Post-doc:

Design of mathematics and artificial intelligence tools for the mapping and sustainable management of crops pests using autonomous UAVs.

Laboratories:

ONERA (The French Aerospace Lab, http://www.onera.fr/en/our-centers/toulouse-center)

INRA (French agriculture, food and environment agency, http://www.toulouse.inra.fr/en).

Period: The post-doc should not start after December 2013 and will last for 2 years.

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Short description:

In the past decade, advances in AI and Information Sciences contributed to an increased use of robotics systems in civilian missions involving the acquisition of masses of data. In Southern France city of Toulouse, researchers from ONERA (the French Aerospace Lab), LAAS (Laboratory for Analysis and Architecture of Systems) and INRA (the French national institute for agriculture and research), have started a collaboration on the use of UAVs for the sustainable management of crops. In precision agriculture, one aim is to reduce pesticides and fertilizers use by targeting pest patches. This requires building maps of pests within crops, and the challenge addressed by the project is to exploit UAVs for the data acquisition aspect.

The selected applicant will use planning under uncertainty approaches to design methods for optimizing UAV-based sampling for the mapping of pests in agricultural areas. These methods will extend currently existing approaches developed at INRA and ONERA. The methods developed by the applicant will be implemented on ONERA UAVs. Experiments will be mainly

conducted in controlled conditions: (i) simulations on the ONERA-LAAS robotic simulator MORSE and (ii) real UAV experiments in controlled conditions (mapping of "pseudo-pests" on an ONERA experimental field). The post-doc will be based both at ONERA (where she/he will benefit from ONERA's experience on autonomous UAVs and AI-based information acquisition techniques) and at INRA, where she/he will benefit from INRA's experience on planning under uncertainty and optimal pest sampling for map reconstruction.

Project detailed description:

The context of the post-doc is the sustainable management of crop pests (weeds, diseases...). Environmental, social and politics pressures for a decrease in the use of chemical products in agricultural and natural areas require to precisely mapping pests spatial distribution within agricultural areas. Acquiring such map information requires a long and tedious man-made information gathering effort (sample acquisition or global visual density estimation). The effort is all the more difficult as it usually has to be performed at a supra-field scale.

There are two ways to make this information gathering process feasible in practice: (i) to limit the number of samples and optimize their choice by using decision theoretic approaches together with image reconstruction quality criteria and (ii) to automate sample collection by using robotic systems (UAVs) and image analysis tools. The aim of this post-doc is to put together and improve recent results on these two points.

More precisely, we aim at designing methods for optimizing data acquisition with autonomous UAVs within an agricultural area, in order to maximize the quality of the pest maps reconstructed from the data. In addition, the proposed methods should take into account resource (time or energy) constraints. Building such pest maps relies on the estimation of pest density in various sites of an agricultural area, whose size prevents exhaustive data collection by UAVs (and a fortiori by humans). Not only the number of observations is limited, but the altitudes at which images are acquired lead to a trade-off between the covered area and the reliability of densities' estimations. Both the method used for density map reconstruction and the method used for choosing the location of the sampled images will play an important role in building accurate weed maps.

Optimization of samples acquisition for pests map reconstruction has already been studied in a PhD thesis defended at INRA Toulouse in 2012. This problem was modeled within the framework of Factored Markov Decision Processes and dedicated feature-based reinforcement learning algorithms were proposed [Bonneau et al., 2012]. This theoretical work has not yet been implemented in UAV experiments. The challenges proposed by this subject are to adapt and extend the approaches that have been proposed so far, to the context of UAVs. First, the observations obtained when using UAVs are complex spatial signals. Translating these signals into density classes over grid cells and then into images, as required by current sampling optimization algorithms, is not trivial. Second, considering the third dimension (altitude)

increases the difficulty of the planning problem, by introducing a necessary compromise between the area covered by the observations and their accuracy. Furthermore, the current assumption of perfectly reliable observations does not hold anymore in the context of UAV-based pest sampling. Finally, the "real-time" constraint enforced by using UAVs instead of laboratory experiments, requires to smartly balance the time used for planning, image acquisition and reconstruction [Carvalho et ., 2013].

Where:

Toulouse is a nice historical city located in Southern France. Nicknamed the "pink city" because of the typical color of its buildings, it was funded by the Roman Empire during the 1st century BC. Toulouse is ideally located between the Mediterranean Sea (150 km), the Atlantic Ocean (230 km), and the Pyrenees mountain (100 km) where you will enjoy skiing and trekking. Toulouse is the regional capital of one of the most touristic regions of France, with many historical cities and gorgeous landscapes.

Applicant:

We expect applicants with a PhD in Artificial Intelligence, robotics or applied mathematics She/he must be familiar either with planning under uncertainty or machine learning. The post-doc will require programming and engineering skills for embedding the developed techniques in UAVs, as well as using image segmentation software. Applicants are also expected to have a taste for environmental problems solving and ecology.

The post-doc salary will be around 50KEuros/year (before taxes). For comparison, the salary of an early-career research scientists in France is around 30-40 Keuros/year. If non-French, the retained applicant will be allowed to apply for a salary top-up of 15 Keuros/year through the INRA/Agreenium program Agreenskills (http://www.agreenskills.eu/agreenskills-cms/)

Reference

M. Bonneau, N. Peyrard, R. Sabbadin. A Reinforcement-Learning Algorithm for Sampling Design in Markov Random Fields, 20th European Conference on Artificial Intelligence (ECAI'12), Montpellier, France, 2012.

C. Ponzoni Carvalho Chanel, F. Teichteil-Königsbuch, C. Lesire. Multi-target detection and recognition by UAVs using online POMDPs. 27th AAAI Conference on Artificial Intelligence (AAAI-13). Bellevue, USA, 2013.