

## **Target-Oriented Dexterous Grasping with a Multi-Fingered Robotic Hand Integrated on a Redundant Industrial Manipulator**

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### **Abstract**

This work presents a reinforcement learning-based approach to target-oriented dexterous grasping using a multi-fingered robotic hand integrated with a redundant industrial manipulator. Unlike many existing methods, the proposed framework does not rely on visual input during policy training. Instead, grasp configurations, including the end-effector pose and finger joint positions, are generated by an external grasp synthesis module and used as target states for goal-conditioned reinforcement learning. This separation between grasp generation and execution simplifies training and reduces computational requirements. Domain randomization is applied to object pose and robot configuration to improve robustness and generalization in simulation. The approach enables functional grasping, allowing objects to be grasped in configurations suitable for subsequent tool use rather than only achieving stable contact. Experimental evaluation in simulation demonstrates successful grasping and lifting of objects with different geometries and scales. The framework can be integrated into long-horizon manipulation pipelines requiring object reorientation and regrasping.

### **Keywords**

Reinforcement Learning, Dexterous Grasping, Functional Grasping.

## **Целеориентированный захват мультипалым манипулятором, интегрированным в избыточный промышленный робот**

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### **Аннотация**

В работе представлен метод целеориентированного мультипалого захвата, основанный на обучении с подкреплением и реализованный на роботизированной кисти, установленной на избыточном промышленном манипуляторе. В отличие от большинства существующих подходов, предлагаемый метод не использует визуальную информацию в процессе обучения политики управления. Вместо этого конфигурации захвата, включающие положение и ориентацию схвата, а также углы суставов пальцев, формируются внешним генератором и используются в качестве целевых состояний для обучения с подкреплением. Такое разделение процессов генерации и исполнения захвата упрощает процедуру обучения и снижает вычислительные затраты. Для повышения устойчивости и обобщающей способности применяется доменная рандомизация начальных положений объекта и конфигурации робота в среде моделирования. Предложенный подход ориентирован на реализацию функционального захвата, при котором объект удерживается в конфигурации, пригодной для последующего использования по назначению. Результаты моделирования демонстрируют успешный захват и подъем объектов различной геометрии и масштаба. Разработанный метод может быть интегрирован в многоэтапные манипуляционные сценарии, включая переориентацию и повторный захват объекта.

## Ключевые слова

Обучение с подкреплением, мультипальный захват, функциональный захват.

Robotic grasping is a fundamental skill that a robot must perform. Many studies have addressed this problem using parallel-jaw grippers, achieving significant success in grasping a wide variety of objects. The use of reinforcement learning has further enabled generalization to a large number of objects, including previously unseen ones. However, grasping a tool or instrument is meaningless unless the grasp is functional. A functional grasp allows the robot to use the tool according to its intended purpose, such as operating a drill or swinging a hammer. Most existing work on dexterous grasping relies on visual data as input during training, which significantly increases computational cost. The proposed approach introduces an RL-based dexterous grasping framework that utilizes grasp poses and configurations generated by an external generator. UniDexGrasp tackles universal dexterous grasping through a two-stage pipeline. The first stage generates grasp poses from point cloud data, capturing object geometry and decoupling translation, orientation, and finger articulation. The second stage uses a goal-conditioned reinforcement learning policy to execute grasps in simulation, adapting to object pose and perception noise [1]. DexGraspNet is a large-scale dataset containing over 1.3 million stable grasps with the ShadowHand across 5,000+ objects. Built using a fast force-closure estimator and physics validation [2].

The proposed approach consists of two main components: the generation of grasp configurations and reinforcement learning-based execution. In the first stage, Grasping configurations (i.e., the gripper pose and finger joint positions) are generated using an external grasp generator. The quality of the generated grasps can be controlled through different energy functions that evaluate grasp effectiveness. In the second stage, the generated configurations are used to train the robot to grasp objects. A dexterous robotic gripper mounted on a robotic manipulator is trained using reinforcement learning to grasp objects of varying scales without relying on visual information about the object's shape. To improve training efficiency and robustness, domain randomization is applied to both the object's initial pose and the robot's initial configuration. For evaluation, the robot is required to successfully grasp and lift at least three different objects of varying scales with different grasping poses off the table.

The proposed approach enables robotic grasping in the absence of visual input. When combined with a functional grasp generator, it facilitates functional grasping capabilities. Moreover, it can be incorporated into long-horizon manipulation pipelines, enabling the system to grasp an object from an initially functionally ungraspable configuration, reorient it, and subsequently perform a functional regrasp.

## References

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