**2018-00741 - [GRAPHDECO] Discrete Optimization and Machine Learning for Line Drawing 3D Reconstruction**

**Contract type:** Public service fixed-term contract  
**Level of qualifications required:** Graduate degree or equivalent  
**Fonction:** PhD Position

**About the research centre or Inria department**

The Inria Sophia Antipolis - Méditerranée center counts 37 research teams and 9 support departments. The center's staff (about 600 people including 400 Inria employees) is composed of scientists of different nationalities (250 foreigners of 50 nationalities), engineers, technicians and administrators. 1/3 of the staff are civil servants, the others are contractural. The majority of the research teams at the center are located in Sophia Antipolis and Nice in the Alpes-Maritimes. Six teams are based in Montpellier and a team is hosted by the computer science department of the University of Bologna in Italy. The Center is a member of the University and Institution Community (ComUE) “Université Côte d’Azur (UCA)”.

**Context**

The PhD will take place at Inria Sophia Antipolis, on the beautiful French riviera. The research will be conducted in the GraphDeco group (https://team.inria.fr/graphdeco/). The group does research on image synthesis and computer-aided design.

Designers draw extensively to externalize their ideas and communicate with others. However, drawings are currently not directly interpretable by computers. To test their ideas against physical reality, designers have to create 3D models suitable for simulation and 3D printing. A long-term ambition of our research group is to bring the power of 3D engineering tools to the creative phase of design by automatically reconstructing 3D models from drawings.

However, reconstructing 3D models from drawings is an ill-posed problem: a point in the drawing can lie anywhere in depth. In addition, lines are often drawn quickly and do not represent a perfect projection of a 3D object. We thus need additional constraints on the solution to reduce ambiguity and correct for drawing inaccuracy, which will be one of the challenges to address in this PhD.

**Assignment**

While line drawing reconstruction remains an open problem, several methods have been proposed for specific shapes (see [1] for polyhedrons) and drawing techniques (see our work [2] that exploits a technique called cross-sections). The main idea behind these approaches is to impose geometric constraints between the lines in the drawing. For instance, two lines that are parallel in the drawing are constrained to be parallel in 3D. However, existing methods often rely on heuristics to detect these constraints, such as thresholds to identify parallel lines. While these heuristics work well on simple examples, they are not sufficiently robust to handle real-world design drawings.

The goal of this PhD is to design a novel optimization method capable of jointly identifying constraints in a drawing and reconstructing the corresponding 3D shape. To do so, we need to consider a number of candidate constraints in the drawing (parallelism, orthogonality, symmetry) and associate each constraint with a binary variable that indicates if the constraint is active. These additional discrete variables make the problem a so-called Mixed-Integer formulation, which is NP-hard since finding the optimal solution would require testing all potential combinations of constraints. Instead, we need to devise efficient strategies to only evaluate a subset of high-quality configurations.

[1] H. Lipson and M. Shpitalni  
Optimization-based reconstruction of a 3d object from a single freehand line drawing Computer-Aided Design 28, 651–663. 1996  
http://dl.acm.org/citation.cfm?id=1281556

True2Form: 3D Curve Networks from 2D Sketches via Selective Regularization  
ACM Transactions on Graphics (Proc. SIGGRAPH) 2014  

**General Information**

- **Theme/Domain:** Interaction and visualization  
  Scientific computing (BAP E)  
- **Town/city:** Sophia Antipolis  
- **Inria Center:** CRI Sophia Antipolis - Méditerranée  
- **Starting date:** 2018-10-01  
- **Duration of contract:** 3 years  
- **Deadline to apply:** 2018-05-27

**Contacts**

- **Inria Team:** GRAPHDECO  
- **Recruiter:**  
  Bousseau Adrien / adrien.bousseau@inria.fr

**The keys to success**

The successful candidate should have taken courses in numerical optimization, computer graphics, computer vision, geometry processing.

**About Inria**

Inria, the French National Institute for computer science and applied mathematics, promotes “scientific excellence for technology transfer and society”. Graduates from the world’s top universities, Inria’s 2700 employees rise to the challenges of digital sciences. With its open, agile model, Inria is able to explore original approaches with its partners in industry and academia and provide an efficient response to the multidisciplinary and application challenges of the digital transformation. Inria is the source of many innovations that add value and create jobs.

**Conditions for application**

**Defence Security:**  
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST). Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

**Recruitment Policy:**  
As part of its diversity policy, all Inria positions are accessible to people with disabilities.

**Warning:** you must enter your e-mail address in order to save your application to Inria. Applications must
Main activities

Several optimization strategies have been proposed for generic mixed-integer problems. For instance, the “branch-and-bound” algorithm explores the solution space by progressively estimating upper and lower bounds on the cost of subsets of solutions [3]. These bounds allow the algorithm to ignore solutions that cannot be better than the ones already evaluated. Other approaches such as Markov Chain Monte Carlo start from an initial solution and generate new ones by randomly changing the values of its variables, keeping the change if it yields a better solution. The first part of the PhD will be to study these methods and adapt them to our context.

However, while more efficient than an exhaustive search, existing methods often require many steps before converging to a good solution, especially if they start from a bad initialization. A second part of the PhD will be to exploit machine learning to speed up the optimization. In particular, deep learning has shown great success in predicting approximate 3D information from images [4,5]. Our plan is to build on such approaches to initialize the optimization with a good solution, or to quickly predict the quality of intermediate solutions during the exploration of the solution space.

[4] David Eigen and Rob Fergus
Predicting Depth, Surface Normals and Semantic Labels with a Common Multi-Scale Convolutional Architecture
ICCV 2015
http://www.cs.nyu.edu/~deigen/dnl/
[5] Learning Shape Abstractions by Assembling Volumetric Primitives
Shubham Tulsiani, Hao Su, Leonidas J. Guibas, Alexei A. Efros, Jitendra Malik

Skills

The candidate must have experience in C++ programming. Knowledge of specialized libraries (geometry processing, rendering, deep learning) would be a plus.

Benefits package

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

Remuneration

Duration: 36 months
Location: Sophia Antipolis, France
Gross Salary per month: 1982€ brut per month (year 1 & 2) and 2085€ brut/month (year 3)