Internship 1: Speckle reduction for medical ultrasound imaging through deep learning approaches

Duration: 6 months
Preferred start date: from January 2020 or later
Localization: Suresnes (92)
Contact: caroline.raynaud@philips.com, hernan.morales@philips.com

Unité d'accueil

Philips Healthcare is a world leader in medical imaging. Its products cover the full range of imaging modalities: X-Rays, MRI, Ultrasound, CT, etc. The company is internationally recognized for the excellence of its technology, developed within innovative research groups.

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Internship description

Medical ultrasound is becoming today one of the most accessible diagnostic imaging modalities. A high image quality is the basis on which clinical interpretation can be made with sufficient confidence. However, medical ultrasound images suffer typically from speckle effect due to interference in the image formation.

In this internship, we propose to study deep learning approaches to perform ultrasound speckle reduction. We will explore several different methods including end-to-end learning and hybrid methods. We would also like to push the understanding and the interpretation of the network behavior through a deeper analysis of network structures and activation functions.

A first step consists of establishing an image base from existing tool of speckle synthesis. This allows us to attempt different existing methods on these synthetic data. The second step will consist in implementing and analyzing hybrid learning approaches to optimize de-speckling performance.

The programming language is Python in Tensorflow environment.

Candidate profile

- Third year of engineer school / Master 2 Recherche, with specialty in machine learning, image processing or applied mathematics
- Solid knowledge of statistics, machine learning, deep learning, image processing
- Knowledge or experience on conventional denoising and filtering will highly appreciated
- Experience in Python and Matlab
- English speaking, reading and writing is mandatory
- Good communication skills and ability to work in a team

Internship 2: Landmark detection in fetal ultrasound, with quality estimation.

Duration: 6 months
Preferred start date: from January 2020 or later
Localization: Suresnes (92)
Contact: caroline.raynaud@philips.com, hernan.morales@philips.com

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Internship description

Ultrasound (US) imaging is the modality of choice for fetal screening. In many countries, the US exam performed between 18 and 22 weeks of pregnancy is used to assess the development of the fetus by performing some biometry measurements. One of those measurement is the femur length, corresponding to the distance between the femur end-points. In this internship, we aim at designing an algorithm for automatic detection of those landmarks.

For such an application, deep learning techniques have reached state-of-the-art performance. However, they usually fail to produce a reliable estimation of the quality of their prediction, for instance on out-of-distribution data. This would be a precious feature during the biometry exam in view of future integration into an ultrasound system.

This internship will be divided into several moments. A first step will be to implement a baseline model for landmark detection. Then, we will review the existing methods for uncertainty/quality estimation. The retained method will be implemented and evaluated, especially on non-standard femur acquisitions. A final development may be to transpose and adapt the pipeline to a more complex problem, for instance for 3-dimensional data, corresponding to a 3D ultrasound acquisition.

Candidate profile

- Third year of engineer school / Master 2 Recherche, with specialty in machine learning, image processing or applied mathematics;
- Solid knowledge of statistics, machine learning, deep learning, image processing;
- Experience Python; knowledge of the Tensorflow/Keras framework;
- English speaking, reading and writing is mandatory;
- Good communication skills and ability to work in a team.

Stage3 : Réseaux profond projectifs pour l'estimation de la pose 3D d'outils en fluoroscopie

Durée : 6 mois
Date de début souhaitée : à partir de janvier 2020 ou plus tard
Localisation : Suresnes (92)
Contacts : caroline.raynaud@philips.com, hernan.morales@philips.com

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L'équipe de *Philips Research Paris – Medisys*, basée à Suresnes en banlieue parisienne, est spécialisée en traitement d'images médicales. Elle regroupe une trentaine d'ingénieurs de recherche, travaillant sur les problématiques les plus prometteuses du domaine (intelligence artificielle, extraction de contours, recalage, quantification automatique, etc.) en collaboration avec des groupes académiques prestigieux (INRIA, CEREMADE, EPFL, Institut Mines-ParisTech, etc.) et de nombreux sites cliniques en France et à l'étranger.

Description du stage

Depuis environ deux décennies, les interventions minimalement invasives bouleversent profondément le paysage de la chirurgie cardiaques. Lors de ces interventions, les instruments chirurgicaux sont amenés vers le cœur via le système sanguin, et leur progression est surveillée par fluoroscopie (imagerie temps réel par rayons X). Les bénéfices pour le patient sont significatifs (morbidité et durée d'hospitalisation réduites notamment).

Pendant ce stage, nous nous intéresserons au suivi des instruments chirurgicaux pendant ces opérations, et plus précisément à l'estimation de leur position en 3D par apprentissage profond à partir des images fluoroscopiques.

Ce problème de recalage 2D/3D peut être vu comme un simple problème de régression (trouver les paramètres de la pose 3D en fonction de l'image), et les approches par apprentissage profond standards donnent en effet déjà de bons résultats en suivant cette approche standard. Dans ces approches, cependant, le réseau n'a qu'une connaissance implicite de l'objet à projeter.

Au cours de ce stage, nous allons nous intéresser au cas où le réseau a une connaissance explicite de l'objet 3D, et est capable de le projeter afin de confronter son estimation à l'image. Nous allons en particulier tenter d'apprendre une mesure de similarité « idéale » entre l'image et la projection de l'objet, qui pourrait être minimisée par des techniques d'optimisation classique, voire, si besoin, par apprentissage par renforcement.

Profil du stagiaire

- Formation : 3ème année d'école d'ingénieur ou master, spécialité informatique, traitement d'images, apprentissage automatique ou plus généralement mathématiques appliquées.
- Fort intérêt pour le *Deep learning* et particulièrement pour son application au traitement de l'image.
- Bonne connaissance de Python, et une librairie de DL (idéalement Tensorflow et/ou Keras).
- Intérêt spécifique pour le domaine médical.
- Maîtrise orale et écrite de l'anglais scientifique.

Internship 4: Inverse problem in 1D models of the arterial network

Duration: 6 months
Preferred start date: from January 2020 or later
Localization: Suresnes (92)
Contact: caroline.raynaud@philips.com, hernan.morales@philips.com, alexandre.this@philips.com

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Internship description

1D models of the systemic circulation allow to study the behavior of blood along vessels approximated by axially symmetric tubes. Those models neglect the transverse behavior of the fluid in exchange of a strong decrease in numerical complexity. As this *direct* problem can be conducted in an efficient manner, this internship aims to investigate the use of inverse problem theory in this context, in particular to estimate model parameters.

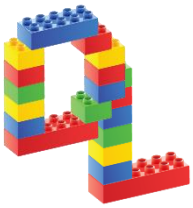
The first step of the internship will be to refine a pre-existing 1D model of the systemic circulation to evaluate and/or improve its fidelity. This step will allow the candidate to understand the model parameters and the causal relationship between the parameters and the model outputs.

In a second step, the intern will conduct a literature review of inverse problem methods and identify a method suited for the estimation of model parameters based on potentially noisy or incomplete observations. The intern will implement the method and assess its capabilities based on synthetic data.

Candidate profile

- Third year of engineer school / Master 2 Recherche, with specialty in numerical modeling, optimization and/or applied mathematics
- Solid knowledge in dynamical systems, optimization methods and signal processing
- Interest in the medical sciences
- Experience in Matlab and/or Python
- English speaking, reading and writing is mandatory
- Good communication skills and ability to work in a team

Stage5: Développement d'une plateforme de *Machine Learning* et *Deep Learning* visuel



Durée : 6 mois
Date de début souhaitée : dès que possible
Localisation : Suresnes (92)
Contacts : caroline.raynaud@philips.com, hernan.morales@philips.com

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Description du stage

L'objectif de ce stage est de développer une plateforme permettant aux utilisateurs de construire des chaînes complètes de traitement d'images par *Machine Learning* et *Deep Learning* sous forme de graphes, à travers une interface visuelle. Les utilisateurs finaux peuvent être :

- des chercheurs, qui souhaitent créer de nouveaux prototypes efficacement ;
- des médecins ou des *data scientists* au sein des hôpitaux, qui ont une excellente connaissance du domaine médical, mais des connaissances limitées en programmation et en intelligence artificielle.

Après l'étude des outils proposés par la compétition (SAS Viya, Dataiku, etc.), le candidat implémentera une première chaîne de traitement complète selon une architecture client / serveur : lecture et traitement des données, construction interactive des réseaux de neurones, etc. Il s'agira d'interfacer les librairies de *Machine Learning* et de *Deep Learning* existantes, telles que Tensorflow/Keras, pour créer des composants génériques (côté serveur).

Dans un deuxième temps, le candidat pourra proposer d'implémenter d'autres composants pour l'analyse de données, la visualisation des résultats lors de l'apprentissage ou pour interpréter les décisions des réseaux de neurones, par exemple. Il pourra également développer des composants de visualisation (interface client).

Lors du stage, le candidat sera en contact avec d'autres chercheurs ainsi que des médecins, afin de recueillir leurs besoins et leurs retours d'expérience pour orienter et évaluer le travail réalisé.

Profil du stagiaire

- Formation : 3ème année d'école d'ingénieur ou master, spécialité informatique.
- Connaissances en C++, C# ou Python
- La connaissance du HTML/CSS/JavaScript et du framework TensorFlow/Keras est un plus.
- Des connaissances en *Machine Learning*, *Deep Learning* et analyse de données sont un plus.
- Maîtrise orale et écrite de l'anglais.

Internship 6: Self-supervised MR to CT synthesis from unpaired data

Duration: 6 months
Preferred start date: from March 2019 or later
Localization: Suresnes (92)
Contact: caroline.raynaud@philips.com, hernan.morales@philips.com

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Internship description

Accurate MR-to-CT synthesis is important for several medical applications. The Cycle GAN [1] deep learning approach derives a synthetic CT image from the available MR image, without requiring spatially aligned MR and CT training volumes. This is a desirable property since it alleviates the need for accurate registration of MR and CT training volumes. However, cycle GAN cannot guarantee structural consistency between CT and MR images needed for clinical applications. Besides Cycle GANs suffer from unstable training inherited from the GAN learning algorithm.

In this internship, we attempt to address the aforementioned limitations by drawing inspirations from self-supervised learning and auxiliary classifier GANs. The trainee will start by familiarizing with an existing in-house implementation of cycle GAN. At a second stage, the trainee will experiment with the proposed algorithmic improvements towards stabilizing cycle GAN training and improving the quality of the synthesized images. Depending on the progress of the internship, further improvements would be investigated by considering methods derived from unsupervised domain adaptation.

A large dataset of brain MR and CT volumes is available for training, and a second dataset of paired pre-registered MR and CT volumes is available for validating the proposed method.

[1] Wolterink et al, Deep MR to CT Synthesis using Unpaired Data

Candidate profile

- Third year of engineer school / Master 2 Recherche, with specialty in machine learning, image processing or applied mathematics
- Solid knowledge of statistics, machine learning, deep learning, image processing
- Experience in Python
- English speaking, reading and writing is mandatory
- Good communication skills and ability to work in a team