WoC-Bots: A Multi-agent Approach to Predicting Lymph Node Metastasis from Primary Breast Tumors

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Background: Multiple methods for predicting lymph node metastasis in breast cancer patients have been presented previously, including the Mayo and Memorial Sloan-Kettering Cancer Center nomograms and Stanford Online Calculator. We present a unique method, using "Wisdom-of-Crowd Bots" (WoC-Bots), a multi-agent, social approach to binary classification of node-positive or node-negative disease, to predict lymph node status in order to avoid surgical dissection.

Technology: WoC-Bots are simple, modular agents that include a small multi-layer perceptron classifier and are trained with different, small subsets of the overall feature space. They interact with each other socially, sharing information about patients features, e.g., primary tumor stage, age, primary tumor size, and histologic grade, to form knowledge-diverse crowds. A swarm aggregation mechanism, based on honeybee foraging optimization, is used to elicit an overall prediction from the WoC-Bots. The distributed and social nature of WoC-Bots allows for the inclusion of additional features without the re-training requirement found in traditional deep neural networks. The swarm mechanism is able to place each prediction into a confidence interval, giving each prediction a categorical confidence value.

Methods: We used an existing dataset of 457 de-identified patients. 4-to-8 randomly selected features were distributed to each of ~250 WoC-Bots; all WoC-Bots received 2 additional features, "primary tumor size" and "histologic grade". WoC-Bots' multi-layer perceptron classifiers were initially trained on their feature subset, followed by interaction periods to share feature and prediction information and build a performance history used to determine individual bot performance and trust. The prediction history of each WoC-Bot was used to assign correctness probabilities by the swarm aggregation mechanism. The testing dataset was split 80% training, 20% testing.

Results: WoC-Bots achieved an overall accuracy of 77%, with a best-case simulation at 81.2% accuracy. Additionally, predictions assigned to the "HIGH" and above confidence intervals, 44 of 81 (55%) of predictions, were able to achieve a combined 83.77% accuracy.

Conclusion: We present a distributed approach to predicting lymph node metastasis that achieves similar results to existing methods, while allowing for the incorporation of addition features as they become available without the expensive re-training required in traditional deep neural networks.