

# CVN

## CENTER FOR VISUAL COMPUTING



**C**omputational vision is one of the most challenging research domains in the engineering sciences. The aim is to reproduce human visual perception through intelligent processing of visual data.

CVN aims at proposing innovative techniques towards automatic structuring, interpretation and modeling of big (visual) data. CVN is associated with Inria Paris-Saclay through a joint research project-team (OPIS). Researchers of CVN are also members of the *Fédération de Mathématiques* de CentraleSupélec (FR CNRS 3487). Our primary objective is to remain a reference center of international scientific excellence and to contribute significantly to the theory and practice in the field of computer vision, artificial intelligence, and (bio) medical imaging.

### Research themes

#### OPTIMIZATION

Variational problems requiring the estimation of a very large number of variables have now to be tackled, especially in the field of inverse problems (e.g.,  $\geq 10^9$  variables in 3D imaging). In addition to the curse of dimensionality, another difficulty to overcome is that the cost function usually reads as the sum of several loss/regularization terms, possibly composed with large-size linear operators. These terms can be nonsmooth and/or nonconvex, as they may serve to promote the sparsity of the sought solution in some suitable representation or to fulfill some physical constraints. In such a challenging context, we

develop advanced deterministic and stochastic optimization methods based on fixed point iterations, proximal techniques, majoration-minimisation (MM) approaches, and distributed/parallel implementations.

#### ARTIFICIAL INTELLIGENCE

Machine learning methods have led to impressive results in various domains of Data Science. Nevertheless, the fundamental reasons for their excellent performance are often still poorly understood. We are developing robust, explainable, and efficient inference methods. Deep neural networks are the current state-of-the-art methods for solving a wide range of diverse tasks in signal/image classification or regression. We are working on reliable design and learning techniques for neural networks. We address challenges raised by partially annotated data and weakly supervised learning. Machine learning on graphs is also an important task with a plethora of practical applications. Our goal is to develop a systematic framework for large-scale data mining and representation learning on graphs.

#### IMAGE PROCESSING

Imaging devices provide a huge amount of information at various scales thanks to a wide range of modalities (MRI, Xray, PET, ultrasound, microscopy, ...). These images can be multispectral, volumetric or correspond to sequences of 2D or 3D fields. Our group has developed a long-term expertise in image analysis, segmentation, denoising, restoration, and reconstruction. Advanced image models are built thanks to convex or nonconvex variational approaches. Bayesian methods are also employed, as well as techniques based on mathematical morphology and graphs.

## APPLICATION DOMAINS

### Health

- Computer aided diagnosis
- Computer assisted surgery
- Image biomarkers

### Complex industrial systems

- Non destructive control
- Safe systems
- Optical flow
- Decision making

## HIGHLIGHTS 2023

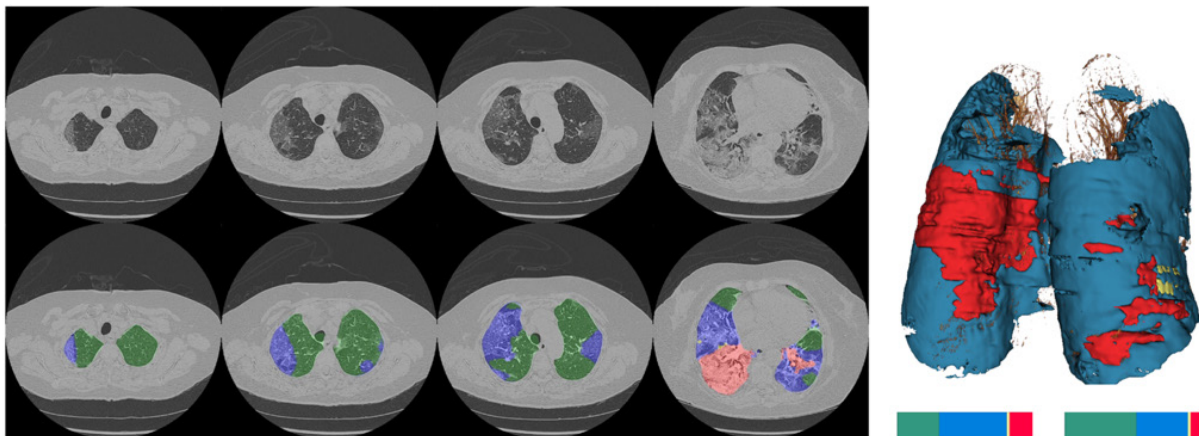
**Yunshi Huang, Emilie Chouzenoux** and **Jean-Christophe Pesquet** in collaboration with V. Elvira from University of Edinburgh proposed a new fast inference method for training Bayesian neural networks. This led to the best oral talk award at the International Conference on Machine Learning and Intelligent Systems (MLIS).

**Younes Belkouchi and Hugues Talbot** in collaboration with **P.-H. Courède** and **Institut Gustave Roussy** proposed a new score for defining the progression of tumors in immunotherapy treatment.

**Alexandre Duval**, under the supervision of **F. Malliaros**, developed a generative graph flow model for crystal structures in collaboration with MILA in Montréal. This model has potential applications in improving the efficiency of renewable energy production and storage.

**Marion Savanier** received an Accessit Ph.D. ICT Award from the University Paris-Saclay and Institute Polytechnique of Paris in 2023. She also received the 2<sup>nd</sup> award for the Impact in Science PhD award delivered by CentraleSupélec Foundation.

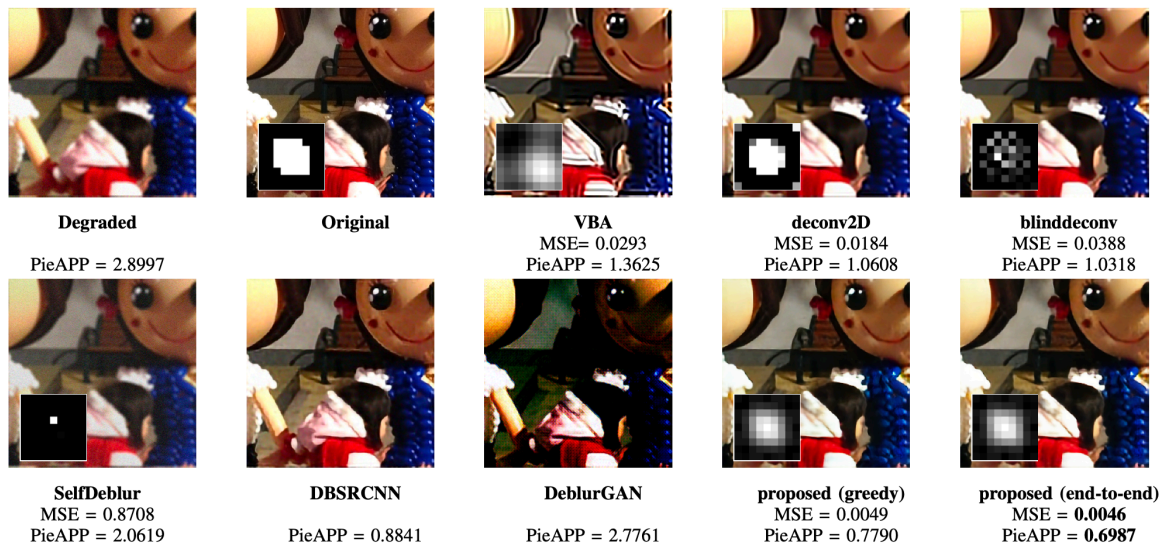
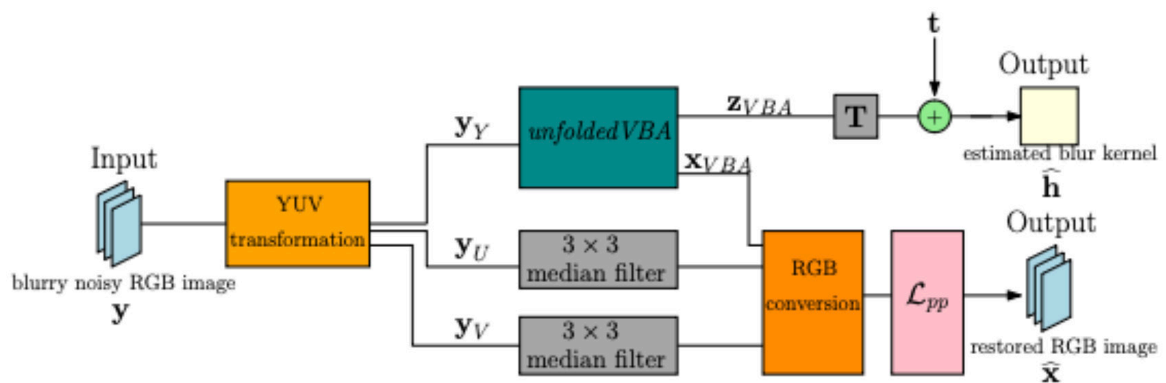
## EXAMPLES OF STUDIES



### ***New image restoration method based on deep learning.***

*In collaboration with two Paris hospitals and a startup, and using a dataset including medical exams of about 1000 patients, we have developed an approach based on ensembling of neural networks for quantifying covid-19 pulmonary lesions (green correspond to healthy areas, blue, yellow, and red to more and more severe lesions). [<https://hal.archives-ouvertes.fr/hal-02586111>]*





### Understanding Images using end-to-end trained deep Gaussian CRFs.

The unknown blur degradation model is estimated and inverted (blind context). The proposed neural network architecture is explainable since it is designed by unrolling an iterative Bayes Variational Approach.

[<https://hal-centralesupelec.archives-ouvertes.fr/hal-03881393>].

## Industrial Partners

- CEA
- Essilor
- General Electric Healthcare
- Heartflow
- Safran
- Schneider Electric
- SNCF
- Thales

## Academic Partners

Institut Gustave Roussy (FR), Kremlin-Bicêtre Hospital (FR), Henri Mondor Hospital (FR), European Hospital Georges Pompidou (FR), Pitié-Salpêtrière Hospital (FR), Université Gustave Eiffel (FR), École des Ponts-ParisTech (FR), North Carolina State University (USA), Stanford University (USA), Stony Brook University (USA), University of Pennsylvania (USA), University of California at Los Angeles (USA), Sup'Com Tunis (TU), Technical University of Munich (DE), Heriot-Watt University (UK), University of Edinburgh (UK), University College London (UK), Aalto University (Finland), Politehnica University (RO), Ecole Polytechnique de Montreal (CA), University of Toronto (CA), Indraprastha Information Institute of Technology, Hyderabad (IN), Aristotle University of Thessaloniki (GR), Polish Academy of Sciences (PO).

## Partnerships and Collaborations

- DATAIA
- Bernoulli Lab

## Key figures

- Professors, Associate Professors & Researchers 8
- Engineers & Administrative staff 2
- PhD Students 16
- Visiting Professor 1
- Publications of the year (WoS) 17


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