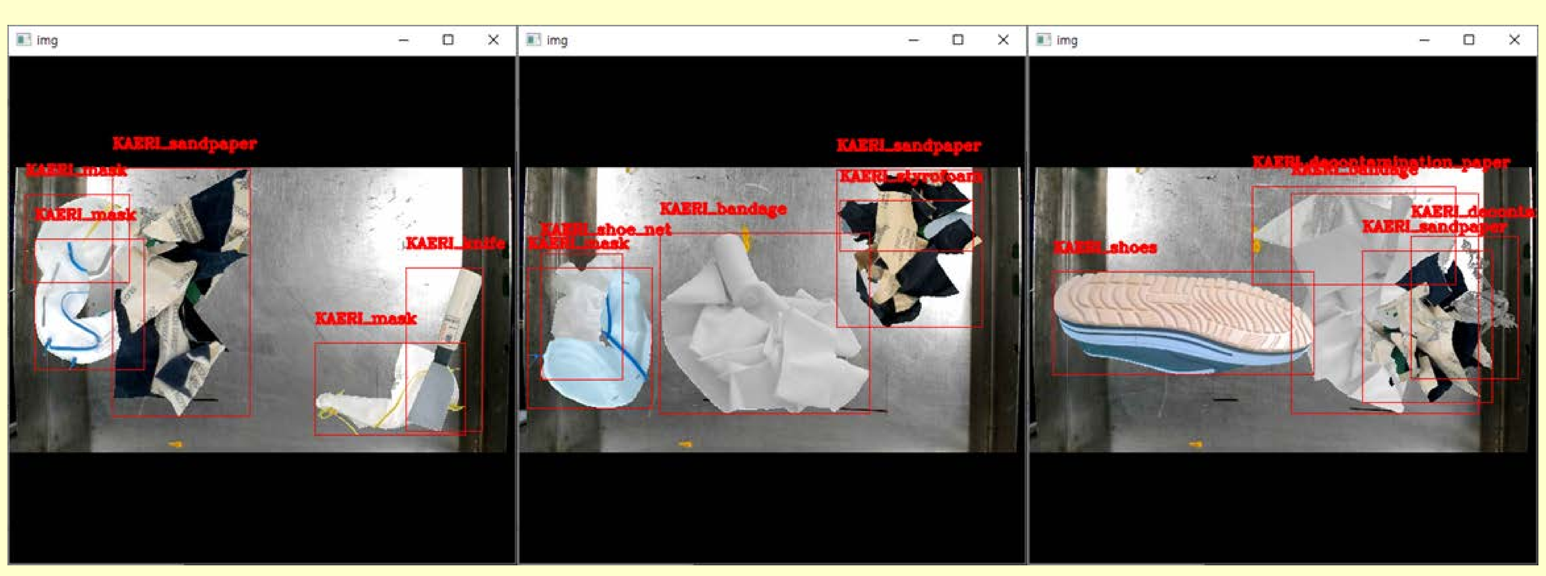
Application of Deep Learning for advanced classification of radioactive waste

Hee Seoung Park*, Sung-Chan Jang, Il Sik Kang, Dong Ju Lee, Yong-gyun Yu, Jong-Jin Kim, Jin-Woo Lee
Korea Atomic Energy Research Institute
Corresponding Author: parkhs@kaeri.re.kr

- **Radioactive waste (RAW): creation, classification and packaging as an original drum**
- **Original RAW drum: transformation to a RAW treatment facility, reclassification, repackaging, and stored small packages**
- **Reclassification of the RAW: performed by experienced workers and mandrolic process**
- **Unexpected human error: occasional total inspection and the work fatigue of the workers**
- **Classification of the RAW: deep learning technique to solve a problem**

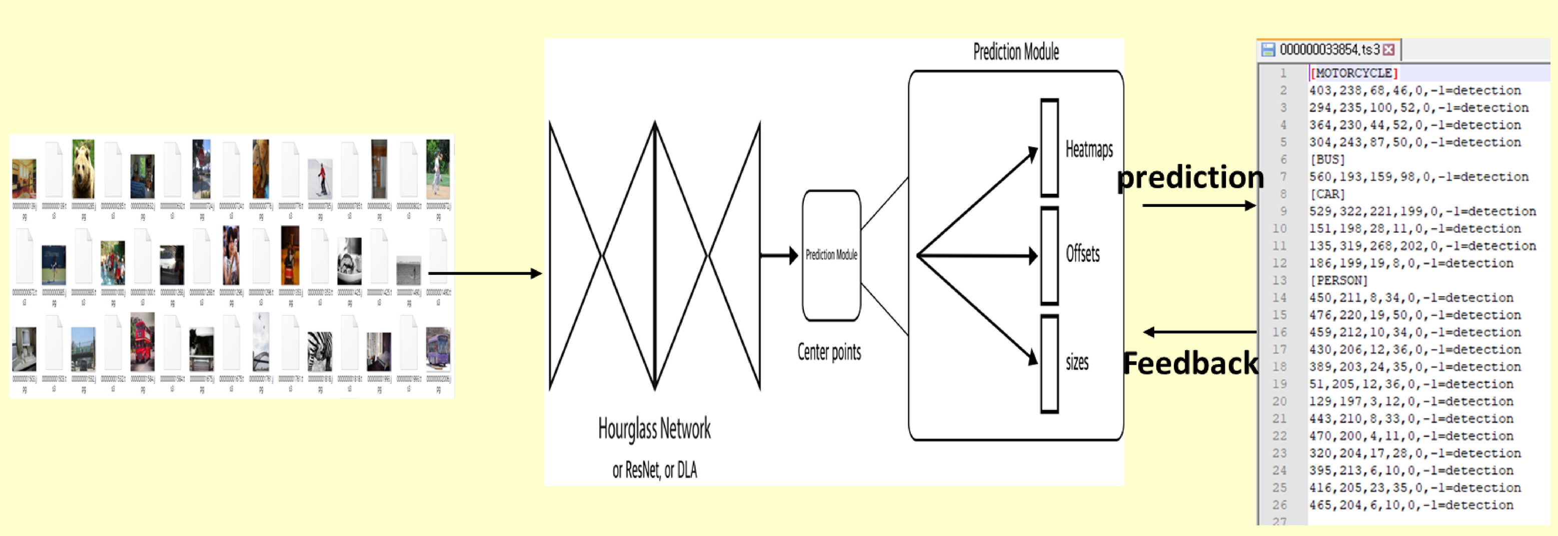
❑ RAW Data collection and Dataset

- **Based on the classification criteria**
  - **Generating 11 kinds of patch data (Mask, Ranch glove, Rubber glove, Filter, Knife, Brush, Hose, Tissue, Sandpaper, Working Shoes, Decontamination paper)**
  - **Performing synthesis: total of 8,307 patch data**
  - **Visualisation and the generation of synthetic data**



❑ DNN learning for RAW object recognition

- **Trainning object recognition model to learn only several category information from an image and to predict only the classification information of the image**
- **Learning process of multiple object recognition model**



Input data **Learning model** **Learning Information (object size, Location, Category)**

❑ Data configuration for learning evaluation

- **Evaluation data: divided into 11 categories**

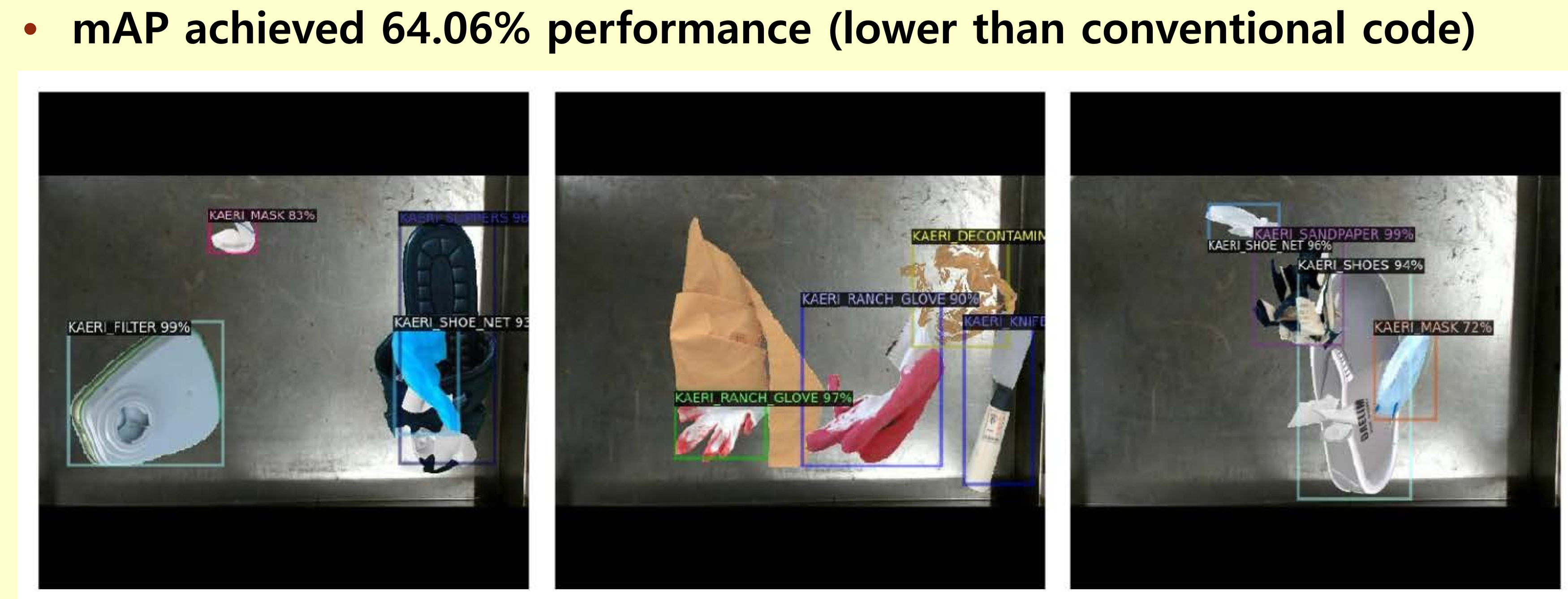
Category	Validation	Test
Mask	1,312	1,331
Ranch glove	1,278	1,347
Rubber glove	1,305	1,289
Filter	1,321	1,359
Knife	1,326	1,254
Brush	1,280	1,287
Hose	1,330	1,362
Tissue	1,337	1,296
Sand paper	1,343	1,389
Working shoes	326	1,327
Decontamination pape r	1,302	1,313
Total	14,460	14,554

☐ Results of learning evaluation

- **Final evaluation: predicted object were 0.5 or higher**
- **mAP of 400 generations (epoch) of models the highest at 70.6%,**
- **Test data (test set): 70.5% of the mAP by selecting the evaluated model**

Category	Result(AP)
Mask	0.936
Ranch glove	0.926
Rubber glove	0.912
Filter	0.908
Knife	0.882
Brush	0.781
Hose	0.828
Tissue	0.62
Sand paper	0.468
Working shoes	0.363
Decontamination paper	0.136
mAP	0.705

- **Compared algorithm: Centernet code vs Detectron2 and EfficientDet**
- **Detectron2: 80,000 learning data and Fast-RCNN model**
  - **Test data: 10,000 identical test datasets**
  - **mAP achieved 64.06% performance (lower than conventional code)**



- **EfficientDet code: four data sets for the experiment**
- **Applied augmentation techniques such as Cutout, Scaling, and contrast**

☐ Result and Consideration

- **Resolution for location, size (width, height): 512 x 512**
- **Generation for single data: Object patch augmentation**
- **Enhance the learning model's performance: pixel-level transform (Blur, Noise) and spatial-level transform**
- **Testing and Comparing:**
  - **Detectron2: object detection and segmentation in the PyTorch library**
  - **EfficientDet: the best performance in the real-time object recognition**
  - **CenterNet learning model: radioactive waste object recognition**
- **Mean average precision (mAP)**
  - **CenterNet: 70.6 % in the 400 epoch of the learned model**
  - **Detectron2 & EfficientDet: 64.06 % & 81~82%**

Conclusion

✓**Implementing of the object recognition and classification of radioactive waste**
✓**Recognizing more mixed and various radioactive waste more numerous data sets should be collected**
✓**Main objective of object recognition should be classified the various radioactive waste in the real world**