How Industrial Robots Benefit from Affordances

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Abstract. Usually industrial robots have been fixed to one physical location and stay behind the separating fences to repeat one specific task. This is one reason that industrial robotic communities haven't drawn attention to affordances or any other high-level cognitive concepts. However, this situation is changing recently when more robots are introduced into industrial environments to collaborate with human co-workers, or even more ambitious development of using mobile manipulators in unstructured environments has been studied. In this paper, we will discuss this change in industrial robotics and further analyze the necessity of affordances for handling this situation. Several issues (e.g. safety and reliability) about how to extend the conventional robotic affordances to fit the pragmatic industrial robotic applications have also been addressed.

1 Why Affordance

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.

Affordances [1], which describe objects' all possible action functionalities of which an actor is aware, can play important role in tackling these three challenges. 1) In order to reduce the uncertainty and complexity caused by a large number of objects and objects in arbitrary positions/poses in human involved collaboration, an general affordance detection approach which ignores individual differences in feature representation could be used as a middle-ware between various features representations and robotic actions. 2) Usually re-purposing and deployment of robot for new tasks involve changing of end effectors. Since

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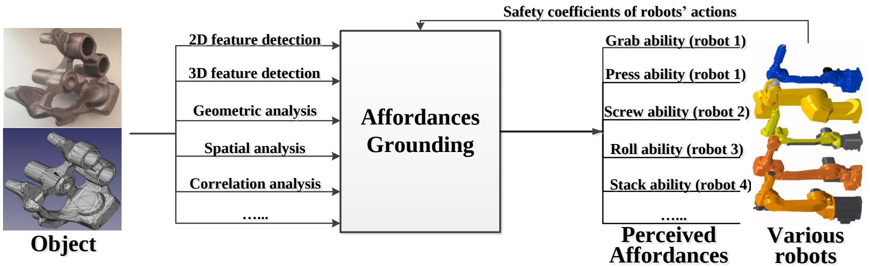

Fig. 1. systematic schema of using affordances for industrial robotic applications

affordances naturally rely on actors' abilities, the grounded affordances of object provide attached information about which tool/robot should be used to do various actions, thereby enabling fast re-purposing of tasks. 3) Safety as a most critical factor for industrial robotics, has been widely researched and standardized for many years. Affordances, which have received much attention as cognitive analysis schema in domestic robotics, as opposed to those methods for industrial applications, don't consider safety issues yet. However, 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

Modern vision-based algorithms for feature detection or character analysis normally have quality estimation outputs as part of their results. These quality estimation values can be used in a unified probabilistic framework to discover a best holistic solution. 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 [2], we further include the success rate of using different tools/robots/end-effectors for various action 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 time and workflow could also be developed based on this probabilistic framework.

References

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