Visual Lego© Counter

Course Project of *Fundamentals of Digital Image Processing* (AU3304, Fall 2023-2024)

1 Introduction

Lego© is one of the most famous toys all over the world. A Lego set is made up of various single pieces as shown in Fig. 1a. Though looking chaos at this status, they can be put together and generate vivid buildings (Fig. 1b), movable machines (Fig. 1c), and virtually everything you can imagine. Featuring simple design and high freedom, it is not strange why Lego keeps prevalent since the birth of its first toy product in 1949.

(a) Lego pieces (b) A building by Lego (c) A machine by Lego

Figure 1: Lego builds up everything!

However, no matter how marvelous it looks after assembly, Lego is made up of separate pieces. As you see, these pieces are varied in shapes and colors, and it is hard to count them manually when they are piled up. Unfortunately, this is common for Lego retailers. They have to track all single pieces to confirm that they are not lost or taken away by naughty kids.

Our problem starts here. With monitors on the shelves, how to get the number of every kind of pieces from the photos of Lego piles like Fig. 1a? The solution frees Lego retailers from cumbersome and repetitive counting job, and enables them to keep more accurate and efficient track of every single piece.

2 Problem Statement

In this project, you need to develop **a method to retrieve the numbers of each kind of Lego pieces from photos of Lego brick piles**. You need to test your method on the provided images, and present detailed results of all images that your method can handle.

The test images roughly belong to 3 levels of complexities, as shown in Fig. 2. There are totally 10 images, with 3∼4 in each level. All photos are taken in top view. Test images are available in `images.zip`.

(a) Simple: Only Bricks and Plates (1∼4)

(b) Mediate: More kinds of pieces and more status (5∼7)

(c) Hard: With occlusions (8∼10)

Figure 2: Sample images from all levels of Complexity

Note that pieces of different sizes should be treated as different kinds and counted respectively, while those with the same shapes but different colors are not required to be separated. For example, in Fig. 2a, you may clarify in your report that there are 15 pieces of "Brick 2x4", 2 pieces of "Brick 1x4", *etc.*, and mark their locations in the image. Refer to Tab. 1 for the piece names.

3 Submission

3.1 Content

You are required to submit a compressed file including your report, your code, and any supplemtary materials. The file should be named as `Your_Name+ID` and submitted directly to Canvas system.

The report should include, but is not limited to, what method you use, how you develop your method, what result you derive, and what conclusion you draw from the results. You are suggested to use the provided template (`project_template.docx`) to organize your report, but you may apply a different structure if it helps to present your method.

The code should reproduce the results you show in your report. A README file elaborating on how to run your code is appreciated.

Supplementary materials are optional. If you find it not suitable to include all your results in a single report, you may provide them here.

3.2 Notes

About piece names. Lego pieces are usually named by "Piece type + size + optional modifiers". Tab. 1 lists all the pieces that will appear in test images and their official names. When referring to a certain kind of piece, use the offical name in the table. You may abbreviate the name for convenience, e.g., "window pane" for "Window 1 x 2 x 3 Pane with Thick Corner Tabs".

About similar pieces. Some pieces look so similar in top view that even human eyes are hard to tell. In this case, these pieces are not required to be seperated. For example, "Bricks" and "Plates" (in the first row of Tab. 1) look similar in top view, so you can mix them and only identify the sizes.

About grading criteria. Since there are different difficulty levels of images, are the grades assigned based on the completions and accuracy? The answer is "Yes, but quantitative results are not the only criterion." If your method solves all the cases with high accuracy and your report clearly presents your method and results, then you are designated to get a high mark. However, if your method is innovative and inspiring, you can also get a high score even the method works only on the easy cases. Generally, completion, accuracy, and innovation all count, and you do not have to excel in all of them to get a high score.

4 Lego© Research Resources

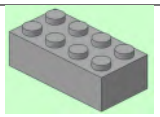
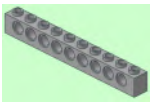
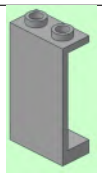
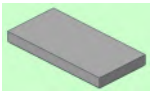
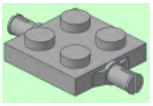
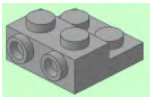
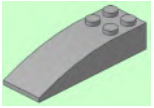
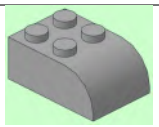
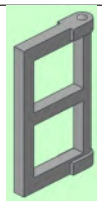
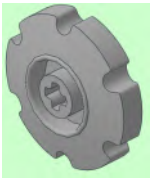
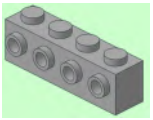
Here are two useful websites where you can find 3D models and photos of Lego pieces with the official names and IDs in Tab. 1.

4.1 LDraw.org

LDraw.org[1] contains the largest open-source Lego part model repository. To get certain brick model for your study, simply navigate through `Part & Tools > Parts Tracker > Parts List`, and then you can search with the official IDs or official names to find the certain piece.

[1] https://ldraw.org/

Table 1: All possible Lego pieces and their official names and IDs

Name	Figure	ID	Name	Figure	ID
Brick 2x4		3001	Plate 2x3		3020
Wheel Rim 20x30 with 6 Dual Spokes and External Ribs		56145	Technic Brick 1x10 with holes		2730
Panel 1x2x3 with Hollow Studs		2362b	Tile 2x4 With Groove		87079
Brick 2x2 round with pin hole		17485	Plate 2x2 with 2 Wheel Pins		4600
Cone 3x3x2		45176	Plate 2x2 with 2 Studs on the side		99206
Slope brick 6x2 curved		52214	Brick 2x3 with Curved Top		6215
Tyre 18/ 56x17 Off-Road with Offset Centre		56891	Tyre 26/ 49x30 Tractor		70695
Window 1x2x3 Pane with Thick Corner Tabs		60608	Technic Sprocket Wheel 25.4		57520
Wheel Rim 14x18 with Holes on Both Sides		55981	Brick 1x4 with Studs on Side		30414

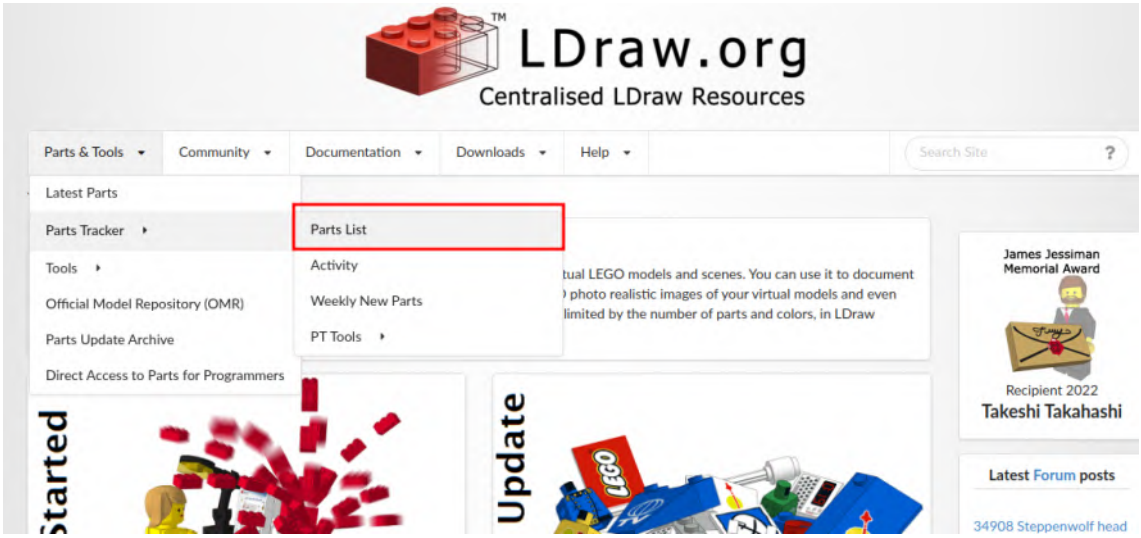


Figure 3: Navigate to Parts List

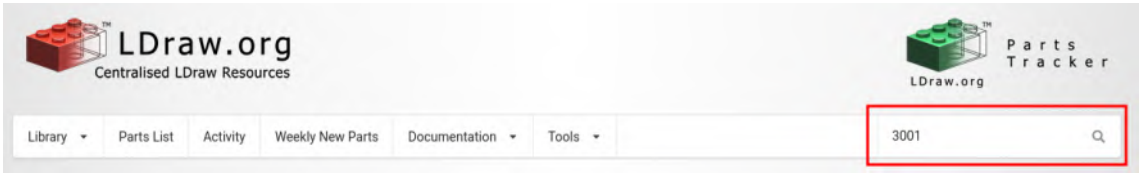


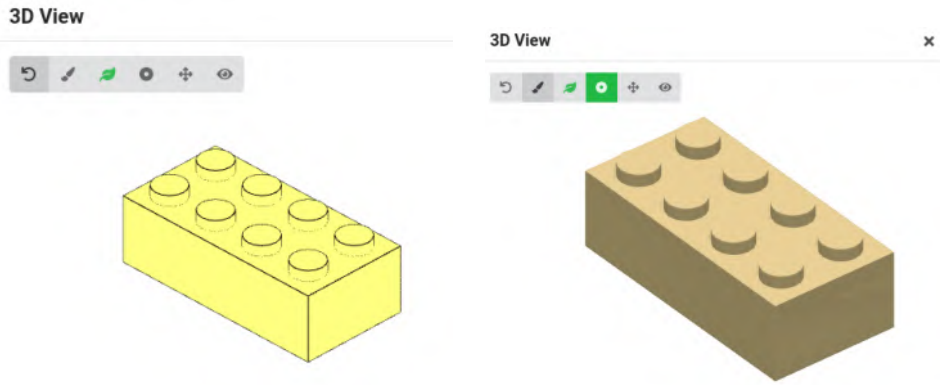
Figure 4: Use red boxed part to search.

After you find a certain piece (*e.g.*, Brick 2x4), you can view its 3D model at this site. Actually, all images in Tab. 1 are from this site. You can turn the stroke off to mimic real scenes.

4.2 Bricklink

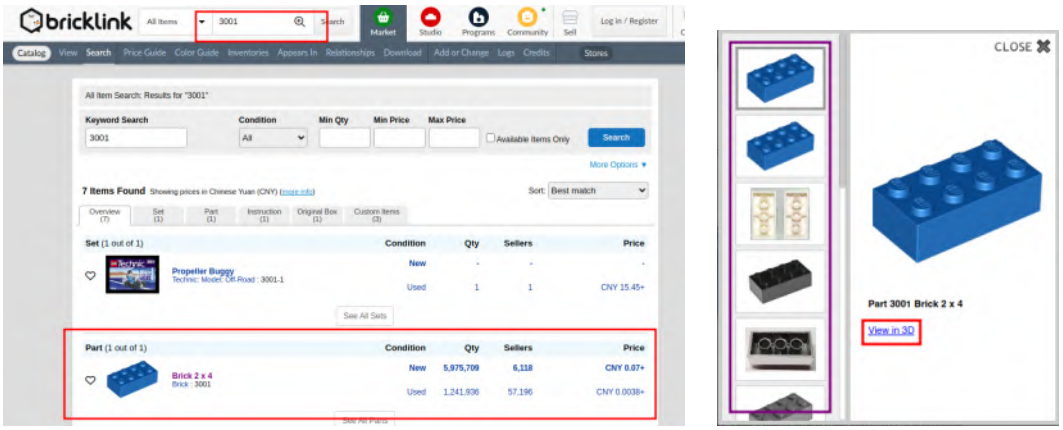
Bricklink[2] provides both 3D models and real photos of certain pieces. It also supports searching with official IDs and names (6a) and viewing 3D models (6b). Compared to LDraw.org, the photos of real pieces in Bricklink are unique and very useful resources for vision research.

[2] https://bricklink.com/



(a) Stroked 3D view (b) Recolored 3D view without strokes

Figure 5: 3D view in LDraw.org



(a) Searching Bricklink (b) Photos(left) and 3D views of a piece

Figure 6: How to use Bricklink.com