Non-negative matrix factorization for differentiation of brain metastasis and glioblastoma multiforme, and visualization of tumor infiltration

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Introduction – This study focuses on the differentiation between solitary brain metastasis and glioblastoma multiforme based on conventional magnetic resonance imaging (MRI) and two-dimensional turbo spectroscopic imaging (2D-TSI) data. The infiltrative nature of glioblastoma multiforme has been further investigated by using non-negative matrix factorization (NNMF) [1,2].

Materials and methods – Fifteen patients with a brain tumor, nine affected by glioblastoma multiforme and six by metastasis, were considered in this study. The data were acquired with 1.5 T Philips magnets (Philips Medical Systems, The Netherlands) at the Radiology Service of Clínica Quirón, and the Hospital La Ribera, Alzira, Valencia (Spain), as a part of the routine clinical preoperative MRI and spectroscopy protocol for the brain and using eTUMOUR FP6 project protocols [3]. High-resolution MRI (T1-weighted (pre- and post-gadolinium injection) and T2-weighted images) data were acquired prior to the 2D-TSI study (24x24, TE = 272 ms, TR = 2000 ms, FOV = 230x230 mm, slice thickness = 20 mm, 256 points). Each volume unit dimension was 9.6x9.6x20 mm (1.8 ml). Data processing included zero filling to 512 points, water removal by using HLSVD-PRO, Fourier transformation, peak integration of NAA, Cr and Cho. For each patient 2D-TSI voxels were assigned to three groups by radiologists: non-T2 hyperintense/non-enhancing, peri-enhancing and enhancing tumor. Furthermore, two constituent vectors of length 3 were extracted from each patient's 2D-TSI data using NNMF. These constituents correspond to a normal component and a tumor component, respectively.

Results and conclusion – Figure 1 shows a scatter plot (Cho/Cr versus Cho/NAA) of the difference of the patients' averaged ratio in the enhancing tumor and the non-T2 hyperintense/non-enhancing area. Glioblastomas and metastases form two separated clusters, the latter having smaller ratio values. Figure 2 provides a scatter plot of the result of automated processing with NNMF. The horizontal axis corresponds to the difference between the ratio element3/element2 of the tumor component and the normal component. Similarly, the vertical axis depicts this difference measure for element3/element1. The NNMF approach results in a clear separation of glioblastomas and metastases. Figures 3 and 4 visualize the abundances of the normal component that is obtained with NNMF for two cases with glioblastoma multiforme. These abundances indicate tumor infiltration. In conclusion, the use of 2D-TSI enables to visualize metabolic differences between glioblastomas and metastases. Automated processing with NNMF allows differentiation of these tumors and enables to visualize tumor infiltration.

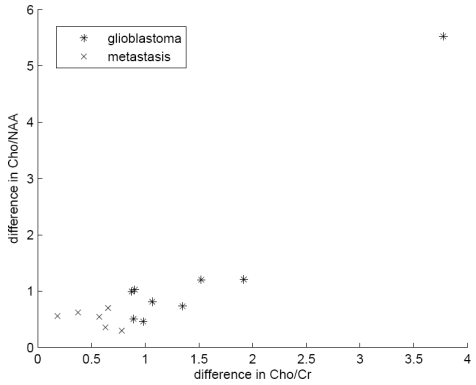

Figure 1. Scatter plot of the difference between the averaged Cho/Cr and Cho/NAA ratio from the enhancing tumor and the non-enhancing/non-T2 hyperintense area for each patient. Metastases and glioblastomas form two separated clusters.

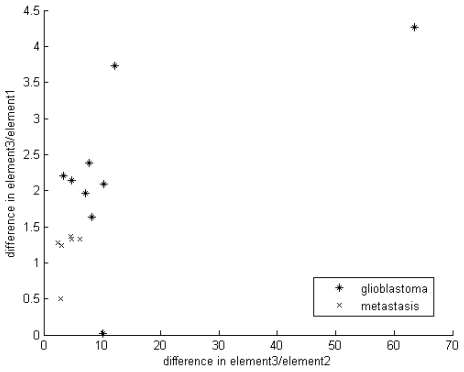

Figure 2. Scatter plot of the difference between the ratios element3/element2 and element3/element1 from the first constituent vector and the second constituent vector for each patient. Metastases and glioblastomas are separated.

References – [1] M. Law et al., Neuroradiology 222 (2002), pp. 715-721; [2] Y. Su et al., NMR Biomed 21 (2000), pp.1030-1042; [3] FP6-2002-LSCH-503094 www.etumour.net.

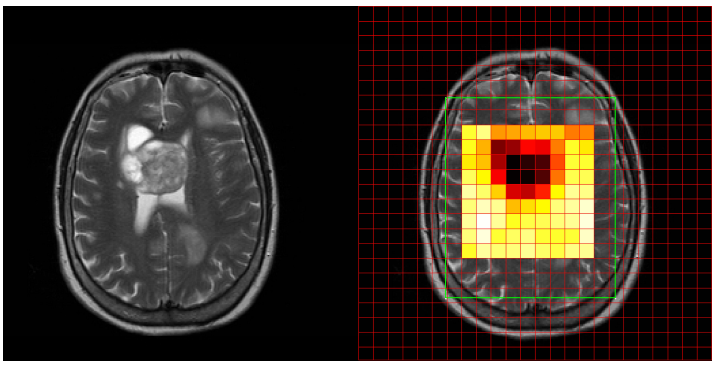

Figure 3. Left: T2-weighted MR image of a patient with glioblastoma multiforme. Right: NNMF abundances for the normal constituent vector [0.651 0.194 0.156]. White reflects high abundances and black corresponds to low abundances. The abundances visualize tumor infiltration.

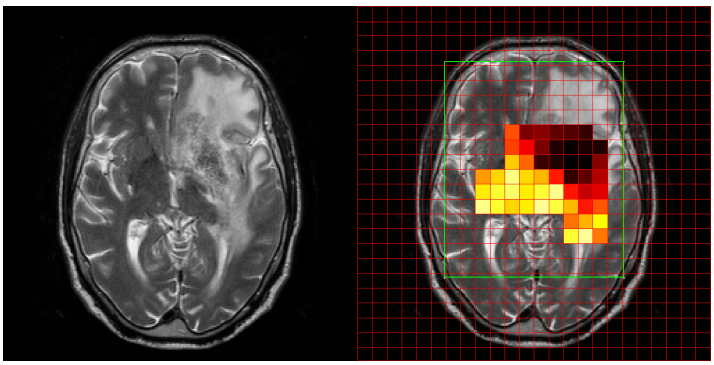

Figure 4. Left: T2-weighted MR image of a patient with glioblastoma multiforme. Right: NNMF abundances for the normal constituent vector [0.789 0.082 0.129]. White reflects high abundances and black corresponds to low abundances. The abundances visualize tumor infiltration in adjacent tissue in the contralateral hemisphere.