# DEEPHEALTH

## Boosting medical imaging with AI

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# AI contributions to medical imaging

- The landscape of healthcare and biomedical research is changing rapidly thanks to contributions from AI
- Recently AI has broken many barrier in the area of vision (recognition, segmentation, image generation, etc.)
- Machine Learning and Deep Learning enabled unprecedented findings starting from data (images) and knowledge (supervised learning)



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# AI contributions to medical imaging

**ARTICLE** OPEN

## Deep echocardiography: data-efficient supervised and semi-supervised deep learning towards automated diagnosis of cardiac disease

Ali Madani[1], Jia Rui Ong[2], Anshul Tibrewal[2] and Mohammad R. K. Mofrad[1,3]

Deep learning and computer vision algorithms can deliver highly accurate and automated interpretation of medical imaging to augment and assist clinicians. However, medical imaging presents uniquely pertinent obstacles such as a lack of accessible data or a high-cost of annotation. To address this, we developed data-efficient deep learning classifiers for prediction tasks in cardiology. Using pipeline supervised models to focus relevant structures, we achieve an accuracy of 94.4% for 15-view still-image echocardiographic view classification and 91.2% accuracy for binary left ventricular hypertrophy classification. We then develop semi-supervised generative adversarial network models that can learn from both labeled and unlabeled data in a generalizable fashion. We achieve greater than 80% accuracy in view classification with only 4% of labeled data used in solely supervised techniques and achieve 92.3% accuracy for left ventricular hypertrophy classification. In exploring trade-offs between model type, resolution, data resources, and performance, we present a comprehensive analysis and improvements of efficient deep learning solutions for medical imaging assessment especially in cardiology.

*npj Digital Medicine* (2018)1:59 ; doi:10.1038/s41746-018-0065-x



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# AI contributions to medical imaging

Arbabshirani, Mohammad R et al. **“Advanced machine learning in action: identification of intracranial hemorrhage on computed tomography scans of the head with clinical workflow integration.”** *NPJ digital medicine* vol. 1 9. 4 Apr. 2018, doi:10.1038/s41746-017-0015-z

Intracranial hemorrhage (ICH) requires prompt diagnosis to optimize patient outcomes. We hypothesized that machine learning algorithms could automatically analyze computed tomography (CT) of the head, prioritize radiology worklists and reduce time to diagnosis of ICH. 46,583 head CTs (~2 million images) acquired from 2007–2017 were collected from several facilities across Geisinger. A deep convolutional neural network was trained on 37,074 studies and subsequently evaluated on 9499 unseen studies. The predictive model was implemented prospectively for 3 months to re-prioritize “routine” head CT studies as “stat” on realtime radiology worklists if an ICH was detected. Time to diagnosis was compared between the re-prioritized “stat” and “routine” studies. A neuroradiologist blinded to the study reviewed false positive studies to determine whether the dictating radiologist overlooked ICH. The model achieved an area under the ROC curve of 0.846 (0.837–0.856). During implementation, 94 of 347 “routine” studies were re-prioritized to “stat”, and 60/94 had ICH identified by the radiologist. Five new cases of ICH were identified, and median time to diagnosis was significantly reduced ($p < 0.0001$) from 512 to 19 min. In particular, one outpatient with vague symptoms on anti-coagulation was found to have an ICH which was treated promptly with reversal of anticoagulation, resulting in a good clinical outcome. Of the 34 false positives, the blinded over-reader identified four probable ICH cases overlooked in original interpretation. In conclusion, an artificial intelligence algorithm can prioritize radiology worklists to reduce time to diagnosis of new outpatient ICH by 96% and may also identify subtle ICH overlooked by radiologists. This demonstrates the positive impact of advanced machine learning in radiology workflow optimization.

*npj Digital Medicine* (2018)1:9 ; doi:10.1038/s41746-017-0015-z



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# AI contributions to medical imaging

Ye, Hai et al. **“Precise diagnosis of intracranial hemorrhage and subtypes using a three-dimensional joint convolutional and recurrent neural network.”** *European radiology* vol. 29,11 (2019): 6191-6201. doi:10.1007/s00330-019-06163-2

**Objectives** To evaluate the performance of a novel three-dimensional (3D) joint convolutional and recurrent neural network (CNN-RNN) for the detection of intracranial hemorrhage (ICH) and its five subtypes (cerebral parenchymal, intraventricular, subdural, epidural, and subarachnoid) in non-contrast head CT.

**Methods** A total of 2836 subjects (ICH/normal, 1836/1000) from three institutions were included in this ethically approved retrospective study, with a total of 76,621 slices from non-contrast head CT scans. ICH and its five subtypes were annotated by three independent experienced radiologists, with majority voting as reference standard for both the subject level and the slice level. Ninety percent of data was used for training and validation, and the rest 10% for final evaluation. A joint CNN-RNN classification framework was proposed, with the flexibility to train when subject-level or slice-level labels are available. The predictions were compared with the interpretations from three junior radiology trainees and an additional senior radiologist.

**Results** It took our algorithm less than 30 s on average to process a 3D CT scan. For the two-type classification task (predicting bleeding or not), our algorithm achieved excellent values (≥ 0.98) across all reporting metrics on the subject level. For the five-type classification task (predicting five subtypes), our algorithm achieved > 0.8 AUC across all subtypes. The performance of our algorithm was generally superior to the average performance of the junior radiology trainees for both two-type and five-type classification tasks.

**Conclusions** The proposed method was able to accurately detect ICH and its subtypes with fast speed, suggesting its potential for assisting radiologists and physicians in their clinical diagnosis workflow.



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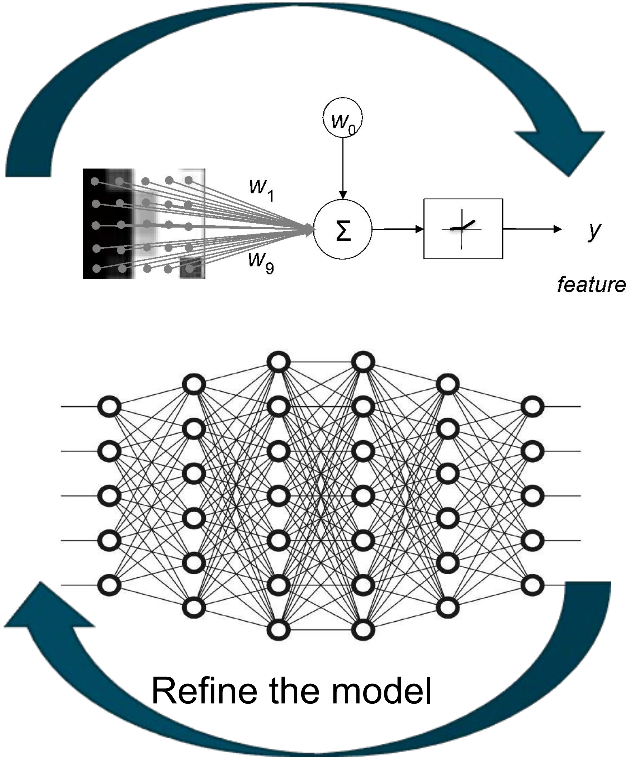
# DeepLearning

Test the model




Data & labels

Target output
&
Loss function



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# DeepHealth project

**Deep-Learning and HPC to Boost Biomedical Applications for Health**

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**22 partners** from **9 countries**: Research centers, Health organizations, large industries and SMEs

## Research Organisations

- Universitat Politècnica de València
- Barcelona Supercomputing Center – Centro Nacional de Supercomputación
- list
- UNIMORE – Università degli Studi di Modena e Reggio Emilia
- Karolinska Institutet
- CRS4
- Università degli Studi di Torino
- Otto von Guericke Universität Magdeburg
- EPFL

## Health Organisations

- Azienda Ospedaliero-Universitaria Città della Salute e della Scienza di Torino
- Fundación para el Fomento de la Investigación Sanitaria y Biomédica de la Comunitat Valenciana
- CHUV
- Spitalul Clinic Prof. Dr. Theodor Burghele București
- Stockholms läns landsting

## Large Industries

- everis – an NTT DATA Company
- PHILIPS
- THALES
- SIMAVI – Software Imagination & Vision

## SMEs

- WINGS ICT Solutions
- TREE Technology
- prodesign electronic gmbh
- Stelar security technology law research

**Duration:** 36 months
**Starting date:** Jan 2019



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# DeepHealth project

## Objectives

- **Facilitate the daily work** and increase the productivity of medical personnel and IT professionals **working on biomedical images**
- Facilitate the use and training of predictive models without the need of combining many different tools
- Offer a unified framework adapted to exploit underlying heterogeneous HPC and Big Data architectures supporting state-of-the-art and next-generation Deep Learning (AI) and Computer Vision algorithms to enhance European-based medical software platforms.
- Put HPC computing power at the service of biomedical applications with DL needs and, through an interdisciplinary approach, apply DL techniques on large and complex image biomedical datasets to support new and more efficient ways of diagnosis, monitoring and treatment of diseases.



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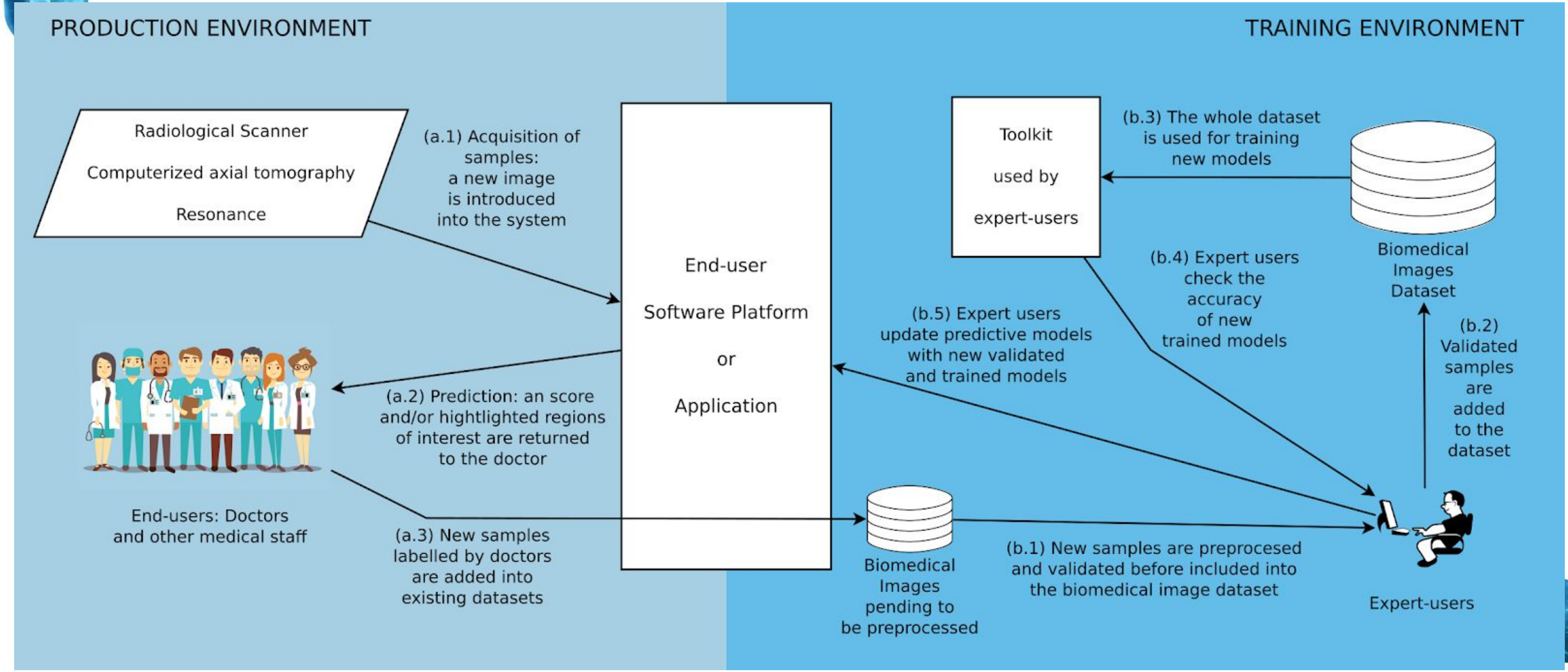
# The context



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# Torino team

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UniTO: 3 departments, 4 research groups: **Image processing**, **Parallel Programming**, **Anatomical pathology**, **Neuroscience radiology**

Città della Salute e della Scienza: **Radiology 2 Molinette**

Deep Learning, High Performance Computing, Medical expertise

HPC4AI

**Use cases**:

- colorectal polyps diagnosis
- estimation of brain perfusion maps
- detection of pulmonary nodules in CT chest scans



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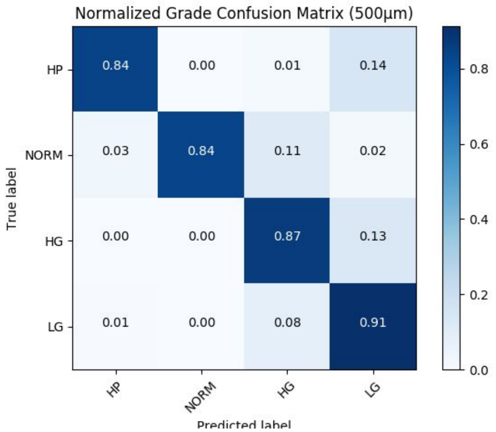
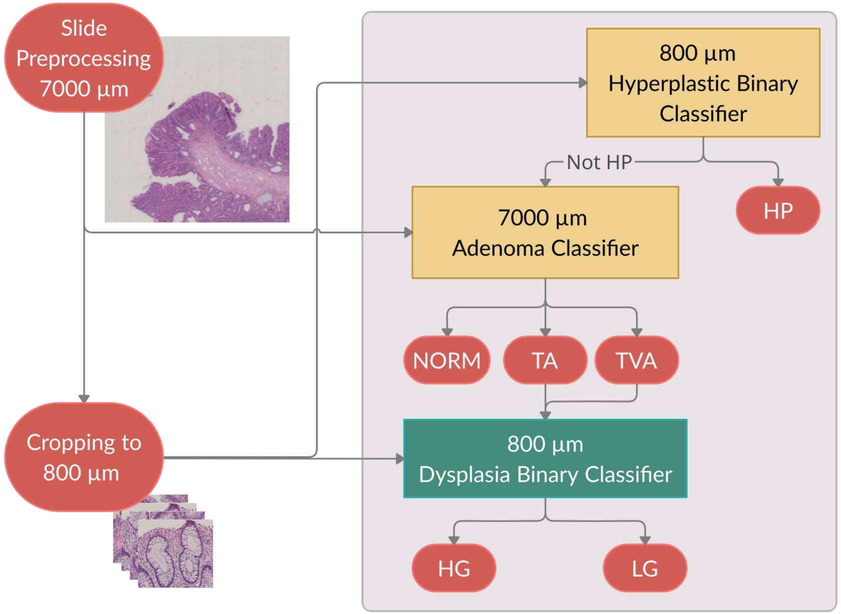
# Histopathology Use Case

**Classification of polyps in colon biopsies:**

- 6 classes identified in the experiments
- Difficult multi-resolution problem
- Pathologists in the loop for both label and ROI




C. A. Barbano *et al.*, "Unitopatho, A Labeled Histopathological Dataset for Colorectal Polyps Classification and Adenoma Dysplasia Grading," *2021 IEEE International Conference on Image Processing (ICIP)*, 2021



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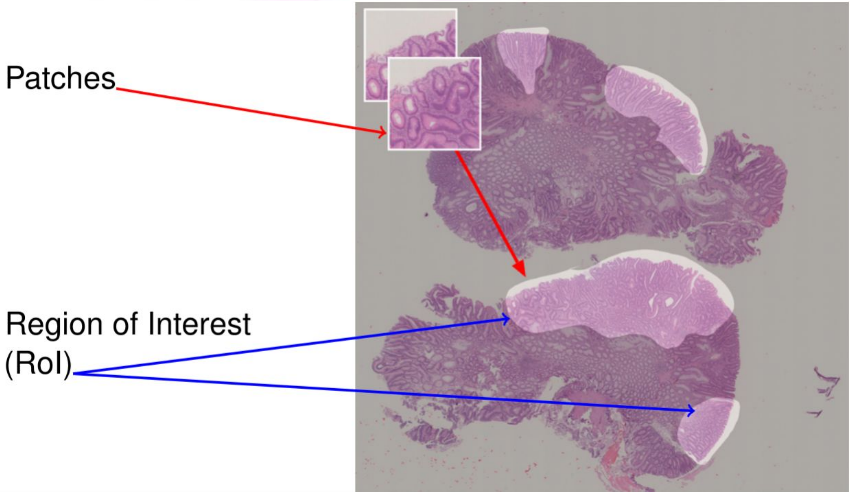
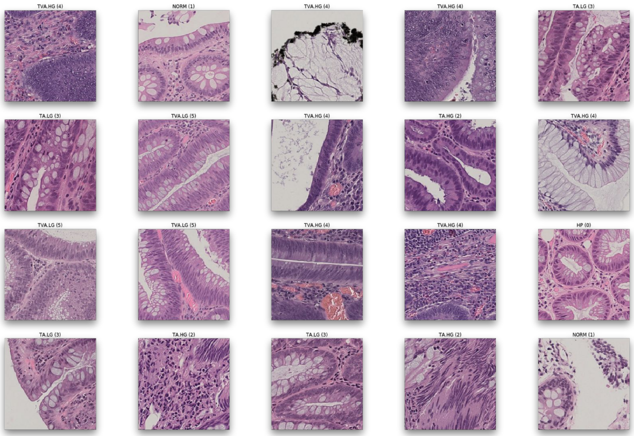
# UNITOPATHO

*UniToPatho*, an annotated dataset of 9536 hematoxylin and eosin stained patches extracted from 292 whole-slide images: https://ieee-dataport.org/open-access/unitopatho





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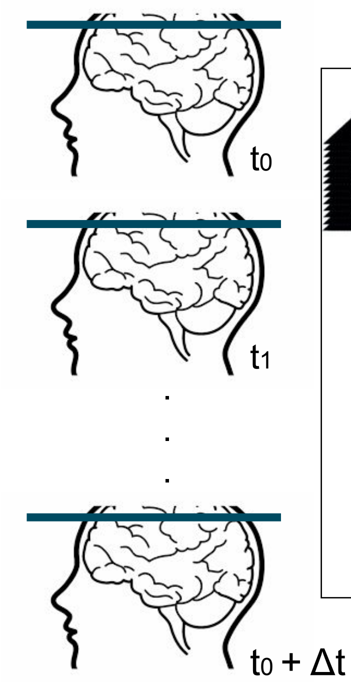
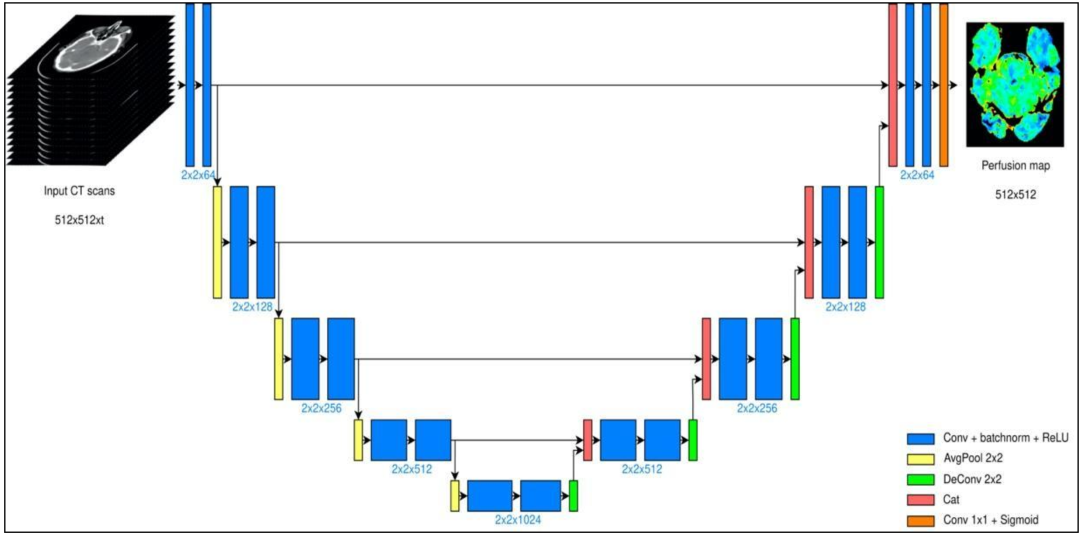
# Brain perfusion Use Case




Gava, Umberto A., Federico D'Agata, Enzo Tartaglione, Marco Grangetto, Francesca Bertolino, Ambra Santonocito, Edwin Bennink, and Mauro Bergui. "Neural Network-derived perfusion maps: a Model-free approach to computed tomography perfusion in patients with acute ischemic stroke." *arXiv preprint*



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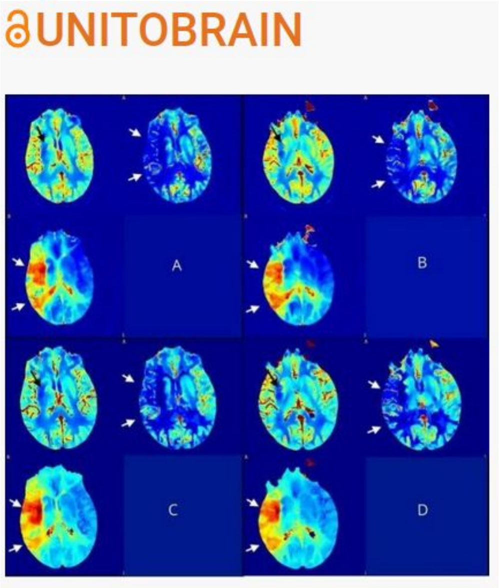
# UNITOBRAIN




Public dataset of Computed Tomography (CT) perfusion images (CTP).
Includes 258 consecutive patients
Used in a submitted publication for the training and the testing of a Convolutional Neural Network (CNN, see for details: https://arxiv.org/abs/2101.05992, https://paperswithcode.com/paper/neural-network-derived-perfusion-maps-a-model, https://www.medrxiv.org/content/10.1101/2021.01.13.21249757v1).
CTP retrospectively obtained from the hospital PACS of Città della Salute e della Scienza di Torino (Molinette).
Dataset is retrievable at https://ieee-dataport.org/open-access/unitobrain



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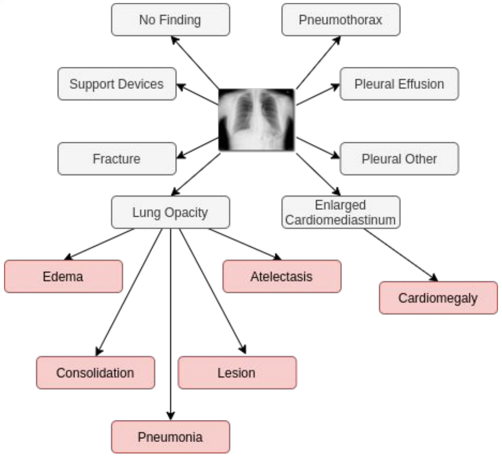
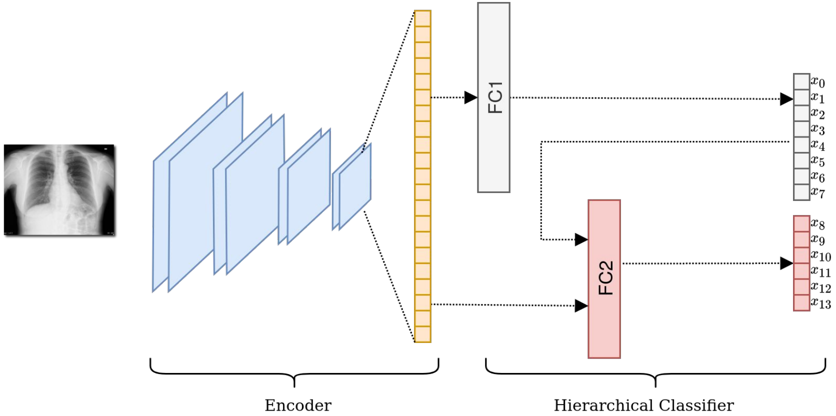
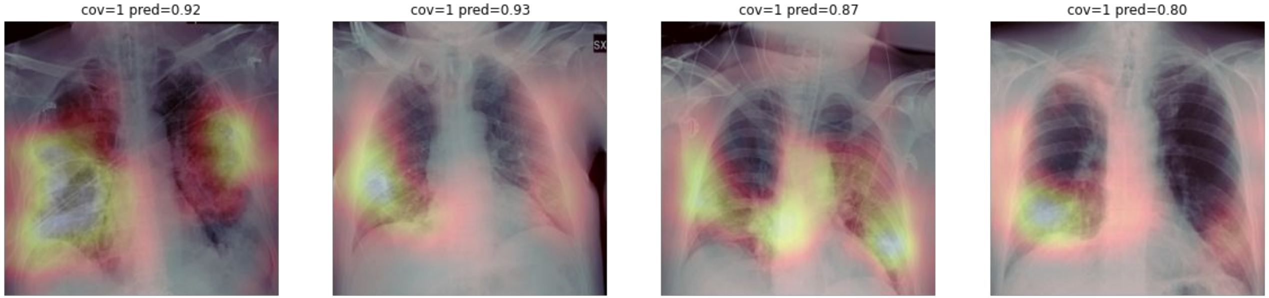
# Covid-19: CXR classification

Tartaglione E, Barbano CA, Berzovini C, Calandri M, Grangetto M. [Unveiling COVID-19 from CHEST X-Ray with Deep Learning: A Hurdles Race with Small Data](). *International Journal of Environmental Research and Public Health*. 2020



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# Nodules segmentation

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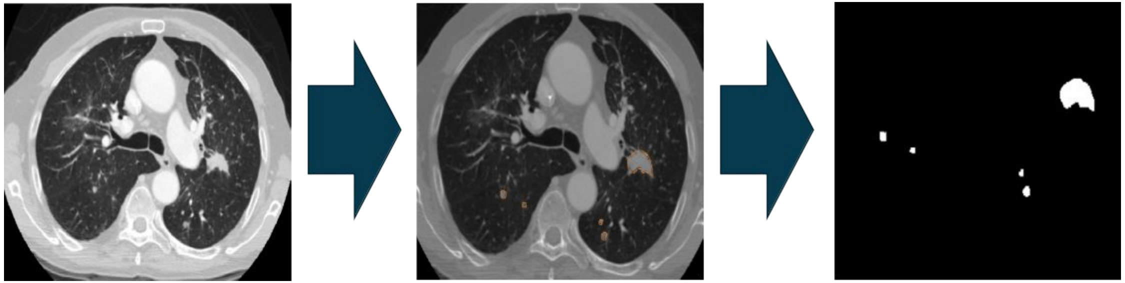
- **Lung nodules** are quite common incidental findings in **CT** (computed tomography) **scans** and can be defined as **small focal lesions** (ranging from 5 to 30 mm) that can be solitary or multiple.
- The **goal** of UC4 is to train **AI systems to recognize lung nodules** using chest CT scans, providing radiologists an efficient tool for daily activity.





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# Nodules segmentation

| | Patients | Labelled Slices |
|---|---|---|
| Training | 361 | 18485 |
| Validation | 93 | 2310 |
| Test | 173 | 2316 |



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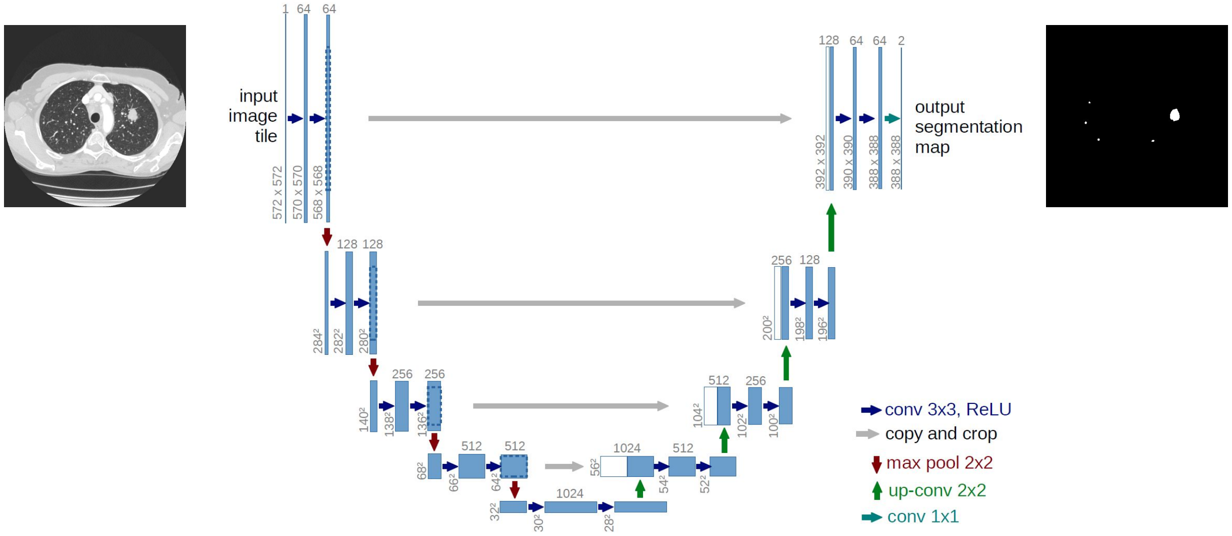
# Nodules segmentation

Model presented in 2015 (pdf) for biomedical image segmentation (UNet-2D).



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# Nodules segmentation

Results on the test set.

| | Input size | Dice Loss | IoU |
|---|---|---|---|
| UNet-2D[1] | 512x512 | 0.26 | 0.59 |
| UNet-3D[2] | 512x512x2 0 | 0.22 | 0.64 |

[1]Models trained on 2 *GeForce* RTX *2080* graphics cards.
[2]Models trained on 4 NVIDIA Tesla V100 graphics cards.



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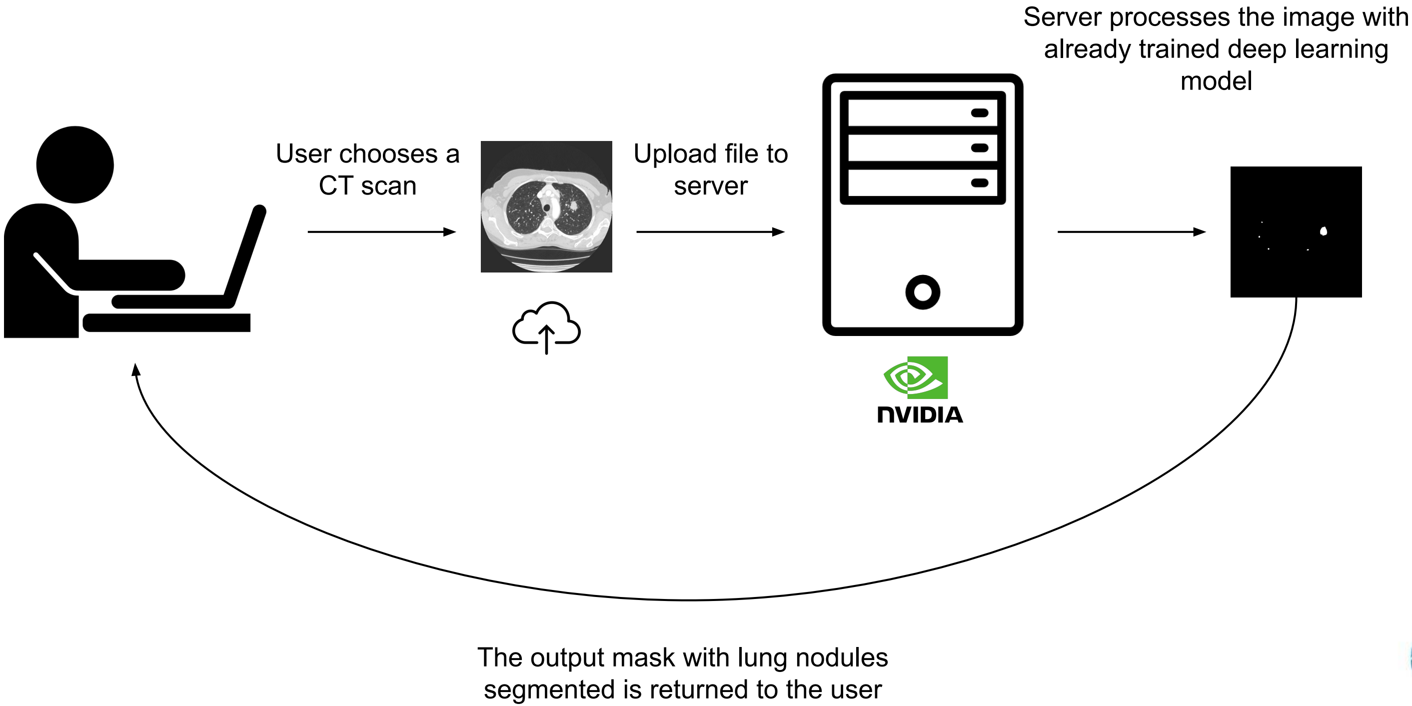
# DEMO

## Behind the scenes



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# Thank you!

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