# Offre n°2025-08653

# No-brain-shift and Comprehensive Neurosurgical Navigation using computer vision

*Le descriptif de l'offre ci-dessous est en Anglais*

**Niveau de diplôme exigé :** Bac + 5 ou équivalent

**Fonction :** Ingénieur scientifique contractuel

**Niveau d'expérience souhaité :** De 3 à 5 ans

## A propos du centre ou de la direction fonctionnelle

Le centre Inria d'Université Côte d'Azur regroupe 42 équipes de recherche et 9 services d'appui. Le
personnel du centre (500 personnes environ) est composé de scientifiques de différentes nationalités,
d'ingénieurs, de techniciens et d'administratifs. Les équipes sont principalement implantées sur les
campus universitaires de Sophia Antipolis et Nice ainsi que Montpellier, en lien étroit avec les
laboratoires et les établissements de recherche et d'enseignement supérieur (Université Côte d'Azur,
CNRS, INRAE, INSERM ...), mais aussi avec les acteurs économiques du territoire. Présent dans les domaines des neurosciences et biologie computationnelles, la science des données et la
modélisation, le génie logiciel et la certification, ainsi que la robotique collaborative, le Centre Inria
d'Université Côte d'Azur est un acteur majeur en termes d'excellence scientifique par les résultats
obtenus et les collaborations tant au niveau européen qu'international.

## Contexte et atouts du poste

The aim of this project is (i) to reconstruct precisely, automatically and continuously the volume of the brain exposed by craniotomy during neurosurgery and (ii) to reposition this volume distorted by the drop in intracranial pressure and resection in standard imaging (MRI, PET-Scan).The ambition is to propose a corrected and complete neuronavigation that is better suited to research.

# Mission confiée

Brain surgery is essentially based on planning the procedure on the basis of pre-operative anatomical images (MRI, PET-Scan). Intra-operatively, apart from surgery on awake patients, there is no relevant anatomical imaging to guide surgery online, mainly because of (i) the collapse of the brain with the drop in intracranial pressure that occurs when the dura mater is opened and (ii) the substantial resection (sometimes more than a hundred $cm^3$ for tumour resection). This overall phenomenon, known as "brain shift", leads to shifts of the order of a centimetre between the actual position of a surgical tool and its position in the anatomical images. Current neuro-navigation systems, based on classic movement analysis tools (infra-red localisation of passive markers):

- cannot compensate for the "brain shift" . However, when the surgical intervention reaches the white matter fascicles, sub-millimetre precision would be necessary to try to limit the resection of fascicles that are critical for cerebral function.
- What's more, these solutions do not allow continuous monitoring of anatomical changes and the various surgical procedures. No access to historical data is currently possible. This makes it impossible to reconstruct resection cavities, stimulation points and tool trajectories.
- Furthermore, when intra-operative neural monitoring is necessary to identify structural connectivity by electrophysiological measurements and requires the placement of electrodes, the precise location of these electrodes and the associated electrical stimulation points on standard imaging is not possible and remains reconstructed a posteriori with considerable imprecision, which limits the interpretation and clinical relevance of the data collected. \cite{rossel23}.

The ultimate aim of this project is to resolve these 3 limitations by changing the technological paradigm. In concrete terms, based on two calibrated video streams (stereoscopic vision probably embarked by the neurosurgeon), the approach will consist of extracting several pieces of information in the space of the camera images: fixed points of interest in the scene, mobile anatomical landmarks linked to the brain shift, 6D pose of the surgical tools. This feature extraction stage will be carried out using various machine learning tools (i.e. convolutional neural networks, transformers). The 2D information will then be combined by triangulation to obtain a *3D+time* description of the surgery in a fixed anatomical frame of reference (linked to the cranial cavity).

This information will be used to estimate **mobile** quantities:

- the 3D volume representing the surface of the bare brain and the resection cavity,
- the main blood vessel segments, which follow the main cortical sulci,
- electrocorticographic collection electrodes,
- 6D time trajectories of surgical tools

and quantitites \textbf{fixed} in the laboratory frame of reference (the patient's skull is fixed by a headrest).
The 3D representation of this data combined with the knowledge of fixed landmarks will enable it to be matched with T1 MRI images. This represents three key innovations compared with existing neuronavigation: A) the brain shift is corrected in the navigation data reprojected into the MRI, B) the trajectories of the surgical tools, the dynamics of the brainshift, etc. are available postoperatively, and C) the measurement and stimulation electrodes are precisely located throughout the surgery.

# Principales activités

**Automatic segmentation**
The cerebral surface will be reconstructed i) by extracting the 2D coordinates of various anatomical and artificial points of interest (moved by the 'brain shit': blood vessels, surgical tags, stimulation electrodes and ii) by estimating the 6D pose of the various rigid tools that the surgeon handles \cite{moullet23} and \textbf{puts in contact with the brain} (suction, ultrasound fragmenter (CUSA), stimulation probe, various forceps). The operating principle is that, knowing the geometry of these tools a priori, we can use the partial vision provided by the stereoscopic vision device worn by the surgeon to deduce the hidden part (in the cerebral matter). By analysing the positional and velocity trajectories of the tips of these tools, we can precisely deduce the obstacles, i.e. the cerebral surface.

**Reprojection of the brain surface in MRI**
The aim is to match the surface obtained by computer vision and the various landmarks with the MRI data. The challenge is to model the geometry of the brain-shift in order to compensate for it mathematically and merge the 2 types of data.

**Flow-Chart**
These segmentations and reconstructions will be used continuously to (i) estimate the 'brain shift' and enrich the models that describe it, and (ii) move the surgical tools and electrodes (stimulation, measurement).
The volume of the resection cavity will be updated each time a surgical tool is placed in contact with the tissue.

We will consider two situations to compare their accuracy. A situation with "calibration" (movement by the neurosurgeon of a rigid tool on the surface of the

brain) and without "calibration" (no particular action on the part of the neurosurgeon).
The development will be carried out in close collaboration with the neurosurgeon E. Mandonnet, to evaluate the practical and ergonomic aspects of the proposed solution.

**Technological development**
This project involves the development of an ergonomic wearable device fixed to the neurosurgeon's head for positioning a pair of stereoscopic RGB cameras. Initially, we will consider the portable case with a fixed distance between the two cameras for continuous stereoscopic vision of the craniotomy zone and minimising obturation of the cameras' field of view (optimal situation for image capture). If this situation proves unviable in the operating theatre or sub-optimal for the neurosurgeon, we will consider relocating the positioning of the cameras while maintaining their fixed distance and orientation, even if they are attached to moving objects in the operating theatre. For the time being, the solutions we are considering involve either attaching the two cameras to the arms of glasses or to a headband.

# Avantages

- Restauration subventionnée
- Transports publics remboursés partiellement
- Congés: 7 semaines de congés annuels + 10 jours de RTT (base temps plein) + possibilité d'autorisations d'absence exceptionnelle (ex : enfants malades, déménagement)
- Possibilité de télétravail et aménagement du temps de travail
- Équipements professionnels à disposition (visioconférence, prêts de matériels informatiques, etc.)
- Prestations sociales, culturelles et sportives (Association de gestion des œuvres sociales d'Inria)
- Accès à la formation professionnelle
- Participation mutuelle (sous conditions)

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Contribution to mutual insurance (subject to conditions)

# Rémunération

A partir de 2692 € brut mensuel (selon diplôme et expérience)

# Informations générales

- **Thème/Domaine :** Neurosciences et médecine numériques
  Instrumentation et expérimentation (BAP C)
- **Ville :** Montpellier
- **Centre Inria :** Centre Inria d'Université Côte d'Azur
- **Date de prise de fonction souhaitée :** 2025-04-01
- **Durée de contrat :** 1 an, 6 mois
- **Date limite pour postuler :** 2025-07-01

# Contacts

- **Équipe Inria :** CAMIN
- **Recruteur :**
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# A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L'institut s'e?orce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

**Attention**: Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

# Consignes pour postuler

**Sécurité défense :**
Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle

que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

**Politique de recrutement :**
Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.