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Article

Title

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Abstract

This paper provides a solution for a robotic gripper to detect objects in the hands of an user and be able to grab them automatically as soon as they are in range. Even though the solution was developed for the 3-Finger-Gripper by Robotiq, the methodic can be used for any other robotic hand. The algorithm is able to detect various objects as well as estimating the size of the objects to configure its hand properly. Furthermore the internal current sensors are used for a suitable force for grabbing the object.

Keywords: keyword 1; keyword 2; keyword 3 (List three to ten pertinent keywords specific to the article; yet reasonably common within the subject discipline.)

0. How to Use this Template

The template details the sections that can be used in a manuscript. Note that the order and names of article sections may differ from the requirements of the journal (e.g., the positioning of the Materials and Methods section). Please check the instructions on the authors' page of the journal to verify the correct order and names. For any questions, please contact the editorial office of the journal or support@mdpi.com. For LaTeX-related questions please contact latex@mdpi.com.

1. Introduction

The introduction should briefly place the study in a broad context and highlight why it is important. It should define the purpose of the work and its significance. The current state of the research field should be reviewed carefully and key publications cited. Please highlight controversial and diverging hypotheses when necessary. Finally, briefly mention the main aim of the work and highlight the principal conclusions. As far as possible, please keep the introduction comprehensible to scientists outside your particular field of research. Citing a journal paper [**?**]. Now citing a book reference [**?** **?**] or other reference types [**?** **?**]. Please use the command [**?** **?**] for the following MDPI journals, which use author–date citation: Administrative Sciences, Arts, Behavioral Sciences, Businesses, Econometrics, Economies, Education Sciences, European Journal of Investigation in Health, Psychology and Education, Games, Genealogy, Histories, Humanities, Humans, IJFS, Journal of Intelligence, Journalism and Media, JRFM, Languages, Laws, Literature, Psychology International, Publications, Religions, Risks, Social Sciences, Tourism and Hospitality, Youth.

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2. Materials and Methods

For the object detection the pre-trained YOLO11n.pt model of Ultralytics [**?**] was used because it provides the best balance between precision and speed [**?**].

The stereo camera - IntelRealSense D435i - was placed in a way to have a frontal vision of the scene as well as to be able to detect wether the object is in reach to grip the obejct. Therefore the resolution must be set to 424 $\times$ 240, which allows to detect the smallest possible depth [**?**].

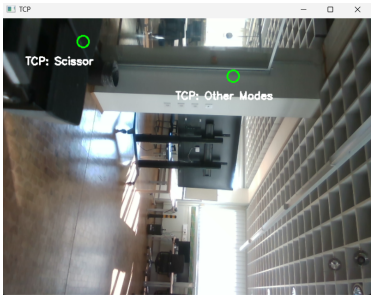

Figure 1. FOV of the camera on the gripper

2.1. Algrotihm

Due to the euclidean distance its possible to estimate the size of the object which should be given to the gripper. If there is more than one detected object in the FOV, the object with the shortest distance greater than zero is chosen as the object to be gripped.

For an intuitive cooperation with the robot, the mechanism is human like: To grab an object the object is given to the middle of the manipulators and the gripper closes as soon as the object is in reach of the manipulators.

Another human like behaviour is the configuration of the opening palm of the gripper which depends on the size of the object.

The size of the object is calculated with the eucledian distance of the x- and y-axis of the object.

$$Size_{xy} = \sqrt{(xy_1 - xy_2)^2 + (z_1 - z_2)^2} \cdot 100 \tag{1}$$

Depending on the size of the object a specified modi of the gripper is chosen. Like a human, the gripper opens its palm slightly more than the object itself. A good value for this are additional 2cm to the estimated size. Because of different sizes of the bounding boxes for different frames a stability criteria was developed, which ensures to have a precise estimation of the size of the object. The size of the identified object is calculated every FPS and compared to the estimated sizes. The last 8 results are stored and compared to each other. If the size difference is smaller than 1cm the mean values for each dimension (x,y) define the size of the object.

With a red bounding box its displayed that the object is ready to be gripped. So the user can give the object to the gripper, which closes as soon as the object is in range. The gripper uses the biggest value of its possible force to grip the object. To achieve a suitable pressure for fragile objects the gripper stops as soon as the current of the motors controlling rises and the fingers of the gripper are still moving.

3. Results

[**?**] This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn. [**?**]

3.1. YOLO

Eventhough the smallest model was used it didn't achieved real-time on the used hardware[1] (fig. 2). But still the video seemed to be fluid.

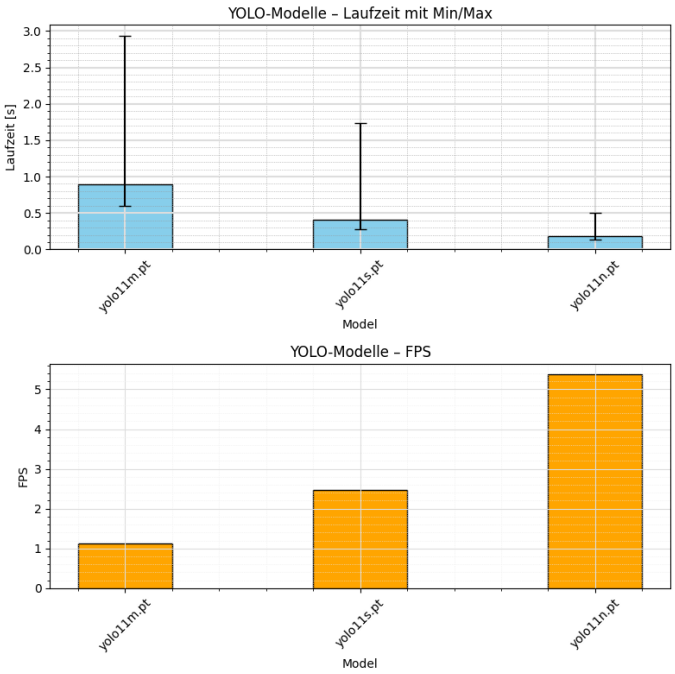

Figure 2. different speed of different YOLO-models

The model detects far more objects than it was trained with and shows different times until the object was detected(war es auch so dass kleineres Modell mehr unbekannte objekte erkannt hat und auch schneller?- testen?). A finding was that materials with bright colors getting faster and more precise detected than colorless or reflective objects. The results also show that squared objects are faster detected than round objects (Tab.1).

The precision of the size estimation depends rather on the size of the object than the recognition speed (liegt sicherlich an dem stabilitätskriterium Tab 2).

Object	Average Time (s)	Standard Deviation (s)
Metal Plate	4.44	1.02
Cube	4.99	2.34
Ball	5.37	2.08
Foam Roller	7.91	4.44
Screwdriver	8.11	7.28
Plastic Water Bottle	15.38	8.06

Table 1. Detection Time per Object – YOLO11n.pt

Object	Diagonal [cm]	Deviation [cm]	Deviation [%]
Foam Roll	38.27	2.19	5.73
Metal Plate	21.95	1.84	8.39
Ball	8.44	0.75	8.83
Screwdriver (Handle)	9.96	1.58	15.89
Cube	3.25	0.69	21.24

Table 2. Average size Deviations for Various Objects - YOLO11n.pt

[1] Hardware: 6AMD Ryzen 7 3700U, Cache: L1:348 kB, L2:2 MB, L3: 4 MB; Interpreter: Python 3.10.0

3.2. Force Controll

The force control was tested on an ditchable ball, with which one its obvious that it works well but still isn't perfect ().

opening[cm] without	opening[cm] with
1.95	5.97
4.99	2.34
1.95	5.97
1.30	6.36
1.30	6.10
2.21	5.97
4.29	5.84

Table 3. OPenings with the force control and without

3.2.1. Subsubsection

Bulleted lists look like this:

- First bullet;
- Second bullet;
- Third bullet.

Numbered lists can be added as follows:

1. First item;
2. Second item;
3. Third item.

The text continues here.

3.3. Figures, Tables and Schemes

All figures and tables should be cited in the main text as Figure **??**, Table **??**, etc.

Figure 3. This is a figure. Schemes follow the same formatting.

Table 4. This is a table caption. Tables should be placed in the main text near to the first time they are cited.

Title 1	Title 2	Title 3
Entry 1	Data	Data
Entry 2	Data	Data [1]

[1] Tables may have a footer.

The text continues here (Figure **??** and Table **??**).

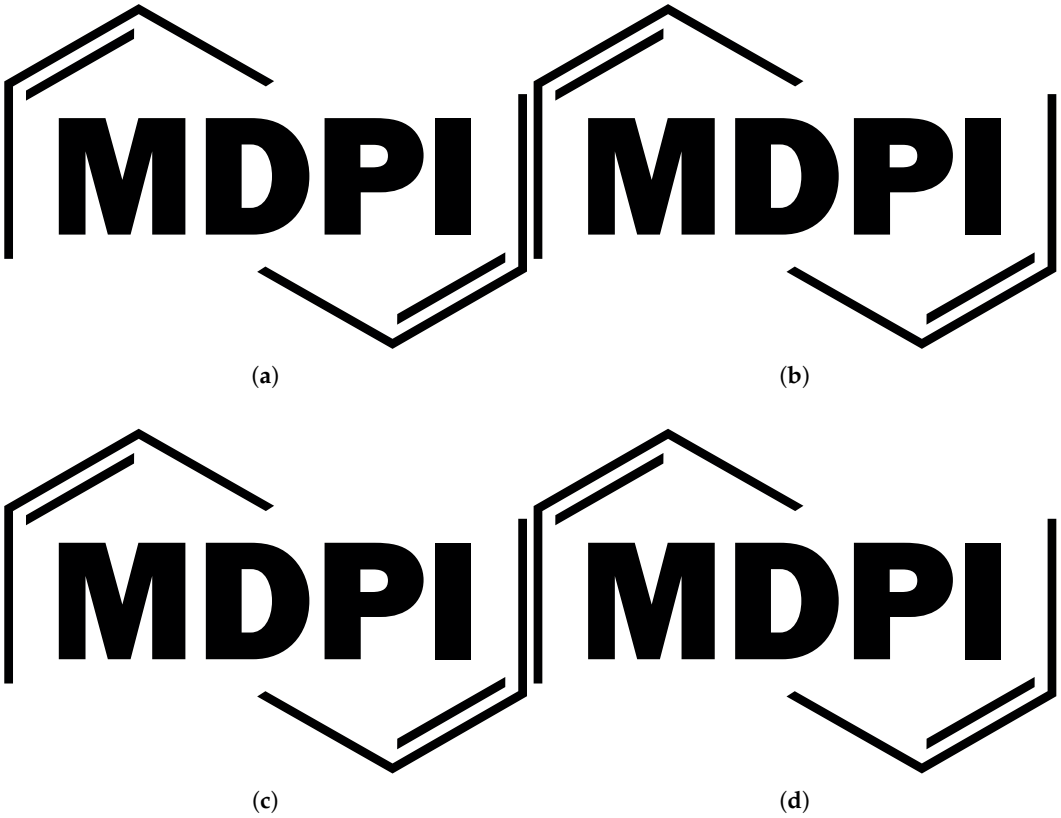

Figure 4. This is a wide figure. Schemes follow the same formatting. If there are multiple panels, they should be listed as: (**a**) Description of what is contained in the first panel. (**b**) Description of what is contained in the second panel. (**c**) Description of what is contained in the third panel. (**d**) Description of what is contained in the fourth panel. Figures should be placed in the main text near to the first time they are cited. A caption on a single line should be centered.

Table 5. This is a wide table.

Title 1	Title 2	Title 3	Title 4
Entry 1 *	Data Data Data	Data Data Data	Data Data Data
Entry 2	Data Data Data	Data Data Data	Data Data Data

* Tables may have a footer.

Text.

Text.

3.4. Formatting of Mathematical Components

This is the example 1 of equation:

$$a = 1, \tag{2}$$

the text following an equation need not be a new paragraph. Please punctuate equations as regular text.

This is the example 2 of equation:

$$a = b + c + d + e + f + g + h + i + j + k + l + m + n + o + p + q + r + s + t + u + v + w + x + y + z \quad (3)$$

Please punctuate equations as regular text. Theorem-type environments (including propositions, lemmas, corollaries etc.) can be formatted as follows:

Theorem 1. *Example text of a theorem.*

The text continues here. Proofs must be formatted as follows:

Proof of Theorem 1. Text of the proof. Note that the phrase "of Theorem 1" is optional if it is clear which theorem is being referred to. □

The text continues here.

4. Discussion

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

5. Conclusions

This section is not mandatory, but can be added to the manuscript if the discussion is unusually long or complex.

6. Patents

This section is not mandatory, but may be added if there are patents resulting from the work reported in this manuscript.

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Abbreviations

The following abbreviations are used in this manuscript:

MDPI	Multidisciplinary Digital Publishing Institute
DOAJ	Directory of open access journals
TLA	Three letter acronym
LD	Linear dichroism

Appendix A

Appendix A.1

The appendix is an optional section that can contain details and data supplemental to the main text—for example, explanations of experimental details that would disrupt the flow of the main text but nonetheless remain crucial to understanding and reproducing the research shown; figures of replicates for experiments of which representative data are shown in the main text can be added here if brief, or as Supplementary Data. Mathematical proofs of results not central to the paper can be added as an appendix.

Table A1. This is a table caption.

Title 1	Title 2	Title 3
Entry 1	Data	Data
Entry 2	Data	Data

Appendix B

All appendix sections must be cited in the main text. In the appendices, Figures, Tables, etc. should be labeled, starting with "A"—e.g., Figure A1, Figure A2, etc.

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