Offer #2021-04130

Optical fiber strain-lag parameter estimation by an adaptive observer method

Contract type : Internship agreement

Level of qualifications required : Graduate degree or equivalent

Fonction : Internship Research

About the research centre or Inria department

The Inria Rennes - Bretagne Atlantique Centre is one of Inria's eight centres and has more than thirty research teams. The Inria Center is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative PMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute, etc.

Context

Distributed fiber optic sensing technologies (Rayleigh or Brillouin) have been experiencing significant growth for just over a decade. They are well adapted to civil engineering structural monitoring, particularly for the identification of areas of high stresses, or the detection of cracks and leaks on large structures (bridge, road, pipeline, dam ...). However, the strain profile measurements obtained by these technologies depend on the type of optical fiber or optical cable used as sensor. Indeed, such sensors are complex assemblies made of concentric layers of different materials which induces a strain transfer. Recent research works on the modeling of the strain transfer [1,2] have shown that it depends on a parameter called strain-lag parameter which is characteristic of each optical fiber or optical cable.

Assignment

The behavior of optical fiber sensors for strain measurement is described by a differential equation [1], whose solution depends nonlinearly on the strain-lag parameter. Consequently, a naïve method for strain-lag parameter estimation would be based on the numerical solution of a nonlinear optimization problem, minimizing the error between the sensor measurement and the model output. This approach is typically locally convergent when the initial approximation is already close enough to the solution. In order to improve parameter estimation robustness, the differential equation model can be appropriately transformed, so that globally convergent adaptive observer algorithms [3,4] can be used. The aim of the internship is to develop a new methodology based on adaptive observer algorithms for the determination of the strain-lag parameter of optical fibers/cables.

Main activities

The internship project will work on both theoretical and experimental aspects. The theoretical part concerns the design and implementation of a strain-lag parameter estimation algorithm. Then, numerical simulations must be carried out to validate it and evaluate its performance, especially for different types of optical fibers/cables that may have very different strain-lag parameters. The influence of the type of strain field applied on the optical fiber must also be evaluated to define the most appropriate test set-up. The experimental part of the internship then concerns the realization of tests to validate the developments mentioned above on different type of optical fibers. In addition, comparison of the strain-lag parameter estimation with previous results presented in [1] will be performed to evaluate the benefit of the new method developed in the internship.

Bibliography

1. Xavier Chapeleau and Antoine Bassil. A General Solution to Determine Strain Profile in the Core of Distributed Fiber Optic Sensors under Any Arbitrary Strain Fields. *Sensors*, *21(16),* 5423, 2021.
2. Antoine Bassil, Xavier Chapeleau, Dominique Leduc and Odile Abraham. Concrete Crack Monitoring using a Novel Strain Transfer Model for Distributed Fiber Optics Sensors. *Sensors*, 20(8), 2220, 2020.
3. Qinghua Zhang. Adaptive observer for multiple-input-multiple-output (MIMO) linear time varying systems. *IEEE Trans. on Automatic Control*, 47(3):525-529, 2002.
4. Qinghua Zhang. Adaptive Kalman Filter for Actuator Fault Diagnosis.*Automatica*, 93:333-342, July 2018.

Web of I4S team: team.inria.fr/i4s/

Web of SII : sii.univ-gustave-eiffel.fr

Skills

The candidate is expected to be in the final year of Master's degree (or an equivalent degree) in Mathematics, Mechanics, Physics or Engineering. He should also feel comfortable with as much following items as possible:

- Basics knowledge in mechanics (in fiber optic sensors would be a plus).
- Background in methods of parameter estimation.
- Taste for both experimental and theoretical works.
- Good spoken and written English.
- Good communication skills.

To candidate, please send a CV and a motivation letter to the following contacts:

Xavier Chapeleau (UGE, COSYS-SII, I4S team, Nantes) : xavier.chapeleau@univ-eiffel.fr
Qinghua Zhang (Inria, I4S team, Rennes) : Qinghua.Zhang@inria.fr

General Information

- **Theme/Domain :** Optimization, machine learning and statistical methods
  Instrumentation et expérimentation (BAP C)
- **Town/city :** Nantes
- **Inria Center :** Centre Inria de l'Université de Rennes
- **Starting date :** 2022-03-01
- **Duration of contract :** 6 months
- **Deadline to apply :** 2021-12-15

Contacts

- **Inria Team :** I4S
- **Recruiter :**
  Zhang Qinghua / QINGHUA.ZHANG@INRIA.FR

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

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.

Instruction to apply

contact : Qinghua.Zhang@inria.fr

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.