Library sorting for real-time multi baseline thermometry

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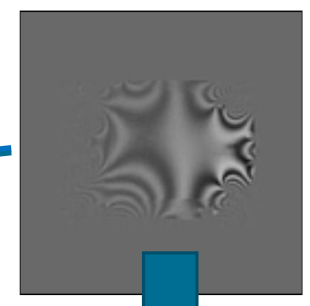
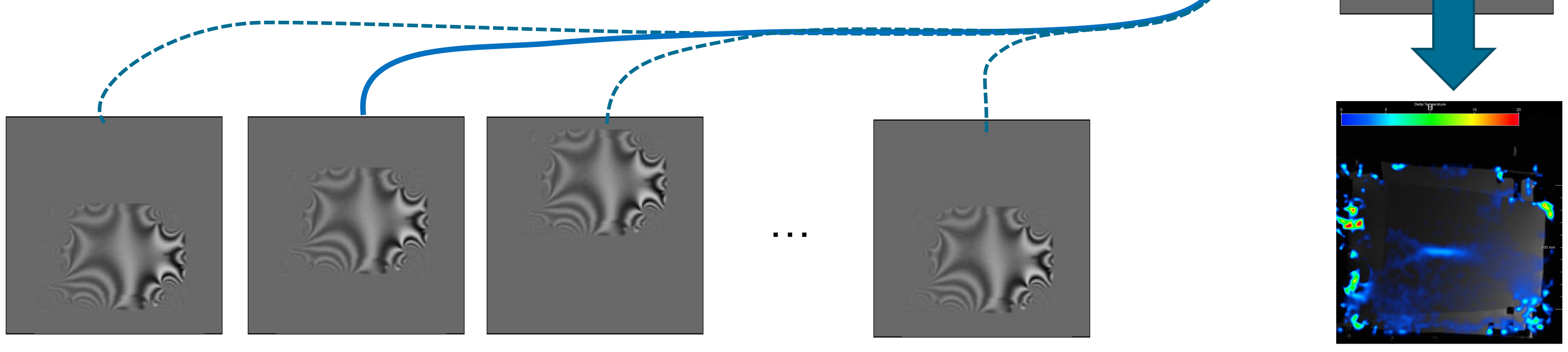
Introduction

Multi-Baseline thermometry is a popular method for MRgFUS in periodically moving scenarios. A set of baseline monitoring images* covering the whole motion cycle (library) is acquired prior to heating.





Temperature during treatment is calculated using the library image that is most similar to the current monitoring image. Finding the most similar image in a library of n images typically requires n comparisons (full search). We propose a library sorting method enabling a fast search with a constant number of comparisons.

The method may be provided as a MeVisLab add-on for research purposes (jan.Strehlow@mevis.fhg.de)

*Monitoring images typically consist of corresponding magnitude and phase images. In this method we use the magnitude images for sorting the atlas and selecting the most similar library image.

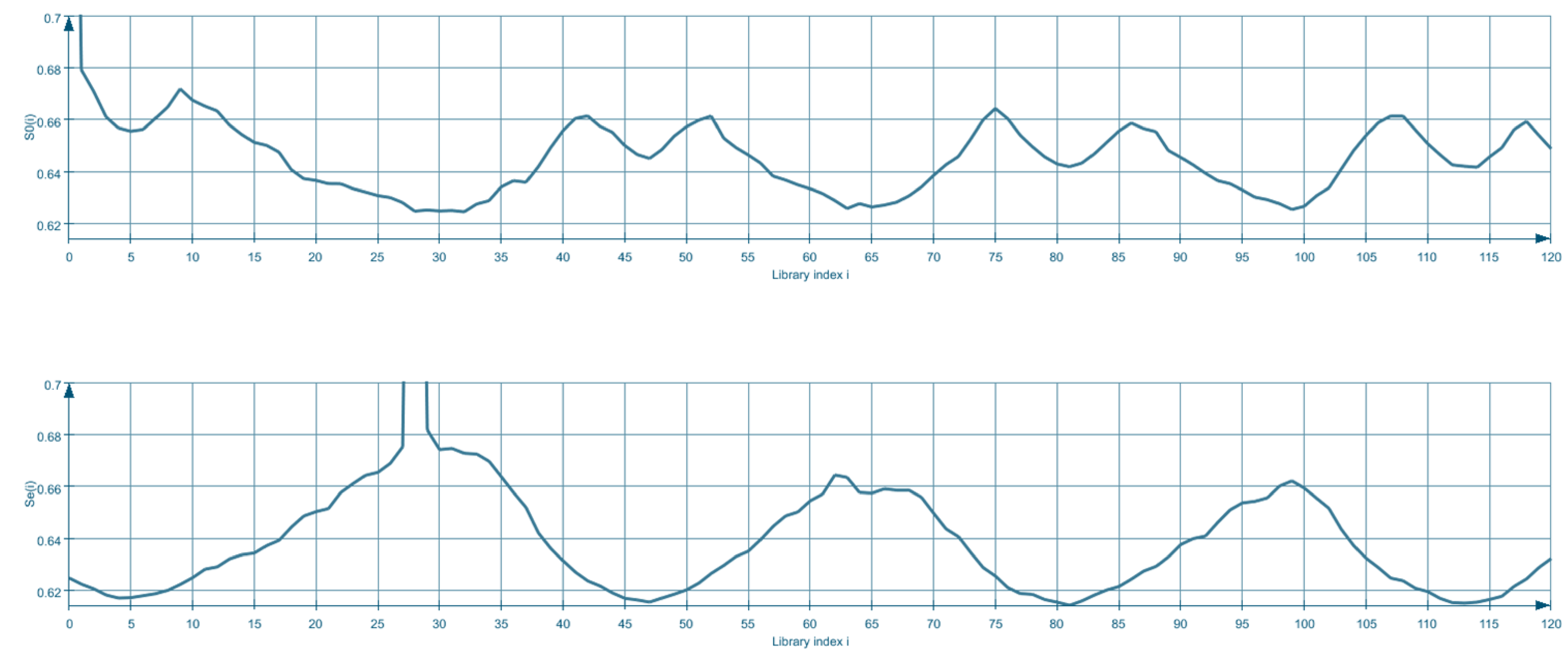
Library Sorting

With a suitable image similarity measure** $S(I_r, I_t)$ and library images I_i we compute:

$S_0(i) = S(I_0, I_i)$, the similarity to the first library image, and select a library image in an extreme respiratory phase as $I_e = \underset{i}{\operatorname{argmin}}\big(S_0(i)\big)$

The similarity to the extremal image $S_e(i) = S(I_e, I_i)$ is then be used to sort the library by an index permutation $j = \sigma(i)$

In the sorted library I_j the baseline images are sorted from one respiratory phase extreme to the other.



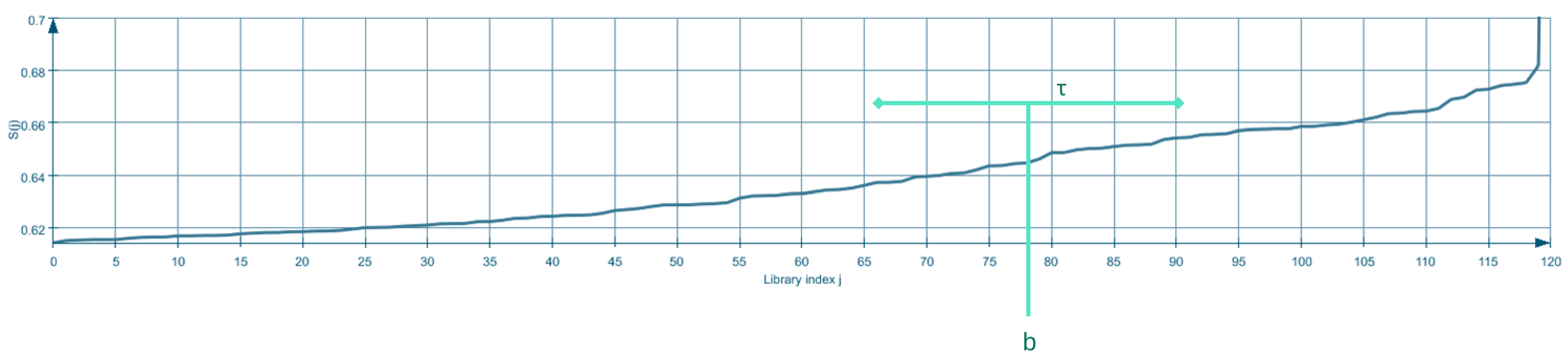
** In the presented method we use Normalized Mutual Information (NMI) as similarity measure S.

Fast Search on Sorted Library

Our fast search is based on the assumption, that if a monitoring image I_m and a sorted library image I_j have approximately the same similarity to the extremal image I_e, they are similar themselves.

$$\mathbf{b} = \underset{j}{\operatorname{argmin}}\Big(S(I_e, I_m) - S(I_e, I_j)\Big) \approx \underset{j}{\operatorname{argmax}}\Big(S(I_m, I_j)\Big)$$

To find the best matching library image we compute $S(I_e, I_m)$ to find an approximate library positon b.



Around position b we define a reduced search window $K = \{b - \lfloor \frac{\tau}{2} \rfloor, \dots, b + \lfloor \frac{\tau}{2} \rfloor\}$ in which we find $\underset{j \in K}{\operatorname{argmax}}\Big(S(I_m, I_j)\Big)$.

Note, that this search terminates after τ+1 evaluations of S and is thus O(1).

Evaluation

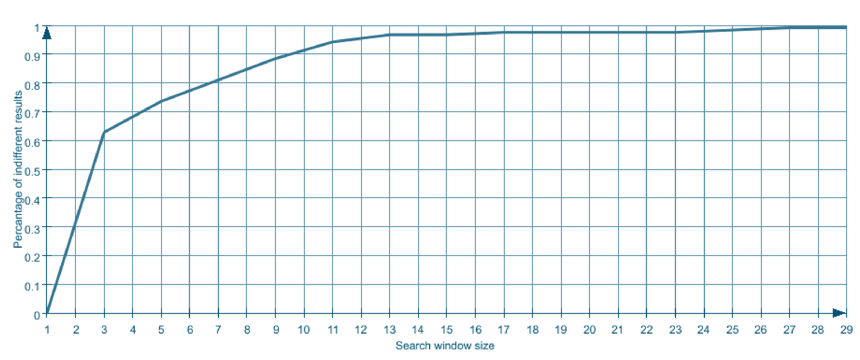
The method was evaluated on 24s of a sagittal 2D EPI monitoring sequence of a human liver under respiration (GE Signa HDxt1.5T). The first 120 images were used to build the library, the second 120 images were used to find the best matching library image for any time point, using full search and the proposed fast search with varying window size τ.

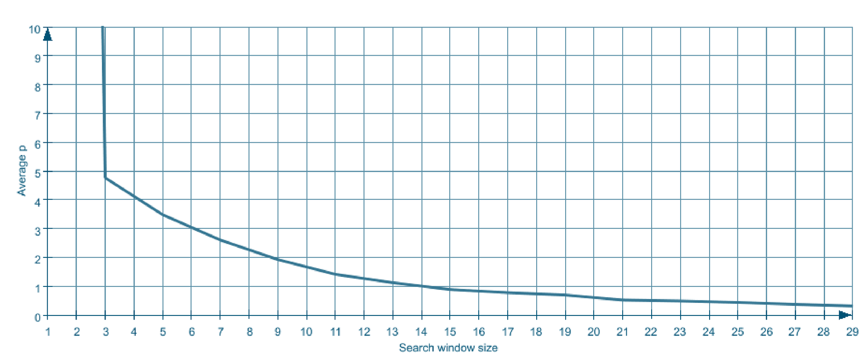
Fast search quality is quantified by **p**, the number of library images that have a higher similarity as the fast search result.

The fast search result is considered indifferent to the full search if p<=5. With τ in {1, 3, …,29} we evaluated

- the percentage of indifferent search results
- average p

Results





With our fast search, based on a sorted library we are able to find the best matching library image in constant time, independent of library size. The evaluation on our data suggests, that relatively small search window sizes (15 and up in our case) are suitable to achieve results that are close to those of a full search through the library.

Acknowledgements

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