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MRI Interpolation for Multiple Sclerosis Lesion Quantification

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***Abstract* - One of the tools for the diagnosis of multiple sclerosis (MS) is the MRI scan. Among the acquisition protocols these exams are the Routine Protocol (PR) and the Specific Protocol (SP). The EP is an expensive and time consuming exam, but allows a more precise quantification of the lesions' volume. On the other hand, the PR is cheaper, however, its accuracy is lower for this task. Within this context, this work presents a study on the application of interpolation methods in order to simulate the SP exam from an PR scan. Tests conducted so far show that the interpolated tests provide a more accurate quantification of the volume of the lesions than that obtained through the PR scan.**

Keywords — Multiple Sclerosis, Image Interpolation.

I. INTRODUCTION

According to Alastair[2], Multiple Sclerosis (MS) is an autoimmune inflammatory disease that affects brain and spinal cord, acting on nerve fibers that are responsible for the commands transmission from the brain to the rest of the body.

The most common tool for diagnosing those illnesses is the Central Nervous System Magnetic Resonance Imaging (IRM) exams. On the current clinical practice, the radiologist identifies and categorizes the hyperintense areas of the exams acquired through the so called Routine Protocol (RP).

Since it is a laborious and a repetitive process, many initiatives intended to create an automatic segmentation algorithm have arisen [1] [3][4].

Those approaches, despite being promising, demands for the exams to be acquired through a methodology named Specific Protocol (SP), that presents a higher quality level than the exams acquired through the RP.

A brain MRI based on the Routine Protocol is acquired faster and produces a small quantity of images. Typically, from 25 to 30 slices are created, each one representing a slice with 5mm of thickness. Between each slice there is, in general, a gap of 6mm.

An SP exam, on the other hand, lasts longer and it is more resource consuming, producing among 120 and 180 images from the same region. The slices on this exam have 1mm of thickness and do not present gaps between slices. Figure 1 shows the quantity of images generated by each one of the protocols.

Facing these characteristics, the quality of the RP's MRIs is compromised, making the lesion volume quantifying process difficult. In tests made, the identified lesion volume on the RP exams reached 42% of the correct quantification at most, and 25% of this volume on average.

In order to avoid this problem, this paper proposes the adoption of a method to generate additional slices, between the original slices from the RP, thus being able to generate results closer to those obtained with the usage of images from the SP.

II. MATERIALS AND METHODS

For this research, it was used seven MRI exams obtained from the Brain Institute of do Rio Grande do Sul, from Pontific Catholic University of Rio Grande do Sul, Brazil. For each exam, it was acquired an image set using the RP ad another using the SP.

To quantify the total MS lesion volume, this paper uses the Lesion Segmentation Tool (LST), a software based on the lesion growth algorithm proposed by Schmidt [3]. The LST requires, as inputs, a T1-weighted and a FLAIR MRI exam.

Initially, the lesion volume from the images of the RP and the SP was calculated. The result of this process is presented in columns 2 and 3 from [4]. The results presented in column 4, shows that the RP generates an average volume

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that represents only 32% of the real volume of lesions. On the best case, it represents 42% of the real volume and on the worst represents 15%.

Following that, for each exam available on the RP, were generated intermediary images, so that these exams had the same amount of slices that the SP exams.

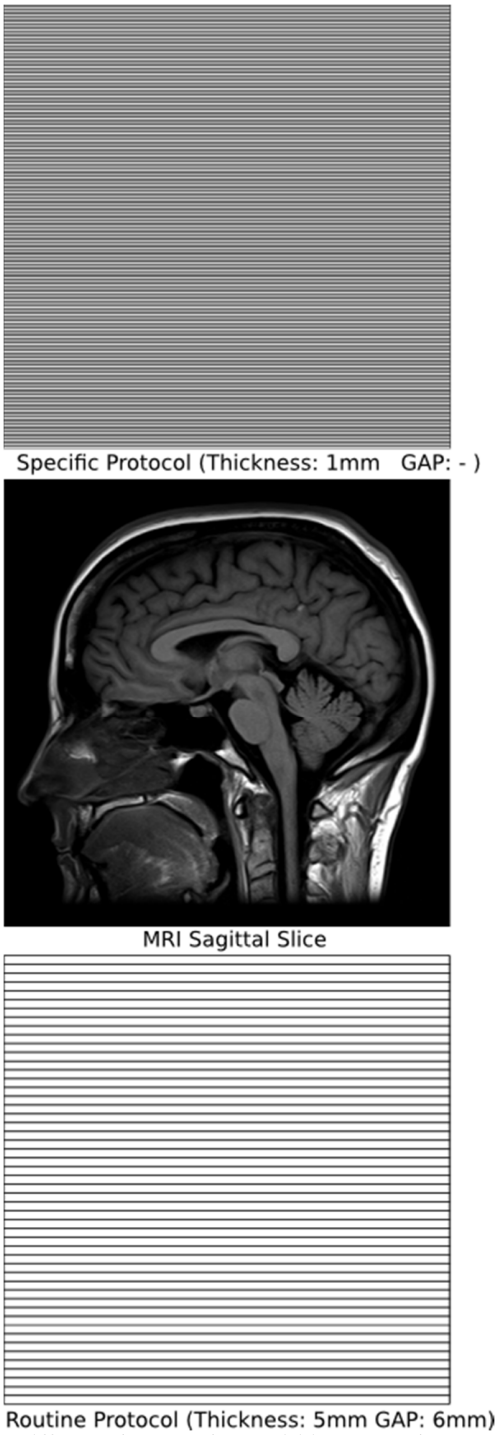

Figure 1 - Difference between the acquisition protocols

For generating intermediary images, were tested methods of Linear Interpolation, Nearest-Neighbor interpolation and Area Interpolation.

Were tested also the cubic and Lanczos with eight neighbors interpolation methods, but those presented worst results. Considering the first three interpolation methods and the seven exams on the RP, 21 new exams were generated.

In order to evaluate the effect of applying the interpolation methods on the MS lesion volume quantification, each interpolated exam passed through the LST segmentation process, generating the results presented in the columns 5 and 6 from [4], separated by each interpolation method. In column 7, the obtained values from the ratio of the data from column 6 and the observed volume on the SP (column 2) are presented. The lesions mean absolute error detected on images with interpolation is showed on the column 8. With these results, it can be concluded that the interpolated exams produces lesion volumes that are closer to the volumes obtained with the SP than to the volumes produced by the RP images.

However, in almost half of the cases, the interpolated exams generated higher values than those existing in the SP. This indicates that inexistent lesions (false positives) are being generated through the image interpolation. Figure 2 shows the occurrence of some of those false positives on interpolated images, as well as false negatives. In the example, both images correspond to the same position on the patient's brain.

In order to improve the analysis of the false positives, it was made a comparison of the location of the SP identified lesions and the lesions found in the interpolated exams, which lead to the data presented in the last two columns from [4]. These data shows the lesion volume identified on the interpolated exams that were in fact lesions on the SP exams. On average, 70% of the MS lesions where located in the correct position.

III. CONCLUSION AND FINAL REMARKS

The volume calculation of MS lesions through the usage of MRI exams acquired with the RP is a desirable alternative, from the clinical point of view, since that this is a low costing exam and it is fast to acquire, in comparison to the SP exams.

However, a low precision from the obtained quantification is observed on the low costing exam (RP) compared to the nowadays exams used on automatic lesion detection methods (SP).

Aiming on finding a way to minimize the problems resulting from the low precision of the RP, this paper tested different interpolation methods in order to improve the precision of the results. A comparative was made between the results of three interpolation techniques and the obtained results from the RP.

The results showed themselves as promising, with quantification close to the SP. However, in the presented

results is evidenced that the interpolation produces a not insignificant amount of false positives. Future works on this topic should aim on the research of methods that could reduce the amount of these false positives.

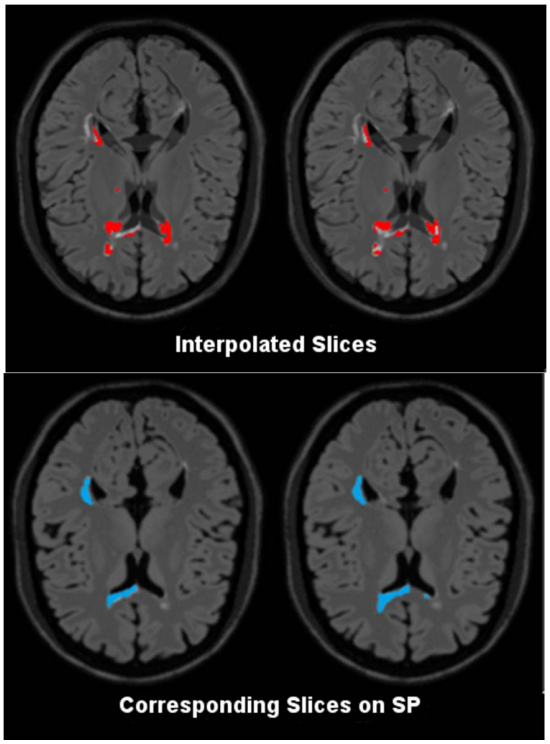

Figure 2: Lesion Segmentation Examples in RP and SP

IV. ACKNOWLEDGEMENTS

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Table 1 - MS Lesions volume quantification

1	2	3	4	5	6	7	8	9	10
Exams	**SP (ml)**	**RP (ml)**	**Volume % (RP/SP)**	**Interpolation Method**	**Total Quantification (ml)**	**% (Int/SP)**	**Absolute error**	**Correct Quantif. (CQ)**	**% (QC/SP)**
Exam 1	20,85	8,85	42%	NN	17,54	84%	16%	13,39	64%
				Area	18,18	87%	13%	13,93	67%
				Linear	22,14	106%	6%	15,70	75%
Exam 2	19,54	6,37	33%	NN	18,49	95%	5%	13,47	69%
				Area	19,12	98%	2%	14,06	72%
				Linear	22,49	115%	15%	15,46	79%
Exam 3	17,09	5,12	30%	NN	18,62	109%	9%	12,44	73%
				Area	19,32	113%	13%	12,80	75%
				Linear	22,13	130%	30%	13,76	81%
Exam 4	7,02	1,62	23%	NN	5,77	82%	18%	3,80	54%
				Area	5,97	85%	15%	3,94	56%
				Linear	6,87	98%	2%	4,20	60%
Exam 5	6,20	1,46	23%	NN	6,14	99%	1%	3,79	61%
				Area	6,37	103%	3%	3,90	63%
				Linear	7,13	115%	15%	4,14	67%
Exam 6	5,37	0,83	15%	NN	6,33	118%	18%	3,40	63%
				Area	6,58	122%	22%	3,53	66%
				Linear	7,40	138%	38%	3,71	69%
Exam 7	0,86	0,12	15%	NN	0,85	99%	1%	0,52	61%
				Area	0,79	93%	7%	0,37	43%
				Linear	0,77	91%	9%	0,42	49%
Aver.	**10,99**	**3,48**	**32%**	**-**	**11,38**		**12%**	**7,65**	**67%**