Information Management for Nuclear Decommissioning: Synthesizing Text with Drawings

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Outline

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1. Introduction

- The nuclear power plant (NPP), one of the most delicate and advanced man-made structures, has a complex structure and no margin for error, as any radioactive leak could affect public health. As a result, any NPP's decommissioning procedure should adhere to the "as low as reasonably achievable" principle.

- The multi-agency radiation survey and site investigation manual (MARSSIM) requires a thorough investigation of big data related to the respective NPP for decommissioning, which is an essential step, known as site characterization, in any NPP decommissioning project.

1. Introduction

- We propose a deep neural network (DNN)-based framework to both alleviate the burden of human labor and accelerate the overall execution speed of the detection and marking process. Our goal is to identify and mark all boundaries of areas contaminated by the corresponding event.

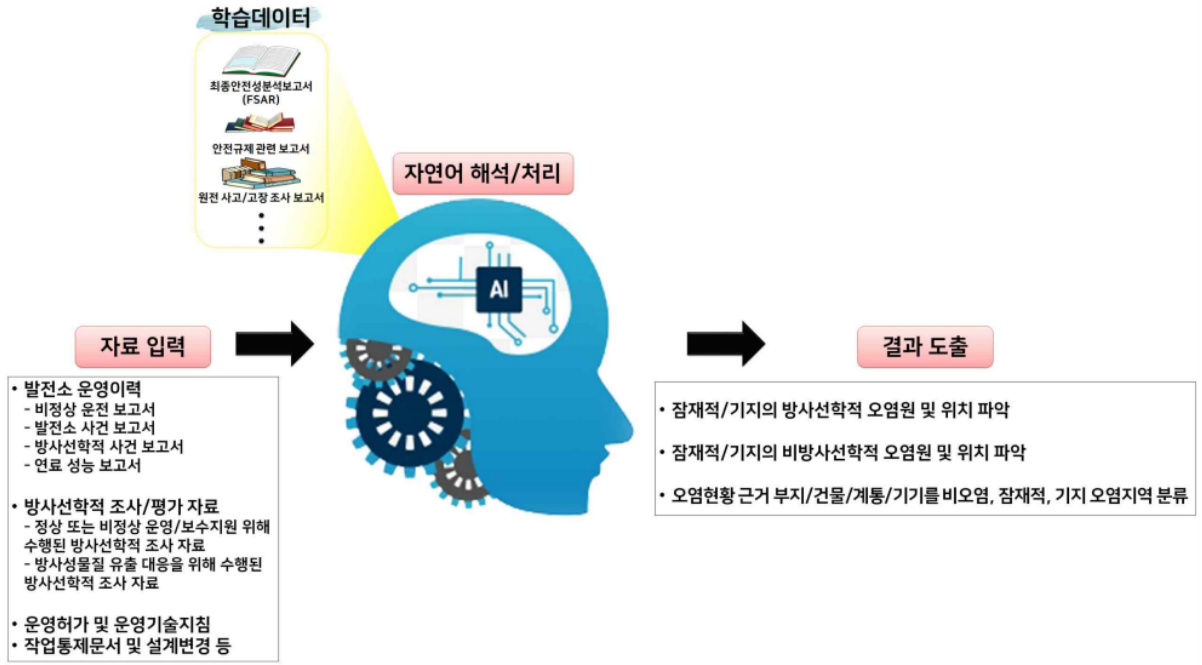


Fig 1. Project summary

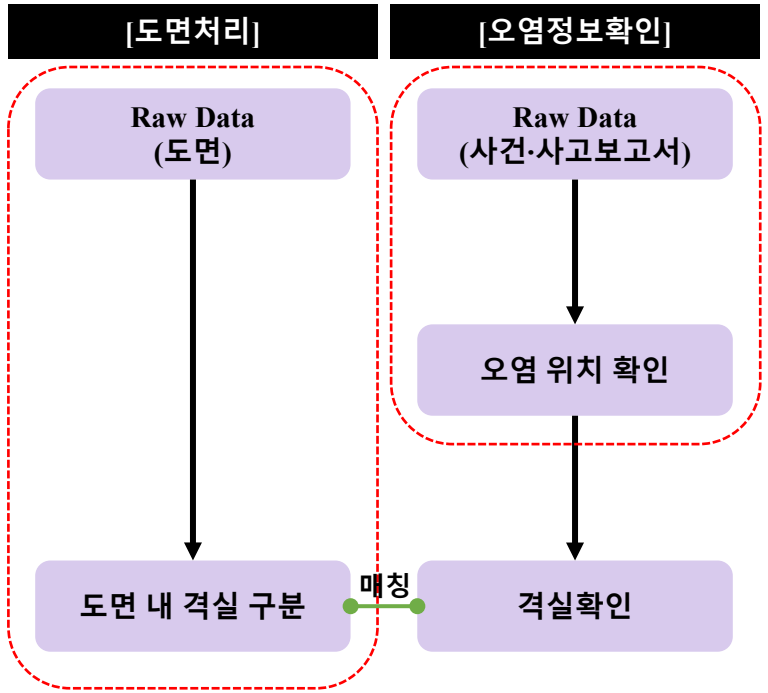
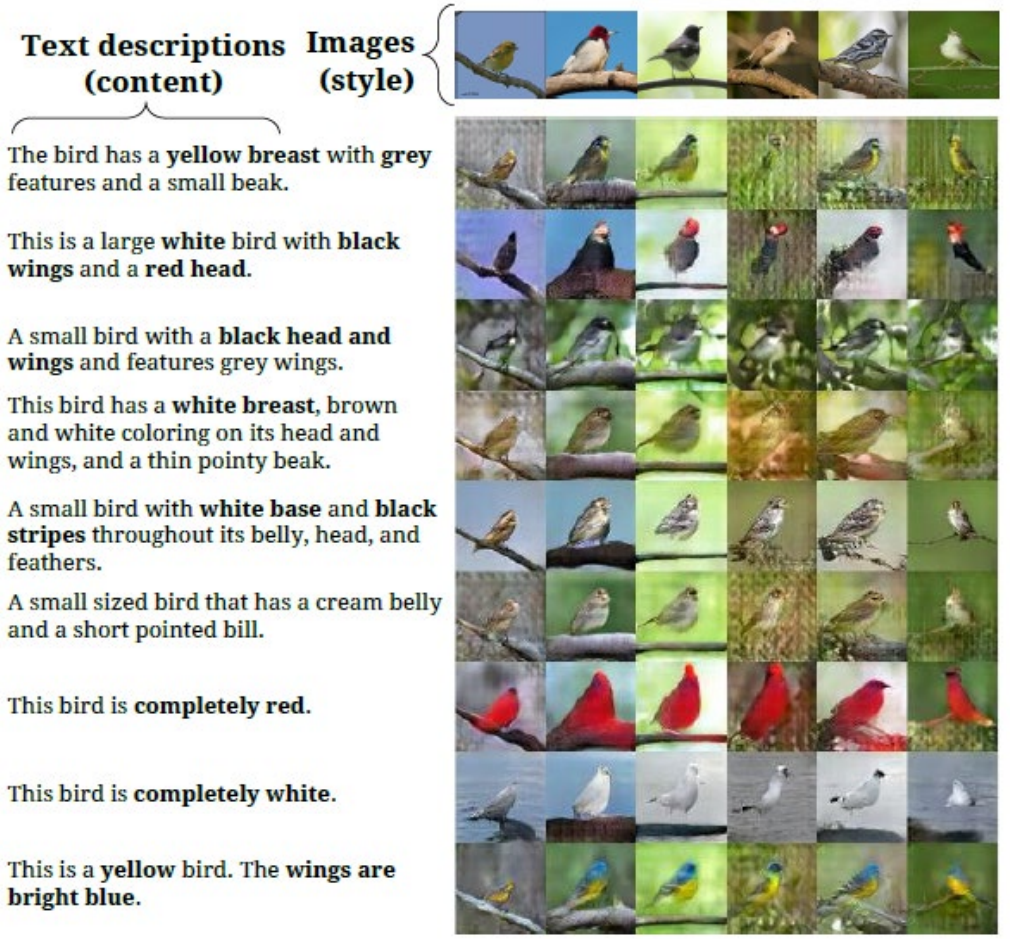


Fig 2. AI Model Flow Diagram

1. Introduction

- Specifically, our framework is conceptually based on Reed et al. (2016), in which images are synthesized according to text; in our case, it refers to the boundaries within an NPP drawing that corresponds to a specific radioactive incident.

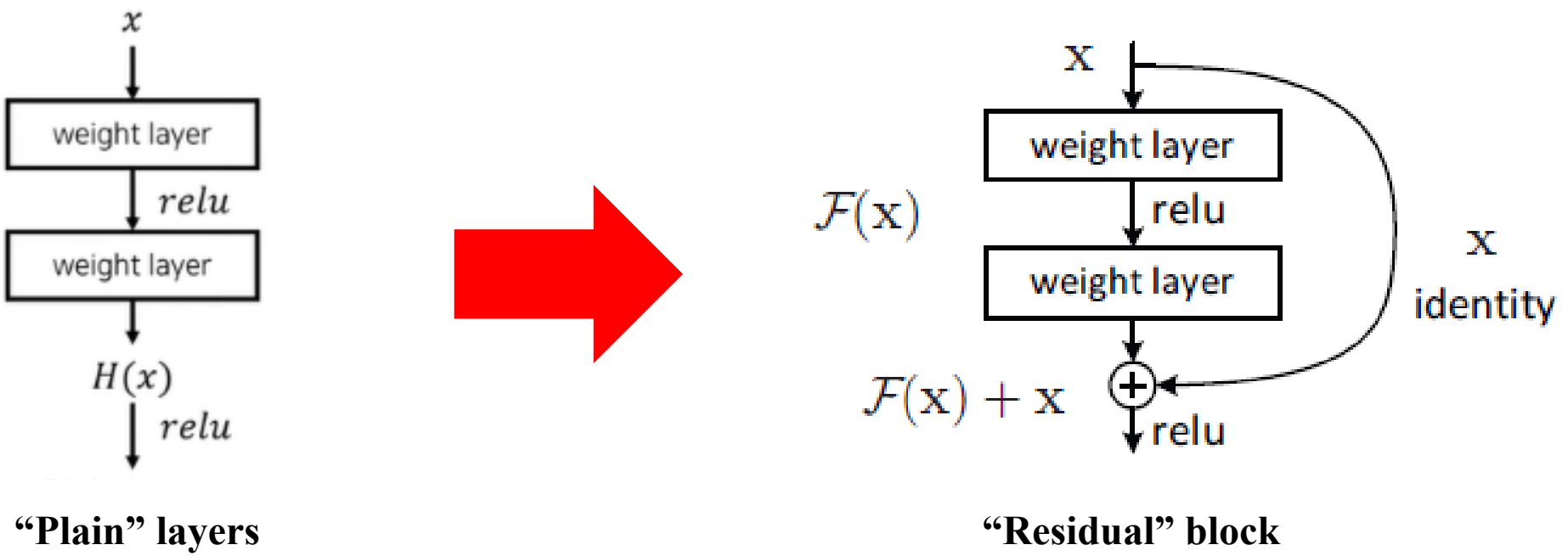


Source: Reed et al. (2016)

Fig 3. Example of synthesizing images to text

1. Introduction

- Our model structure is based on He et al. (2016) which introduces a methodological innovation aimed at lowering computational costs when training and applying DNN-based frameworks, particularly image-based framework.



"Plain" layers **"Residual" block**

Fig 4. Residual block network

2. Method and Result

2.1 Framework

• We aim at synthesizing the image representation of a room in an NPP drawing with query which is hypothesized to contain information on i) what structures, systems, and components were contaminated and ii) where the corresponding figure is in the drawing.

• Since queries, which are semantic representations and thus solely text data, are directly matched with and converted to their corresponding image representations, we refer to our model as an object conversion system (OCS).

2. Method and Result

2.2 Evaluation Citeria

• We assess the accuracy of our text model using the intersection over union (IoU) metric calculated using the Jaccard index. IoU is calculated by dividing the intersection of the bounding boxes for ground truth data and predicted data by their union area.

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|}$$

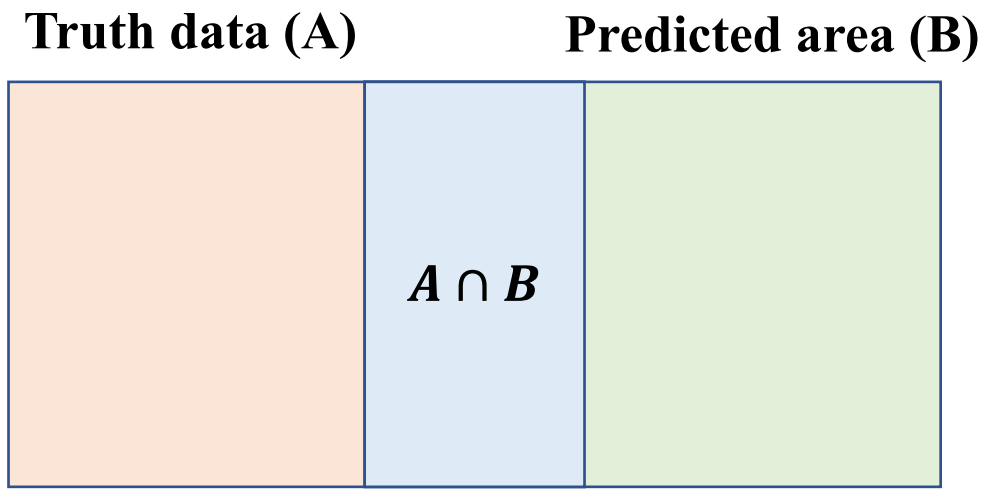


Fig 5. IoU calculation

2. Method and Result

2.3 Data Selection and Preprocessing

• In order to train and test our DNN-based module, we improvise by selecting and utilizing data that is similar to that of actual NPP drawings. NPP expert personnel manually collected our dataset via web image search.

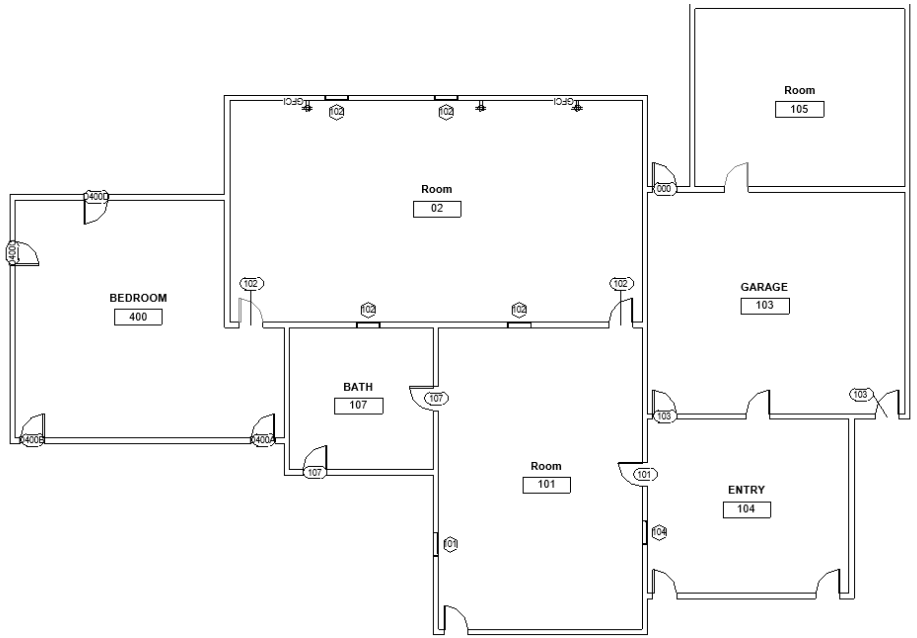


Fig 6. Example of an RN drawing

2. Method and Result

2.4 Object Conversion System

- We use solely text data to infer the image representation indicating potentially contaminated areas.

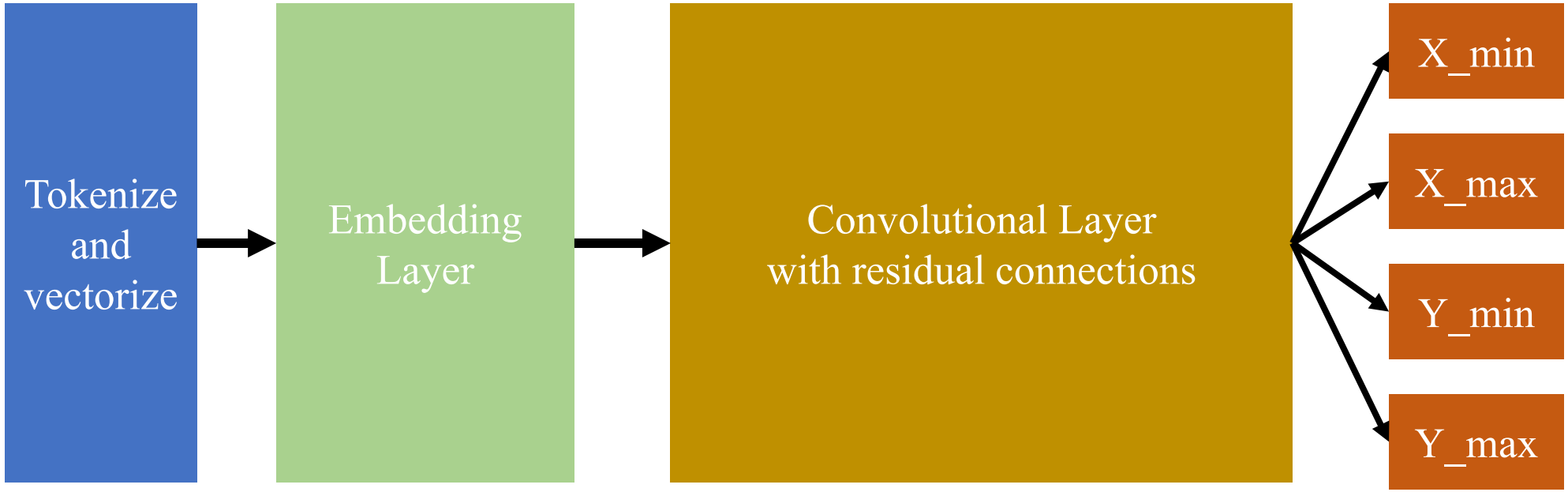


Fig 7. AI Model framework

2. Method and Result

2.5 Results

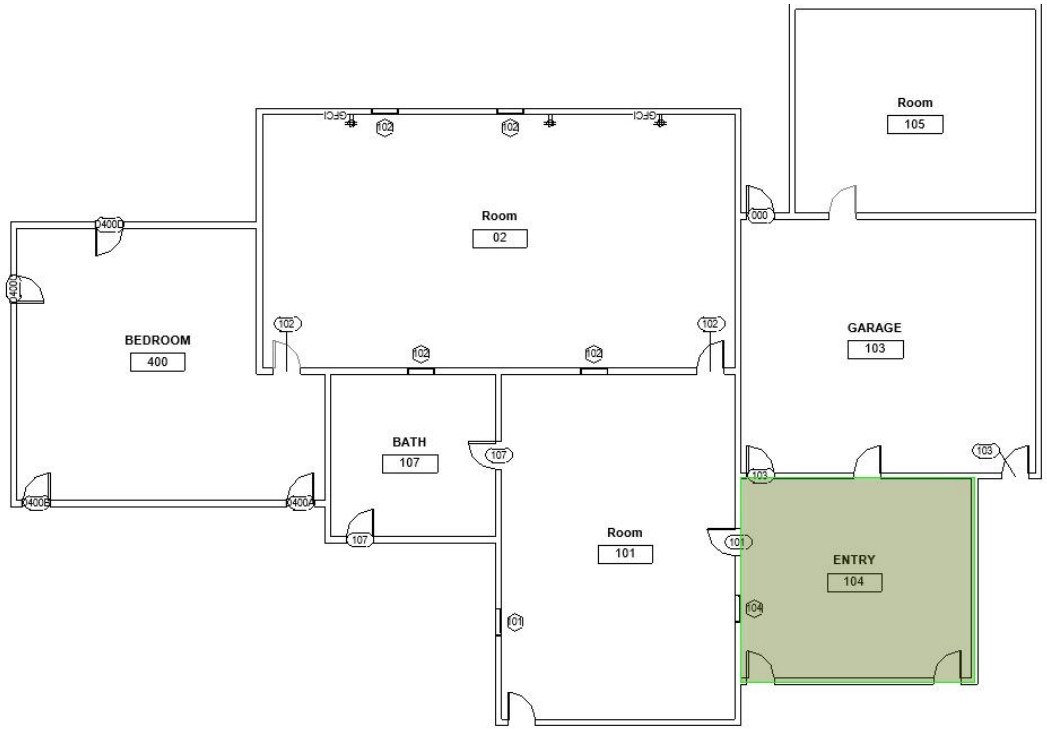


Fig 7. RN drawings annotated with OCS-detected regions.

Room name	Query	IoU (%)
Room 105	룸105번에서 오염 발생	99.30
Garage 103	개러지103번에서 오염	99.71
Entry 104	엔트리 104번에서 오염 발생	99.84
Room 02	룸 02번에서 오염 발생	99.91
Room 101	룸 101번에서 오염 발생	99.92
Bath 107	배쓰룸 107번 에서 오염 발생	99.92
Bedroom 400	베드룸 400번에서 오염 발생	90.20

Table 1. Test results of the trained model

3. Conclusion

- We propose a OCS, a model capable of converting only text input to image outputs, for automating and lowering the cost of an extensive site characterization process for decommissioning NPPs.

- Our research would serve as a backbone for implementing lightweight, yet sufficiently accurate procedures for decommissioning NPPs. Not only our research applies to HSA, but it also applies to the entire MARSSIM site characterization procedure for decommissioning NPPs.