PhD students in Statistical Machine Learning/nonlinear system identification
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We continue ramping up our research within statistical machine learning and computational statistics. In this opening we are now looking for new PhD students who want to join us in this effort. In Section 1 you will find a short description of what we do in our team and in Section 2 we provide a few concrete research problems that could serve as a basis for a PhD. Some administrative details:

• Application deadline: May 31, 2017.
• All applications are to be submitted via Uppsala University online application system, available via this link: (will be available on May 6)

• If you have any questions do not hesitate to contact us via e-mail.

1 The Statistical Machine Learning team

The statistical machine learning team consists of Dave Zachariah, Fredrik Lindsten and Thomas Schön with associated PhD students and postdocs.

We develop methodology and concrete tools for learning, reasoning and acting based on measured data. One of the cornerstones in our research is a probabilistic model allowing us to systematically represent and cope with the uncertainty that is inherent in most data. An important goal is to develop flexible models that can capture complex dynamical phenomena and their environments allowing machines and humans to better understand the world around us.

The data and the model are two of the cornerstones of our research. The third cornerstone is the inference methodology. Inference relates to the fundamental objective of automatically constructing models based on data. Over the past decades we have experienced a continuous development of increasingly more powerful computational inference methods. However, for many highly relevant applications the state-of-the-art algorithms still struggle. For example, it remains a major challenge to develop efficient and accurate inference algorithms capable of handling high-dimensional models, data rich applications, complex model structures, and diverse data sources that arise in many of the data analysis problems that we are currently facing.
The fourth and final cornerstone of our research is that of control. The main task here is to make use of all that has been learnt from the data and represented within the probabilistic model to automatically make decisions and influence the current situation in a suitable manner. Most existing control approaches cannot explicitly account for and make use of uncertainty. We want to change this by using probabilistic models to develop new control strategies, that are better suited to operate in uncertain environments.

From a methodological point of view we are open to most concepts. However, our specialties include sequential Monte Carlo (particle filters) methods, Markov chain Monte Carlo, Gaussian processes, and deep (reinforcement) learning.

Our group has a wide network of strong international collaborators all around the world, for example at the University of Cambridge, University of Oxford, Imperial College, University of British Columbia, University of Sydney, University of Newcastle and Aalto University. We strive for all PhD students to get a solid international experience during their PhD.

2 Potential Research Topics

The research projects for the advertised positions will be in the areas of statistical machine learning, computational statistics or nonlinear system identification. A few examples of potential research topics are briefly outlined below. As an applicant you are not required to specify a specific research topic in your application (but you are of course welcome to do so if you want). Indeed, the topics below are provided mainly to make the advertised positions more concrete. We do welcome own initiatives and the precise research topic of each PhD student will be decided in a dialog between the student and the supervisor after a successful appointment.

**Nonlinear system identification:** Many real-world systems are dynamical processes, e.g. aircraft, chemical plants, etc. By learning models of such systems we achieve insights about their dynamics, predict their behavior under different scenarios, and, in certain instances, control their output. The rise of computing power has enabled the learning of complex nonlinear systems. A very timely and interesting research topic is to develop new learning methods for nonlinear systems using emerging machine learning techniques along with classical insights from system identification.

**Sequential Monte Carlo for machine learning:** Sequential Monte Carlo (SMC) has emerged as one of the most powerful methods for computational inference in probabilistic models. Traditionally these methods were used mainly for addressing the filtering problem in dynamical models (particle filtering). Recently, however, it has been recognized that SMC is in fact much more general and that the methodology can be used to solve challenging inference problems in a wide range of applications. Much research nevertheless remains to be done to explore the full potential of this methodology for machine learning applications.

**Probabilistic programming inference:** A very flexible modeling approach are so called probabilistic programming languages (see [http://probabilistic-programming.org](http://probabilistic-programming.org)), where probabilistic models are constructed by overloading standard programming operations to have probabilistic meanings. Hence, a software engineer can define a probabilistic model by writing more or less standard code, simply defining certain variables to be unknown and random. This type of generic modeling frameworks have a huge potential for making probabilistic models accessible to a wide range of (non-specialist) users in various application areas. A challenge, however, is to provide efficient and automated inference methods when very little is known about the model beforehand. Indeed, the model can be viewed as a black-box that can be simulated by executing the code, but otherwise its properties are unknown. A possible PhD project with a very high potential impact is to develop new inference methods that can operate under these challenging conditions.