Internship proposal: Dynamic features clustering for object detection and tracking in interactive perception

Overview

- **Supervisors:** Alexandre CONINX, Stéphane DONCIEUX, Elias HANNA (ISIR AMAC Team)
- **Duration:** 6 months

Topic description

Scientific context

In order to be able to interact with its environment and solve non-trivial object-based tasks (e.g. manipulation), a robot must be able to locate objects in its perceptual field, and to track them throughout the interaction. In the case of a static task and structured environment, for example objects on a tabletop, those perceptual abilities can be hardcoded. But in an open-ended context where the environment, the task and the objects can't be known in advance and can change during the interaction, it is desirable for the robot to be able to bootstrap its perceptual abilities with limited assumptions, and to be able to update its interpretation of the visual scene during the interaction to keep track with the changes in the setup (e.g. new objects, changes in the background, ...).

Interactive perception [BHS+17] offers a powerful paradigm to address this issue. Previous works [vHKP14, LLD16, GMCD19] have shown that an interactive perception setup can be used to train an online classifier able to recognize movable object to their visual and geometric features, but those systems do not handle the subsequent tracking of those objects throughout the interactions. Besides, training an online classifier able to adapt to a shifting input data distribution (the "concept drift" problem [MS03]) while correctly handling outliers remains a challenging problem. On the other hand, computer vision-based tracking and segmentation algorithms that can provide a persistent segmentation of the visual world and track a moving object have been proposed [PKAW13, KKAS13, PZV18] but they usually assume a known initial segmentation or at least a known, static environment.

Recent progress has been done on both those issues, with new dynamic clustering techniques able to track evolving environments [BTmGp19] and an improved segmentation algorithm for interactive perception able to efficiently detect and track moving objects with little assumptions on the environment [Han19], but a comprehensive interactive perception system integrating those advances has yet to be designed.

Internship goals and roadmap

We propose to build an integrated system for low level interactive perception, that could be reused as a building block in further robotics experiments. That system will follow the same general approach as the setup proposed in [GMCD19], using interaction with the environment to collect data about movable and non-movable parts of the

Sous la co-tutelle de

Institut des systèmes Intelligents et de Robotique
Sorbonne Université - CNRS / UMR 7222
Pyramide Tour 55 - Boîte Courrier 173
4, place Jussieu - 75252 PARIS CEDEX 05 - France
Tél: +33 (0)1 44 27 51 31 / 51 41 - Fax: +33 (0)1 44 27 51 45

environment to train a classifier able to segment objects from the background, with two major modifications. First, it will also use the persistent interactive segmentation system proposed in [Han19] to build and maintain a persistent model of the world and track recognised objects throughout the interaction. Second, instead of the CMM classifier proposed in [GMCD19], it will use a dynamic clustering such as the DyClee algorithm [BTmGp19] to improve performance and adress continual learning and concept drift. The system will be evaluated first in simulated environments and then on the team's robotic platforms such as the Baxter and PR2 robots.

The proposed roadmap for the internship is described below:

1. The first step is to build an interactive perception system for movable object recognition based on the same principles and objectives as [GMCD19], but replacing the CMM classifier with the DyClee algorithm [BTmGp19], using the authors' open-source implementation. The system would be evaluated with the same metrics as in [GMCD19] and the results compared.

2. The second step is to add the interactive segmentation system from [**?**], in order to allow the system to track the detected moving objects and maintain a persistent world model throughout the interaction.

The complete system would then be evaluated on simulated and real robotics platforms, and compared to the state of the art in interactive perception, segmentation and tracking, in the perspective of submitting a conference or journal article.

Candidate profile

The candidate should have a strong interest in robotics and be enrolled in am MSc or engineering school program in robotics, computer vision or a related fields. Good development skills and proficiency in C++ and Python programming languages are required, and some experience with simulated or real robots (and with the ROS middleware) would be greatly appreciated. The project will require working in close cooperation with several PhD students and researchers and requires good teamwork abilities. A working knowledge of English is required; knowledge of French is appreciated but not necessary.

How to apply

Send an e-mail to `alexandre.coninx@sorbonne-universite.fr` with [Interactive perception internship] in the topic with a CV and motivation letter.

References

[BHS+17] Jeannette Bohg, Karol Hausman, Bharath Sankaran, Oliver Brock, Danica Kragic, Stefan Schaal, and Gaurav S. Sukhatme. Interactive perception: Leveraging action in perception and perception in action. *IEEE Transactions on Robotics*, 33(6):1273–1291, 2017.

[BTmGp19] Nathalie Barbosa Roa, Louise Travé-massuyès, and Victor H Grisales-palacio. DyClee : Dynamic clustering for tracking evolving environments. *Pattern Recognition*, 94:162–186, 2019.

[GMCD19] Léni K. Le Goff, Ghanim Mukhtar, Alexandre Coninx, and Stéphane Doncieux. Bootstrapping Robotic Ecological Perception from a Limited Set of Hypotheses Through Interactive Perception. *arXiv preprint*, jan 2019.

[Han19] Elias Hanna. Segmentation interactive : découverte d'objets à l'aide d'un robot. Technical report, Sorbonne Université, Paris, 2019.

Institut des systèmes Intelligents et de Robotique
Sorbonne Université - CNRS / UMR 7222
Pyramide Tour 55 - Boîte Courrier 173
4, place Jussieu - 75252 PARIS CEDEX 05 - France
Tél: +33 (0)1 44 27 51 31 / 51 41 - Fax: +33 (0)1 44 27 51 45

[KKAS13] Dov Katz, Moslem Kazemi, J. Andrew Bagnell, and Anthony Stentz. Interactive segmentation, tracking, and kinematic modeling of unknown 3D articulated objects. In *2013 IEEE International Conference on Robotics and Automation*, number March, pages 5003–5010. IEEE, may 2013.

[LLD16] Leni K. Le Goff, Pierre-Henri Le Fur, and Stephane Doncieux. Exploration of unknown dynamic environments: A visual saliency-based babbling approach. In *2016 Joint IEEE International Conference on Development and Learning and Epigenetic Robotics (ICDL-EpiRob)*, pages 152–153. IEEE, sep 2016.

[MS03] Markos Markou and Sameer Singh. Novelty detection: A review - Part 1: Statistical approaches. *Signal Processing*, 83(12):2481–2497, 2003.

[PKAW13] Jeremie Papon, Tomas Kulvicius, Eren Erdal Aksoy, and Florentin Worgotter. Point cloud video object segmentation using a persistent supervoxel world-model. *IEEE International Conference on Intelligent Robots and Systems*, pages 3712–3718, 2013.

[PZV18] Timothy Patten, Michael Zillich, and Markus Vincze. Action Selection for Interactive Object Segmentation in Clutter. In *2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, number June, pages 6297–6304. IEEE, oct 2018.

[vHKP14] Herke van Hoof, Oliver Kroemer, and Jan Peters. Probabilistic Segmentation and Targeted Exploration of Objects in Cluttered Environments. *IEEE Transactions on Robotics*, 30(5):1198–1209, oct 2014.

Institut des systèmes Intelligents et de Robotique
Sorbonne Université - CNRS / UMR 7222
Pyramide Tour 55 - Boîte Courrier 173
4, place Jussieu - 75252 PARIS CEDEX 05 - France
Tél: +33 (0)1 44 27 51 31 / 51 41 - Fax: +33 (0)1 44 27 51 45