STUDENT SUMMER INTERNSHIP TECHNICAL REPORT

Dataset Curation and Virtual Environment Creation for Machine Learning Tasks

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ABSTRACT

During this internship with Idaho National Laboratory (INL), two tasks were assigned that relate to two efforts: automated fire watch in industrial environments and route operable unmanned navigation of drones (ROUNDS). For the automated fire watch task, a training dataset was created and optimized. This dataset will be used to train a convolutional neural network to recognize smoke in a video stream. For ROUNDS, targeting autonomously navigating drones task, INL created a model to be able to scan QR codes from multiple different angles and used that measurement to determine the drone relative location to the QR code. The drone is being tested in a virtual environment, and the internship task was to create this environment.

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1. INTRODUCTION

Fire watch is a safety measure at multiple different nuclear power plants and is currently reliant on the use of personnel that are located in the watch location as long as needed. This is especially needed if the work done on a specific site has the potential to cause a fire or if the fire protection system is down for maintenance or due to a malfunction. Some sites require more personnel on hand for this task depending on the plant. Through the application of artificial intelligence with high-resolution cameras, the task of fire watch can be automated through video systems. When successfully implemented, this will increase the process safety for plant workers, as well as reduce personnel cost and any potential human error.

The ROUNDS task holds similar benefits; currently, there are personnel in charge of walking through power plants in order to check on all the equipment, collect reading, or for security. This is done regularly. Drones can be programmed to move autonomously on a route through a nuclear power plant to automate those regular activities. Using a drone equipped with a camera, this process can still be performed without having to do physical rounds.

Both tasks are important in transforming to a more autonomous and safe work setting at nuclear power plants.

2. ACKNOWLEDGMENT

This research work has been supported by the DOE-FIU Science & Technology Workforce Initiative, an innovative program developed by the U.S. Department of Energy's Environmental Management (DOE-EM) and Florida International University's Applied Research Center (FIU-ARC).

During the summer of 2021, a DOE Fellow, Christian Dau, spent 10 weeks doing a summer internship at INL remotely from ARC in Miami, Florida under the supervision and guidance of Dr. Ahmad Al Rashdan. The intern's project was initiated on June 4, 2021 and continued through August 13, 2021 with the objective of (dataset creation for fire watch and virtual environment creation for ROUNDS).

3. RESEARCH DESCRIPTION

For the fire watch task, the scope of research was in the creation and curation of a new unbiased dataset to be used to train a model that will be used to detect smoke in the images captured by camera video on site at nuclear power plants. This is essentially an extension of the fire watch task, but rather than fire, it is to detect smoke and preemptively warn about fire. Two different datasets were developed for smoke detection. For the first dataset, a large number of images were taken from public source smoke detection datasets. The dataset was downloaded and curated to attempt to remove an inherent biases to ultimately achieve good accuracies for the artificial intelligence models. Once the first dataset was complete, a test training of the model was pursued, mainly to evaluate the validity of the dataset; although issues were encountered during this process due to some images formats, a preliminary testing model was trained using this dataset and achieved a satisfactory accuracy. For the second dataset, the aim was to differentiates between smoke and steam, as the similarities between them can cause problems with smoke detection. This task is still in progress by the project team, which will build on what was initiated through this internship.

As for the ROUNDS task, a virtual environment was created using a robotics simulation software, in which it is possible to test an automated flight of a drone; multiple drafts of the testing environment were developed. Specifically, a building plan with multiple rooms and turns was developed, and obstacles were introduced into it that could help to simulate a proper setting. Multiple QR code models and placed them in the setting in a way the simulated drone could follow them (i.e., they represent the drone route path throughout the environment).

4. RESULTS AND ANALYSIS

For the smoke detection task, the first dataset that was created achieved an overall satisfactory accuracy using preliminary models, indicating the dataset is suitable. The second dataset classification testing has not been performed as the dataset creation is still in progress.

As for the ROUNDS task, the finished product of the virtual environment is shown in Figures 1–3. The two environments were created with the same basic layout but with and without obstacles in the way of the drone.

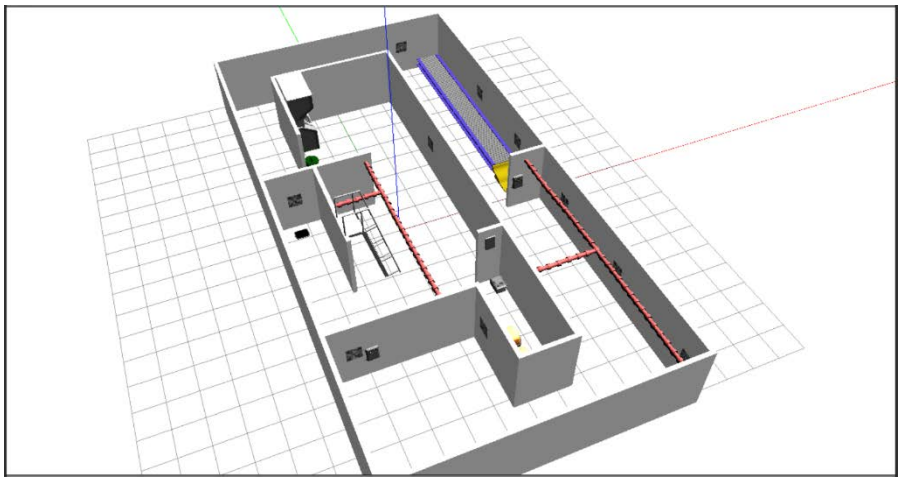

Figure 1. The drone environment with obstacles directly in its path.

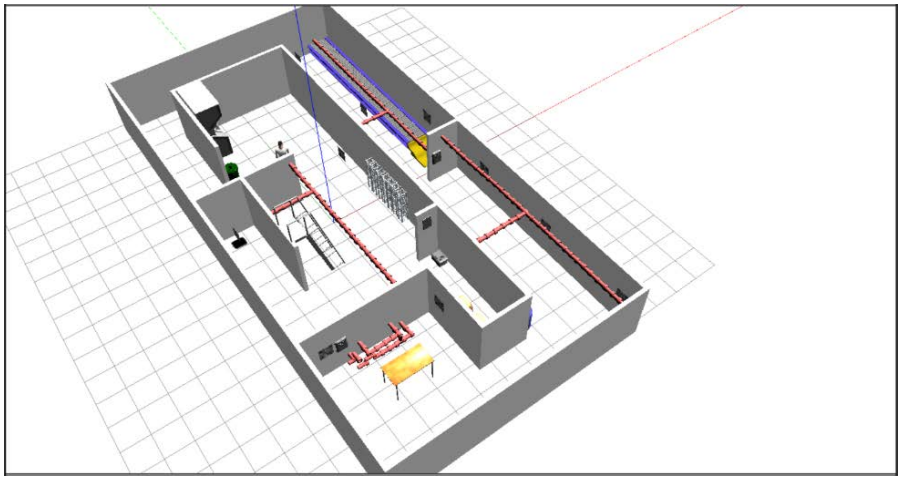

Figure 2. The drone environment with no obstacles in its direct path.

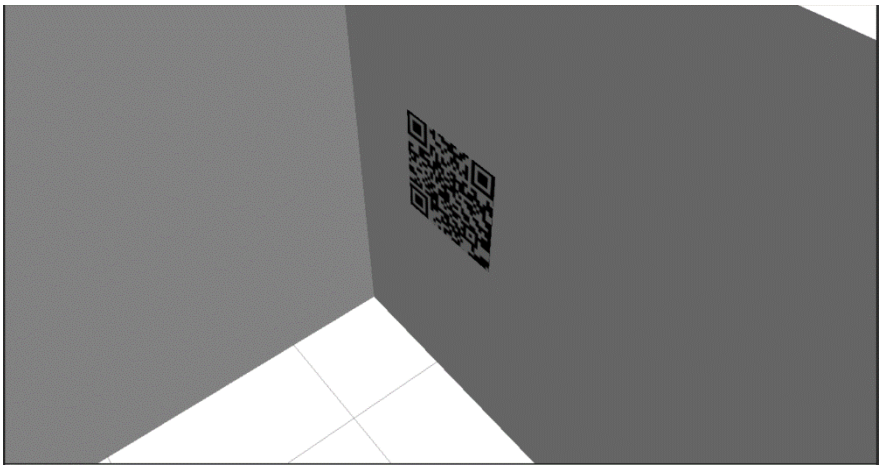

Figure 3. A close up of QR that was created for the drone to navigate with inside the virtual environment.

5. CONCLUSION

Both tasks that I worked on over the summer at INL were related to using artificial intelligence in nuclear power plants to lower cost and enhance safety. There is great potential in using artificial intelligence in both fire and smoke detection. For the fire watch task, one challenge was discerning smoke from steam or fog when they can look so similar. Another challenge was also faced during the testing model training due to a bug that relates to image formatting. One of the INL mentors took a closer look at it and helped resolve it.

For the creation of the drone virtual environment, the software had some specifics about how it operates that needed to be learned. Despite the internship challenges, a great deal about some concepts of artificial intelligence were learned. Also, a good amount of practical experience was gained while attending this internship.

I am extremely grateful for the opportunity I was given by attending this internship. My mentors, coworkers, and INL in general were all extremely accommodating and helpful.