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A Globally Optimum Parallelizable Whole Slide Image Registration Algorithm

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Introduction/ Background

Advancements in imaging, communication and computing technologies lead to commercially available digital slide scanners for pathology. These devices help to increase the quality of consultation, diagnosis, research, education and archiving processes as well as contribute to cancer research. At this point, high resolution imaging of the whole pathological specimen is one of the most important parts of the digitalization process. The imaged tiles must be perfectly combined to create the While Slide Image (WSI). In the literature, there are publicly available registration schemes to create the WSI [1] [2]. These methods mainly suffer from the high computational times and high computational resource usage (mainly RAM). To overcome these weaknesses, we have developed a novel, fast, globally optimum WSI registration algorithm.

Aims

In this study, we plan to develop a new globally optimum WSI registration scheme for digital pathology. Time consumption, RAM usage, starting tile invariance and compliance to parallel processing are selected as the main design concerns of the registration algorithm.

Methods

The proposed registration scheme has 2 main steps: In the first step, Phase Correlation Method (PCM) given in [3] is utilized to compute the translational offsets between an image and its 4-neighbors. Since PCM requires computing Fourier and inverse Fourier transforms, only overlapping parts of neighbours plus an error region is used to reduce the amount of calculations. Then, all the translational offsets are stored in memory to be used in the global optimization step. In the second step iterations are run to globally optimize the registration according to the neighbouring tile relations. First, the priory knowledge from the motorized table is used to assign global coordinates to the tiles. Then, tiles best position is calculated by maximizing the translational offsets of the neighbors. Here, the tile coordinates are not updated, but the shift values both in X and Y coordinates are saved. After finishing the shift calculation process for all tiles, the shift map is updated, which concludes the first iteration. The iterations continue until zero shift is calculated for all images.

Results

The performance of the proposed scheme is evaluated using 2 basic scenarios. In the first scenario, 40 different pathology slides are registered using the proposed scheme and then stitched using a bilinear blender. The resulting WSI's are reviewed by 3 pathologists for stitching errors, and no faulty registration is recognized. In the second scenario, registration time and maximum RAM usage are employed to evaluate the performance of the proposed scheme under different number of tiles. In the evaluations the proposed scheme is compared with Grid Stitching algorithm [1] implemented in ImageJ using the same tile sets and the same PC. The results given in below table show that the proposed scheme has significant RAM and processing time advantages which are very important for real-world applications.

	Registration Time (min:sec) for 150 Tiles	Registration Time (min:sec) for 540 Tiles	Registration Time (min:sec) for 1890 Tiles	Max RAM Usage (MB) for 150 Tiles	Max RAM Usage (MB) for 540 Tiles	Max RAM Usage (MB) for 1890
Grid Stitching (RAM Opt.)	01:01	03:36	14:37	1567	5133	15427
Grid Stitching (Speed Opt.)	00:39	02:06	08:26	1721	5380	17559
Proposed	00:28	01:41	06:57	217	849	3641

Comparative processing time and RAM usage performance of the proposed scheme

References:

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