# MRI of the moving TMJ using Contour Fitting in the Correlation Matrix (CoFi-CoMa)

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**Introduction:** Assessment of the motion of the temporomandibular joint (TMJ) is of interest for a variety of pathologies, e.g. the abnormal motion of the articular disc. The dynamic visualization of the TMJ under realistic mastication is still limited by the poor spatio-temporal resolution [1, 2]. In this contribution we combine the advantages of self-gating and adaptive averaging [3] by using contour fitting in the correlation matrix (CoFi-CoMa) to increase the achievable temporal resolution and SNR.

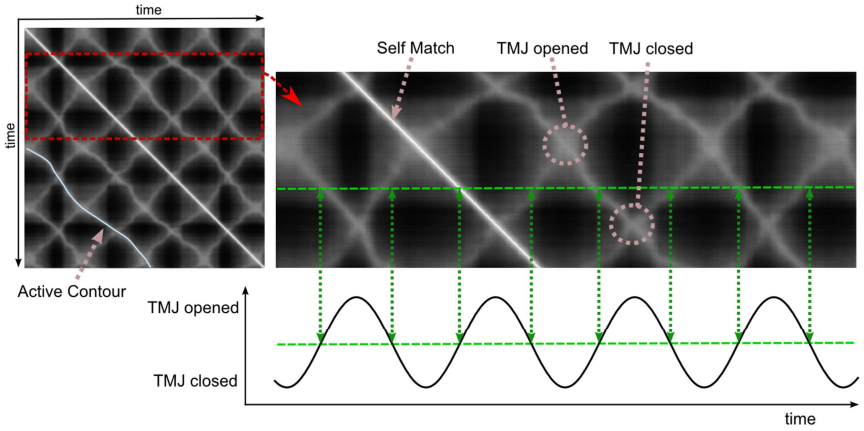


**Figure 1:** Values in the correlation matrix D indicate the similarity of the reference image (row) with the comparison image (column). The movement of the TMJ (sine curve) explains the diagonal checked pattern structure of the matrix. The reference image is similar to images in the same position and same movement direction (lines parallel to the main diagonal) and in the same position and the opposite movement direction (lines anti-parallel to the main diagonal). The intersection points of these lines are the opened and the closed positions.

**Methods:**

Correlation Matrix: A sequence of radial k-space profiles in golden angle order [4] is acquired during multiple opening / closing cycles of the joint. Sliding window reconstruction is used to reconstruct an initial undersampled image sequence $m$ using a fixed window width of 61 k-space profiles. The sequence $m$ is restricted to an region-of-interest around the condyle and is used to generate the pair-wise correlation matrix $D$ with $d_{u,t} = (m_t - \overline{m_t})^T(m_u - \overline{m_u})/n\sigma_u\sigma_t$, where $\sigma_x$ is the standard deviation of $m_x$ and $n$ is the number of pixels. The correlation matrix exhibits the typical structure shown in Figure 1.

Contour Fitting: To take into account the continuous and smooth motion of the condyle, smooth and continuous curves are fitted onto the line structures of $D$ using active contour matching [5]: the internal energy term $E_{int}$ models the continuity and smoothness of the contour, and the external energy term $E_{img}(u,v) = 1.0 - d_{u,v}$ forces the active contour towards the maxima of the correlation matrix. For each row of $D$ one frame is reconstructed using gridding reconstruction of all k-space profiles in a neighborhood around the intersections of the active contours with this row.

Acquisition: Eight healthy volunteers and eight patients with TMJ dysfunction were instructed to open and close the mouth continuously and uniformly during a time period of four seconds. Acquisition parameters were: 3T, balanced SSFP, a 2x4 channel carotid coil (Chenguang Medical Technologies, Shanghai, China), TE / TR = 2.3 / 4.6 ms, flip angle = 48°, pixel bandwidth 949 Hz, and spatial resolution 0.75 x 0.75 x 5 mm³.

**Results:** Figure 2 shows M-mode-like plots of a moving condyle. The proposed method is able to reproduce a high temporal fidelity even during the phases of fastest condyle movement. In comparison to a sliding window reconstruction using 256 k-space profiles per frame image analysis showed a significantly improved edge sharpness of the moving condyle ($p < 0.01$), and in comparison to a sliding window reconstruction using 61 k-space profiles a significantly improved SNR ($p < 0.01$).

**Conclusion:** Using contour fitting in the correlation matrix seems feasible for the imaging of the moving TMJ. Moving images of the TMJ at this fast opening / closing cycle rate in combination with the achieved high temporal resolution and high SNR have not been shown in the literature before.

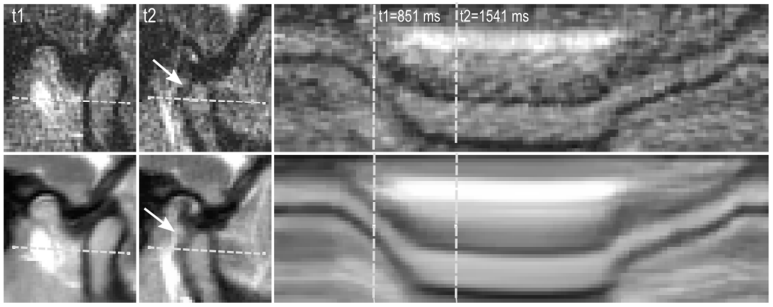


**Figure 1:** The moving TMJ opening and closing in 4.2 seconds using sliding window with 61 profiles per frame (top) and CoFi-CoMa (bottom) reconstruction. Left column shows the open position, the middle column the moving TMJ and the right column M-mode plots of the condyle.

**References:** [1] Zhang, et al. OMIJ 2011; 5:1-7. [2] Hopfgartner, et al. DFMR 2013; 42: 20120436 [3] Scott et al. MRM 2013; 70, 865–874. [4] Winkelmann, et al. IEEE TMI 2007; 26:68-76. [5] Kass, et al. Intl. J Comp Vision 1988; 1(4), 321–331.