2018-00637 - PhD Position / Mixed-representation state estimation [S]

Niveau de diplôme exigé : Bac + 5 ou équivalent
Fonction : Doctorant

Contexte et atouts du poste

Team
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Mission confiée

Scientific context

Autonomy of robots often requires an internal representation of the current state of both the robot and its environment. For instance, a mobile robot aiming to go at a specific location will often estimate its current location and the map of the place; a robotic arm trying to pick an object will need the pose of the object (position and orientation), the description of potential obstacles, and its own current configuration; a humanoid robot in interaction with a human will need to know what the human is currently doing, her pose, her intention, her emotional state... Standard state estimation techniques often rely on a probabilistic representation wherein a probability distribution over the state space is recursively computed based on some observations and a model of the evolution of the system. This is generically known as a Bayesian filter, which has several classical instantiations according to the specificities of the system. Typical examples cases are Hidden Markov Models for discrete state representation and full transition matrices [Rabiner, 1989], Kalman filters for continuous states with Gaussian distributions and linear models [Kalman, 1960], or even particle filters for a sampled representation of the distributions [Doucet et al., 2000]. These techniques have been applied for distinct parts of the estimation either of the state of the robot with embedded sensors [Kubelka et al., 2015, Hitz et al., 2016], for the state of the robot with distributed sensors [Rio et al., 2016], for the estimation of human activity [Dubois and Charpillet, 2013] or sound sources [Nguyen et al., 2016], or even mapping the environment [Durrant-Whyte and Bailey, 2006]. As expected various representations are suited for different purposes.

The key challenge comes when **fusing information from multiple sources of different characteristics**. Classically, either you opt for a single system with the full state and all sensors in a monolithic filter, or you choose a specific representation shared across all sub-filters that can be treated together in a weak-fusion scheme. This works well until
you need to build an integrated representation of both the robot and the environment based on various modalities and processes. For instance, it is important to jointly work with discrete probabilities, Gaussian or mixture of Gaussian distributions, and particles in order to build a representation of the environment including an occupancy map of the obstacles, the location of sound sources and of several persons with different activities, and the current state of the robot based on the results in the literature.

A second challenge is to be able to integrate machine learning prediction into the model-based filters. Indeed, as the world representation becomes more complete it becomes more difficult to specify relevant models. A solution can be to completely resort to machine learning, not even attempting to specify any model, but it would be better to reuse the models we already have despite their shortcomings and use machine learning as a complement.

References


Principales activités

Project description

The aim of this PhD project is therefore to advance the state of the art
The first objective is to find a way to **propagate information between the different kinds of filters**, how to do efficient Bayesian inference with distinct distribution representations? An approach of this question could typically come from approximation techniques such as sampling or moment matching.

The second objective will be to **combine those model-based filtering techniques with machine learning**. Indeed the models are never complete or correct and several techniques require approximations to become tractable. There are therefore systematic errors that could potentially be corrected by model-less learning techniques such as deep neural networks. This second objective requires again to be able to transfer information across different kind of representations.

Finally, the emphasis will be laid on the **experimentation and validation methodology**. The algorithms developed should be demonstrated and applied to concrete robotics problems, for instance in the context of the smart apartment. This experimental setup is a small flat equipped with a wide range of sensors from pressure tiles on the ground to RGB-D cameras. We dispose of several mobile robots from turtlebots to a Pepper robot as well as a motion capture system that can provide ground truth information for the pose of the robots and of humans. Right now, we can separately locate the robot, build a map of the obstacles, locate sound sources, locate people and assess their current activity, etc. The aim is to **build an integrated representation** of this all and to leverage the synergies to improve their respective estimates. Indeed, knowing that there is somebody at a given place in the environment might give a hint about the location of a sound because it might come from a device she operates. Furthermore, the identification of this sound could help for the activity recognition.

### Compétences

### Required qualifications

MSc in computer science, robotics, or automation with strong skills in robotics, Bayesian or probabilistic inference, and programming (C++ or Python).

### Language

French or English.

### Avantages sociaux

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- French courses

### Rémunération


Monthly salary after taxes: around 1596,05€ for 1st and 2nd year. 1678,99€ for 3rd year. (medical insurance included).

### Informations générales
• **Thème/Domaine** : Robotique et environnements intelligents
• **Ville** : Villers-lès-Nancy
• **Centre Inria** : CRI Nancy - Grand Est
• **Date de prise de fonction souhaitée** : 01-10-2018
• **Durée de contrat** : 3 ans
• **Date limite pour postuler** : 01-05-2018

**Contacts**

- **Equipe Inria** : LARSEN
- **Recruteur** :
  Colas Francis / francis.colas@inria.fr

**L'essentiel pour réussir**

**Application deadline**

May 1st, 2018 (Midnight Paris time)

**How to apply**

Upload your file on *jobs.inria.fr* in a single pdf or zip file, and send it as well by email to francis.colas@inria.fr and vincent.thomas@loria.fr. Your file should contain the following documents:

- Your CV.
- A cover/motivation letter describing your interest in this topic.
- A short (max one page) description of your Master thesis (or equivalent) or of the work in progress if not yet completed.
- Your degree certificates and transcripts for Bachelor and Master (or the last 5 years).
- Master thesis (or equivalent) if it is already completed and publications if any (it is not expected that you have any). Only the web links to these documents are preferable, if possible.

In addition, one recommendation letter from the person who supervises(d) your Master thesis (or research project or internship) should be sent directly by his/her author to francis.colas@inria.fr and vincent.thomas@loria.fr.

Applications are to be sent as soon as possible.

**Conditions pour postuler**

**Sécurité défense** :
Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

**Politique de recrutement** :
Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.

**Attention** : Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.