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Final Degree Project

Grade: Biomedical Engineering

Title: Semantic Segmentation of LUS Retraining a Convolutional Neural Network

Document: Summary

Student: Ferran Franco i Moral

Tutors: Xavier Cufí, Joan Aranda, Maria Farahi

Department: Arquitectura i Tecnologia de Computadors

Area: Arquitectura i Tecnologia de Computadors

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1. Abstract

On the last years respiratory diseases have been on the news almost every day. After the Covid-19 global pandemic, many studies where done in order to detect and avoid spreading the disease. As in many other different diseases, this studies tend to work with techniques that are available mostly on first world countries (using MRI, TC and X-Ray). **Lung Ultrasound (LUS)** has been increasingly used to diagnose and monitor different lung diseases. It's a non-invasive and cheaper technique than the others talked previously. The main issue is that acquiring a LUS scan is easier than analysing and understanding the images and characteristics of each respiratory disease.

To try solving this issue, over the last decade, many studies had the main purpose to demonstrate that **deep learning** techniques can be a possible solution. Despite having very promising results in automatic segmentation, there's still a necessity of **available data** to train and test this structures.

Through this work, a convolutional neural network based on the architecture **U-Net** has been re-trained, validated and tested in order to segment different patterns from lung ultrasound images obtained from papers published around the last years.

At the end of this project, a U-Net network has been obtained with 98.1455 % accuracy detecting a mask with all 3 types of lines that can be found in LUS, **A-lines, B-lines and Pleural line**. And a U-Net Network with 98.6894 % accuracy detecting a **B-line mask**. Despite being high accuracy values, as it will be seen on this project, the results aren't good.

From this bad results, at the end of this final degree project, it couldn't be concluded that the use of deep learning techniques in **Semantic Segmentation of LUS** isn't a good combination. In order to discard this theory, more tests and further investigation should be done.

Keywords: Lung Ultrasound, U-Net, Deep Learning, Convolutional Neural Network, Semantic Segmentation.

1. Hypothesis and objectives

1.1 Research Question

Can it be obtained a good accuracy by combining Deep Learning (U-net network) with Lung Ultrasound Segmentation in order to differentiate the patterns that appear on the images?

1.2 Hypothesis

We are able to obtain good accuracy results retraining a pre-trained U-net network to differentiate the patterns that appear on lung ultrasound images.

1.3 Objectives

The main objectives of this final grade project are the following: being able to differentiate background and the mask for each frame extracted from an ultrasound video, retrain a U-Net network and determine if the combination of Deep Learning and Lung Ultrasound Segmentation is a good procedure with high accuracy.

2. Results obtained

In order to modify and try to obtain better accuracy results while training a neural network, there are some parameters, known as hyperparameters, that have to be modified to find the best outcome to the net training.

These main modified hyperparameters have been the Initial learning rate (Ilr), the Optimizer (Solver), the Mini Batch Size (MBS) and the Max Epoch (MxE) shown on the following Table 1.

The training procedure was repeated 16 times obtaining 16 different nets with different accuracies. All these nets have been trained with the first 10.000 images (7000 for training and 3000 for validation) from the simulated data obtained from the paper [1].

Trial	Elapsed Time (h)	Ilr	Solver	MBS	MxE	Training Accuracy	Training Loss	Validation Accuracy	Validation Loss	MASK	Weighted
1	15:26:54	0.01	adam	16	10	0.01647	99.8309	99.89	NaN	GT	No
2	7:29:36	0.01	adam	32	10	0.0259	99.745	99.89	NaN	GT	No
3	0:05:26	0.01	sgdm	16	10	NaN	NaN	NaN	NaN	GT	No
4	0:06:12	0.01	sgdm	32	10	NaN	NaN	NaN	NaN	GT	No
5	14:31:45	0.001	adam	16	10	0.0083	99.8608	99.91	NaN	GT	No
6	7:32:14	0.001	adam	32	10	0.0128	99.8283	99.90	NaN	GT	No
7	10:51:27	0.001	adam	64	10	0.060	98.9939	99.52	NaN	GT	No
8	14:09:21	0.001	sgdm	16	10	0.0102	99.8749	99.89	NaN	GT	No
9	7:32:34	0.001	sgdm	32	10	0.0095	99.8565	99.87	NaN	GT	No
10	0:07:32	0.01	sgdm	4	4	NaN	NaN	NaN	NaN	GT	No
11	1:52:34	0.01	sgdm	4	4	98.1455	0.433	89.68	3.04	GT	Yes
12	30:45:55	0.01	adam	4	4	0.2535	92.5946	96,75	NaN	GT	No
13	5:18:22	0.01	adam	64	5	0.2329	92.8338	94.69	NaN	GT	No
14	0:08:57	0.01	sgdm	64	5	NaN	NaN	NaN	NaN	GT	No
15	1:50:07	0.01	adam	4	4	97.0846	0.0672	76.39	2.528	BL	Yes
16	1:43:48	0.01	sgdm	4	4	98.6894	0.0331	79.34	5.4995	BL	Yes

Table 1: Results of nets training depending on the modified hyperparameters that has been used.

[1] Zhao L, Fong TC, Bell MAL. COVID-19 feature detection with deep neural networks trained on simulated lung ultrasound B-mode images. En: 2022 IEEE International Ultrasonics Symposium (IUS). IEEE; 2022.

3. Conclusion

Taking in account the initial objectives, that where being able to differentiate background and the mask for each frame extracted from an ultrasound video, retrain a U-Net network and determine if the combination of Deep Learning and Lung Ultrasound Segmentation is a good procedure with high accuracy, I could say that not all of them have been accomplished.

It hasn't been possible to find a method, using Deep Learning and Lung Ultrasound Segmentation, which obtains a real high accuracy value. What has been found was a group of networks that are able to create a predicted mask containing almost 100% of pixels determined as background.

After understanding how the training networks had gone and why the high accuracy values can't be taken in account as good results, it could not be affirmed that the networks can segment properly a GT/B mask from the background.

In order to determine if Deep Learning combined with Semantic Segmentation of Lung Ultrasound could be a good technique, more investigation should be done with different datasets, hyperparameters and other factors.

As an improvement, more tests should have been performed with different hyperparameters and datasets. Another improvement could have been, despite having used Grad-CAM, finding more methods to analyse and understand the algorithm that the neural network followed.

The results of this project will be useful for Maria Farahi's thesis where she will continue exploring different paths in order to obtain the optimum method for Lung Ultrasound Segmentation to, in further phases of the investigation, assist and help diagnose lung pathologies such as Pneumothorax, Pneumonia or Covid-19.