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Development and analysis of indirect object isolation algorithms on a vision base 5dof kuka robot

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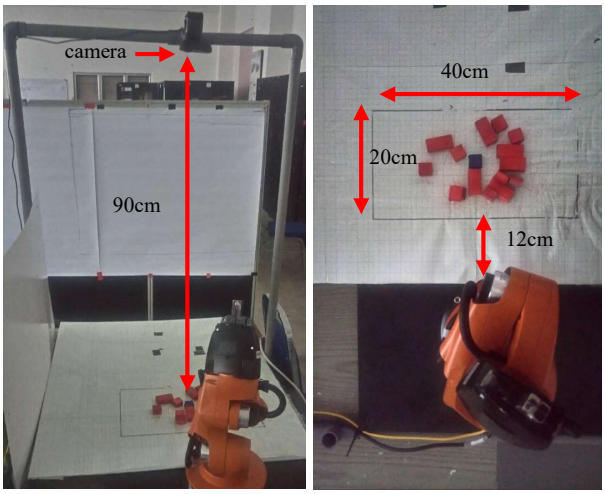
ABSTRACT– This paper explores the idea of manipulation aided-perception in the context of isolating the noise objects from the singular object of interest in varying degree and variation of clusterization. This work proposes and compares 3 novel algorithms. The algorithms are designed to plot the trajectory which subsequently utilizes manipulation primitives (pushing motion) to move object along the planned trajectory. The algorithm was demonstrated using a Kuka Youbot with a camera fitted above the workspace. Results from the experiment indicated that all proposed algorithms successfully reduced the number of manipulations per object from 1.78 manipulations in other research up to 0.333 manipulations albeit with a small tradeoff in terms of displacement of the object of interest from its initial position.

1. INTRODUCTION

Object isolation in essence is the problem of removing the clutter/unwanted objects away from the object of interest or the object of interest from the cluttered environment. Most research when it comes to isolation focuses on the removing the object of interest from the scene [1,2]. However, there is a case to be made for the removal of clutter/unwanted objects from the object of interest as well. There're cases where we're unable to remove the object of interest because it is either too big or heavy to be manipulated. An example of such case would be the case of an exploratory robot wanting to collect training images of a interesting monolith but is blocked by environmental objects such as leaves, smaller manipulatable rocks and even people where if allowed to remain in the training image can lead to incorrect perception [3] and ultimately failure in future operations. There are also cases where we might not want to manipulate the object of interest even if we could. Such a case is for example robots used the rescuing of victim after an earthquake or even robots used for archaeological excavations. In both cases, while it is possible to manipulate the victim/artefact from where they are found, we would not know if said person is injured or the artefact is brittle potentially causing more harm than good. Therefore, a better course of action would be to clear off the surrounding rubble so that experts can come in to access the victims or said artefact.

2. METHODOLOGY

we propose the use of single manipulation primitive (pushing movement) to isolate an object efficiently from a cluttered/complexed environment exploiting the effects of manipulation casualties to remove more than one noise object per manipulation hence reducing the overall time/manipulations required to fully isolate the object. At the same time, the designed algorithm has the capacity to be integrated on any mobile robot with any kind of end effector. In order to achieve the aforementioned goals, we developed and compared 3 novel algorithms which are the Mono-directional Single Manipulation Algorithm Using Pile Position Strategy (MSMAPPS), Mono-directional Single Manipulation Algorithm Using Pile Overlap Strategy (MSMAPOS) and Bi-directional Single Manipulation Algorithm Using Pile Overlap Strategy (BSMAPOS) to identify the most efficient of the three in comparison to the performance of Gupta et al's manipulation aided method [2]. All 3 algorithms comprise of 5 steps: 1) Object segmentation, 2) Pile Selection 3) Path Planning 4) Manipulation of region 5) repetition until the object of interest is completely isolated or the field is empty. The experiment set up can be seen in Figure 1.



(a) (b)

Figure 1: Full experimental setup: Kuka Youbot Robotic arm mounted on a platform with a camera overlooking the designated workspace and the pseudo duplo bricks. The task is to remove the noise objects (red) leaving only the object of interest (blue) in the works. (a) experimental

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setup (b) field set up

3. RESULT AND DISCUSSION

We ran the experiment 3 times per algorithm to obtain its average performance in a field of 18 randomly placed 2x2 and 2x4 duplo bricks and 1 additional 2x2 duplo brick designated as the object of interest. We gathered information regarding the number of manipulations required to fully isolate the object of interest as well as the displacement of the object of interest throughout the operations. The results are as follow

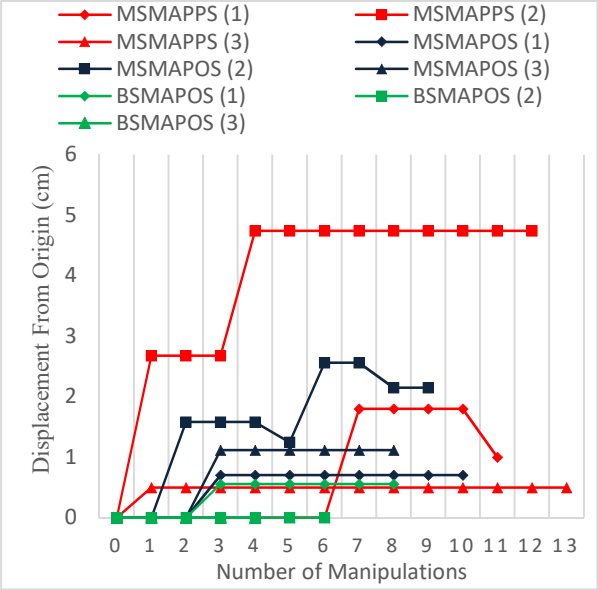

Figure 2: Performance comparison between MSMAPPS, MSMAPOS and BSMAPOS algorithm in terms of the displacement of the object of interest across the entire operation as well as the total number of manipulations required to achieve isolation

Results as seen in Figure 2 indicates that MSMAPPS algorithm requires the most amount of manipulation (12 manipulations average / 0.6MPO) to clear the field of 18 objects seconded by MSMAPOS (9 manipulations average / 0.5MPO) method followed by BSMAPOS (6 manipulations average / 0.333MPO). However, even the least performing algorithm still outperform current methods utilized to tackle the issue namely Gupta's manipulation aided method [2] which clocks in at 1.78 MPO or 32 manipulations average in a field of 18 randomly places objects.

Lastly we look at the algorithms ability to remove objects with minimal disturbance towards the object of interest. It can be seen that MSMAPPS is the least accurate as well as least consistent with displacements ranging from 5mm to 0.5mm. MSMAPOS method is more consistent in contrast and strikes a better result with displacement ranging from 2.15cm to 0.5cm. BSMAPOS is the best performing method with consistent results of low displacements ranging from 0.5cm to 0cm.

4. CONCLUSION

This paper explores manipulation aided perception in the context of isolating small objects (Duplo Bricks) off the Kuka Youbot workspace. We presented three different algorithm which combines perception and manipulation to efficiently and quickly to isolate unwanted noise objects from the object of interest using a single manipulation method coupled with cluster identification. Result on the Kuka Youbot successfully reduced the total number of manipulations from 1.78 manipulation per object 0.6 manipulations per object for the Mono-directional Single Manipulation Algorithm Using Pile Position Strategy (MSMAPPS), 0.5 manipulation per objects for Mono-directional Single Manipulation Algorithm Using Pile Overlap Strategy (MSMAPOS) and a further drop to 0.33 using Bi-directional Single Manipulation Algorithm Using Pile Overlap Strategy (BSMAPOS). However, this improvement in manipulation is offset by the accidental displacement of the object of interest in the process of isolation. Out of the 3 developed method, we learn that using bi directional methods coupled with pile overlap strategy (BSMAPOS) affords the best results in terms of low displacement of the object of interest which can be attributed to the increased number of available direction of actions.

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REFERENCES

[1] Lin Y., Min H., Zhou H., Pei F. (2018). A Human-Robot-Environment Interactive Reasoning Mechanism for Object Sorting Robot. *IEEE Transactions on Cognitive and Developmental Systems 10(3),* 611-323.

[2] Gupta M. Müller J. and Sukhatme G. S. (2015). Using Manipulation Primitives for Object Sorting in Cluttered Environments. *IEEE Transactions on Automation Science and Engineering 12(2),* 608-614.

[3] Katz D., Kazemi M., Bagnell J. A. and Stentz A. (2013). Clearing a pile of unknown objects using interactive perception. *IEEE International Conference on Robotics and Automation, Karlsruhe*, 154-161.

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