

Open Early Stage Researcher/PhD Position at INRIA, France, as part of

European Innovative Training Network
**Reduced Order Modelling, Simulation and Optimization of Coupled systems
(ROMSOC)**

ROMSOC is a European Industrial Doctorate (EID) project in the programme Innovative Training Networks (ITN) and part of Marie Skłodowska Curie Actions within the Horizon 2020 programme. The ROMSOC EID Network brings together 15 international academic institutions and 11 industry partners and supports the recruitment of eleven Early Stage Researchers (ESRs). Each ESR will be working on an individual research project in the host institution with secondments related to their research in other academic and industrial partners of the network. The research is focused on three major topics: coupling methods, model reduction methods, and optimization methods, for industrial applications in well selected areas, such as optical and electronic systems, economic processes, and materials. The ROMSOC EID Network offers a unique research environment, where leading academics and innovative industries will integrate ESRs into their research teams for the training period, providing an excellent structured training programme in modelling, simulation and optimization of whole products and processes.

We seek excellent open-minded and team-spirited PhD candidates who will get unique international, interdisciplinary and inter-sectoral training in scientific and transferable skills by distinguished leaders from academia and industry. Within the ROMSOC network we offer the following PhD position at INRIA:

FreeForm Optics applications of Optimal Transport Solvers

Reference number: ROMSOC-ESR03

Supervision

J.-D. Benamou (INRIA,Paris), W.L. IJzerman (Philips Lighting, Eindhoven).

Localisation and status

The ESR will be half time based between the MOKAPLAN group at INRIA-Paris and Philips Lighting-Eindhoven. He will be employed by INRIA, Paris and registered as a PhD student in applied Math. in the doctoral school of Université Paris Dauphine.

Scientific context

FreeForm Optics [FFO] is the branch of Optics concerned with the design of non-conventional asymmetric refractive and reflective optical elements [OE] or systems of such elements. This research is important to improve the energy efficiency of lighting devices and reduce light pollution (for example of street lighting). A classic application of FFO (amongst many) is the irradiance tailoring problem : design an optical system transferring a given light source emittance (e.g a car headlight bulb) to a prescribed irregular target irradiance (e.g. the angular far field distribution of projected light). The FFO design at the industrial level has remained so far largely heuristic. On the academic side, two classes (collimated or point source illuminance) of idealised tailoring irradiance problems can be exactly modelled and solved using Optimal Transport [OT] theory. OT defines a unique map or a coupling between prescribed distributions representing given illuminance and irradiance. This map can then be used to construct the OE shape. Recent advances in OT numerical solvers allow to tackle systems described by millions of degrees of freedom. This offers a sound mathematical and numerical background to FFO.

Challenges

1) OT modeling cannot be directly used for systems of OE involving multiple reflectors/lenses. 2) The collimated or point source illuminance hypothesis is not compatible with the use of LED light source technology and the current miniaturization trend. The size of the light source is too large compared to be considered as a far field point source for the reflector part of the OE. The OT theory and solvers again cannot directly be used.

Proposed research program

In the first challenge we propose to use the very efficient Sinkhorn algorithm for OT problems (including Multi-Marginal OT). This method doesn't give the optical map, but only an approximation. We need to devise a robust method to construct the OE from it. Sinkhorn algorithm solves an optimality systems for the OT variational problem. It can be formally modified to treat the extended source problem. As a first step a semi-extended source could be used. The mathematical and numerical analysis of this new system is fully open.

For the second challenge we propose to start with a simple lens system. In case a single lens surface is free-form the OT modeling can be used directly. However, if both lens surfaces are free-form the current OT modeling is not directly applicable. We envision two approach. In the first there is an intermediate light distribution described between the two surfaces. In this case the OT modeling can be applied to both surfaces independently, although for the second surface a more generalized approach needs to be developed. In this more general approach the (virtual) source for the second surface is a semi-extended source from the first challenge. In the second approach we will introduce multi-marginal OT formulation where unknown intermediate illuminance/irradiance distributions between single elements of the system are also unknown.

Depending on the profile of the ESR, the research may involve all or part of the following fields : mathematical analysis - numerical analysis - coding/testing algorithm - numerical simulation and testing of OE

A few relevant papers

L. A. Caffarelli, S. A. Kochengin, and V. Oliker. On the numerical solution of the problem of reflector design with given far-field scattering data. *Contemporary Mathematics*, 226-1332, 1999. 19, 24

Xu-Jia Wang. On the design of a reflector antenna II. *Calc. Var.* 20, 329-341 (2004).

M. Cuturi. Sinkhorn distances: Lightspeed computation of optimal transport. In *Conference on Neural Information Processing Systems (NIPS'13)*, pages 2292-2300, 2013.

JD Benamou, G Carlier, M Cuturi, L Nenna, G Peyré. Iterative Bregman projections for regularized transportation problems. *SIAM Journal on Scientific Computing* 37 (2), A1111-A1138.

Prins, C.R., Thijs Boonkamp, ten, J.H.M., IJzerman, W.L. & Tukker, T.W. (2015). A least-squares method for optimal transport using the Monge-Ampère equation. *SIAM Journal on Scientific Computing*, 37(6), B937-B961.

Requirements:

- Master degree (or equivalent) in Applied Mathematics or Optical Engineering
- Excellent Programming skills.
- Optional : Familiarity with convex analysis, calculus of variation and non linear optimization techniques.
- Strong interest in interdisciplinary scientific work.

- Ability to work independently and as part of a team.
- Strong motivation to pursue a PhD degree.
- Excellent command of English, together with good academic writing and presentation skills.

Starting Date:	1st of March 2018
Contract:	Full-time contract for 36 month
Host institution:	INRIA, Paris, France
Salary:	The Marie Skłodowska-Curie programme offers highly competitive and attractive salaries. Gross and net amounts are subject to country-specific deductions as well as individual factors and will be confirmed upon appointment.
Information/Contact:	Dr. Jean-David Benamou (Primary Supervisor) Prof. dr. ir. Wilbert IJzerman (Secondary Supervisor) Email: Jean-David.Benamou@inria.fr, Wilbert.Ijzerman@philips.com
Application:	Applications (motivation letter, detailed CV, certificates, list of MSc courses and grades, copy of the master thesis, reference letter etc) with indication of the position reference number should be sent to Jean-David.Benamou@inria.fr, Wilbert.Ijzerman@philips.com Applicants that apply for more than one individual research project should indicate the order of preference (e.g. 1st, 2nd and 3rd choice).
DEADLINE	15.12.2017

To ensure the equality of opportunities we strongly encourage women with the appropriate qualifications to apply. If equally qualified, handicapped applicants will be preferred.

Eligibility: *The candidate recruited in the ROMSOC project must be in the first four years from the date when the candidate obtained the degree entitling him or her to embark on a doctorate (e.g. master degree). No doctoral degree has been awarded during these four years. The candidate must not have resided or carried out her/his main activity (work, studies, etc.) in France for more than 12 months in the 3 years immediately prior to the recruitment date. Compulsory national service, short stays such as holidays, and time spent as part of a procedure for obtaining refugee status under the Geneva Convention are not taken into account. The candidate must work exclusively for the project during the employment contract. The candidate must fulfill the conditions to be admitted in the PhD programme indicated in the job vacancy. Tuition fees will be covered by the fellowship. These conditions must be fulfilled at the starting date of the contract. The starting date for each position is tentative.*