Interventional radiology is a minimally invasive surgical technique based on the use of a catheter: a thin (diameter ranging from less than one millimeter to a few millimeters at most), long (more than one meter long) and flexible tube. Inserted into the femoral artery by a simple groin puncture, the catheter is manipulated to navigate through the blood network to the pathology (brain, heart, liver, kidney...). An access path is thus established through which other surgical micro-tools are routed to perform the treatment. The interventional radiologist must guide the catheter tip only by translational and rotational movements applied to its insertion base, approximately one meter away from the tip. The practitioner must therefore play with complex physical behaviors such as the torsion and the elasticity of the catheter, as well as the catheter reaction to the contact it may have with the arterial wall.

Learning, performing and mastering this difficult technique would benefit from high fidelity simulation capabilities. Several models have been investigated to model the catheter (mass springs, beam FEM, Cosserat model), but these solutions still have a hard time reproducing the catheter behavior. The current project aims at designing a new simulation framework able to tackle the complex boundary conditions in actual patient vasculature, at interactive rates. This framework will combine and leverage the respective properties of a Cosserat model for the catheter [1] with an implicit representation for the blood vessel surface [2].

This project has four modules. A first module will aim to study and implement in C++ the model we have already developed in Matlab. A second module will aim to improve our implicit reconstruction algorithm of the vascular surface from patient data. The third module will develop a collision and friction management method. It will exploit the properties of implicit surfaces to integrate them continuously along the curve, in order to formulate mechanical stresses both efficiently and mathematically accurately. Finally, a fourth module will cover the tasks of evaluation and validation of the model developed. The recruited person will be involved in the first two modules and responsible for the latter two.

References

Main activities
The recruited person will pursue research activities on computer models of 1D mechanical structures. A particular focus will be put on contact management: exact force computation and application, response (e.g. deformation) of contact surface, self-contact. The proposed solutions will rely on the basis of Solid Mechanics but will harvest the field of Computer Graphics to efficiently leverage implicit surfaces. A second focus will be placed on validation, and the evaluation of the physical accuracy of the proposed simulation framework. In that context, we’ve been collaborating for many years with physicians at the local University Hospital.

Skills
**Technical skills and level required:** PhD in computer science or applied mathematics; solid knowledge in computer graphics; good to excellent level in C++ programming; knowledge in solid mechanics as well as skills in computer vision and experience in designing and carrying out experimentations will be appreciated.

**Languages:** French or English

**Relational skills:** readiness to work in a team, in a multicultural environment; ease in communicating research work; eagerness to convey new research ideas

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

Remuneration
Salary: 2653€ gross/month

Applications are to be sent as soon as possible.

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 be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.