human involved collaboration;

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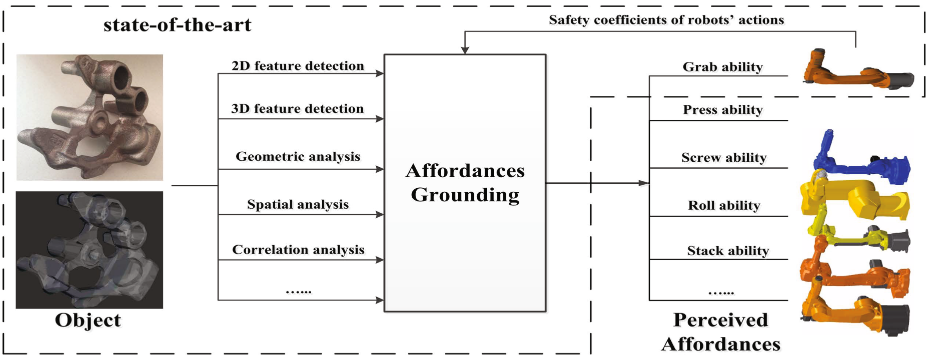

Fig. 1. Schema of using affordances for industrial robotic applications: differing with the traditional affordance-based robotic grasping applications which use one configuration of robot/end effector to handle various objects, we select the most suitable robot/end effector according to the object and its affordable actions.

- increase the flexibility and fast re-purposing of tasks, since affordances naturally rely on actors' abilities and the grounded affordances of object provide attached information about which tool/robot should be used to do various actions;
- provide an alternative safety concept since affordances are always related to actions, which can be assigned to different safety evaluations according to the control parameters of these actions.

Therefore, we propose a new systematic schema, which mediates information of perceived object (e.g. 2D/3D features, geometrical characters etc.) and safety awareness data of actions that could be executed by different robots/end-effectors, to produce perceived affordances that can be safely and effectively used by industrial robots (Fig. 1).

2 How to Use Affordance for Industrial Robotics

While the state-of-the-art affordance-driven robotic grasping is focusing on the solution to find the best grasp points of various objects, we in contrast use affordance to help our industry partners to decide which robot/end effectors are the most suitable for manipulating the specific object in their application (Fig. 2). Also the affordance based evaluation of robot/end effector combinations can provide customers both quantitative and qualitative measurements, thereby facilitating the most suitable solution for trade off hardware cost and system productivity.

For several industrial applications, particularly for the applications involving large part manufacturing such as aerospace industry or shipbuilding industry, large parts are worked on in a stationary production cell. In such a production

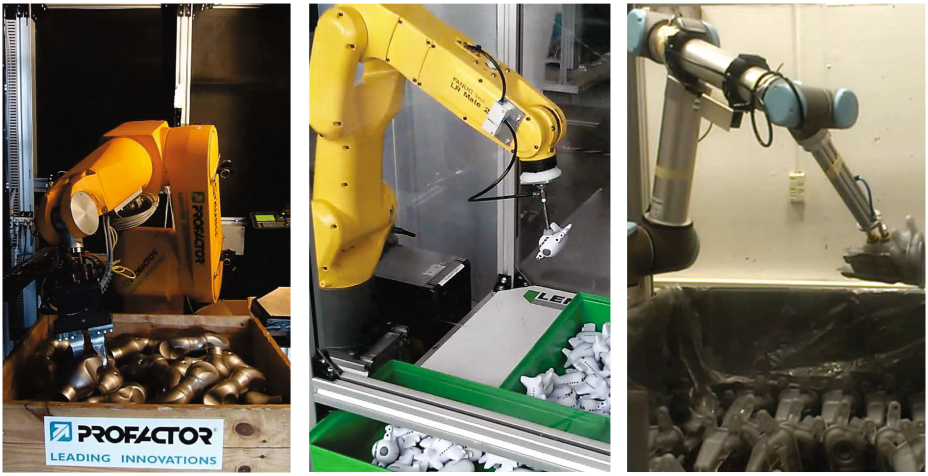

Fig. 2. Various robots/end effectors designed by PROFACTOR GmbH, are picking different objects, systems are designed according to the affordances (based on shape, material, weight etc.) of the objects it faces on.

environment, specialized, stationary robotic systems are not economical and a mobile manipulator is desirable [4]. These mobile manipulators with tool changer can benefit from affordance-based end effector selection when cost of changing tool and safety coefficient of actions are taken into account, i.e. use affordance to evaluation the successful rate of executing one specific action with various end effectors thereby deciding if the tool changing behavior is required at the present time.

Modern vision-based algorithms for feature detection or character analysis normally have quality estimation outputs as part of their results[5]. These quality estimation values can be used in a unified probabilistic framework to discover a best holistic solution [6][7]. We plan to expand this probabilistic framework by combining quality of object analysis/detections and safety estimation of using various robots/end-effectors/tools to execute different action tasks. The maximization of the joint probability will find the safest and most reliable affordance of object which can be manipulated with one specific robotic hardware configuration. Following the work of modeling affordances using Bayesian Network [8], we further include the successful rate of using different tools/robots/end-effectors for various execution tasks, to make the system able to decide whether it requires to change the tool or not, as industrial robots usually are equipped with many tools in order to perform various tasks. Future optimization of tool change frequencies and workflow could also be developed based on this probabilistic framework.

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