Deep neural network as a decision support tool for the detection of lymph node metastases of colorectal cancer

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Background
The identification of lymph node metastases in colorectal cancer specimens can be a time-consuming and challenging task for pathologists. The aim of this study was to develop a deep learning-based segmentation algorithm for the detection of cancer foci in digitalized histological sections of lymph nodes and evaluate its performance as a diagnostic tool.

Methods
Algorithm performance

<table>
<thead>
<tr>
<th>758 WSI</th>
<th>2500 images</th>
<th>DNN Training</th>
<th>Algorithm performance evaluation</th>
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<tbody>
<tr>
<td>(100 mm)</td>
<td>(750 mm)</td>
<td>pixel level annotations of tumor areas</td>
<td>(90% Q3, 43 mm with cancer)</td>
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</tbody>
</table>

**Figure 1:** Evaluation of analytical performance of deep neural network (DNN)

Decision support
A randomized 2x2 cross-over study on whole slides images (WSI) was performed by two senior pathologists without (unassisted) and with (assisted) help of the algorithm. Recording the time needed for the evaluation of each lymph node, any presence of macrometastases (>2 mm), micrometastases (0.2-2 mm), isolated tumor cells (<0.2 mm) or tumor deposits (metastatic tissue without identifiable lymph node) were documented.

**Figure 2:** Study conduct to test algorithm as decision support tool

**Results**

**Algorithm performance**
The deep neural network (DNN) achieved a median pixel-level accuracy of 0.952 on cancer slides and 0.996 on benign slides.

**Figure 3:** Tumor deposit with cancerous areas annotated by a pathologist (left) and predicted by the DNN(right)

**Decision support**
When using the algorithm as decision support tool (DST), the time needed for the evaluation was significantly shortened.

**Figure 4:** Significantly faster evaluation with DST (median(lower quartile, upper quartile) for pathologist 1: 266 (198, 386) vs 146 (115, 208), p=0.001; pathologist 2: 258 (174, 373) vs 238 (155, 346), p<0.001)

**Conclusions**
A deep neural network can identify metastatic cancer foci on digitalized histological sections of colorectal lymph nodes, with at least the same accuracy as pathologists. Using the algorithm as a decision support tool can significantly shorten the time needed for the assessment of the lymph nodes.

**Figure 5:** Examples of benign lymph node (left) and lymph node with metastasis (right) with cancerous areas predicted by the DNN(lower) and without predictions (upper)

Diagnostic discrepancy between the pathologists was found in 15 cases: 13 lymph nodes with isolated tumor cells and 2 with micrometastases. In these cases, the algorithm missed to highlight the tumor area in 6 lymph nodes with isolated tumor cells and in 1 node with micrometastasis.