# Development and evaluation of overscan detection algorithm for AI-augmented auditing of low-dose chest CT: Experience of Korea Institute for Accreditation of Medical Imaging (KIAMI)


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**Background**

CT scan protocol audit is an indispensable activity to drive diverse scan protocols to better optimized and keep the front-line CT scan operator alert in clinical routine. Among many CT scan parameters, scan-range is one of the most objectively justified factors in accordance with the as low as reasonably achievable (ALARA) principle as it can effectively limit radiation to body parts of interest without compromising image quality. In practice, however, CT scan-range is subjectively defined by technologists based on the scout-view and seldom reviewed by radiologists in the clinical routine. In South Korea, the government commissioned agency, the Korea Institute for Accreditation of Medical Imaging (KIAMI), set guidelines and periodically audit an appropriateness of the scan-range to regulate whether they are subjective and excessive, and more than 1,200 CT scanners are evaluated by the KIAMI in a year. Experienced radiologists are recruited by KIAMI and asked to review the appropriateness of scan-range and give feedbacks to the imaging institutions while spending a considerable amount of experts' labor and time. To save enormous resources, authors organized a collaborative team and developed an AI-based algorithm that can substitute conventional scan-range audit work by automatically detecting overscan cases and give alarm to the reviewers. This study presents our experience of development with KIAMI and evaluation results.

**Methods**

A total of eighty low-dose chest CT scans was used in this study after an institutional review board approval (IRB No. 2012-187-1186) from a university hospital. Among them, 50 cases were used for training of convolutional neural network (CNN) model, and the rest 30 cases were used for validation. Our algorithm consisted of three stages; landmark segmentation, rule-based logic, and final determination of the overscan. The landmark segmentation stage used the CNN model which was trained with manually labelled segmentation masks of thyroid cartilage and kidney. The segmentation masks were firstly prepared by an experienced operator, and adjusted by feedback of the audit-experienced radiologist. The performance of landmark segmentation stage was evaluated with Dice-similarity coefficient (DSC). The rule-based logic used the information on the landmarks and their relative location from the reconstructed CT volume. All information derived from the second stage was delivered in Boolean logic to the last stage. The last stage conducted the final determination of the overscan and generated alerting alarm based on the information of the second stage.

To validate the performance of overall detection algorithm, we used 50 external CT scans collected through a lung cancer screening program. The CT data was collected from 47 institutions, and with 26 different CT machines across the country. It contained 16 over-scans (32%); 14 scans for superior-side and 2 scans for inferior-side, which were labeled by a 20-year-experienced radiologist. They were categorized into the overscan when the scan-range exceeds the superior and inferior scan limit, which are the thyroid cartilage and the lower end of the kidney, respectively. The overall detection performance was evaluated with area under receiver operating curve (AUROC), sensitivity and specificity. In addition, Fisher's exact test was performed to determine if the algorithm possessed an ability to detect the overscan comparable with that of audit-experienced radiologist.

## Results

The developed landmark segmentation stage showed a DSC of $0.76 \pm 0.09$ for thyroid cartilage and $0.88 \pm 0.14$ for kidney, respectively. The AUROC of the overall detection algorithm was 0.99 (95% C.I.: 0.80 to 0.99) with sensitivity of 0.94 (95% C.I.: 0.69-0.99) and specificity of 0.97 (95% C.I.: 0.84-0.99). While the landmark segmentation performance is less precise, the overall detection algorithm showed high AUROC, which indicated the synergistic effect obtained by combining the CNN and rule-based logical algorithms. Fisher's exact test was statistically significant ($p<0.005$) indicating that our developed algorithm has an ability to detect overscan matched to that of audit-experienced radiologist.

## Conclusion

Our group developed an AI-assisted algorithm that can potentially substitute the current hand-operated overscan audit process of low-dose chest CT scan. The study results demonstrated that the developed algorithm could determine the overscan as accurately as an audit-experienced radiologist. As low-dose chest CT is a critical element for national low-dose lung cancer screening program in South Korea, our AI-assisted algorithm could contribute to follow ALARA principles in a national level. We hope our efforts to employ AI technology in auditing process could save enormous human and time resources, and improve the accuracy of the auditing result.