CREATIS Centre de Recherche en Imagerie Médicale

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MSc project proposal 2024

Title of the MSc project:	**Smooth volumetric copy-paste for ARDS CT database augmentation to improve lung segmentation**
University:	Université Claude Bernard Lyon 1, France
Laboratory:	CREATIS CNRS 5220, INSERM U1206 (head O. Beuf)
Supervisors:	M. Emmanuel ROUX, M. Maciej ORKISZ, in MYRIAD team
Co-supervisors:	M. Laurent BITKER, M. Jean-Christophe RICHARD, Service de Réanimation Médicale Hôpital de la Croix Rousse and MYRIAD team
Keywords:	deep learning, segmentation, CT, lungs, data augmentation

UMR 5220

U1206

Scientific field and context:

Our goal is to segment the lungs in computed tomography (CT) images of patients suffering from acute respiratory distress syndrome (ARDS). Indeed, comparing lung CT images at different respiratory conditions (e.g., end-inspiratory and end-expiratory), allows quantifying such phenomena as alveolar recruitment or cyclic hyperinflation, that help intensive care clinicians to adjust the artificial ventilation settings. The aim of the project is to improve the robustness of our deep model trained to segment the lungs in patients suffering of ARDS. The current version achieves a success rate of 85% and an uncertainty close to the inter-expert variability [1]. Moreover, it only requires an inference time of about 2 minutes [2], which is compatible with the intensive care unit logistical and operating constraints.

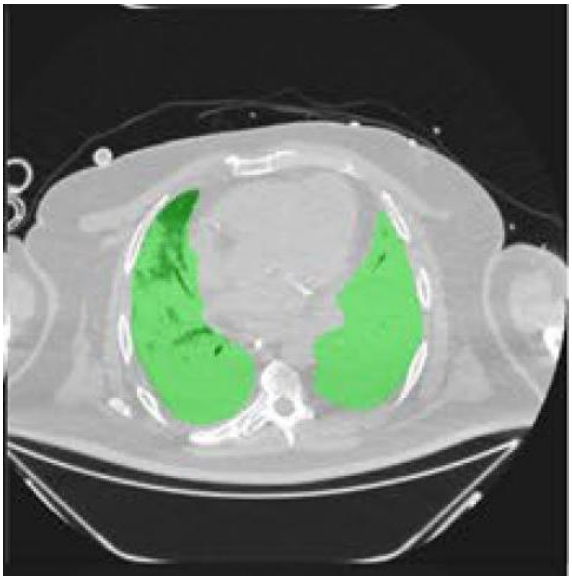

Figure 1 : example of current result obtained with our deep model trained to segment the lungs on computed tomography (CT) images of patients suffering from acute respiratory distress syndrome (ADRS) [1].

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Scientific challenges: One of the main challenge of our application is the scarcity of annotated medical images as the expertise and time required to delineate the lungs in CT images of ARDS patients is huge, which limits the diversity of our training dataset compared to other application fields. The automatic generation of CT lung images by a copy-paste data augmentation [3] approach seems promising for several imaging modalities [4]. However, it needs to address several challenges, such as avoiding a bias towards a specific lesion or aeration pattern, as well as seamless incorporation of lesions avoiding the creation of perceptible boundaries.

Expected innovative contributions: To overcome the limitation of available annotated data from ARDS patients, and increase the diversity of lung morphologies, the MASTER student will use CT scans from patients with normal lungs and incorporate heterogeneous aeration patterns, as well as lesions of varying extent, density, and location, learned from ARDS patients. In short, the main contribution is the generation of an ARDS CT-lung database with an unprecedented diversity of lesions and aeration patterns, with ground truth for both training and evaluation purposes.

Research program and proposed scientific approach: First, familiarize with the available ARDS data and implemented models. Second, propose a method to learn the ARDS lesion and aeration patterns thus retrieved. Third, identify publicly available databases of CT scans with segmented lungs. Then, propose a method for seamlessly incorporating lesions into normal lungs. Finally, retrain the model using the newly generated database and evaluate its robustness to new cases.

Expected candidate profile (prerequisite): image-processing, machine learning, programming. Interest for biomedical field and biomechanical modeling for health sector.

Skills that will be developed during the project: deep image processing, strong experience in applied machine learning, integrating simulation tools for deep model training, collaborative/versionned programming. Ability to interact with the medical community.

CREATIS laboratory and MYRIAD team environment

The proposed MASTER project will take place within the Computational Lung working group within the MYRIAD team, which offers a very dynamic and vivid environment to develop new skills and relationships. Check out our *github page/website* : https://creatis-myriad.github.io/

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References:

[1] Penarrubia L., *Verstraete A.*, **Orkisz M.**, Dávila Serrano E.E., Boussel L., *Yonis H.*, *Mezidi M.*, Dhelft F., *Danjou W.*, *Bazzani A.*, *Sigaud F.*, *Bayat S.*, *Terzi N.*, *Girard M.*, Bitker L., **Roux E.**, and Richard J.-C., "Precision of CT-derived alveolar recruitment assessed by human observers and a machine learning algorithm in moderate and severe ARDS", *Intensive Care Medicine Experimental*, 2023, **11**, 8. DOI: 10.1186/s40635-023-00495-6.

[2] Penarrubia L., Pinon N., **Roux E.**, Dávila Serrano E.E., **Orkisz M.**, Sarrut D., "Improving motion-mask segmentation in thoracic CT with multi-planar U-nets", *Medical Physics*, **49**, 420-431, 2022, DOI: 10.1002/mp.15347.

[3] Pérez P., Gangnet M., and Blake A., "Poisson image editing". *ACM Transactions on Graphics (TOG)*, 2003, vol. 22, no 3, p. 313-318.

[4] Shen, W. H., & Li, M. L. (2023). Copy-Paste Image Augmentation with Poisson Image Editing for Ultrasound Instance Segmentation Learning. *arXiv preprint arXiv:2308.14772*.