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Deep Learning Systems for Increased Safeguards Surveillance Review Productivity

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Abstract

Nuclear safeguards inspectors expend significant time and maintain intense focus in reviewing video surveillance for safeguards relevant events. To increase efficiency and reduce the time burden of safeguards inspectors performing surveillance data review, this paper presents a novel deep learning (DL) systems concept to integrate generalized DL models into the safeguards surveillance review workflow. The Agency is investigating several DL algorithms for object recognition, localization, tracking, and flagging relevant activities. The project team is working closely with nuclear safeguards inspectors to identify review use cases (based on specific safeguards objectives) and collect their associated requirements. We focused on CANDU and LWR Nuclear Power Plants (NPPs) and their associated dry storage areas as these present a particularly heavy burden on the inspector surveillance review process due to the number of these facilities under safeguards worldwide. Initial DL algorithm results on safeguards data are promising. Using a convolutional neural network, the team attained a mean average precision (mAP) of 92.9% identifying and localizing spent fuel (SF) casks from a 475 surveillance image dataset. Further, the team had initial success in training a recurrent neural network to identify reactor area activities in video clips, successfully indicating when SF casks enter or exit a pool. We discuss how such DL algorithms would be integrated into the Next Generation Surveillance Review (NGSR) software application. Another issue impacting review productivity is the long time inspectors may have to wait when running these algorithms in NGSR. We present a concept to pre-process remotely collected surveillance data with DL models as the data arrives to IAEA headquarters so that results are already available when starting a new review in NGSR. The proposed DL system concept shows a pathway and workflow for increasing an inspector's surveillance review productivity by quickly and accurately identifying declared and undeclared safeguards relevant objects and activities in large quantities of surveillance imagery data.

Keywords

Deep learning, nuclear safeguards, surveillance review, systems, algorithms