

## Deep convolutional neural network models for the diagnosis of thyroid cancer

### Authors' reply

We appreciate the comments from Dan Hu and colleagues and Eun Ha and colleagues about our Article.<sup>1</sup> We agree with Hu and colleagues regarding the incorporation of demographic features and laboratory test results in the model. Specifically, two neural networks can be devised that tailor for demographic features and laboratory test results. Subsequently, these two networks can be combined into a new model with the existing deep convolutional neural network model. Data curation from clinical and laboratory reports is ongoing.

Ha and colleagues state that the sensitivity of radiologists' assessment in our study is different from that reported elsewhere.<sup>2,3</sup> Several factors might contribute to this discrepancy. First, we report sensitivity at the patient level, whereas Ha and colleagues report sensitivity at the image level. Second, the diagnosis of nodule in our study was made on the basis of surgical specimen, whereas in the studies by Ha and colleagues,<sup>2,3</sup> the diagnosis was based on either surgical specimen, core-needle biopsy, histology, cytology, or benign features from ultrasound examination. Finally, the number of images examined by radiologists in our study (6708 images) is much larger than the number examined in the study by Ha and colleagues (<200 images in one study<sup>2</sup> and 2000 in the other<sup>3</sup>). Ha and colleagues also inquire how ultrasound features might affect our developed model. In our ongoing analysis, we are linking features learned by the deep convolutional neural network model to ultrasound features defined by the American College of Radiology Thyroid Imaging, Reporting and Data System.<sup>4</sup> We plan to report our conclusions at a later date. Lack

of validation in different geographic setting is a limitation of the published study. We appreciate data from different geographic settings, such as those from Hu and colleagues, to test our model.

We declare no competing interests.

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- 2 Ha EJ. A computer-aided diagnosis system for thyroid nodules on ultrasonography: initial clinical experience. *Korean J Radiol* 2018; **19**: 665–72.
- 3 Ha EJ, Na DG, Baek JH, Sung JY, Kim JH, Kang SY. US fine-needle aspiration biopsy for thyroid malignancy: diagnostic performance of seven society guidelines applied to 2000 thyroid nodules. *Radiology* 2018; **287**: 893–900.
- 4 Tessler FN, Middleton WD, Grant EG, et al. ACR Thyroid Imaging, Reporting and Data System (TI-RADS): white paper of the ACR TI-RADS committee. *J Am Coll Radiol* 2017; **14**: 587–95.