45ème journée ISS France

Jeudi 3 février 2022

PROGRAMME

Session 1: Apprentissage profond – 10:00 – 10:50

10:00 – 10:25 **Semantic Segmentation with Scale-Equivariant Networks** **Mateus Sangalli[1], Samy Blusseau[1], Santiago Velasco-Forero[1], Jesus Angulo[1]**
[1]Centre de Morphologie mathématique – Mines ParisTech – PSL Research University

10:25 – 10:50 **Using deep learning to retrieve 3D geometrical characteristics of a particle field from 2D projected images: Application to multiphase flows** **Kassem Dia[1,2], Fabrice Lamadie[1], Johan Debayle[2]**
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Session 2: Segmentation – 11:00 – 11:50

11:00 – 11:25 **Segmentation of ordered skin layers in histological images with a structural guarantee** **Thomas Langrognet[1], Etienne Decencière[1], Thérèse Baldeweck[2], Hélène Zucchi[2]**
[1]Centre de Morphologie mathématique – Mines ParisTech – PSL Research University
[2]L'Oréal R&I

11:25 – 11:50 **Caractérisation anatomique de l'arche aortique à partir de volumes ARM: une approche de segmentation basée sur les CNN** **Mounir Lahlouh[1,2,3] , Yasmina Chenoune[2,4] , Raphaël Blanc[3,5] , Jérôme Szewczyk[3,6] , Nicolas Passat[1]**
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Session 3: Détection – 13:30 – 14:45

13:30 – 13:55 **Syncrack: Improving pavement and concrete crack detection through synthetic data generation**
Rodrigo Rill-Garcia[1, 2,] Eva Dokladalova[1], Petr Dokladal[3]
[1]LIGM – Laboratoire d'informatique Gaspard Monge [2]NAVIER UMR 8205 – Laboratoire Navier [3]Centre de Morphologie mathématique – Mines ParisTech– PSL Research University

13:55 - 14:20 **Particles detection in a 2D image of overlapping crystals based on community detection.**
Said Rahmani[1] , Roger de Souza Lima[1] , Ana Cameirão[1] , Eric Serris[1] , Johan Debayle[1]
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14:20 – 14:45 **Real-Time Mixed Method for SLAM.** **Thomas Belos[1] , Pascal Monasse [1] , Eva Dokladalova [21]**LIGM, Ecole des Ponts ParisTech, Université Gustave Eiffel, CNRS, F-77454 Marne-la-Vallée,France [2]LIGM, Université Gustave Eiffel, CNRS, ESIEE Paris, F-77454 Marne-la-Vallée,France

Session 4: Géométrie stochastique – 15:00 – 15:50

15:00 – 15:25 **Parameters Estimation of a Stochastic Geometrical Model for Multiphase Flow Images Using Local Measures: Towards a Predictive Model for Multiphase Flows** **Léo Théodon[1], Tatyana Eremina[1] , Kassem Dia[1,2] , Fabrice Lamadie[2] , Jean-Charles Pinoli[1] , Johan Debayle[1]**
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[2]CEA, DES, ISEC, DMRC, Univ Montpellier, Marcoule, France

15:25 – 15:50 **On the Geometry of Random Multiphase Excursion Sets and their Applications to Solid Oxide Fuel Cells Modeling.** **Lucas Reding[1], Yann Gavet[1]**
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Semantic Segmentation with Scale-Equivariant Networks

Mateus SANGALLI[1], Samy BLUSSEAU[1], Santiago VELASCO-FORERO[1], Jesus ANGULO[1]
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ABSTRACT

Equivariant Neural Networks have produced interesting results in tasks where some kind of symmetry is present on the data.

In many tasks in computer vision, scale symmetry is present in the data, e.g. in a semantic segmentation task of an urban scene, the same class of object can be visible by the camera at different distances, hence the object will appear at different scales. To this end, it is interesting to study the properties of scale-equivariant networks. The scale semigroup equivariant networks are a class of scale-equivariant networks which are based on a scale-space operator, such as the Gaussian scale space or morphological scale-spaces, and scale-cross-correlations, which are scale-equivariant counterparts of the convolution operators.

The U-Net, on the other hand, is a neural network which provides state-of-the-art in semantic segmentation tasks.

In this work, we present a U-Net constructed based on the scale-cross-correlation and different scales-spaces, in particular the Gaussian and quadratic morphological ones, and we test its equivariance in a segmentation task of obtaining the strands of a 3D tissue object based on 2D slices of the object. We find that this change significantly improves the performance of the model in scales unseen during training.

Using deep learning to retrieve 3D geometrical characteristics of a particle field from 2D projected images: Application to multiphase flows

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Keywords: Deep Learning, 3D modeling, stochastic geometry, multiphase flow

ABSTRACT

The main part of recycling processes are carried out in chemical engineering reactors that involve multiphase flows with dense dispersed phase. In a study and modeling approach of these processes, the description and characterization of hydrodynamic phenomena is crucial. A variety of techniques allows us to realize this type of measurement, but the most used one is the direct imaging associated with an efficient image processing. Recently, deep learning algorithms have proven to be very effective in solving image-based problems, which led to the use of these algorithms to extract critical information in chemical engineering apprentices.

The goal of this project is to use a deep learning algorithm, called convolutional neural network (CNN), in order to extract critical 3D information of multiphase flows using their 2D projected images (i.e. dispersed phase percentage and particles size distribution parameters). This algorithm requires a huge amount of labeled data set to be trained properly. Therefore, a 3D stochastic geometrical model is used to generate synthetic images of the multiphase flow. It consists of a generalization of the Matérn's model enabling to take into account non-penetrating particles. The generated 3D field is orthogonally projected into a 2D image in order to create synthetic images (Figure 1) labelled with 3D parameters of the stochastic model and usable for the training. The trained CNN network has been successfully tested and validated on real 2D images of beads in motion in a continuous phase. Note that in this study, we focus only on the study of images that contain strictly spherical shaped particles.

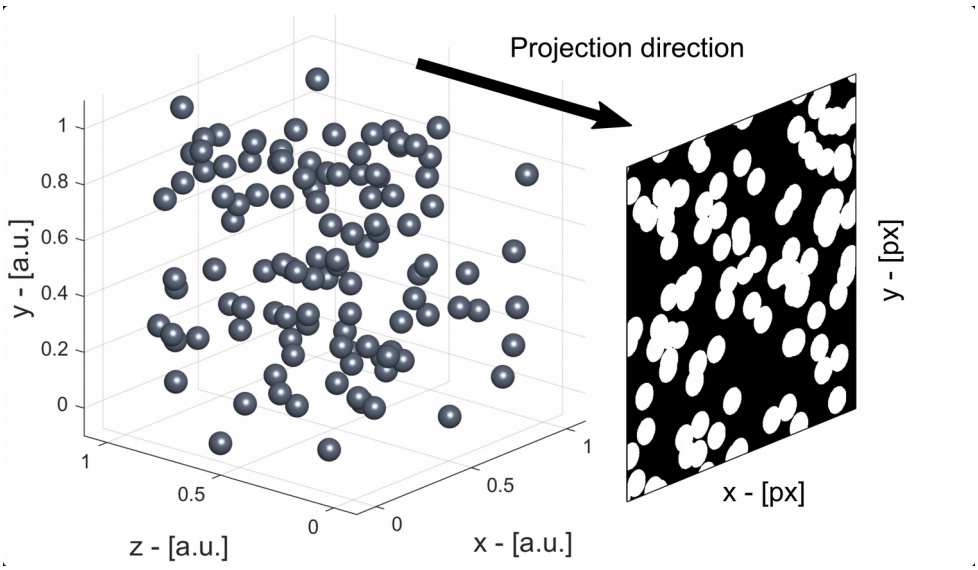

Figure 1. *A 3D illustration of the modeling approach. A 3D geometrical model of hardcore particles is constructed and orthogonally projected in order to construct the 2D images.*

Segmentation of ordered skin layers in histological images with a structural guarantee

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ABSTRACT

The presented work aims at introducing a novel approach to segmentation providing a structural guarantee. The task consists in the segmentation of different skin layers within histological images of reconstructed human epidermis. We combined a U-Net type architecture with a «cumulative layer» in order to enforce the layered structure of the output. Moreover, we include an alternate sequential filter within the network to further constrain the shape of the layer contours. The resulting model is trained end-to-end and is fully convolutional.

Caractérisation anatomique de l'arche aortique à partir de volumes ARM: une approche de segmentation basée sur les CNN

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Résumé

Les pathologies neurovasculaires sont souvent traitées par thérapie endovasculaire en s'aidant de l'imagerie pour le guidage des cathéters à l'intérieur des vaisseaux. Cependant, positionner un micro-cathéter dans la crosse aortique et le faire passer dans les vaisseaux sanguins qui alimentent le cerveau pour une embolisation, une thrombectomie mécanique ou la pose d'un stent est une tâche qui peut s'avérer difficile. En effet, connaître l'anatomie de l'arche aortique est primordial en neuroradiologie interventionnelle, puisque c'est à ce niveau anatomique que se situent les difficultés de navigation avec les cathéters. Ceci est particulièrement vrai pour des crosses aortiques dilatées ou à cause de l'élongation, des angulations ou de la tortuosité des troncs supra-aortiques.

Dans cette étude qui porte sur la mise en œuvre d'outils d'aide à la planification du geste et à la navigation interventionnelle, nous proposons un pipeline utilisant des réseaux de neurones convolutifs pour la segmentation de l'arche aortique à partir d'images par résonance magnétique. Ce pipeline est composé de deux modules successifs, dédiés à la localisation et à la segmentation précise de la crosse aortique et de l'origine des troncs supra-aortiques, respectivement. Ces segmentations sont ensuite utilisées pour générer des modèles 3D qui permettront la caractérisation géométrique de l'anatomie des arches aortiques. Une évaluation quantitative de cette approche, réalisée sur différentes architectures U-Net et différents optimiseurs montre des résultats de segmentation satisfaisants, permettant une caractérisation fiable.

Mots clés: Arche aortique, segmentation, caractérisation, UNet, angiographie par résonance magnétique, thérapie endovasculaire.

Syncrack: Improving pavement and concrete crack detection through synthetic data generation

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ABSTRACT

In crack detection, pixel-accurate predictions are necessary to measure the width – an important indicator of the severity of a crack. However, manual annotation of images to train supervised models is a hard and time-consuming task. Because of this, manual annotations tend to be inaccurate, particularly at pixel-accurate level. The learning bias introduced by this inaccuracy hinders pixel-accurate crack detection. In this paper we propose a novel tool aimed for synthetic image generation with accurate crack labels – Syncrack. This parametrizable tool also provides a method to introduce controlled noise to annotations, emulating human inaccuracy. By using this, first we do a robustness study of the impact of training with inaccurate labels. This study quantifies the detrimental effect of inaccurate annotations in the final prediction scores. Afterwards, we propose to use Syncrack to avoid this detrimental effect in a real-life context. For this, we show the advantages of using Syncrack generated images with accurate annotations for crack detection on real road images. Since supervised scores are biased by the inaccuracy of annotations, we propose a set of unsupervised metrics to evaluate the segmentation quality in terms of crack width.

Full paper available at: https://hal-normandie-univ.archives-ouvertes.fr/IFSTTAR/hal-03451685v1

Particles detection in a 2D-image of overlapping crystals based on community detection

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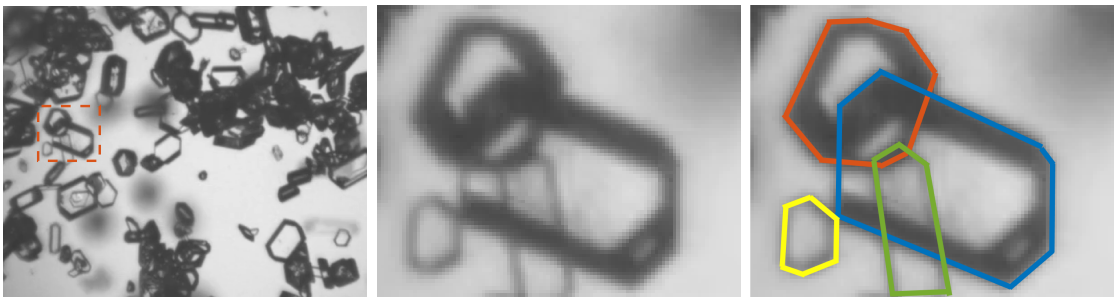
Abstract



(a) Example of an image (b) A cropped aggregate (c) Identified crystals

Figure 1: An image of Adipic acid crystals and the cropping windows (a), a crop of an aggregate of crystals (b) and its hand made individualization (c).

This work is motivated by the control of industrial crystallisation processes, which involve the knowledge of the crystals distribution over time. For this purpose, an in situ camera in batch crystallisers provide 2D images of the projected crystals population in real time such as Figure 1 (a). The proposed approach in this study is based on community detection (as done in social networks). One can see on the images that the borders of individual crystals is quite visible and such a data Figure 1(b) looks like a tessellation of the union of crystals. Indeed, for instance in Figure 1 (b-c), four polygonal crystals are recognizable from a human visual perception (Gestalt theory). It involves the use of topological and geometrical relationship between tessellation cells to make the decision to put the cells in the same crystal or not. Our objective is to provide an automatic detection of the crystals based on such "community membership" rules.

Real-Time Mixed Method for SLAM

Thomas BELOS[1] , Pascal MONASSE[1] , Eva DOKLADALOVA[2]

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ABSTRACT

In recent years, the state-of-the-art of monocular SLAM has seen remarkable advances in reducing errors and improving robustness. At the same time, this quality of results can be obtained in real-time on small CPUs.

However, most algorithms have a high failure rate out-of-the-box. Systematic error such as drift remains still significant even for the best algorithms. This can be handled by a global measure as a loop closure, but it penalizes online data processing.

We propose a mixed SLAM, based on ORB-SLAM2 and DSO: MOD SLAM. It is a fusion of photometric and feature-based methods, without being a simple copy of both. We propose a decision system to predict at each frame which optimization will produce the minimum drift so that only one will be selected to save computational time and resources. We propose a new implementation of the map that is equipped with the ability to actively work with DSO and ORB points at the same time. Our experimental results show that this method increases the overall robustness and reduces the drift without compromising the computational resources. Contrary to the best state-of-the-art algorithms, MOD SLAM can handle 100% of KITTI, TUM, and random phone videos, without any configuration change.

Parameters Estimation of a Stochastic Geometrical Model for Multiphase Flow Images Using Local Measures: Towards a Predictive Model for Multiphase Flows

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Abstract

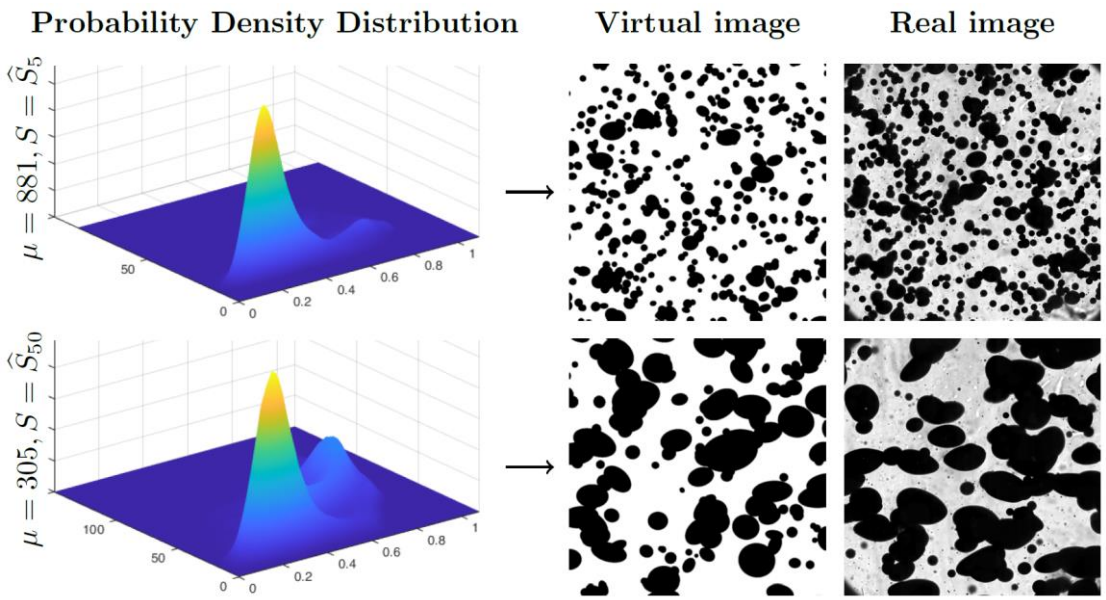

Figure 1 : Probability density functions of joint distributions of ellipticity and size of the particles as a model input (left). Comparison between virtual images generated by the model and real images of multiphase flows (right).

This work presents a new method for estimating the parameter values of a stochastic geometric model of multiphase flow images, using local measurements. Local measures differ from global measures in that they are only based on a small part of a binary image. The model is tested on several multiphase flow images with different characteristics (Fig. 1). The real multiphase flow images studied are obtained by injecting gas at a different flow rate into a fluid through a sinter. The predictive side of the model is then highlighted, showing that it is possible to generate multiphase flow images for a given flow rate. Model validation is ensured by comparing global characteristics such as the area or perimeter of the virtual images to those of the real images, as well as the covariance and PSD, and the results obtained show differences of less than 2% on average.

On the Geometry of Random Multiphase Excursion Sets and their Applications to Solid Oxide Fuel Cells Modeling

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ABSTRACT

Unlike its classical counterpart, a Solid Oxide Fuel Cell electrolyte is not a liquid but rather a ceramic usually made up of Yttria Stabilized Zirconium (YSZ) or Gadolinium Doped Ceria (GDP).This electrode being heated at high temperatures is what allows the oxygen ions to travel from the cathode to the anode through the solid electrode. Once in contact with porous anode, an oxidation reaction takes place between the oxygen ions and the dihydrogen producing heat, water and electricity. On the cathode side, dioxygen molecules penetrating the porous cathode interact with the solid oxide layer where a reduction reaction takes place producing the oxygen ions. Solid Oxide Fuel Cells present many advantages over standard Liquid Oxide Fuel Cells. Indeed SOFC efficiency can reach up to 70%, they are cost effective, reliable, deteriorate slowly and produce less carbon emissions during production. However they suffer from one major drawback: their operating temperature located between 450°C and 1000°C making them unviable for embarked systems.

One of the area of current research consist in reducing the operating temperature. A way to do that is by using composite material for the anode. Recently Moussaoui et al. (2019) showed that Gaussian Random Fields adequately model the micro-structure of the composite anode. In this talk, we study in depth the suggested model and we obtain some expected values for intrinsic volumes and generalized Killing-Lipschitz curvature measures of the multiphase excursion set of this model. These theoretical values depend on the generalized Minkowski functionals whose computation can be a arduous task. We also propose two algorithms: one to automatically compute the differential structure of a smooth set endowed with a certain Remannian metric and the other to compute said generalized Minkowski functionals.