Job ad n° LVA-2021-CDD3 **Date of publication : 07/11/2020**

Post-doc : Researcher in Computer Vision and Deep Reinforcement Learning

Tasks of high-precision robotized industrial assemblies with reinforcement learning based on sim2real transfer

ORGANISATION

Based in Saclay (Essonne), the List Institute is one of the three technological research institutes of CEA Tech, the technological research department of CEA. Dedicated to smart digital systems, its mission is to carry out technological developments of excellence on behalf of industrial partners in order to create value.

Within the List Institute, the Computer Vision and Machine Learning for scene understanding carries out research in the field of computer vision and artificial intelligence for the perception of intelligent and autonomous systems. The laboratory's research topics are visual recognition, behavior and activity analysis, large-scale automatic annotation and perception and decision models. These technologies find their application in major sectors of activity (safety, mobility, advanced manufacturing, health).

LOCATION

CEA Centre de Nano-Innov - plateau de Saclay (91)

CONTRACT

Post-doc contract of 12 months renewable once
Salary depending on education and experience level

INDUSTRIAL AND SCIENTIFIC CONTEXTS

High-precision robotic manipulation for grasping and assembling objects is a major challenge for the industry. However, the flexibility and agility of current systems are still too limited to respond effectively to the need for rapid adaptation to a new environment or new production requirements.

The majority of existing systems rely on path planning to pick up and move parts, and the implementation of fine insertion tasks requires tedious robot set-up procedures to be developed. This approach indeed requires a precise modeling of the dynamics of the underlying system (friction, contact, kinematics, ...). However it is generally difficult to obtain this information from the CAD data in a precise way, which makes the system not very scalable.

Another category of approach uses the reinforcement learning paradigm. This paradigm is based on the principle of trial and error by interacting with the environment. Associated with the use of deep neural networks, reinforcement methods have shown to be effective in solving difficult control problems with high-dimensional observations. This makes this approach an interesting candidate for building a solution that is both robust but also easily adaptable to a new context of use or a new type of production. However, reinforcement learning approaches are not yet widely deployed in the industry because they still face several major problems:

- In particular, a lot of data is required for successful learning, and acquiring it with a real system takes a lot of time. To overcome this problem, it would be necessary to be able to deploy several tens (or even hundreds) of robots during the learning phase.
- Reinforcement learning algorithms also use a reward function to validate that a task has been completed successfully. However, it is not easy to construct these reward functions.

To answer these problems, the concept of sim2real, which we are interested in here, has been introduced. This approach consists in training the industrial robot in simulation by making the simulated learning transfer to the real world. According to this paradigm, the data necessary for the teaching is generated on the simulator, and the simulator is also used to test and validate the reward function.

Although this idea seems convincing at first glance, it still requires bridging the gap between simulation and reality, which is a major challenge, especially when performing fine insertion tasks that involve managing friction contacts but also taking into account the associated sensors (3D vision, stress and tactile sensors).

MISSIONS

The objective of this post-doctorate is to develop a tool that will allow to carry out industrial tasks of high precision fine insertion, based on reinforcement learning using sim2real transfer.

To set the framework, we limit ourselves in this study to the tasks of assembling industrial products from CAD parts. We will first focus on tasks similar to those of the World Robot Challenge before proposing a generalization to other types of assembly tasks proposed by automotive and aeronautics industries with which CEA LIST collaborates.

More specifically, the following research questions will be addressed:

- Can the sim2real concept really manage tasks of industrial complexity?
- What level of realism is required in the physical simulation of the insertion task to be performed (geometry, kinematics, dynamics, sensors, etc.)?
- What is really the difference compared to conventional control techniques for industrial robots based on models and identifications?
- How to define the task for reinforcement learning, the associated reward function and the implementation of a time-efficient and convergent algorithm?
- How to transfer learning from the simulator to the real world?
- What are the good methods to quickly adapt the algorithm in case of change of environment (installation, type of robot) and type of production (new products, new parts, new materials, ...)?

Within the framework of this post-doc, you will be in charge of :

- To carry out a state of the art review of recent methods and results in relation to the problem addressed
- To propose new approaches to reinforcement learning based on sim2real transfer.
- To study the robustness of the methods developed in assembly scenarios for parts of increasing complexity.
- To participate in the scientific dissemination of the methods developed.

METHODOLOGY

CEA LIST is developing a robotic platform dedicated to fine insertion of mechanical parts, based on a Franka Emika robot equipped with a 3D vision sensor and force and tactile sensors.

We are also developing a simulation environment based on the XDE physics engine developed in-house, which enables the simulation in virtual reality of high-precision robotized industrial assembly tasks (automotive or aeronautics for example).

The post-doctoral student will use XDE as a simulator for learning and transfer the trained agent to the Franka Emika robotic platform.

SUPERVISION

The post-doc will be co-supervised by Vincent Weistroffer from the Interactive Simulation Laboratory, Jaonary Rabarisoa from the Computer Vision and Machine Learning Laboratory and Mathieu Grossard from the Robotic Systems Architecture Laboratory.

CANDIDATE PROFILE

- PhD in Robotics and/or Reinforcement Learning (in particular, modeling and control of articulated systems, 2D/3D vision)
- Knowledge and skills in Reinforcement Learning if PhD thesis in Robotics, and in Robotics if PhD thesis in Reinforcement Learning and computer vision
- Programming: C++, Python
- Framework: TensorFlow
- Knowledge in real-time physical simulation will be a plus.

Your qualities are creativity, a taste for challenge, autonomy and a sense of teamwork. You welcome the project to join an ambitious institute in the heart of the dynamic environment of the Saclay plateau.

If you recognize yourself in these skills, please send your CV + cover letter to

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