

Multi-Modal and Multi-Task COVID-19 Prediction

1. General Info

Project Title: Multi-Modal and Multi-Task COVID-19 Prediction

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2. Project Abstract

COVID-19 is an infection disease caused by novel corona virus, and in early 2020 it was declared a pandemic by the World Health Organization. The disease causes respiratory symptoms that overlap with community-acquired pneumonia and seasonal flu. Quick diagnosis and assessment of the disease are important for treatment and for reducing transmission, however, this represents a challenge for the medical services, given the high number of patients. In this project, we will explore and compare two topics related to COVID-19 diagnosis and assessment: Multi-modal COVID-19 prediction and Multi-task learning for simultaneous COVID-19 and Morbidity predictions.

3. Background and Motivation

Early detection of COVID-19 is important for an opportune treatment and potentially reduce transmission. The virus generally progresses with mild respiratory symptoms or non-symptoms; however, it can lead to fatal pneumonia in 2-8% of the cases¹. Since the beginning, the disease has presented a challenge for the medical services given the high number of patients, making important the designing of tools to assist with the diagnosis. In this project, we will work on COVID-19 prediction following a multi-modal (Fig. 1) and multi-task (Fig. 2) approach.

Current deep learning methods employ image information to generate a predictive model. However, medical data also includes non-image modalities, like the results of clinical studies, that can be relevant to the given task². In this project, we will evaluate the use of clinical features in addition to CT data, for the COVID-19 prediction task.

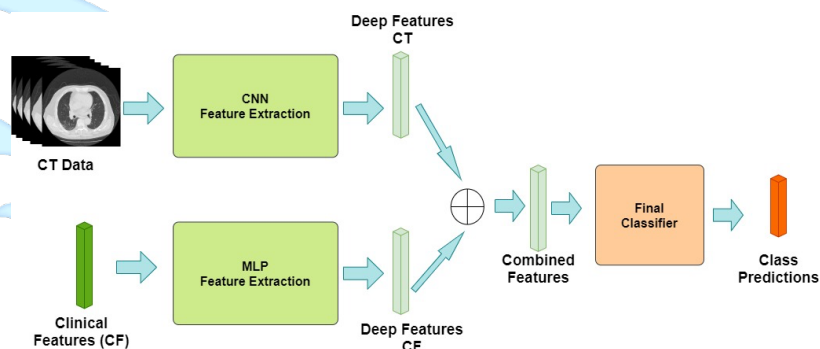


Fig. 1. A multi-modal classification approach.

¹ Stephanie A. Harmon, et.al. Artificial intelligence for the detection of COVID-19 pneumonia on chest CT using multinational datasets. Nature Communications. 2020

² Wanshan Ning, et.al. Open resource of clinical data from patients with pneumonia for the prediction of COVID-19 outcomes via deep learning. Nature Biomedical Engineering. 2020

On the other hand, multi-task learning³ aims to simultaneously learn two or more related tasks. In this scenario, the model is composed of a set of shared parameters and a set of task-specific parameters. The addition of a complementary task can help to improve a primary job. With this hypothesis, we will evaluate the performance of a multi-task model on COVID-19 prediction, when the additional task of COVID-19 Morbidity prediction is included.

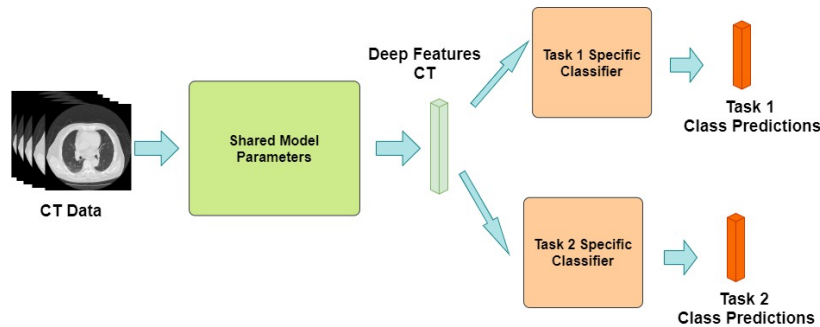


Fig. 2. Multi-task classification scheme.

The efforts to understand and develop fast detection methods for this disease have led to the creation of datasets made publicly available for these tasks. We will employ the publicly available iCTCF⁴ dataset, which contains around 1300 CT scans with clinical studies for positive and negative COVID-19 cases.

4. Technical Prerequisites

- Good skills in Python
- Familiar with PyTorch or related CNN packages (e.g., Tensorflow)
- Previous knowledge on machine learning or/and deep learning.

5. Benefits:

- Working on a current medical problem.
- Learning or practicing PyTorch Lightning programming skills.
- Exploring the use of non-image together with image modalities.
- Learning and evaluating the multi-task learning strategy.

6. Students' Tasks Description

Students will work in two groups. Each group will implement and evaluate one approach:

Group 1:

Multi-modal. We will include clinical features into the classification problem and compare them with the performance of the model with no clinical features.

Group 2:

Multi-task. We will train and evaluate a model for simultaneous COVID-19 prediction and Morbidity prediction. For Morbidity we will use the class scheme of [2, 4]: Control (Negative COVID-19), Type I and Type II. We will compare the performance with the single task COVID-19 prediction.

³ Caruana, R. Multitask Learning. Machine Learning 28, 41–75 (1997)

⁴ [iCTCF - CT images and clinical features for COVID-19 \(biocuckoo.cn\)](https://biocuckoo.cn)

(Optional) Group 1 and 2:

Multi-modal Multi-task. Have you ever wondering what would be the performance of a Multi-modal Multi-task classifier for COVID-19 classification? Then this is your call. Considering progress during the project we can additionally evaluate a Multi-modal multi-task approach for COVID-19 and Morbidity prediction.

Group 1: Multi-modal

- State of art.
- Familiar with the dataset and data loaders
- Implement a modular CNN for classification of COVID-19.
- Implement a MLP for feature extraction.
- Implement a multi-modal architecture with the CNN and the MLP
- Testing, and evaluation for Multi-modal vs single CNN classification.
- (Optional) Integration and evaluation of a multi-modal multi-task architecture

Group 2: Multi-task

- State of art.
- Familiar with the dataset and data loaders
- Implement a modular CNN for classification of COVID-19.
- Implement Task specific classifiers.
- Implement a multi-task architecture with the CNN and the Task specific classifiers.
- Testing, and evaluation for Multi-task vs single CNN classification.
- (Optional) Integration and evaluation of a multi-modal multi-task architecture

7. Work-packages and Time-plan:

	Description	#Students	From	To
WP1	Familiar with the state of art.	4		
WP2	Familiar with the dataset and data loaders	4		
WP3	Implement a modular CNN for classification of COVID-19	4		
WP4	Implement MLP feature extraction and a multi-modal architecture	2		
WP5	Implement task-specific classifiers and a multi-task architecture	2		
M1	Intermediate Presentation II	4	10.06.2021	
WP6	Evaluation of the Multi-modal architecture	2		
WP7	Evaluation of the Multi-task architecture	2		
WP8	(Optional) integration of a Multi-modal multi-task classifier	4		
WP9	Testing and Documentation	4		
M2	Final Presentation	4	15.07.2020	