DeepClaw: A Standardized Framework of Experimental Work-flow for Reproducible Robot Manipulation

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Introduction

Challenges

a. Robot manipulation has been a significant challenge in robotics learning research.
b. Design of manipulation workflow has largely relied on specific tasks, which could be abstracted out as a conceptual unit, to avoid repetitive but meaningless work.
c. Prior work has explored the potential of using standardized benchmark for robot learning research.
d. However, the challenges of reproducibility and replicability in coding implement of algorithms have impaired robot manipulation research progress.

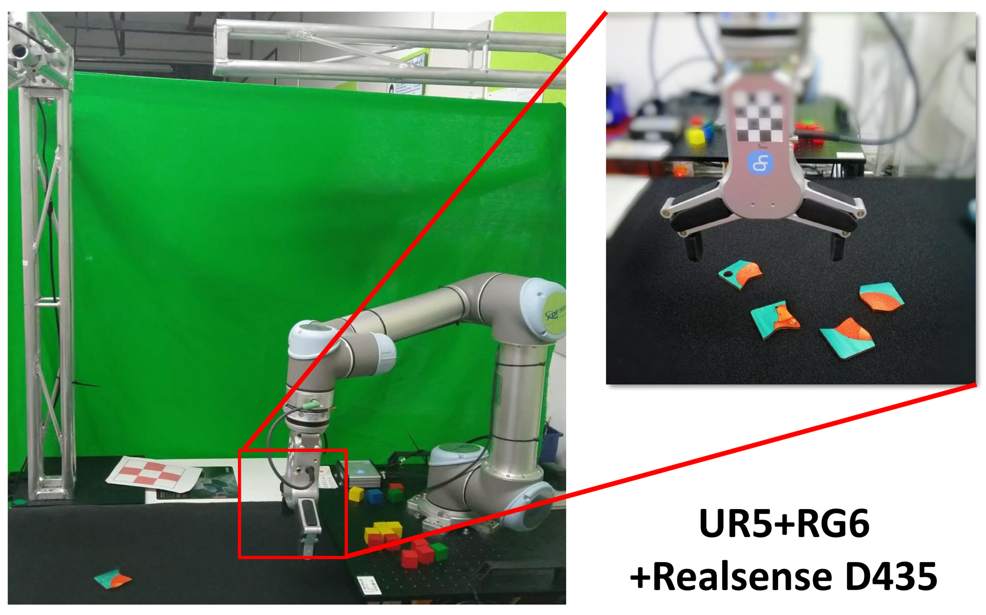

Figure 1. Real robot system setup.

Contributions

In this paper, we introduce the open-source framework DeepClaw. DeepClaw offers a reproducible and standardized manipulation work-flow to general robot manipulation research. DeepClaw decomposes a manipulation work-flow to four components: segmentation, classification, pick plan and place execution. To enable standardization, we inherit assessment criteria in each area, such as mIoU in segmentation.

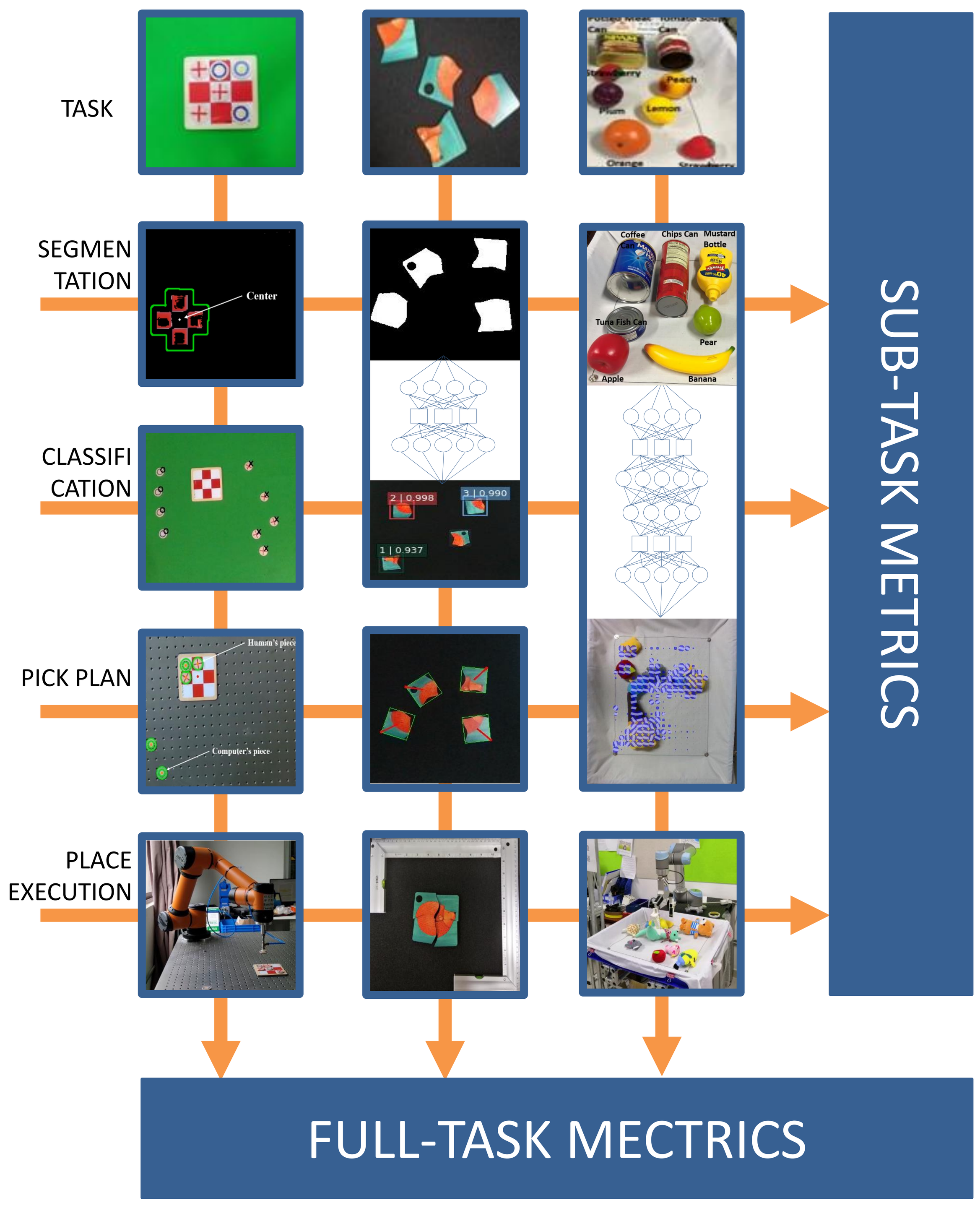

Figure 2. DeepClaw Work-flow

DeepClaw Manipulation Framework

Reproducibility

The goal of DeepClaw is to provide a standardized framework of experimental work-flow for reproducible robot manipulation. DeepClaw consists of four major components illustrated in Figure 2.

Shareability

DeepClaw unify manipulation experimental work-flow under a standardized framework(Figure 3).
Based on software design principles, we develop an open source, reproducible and cross-system program.
We refer this software platform as DeepClaw implementation.

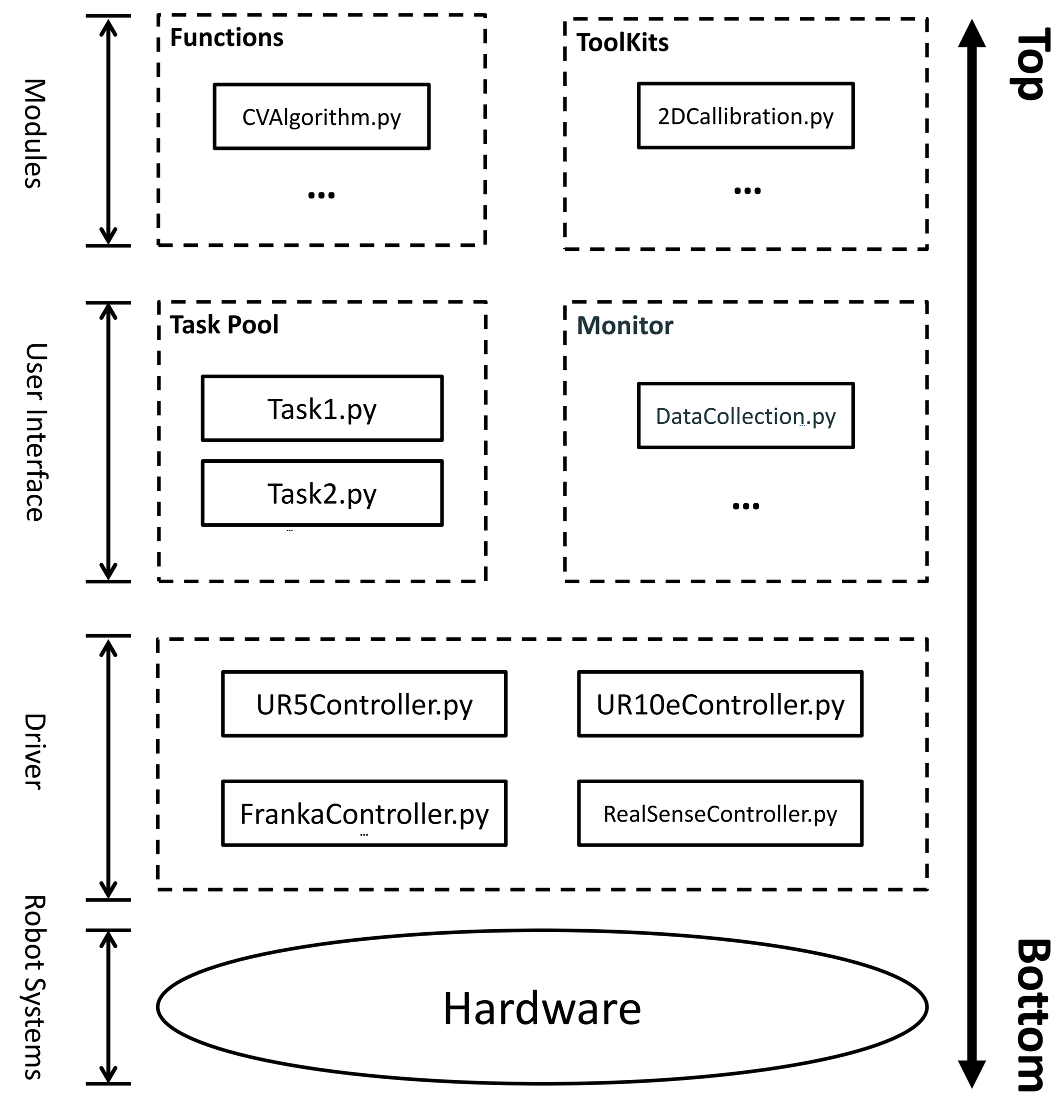

Figure 3. Modular design for DeepClaw.

Cross-robot System Benchmarking

Prior approaches have relied on well-defined robot system and its around environment.
In this work, we can transplant our framework in multiple robot systems.
We perform two or three tasks in three different physical robot systems, such as UR5 with RG6 gripper, UR10e with Hande gripper and Franka Panda with its original fingers.
All robot systems use Realsense D435 as vision sensor to collect visual information from workspace.
The module design of DeepClaw outperform in cross-system than others.

Figure 4. Robot systems: UR5+RG6+D435, UR10e+HandE+D435 and Franka Panda+D435

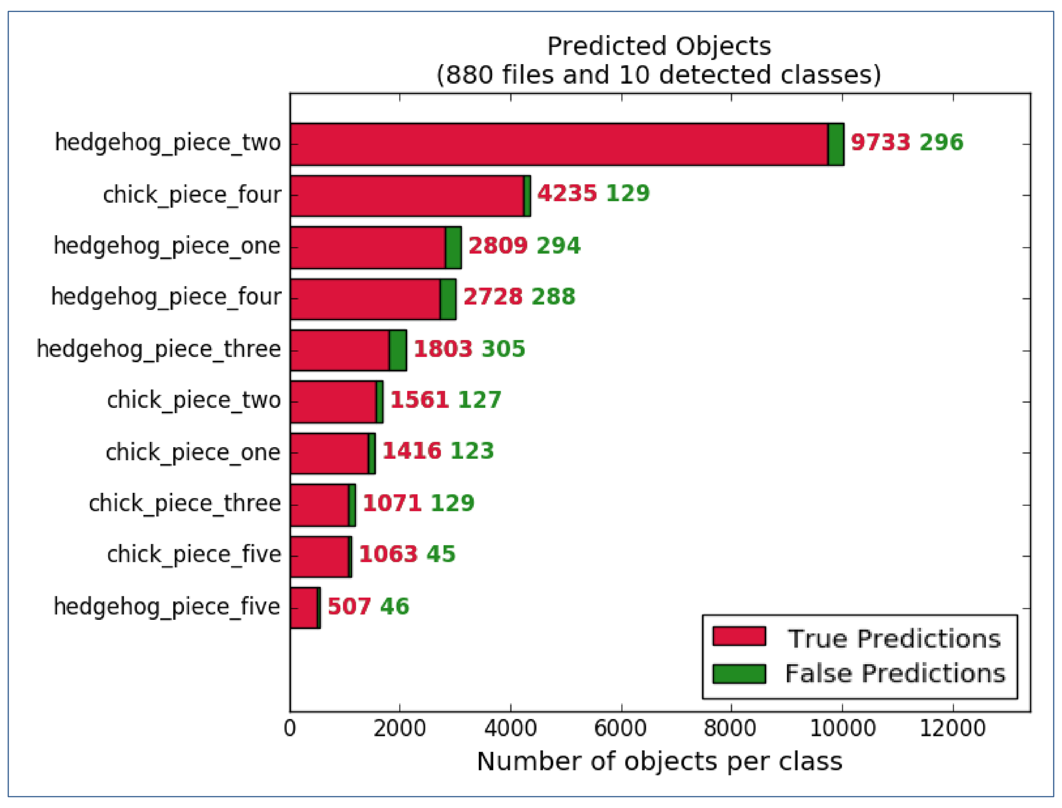

Chart 1. Classification Accuracy of Each Jigsaw Pieces.

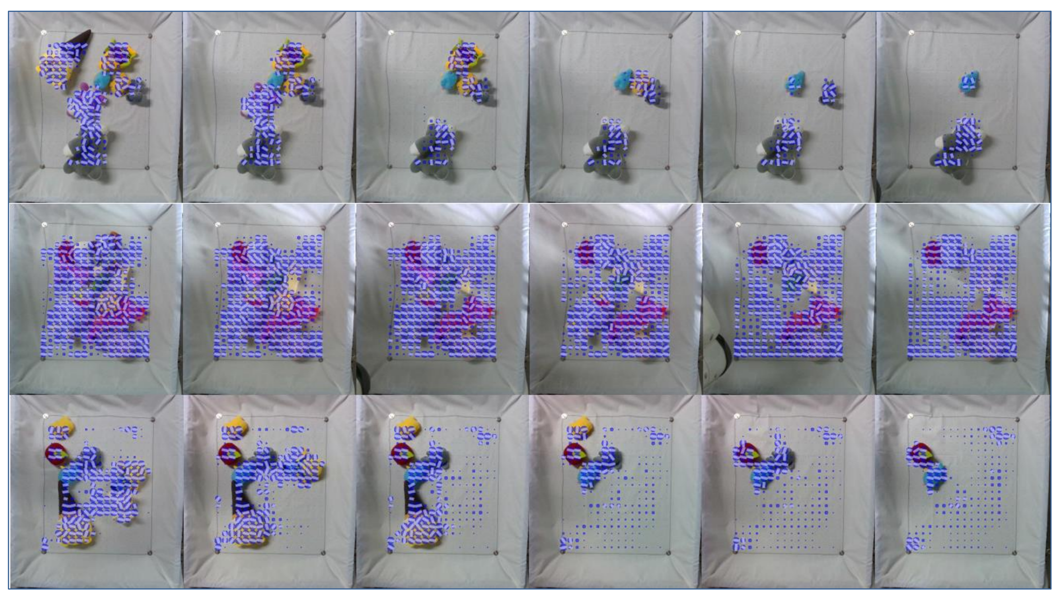

Chart 2. Picking position prediction and pose estimation results by different deep learning model

Experimental Results

We employ three tasks to validate DeepClaw in cross-system.
Tasks include "Toy Claw Machine", "Tic Tac Toe Game" and "Jigsaw Manipulation".
"Toy Claw Machine" is a classical robot manipulation task, which require pick-place action in each sub-task.
We perform different "end-to-end" deep neural network models in cross-system, and record their prediction and estimation results(Chart 2).
In "Jigsaw Manipulation", we evaluate different targets in the same YOLOv3 prediction model. And we demonstrate its performance in different pieces(Chart 2).

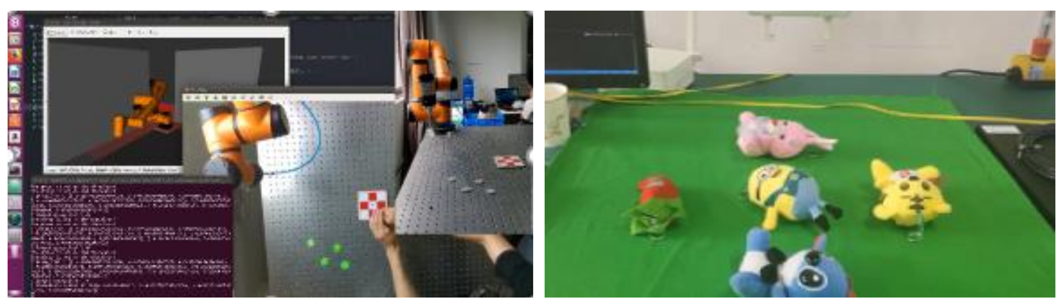

Figure 5. Tic-tac-toe game and toy claw in DeepClaw.

Future Work

In this paper, we provide a standardized framework of experimental work-flow for robot manipulation.
It offers straightforward guidance for variant manipulation tasks.
We demonstrate tree classical manipulation tasks with DeepClaw in cross-systems.
To rigorously evaluate the performance of different learning algorithm, we perform "end-to-end" deep neural networks.
In the future, we plan to expand DeepClaw with new manipulation tasks and learning algorithms.
We will release DeepClaw source code on Internet and hope researchers share their algorithms there.

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