Project Title	Detection of Mineral Resources in Extreme Environments
Team Name	GSBot (Team 7)
Team members	Sooyoung Kim(김수영) / [redacted] / [redacted] Gaon Choi(최가온) / [redacted] / [redacted]

Motivation and Objectives

- ✓ Design a robot capable of performing a specific task on behalf of humans in extreme environments
- ✓ Detection and extraction of Gemstones from mines(extreme environments), including their physical location information, with MobileNet-based AI model.
- ✓ Capture each object's location each time and save them to visualize later

Technical contributions (Skill, Knowledge, Novelty)

(baseline)

1-1. Collecting dataset

We started the project through the gemstone dataset obtained from kaggle. However, since this data was created for classification purposes, there was an issue that only images and labels existed. Therefore, I had to label the bounding box myself while working on the project.

https://www.kaggle.com/datasets/lsind18/gemstones-images

1-2. Model

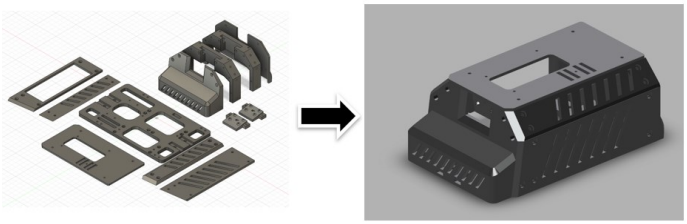
Initially, the model was trained using YOLOv5. The dataset created by Roboflow could be linked through API. This allowed the .pth file to be obtained, where the conversion to the .onnx file was performed. However, the speed of the interference was very slow, so it was judged that the optimization process was more necessary.

.pth -> .onnx -> .engine conversion process was successful for MobileNet. Therefore, the entire project was carried out using this model. In general, a speed of about 16fps to 17fps decreases to 10fps to 13fps when the robot control part enters. We don't use cv2 here, we use Gstreamer. In our project, we reduced the reference time by reducing the number of TRTs, CSI cameras, and pixels.

(skills)

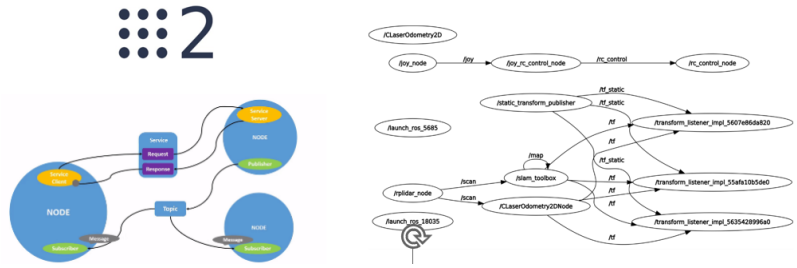
2-1. Robot design & 3D printing

Part design with 3D CAD & Print them through 3D printer



2-2. Robot control system through ROS

Robot operating system(ROS) for hardware control and sensor driver



(Knowledge / Novelty)

3-1. Dataset Annotation using Roboflow

Because the Gemstone dataset that was first used was for classification purposes, only images and labels were included. However, the problem we are trying to solve is detection. Therefore, a bounding box was needed to proceed with the project with the corresponding dataset. Roboflow was used to add this element. We made annotation and bounding boxes for about 4,000 images(original Roboflow dataset + our custom dataset)

3-2. Custom dataset and solving data imbalance problem

Roboflow supports numerous dataset augmentation techniques. We used CenterCrop(resize to same size for all images), random flip, random shear, random brightness, random saturation, and so on. It also produced datasets directly within the team. Several colored stones (with distinct distinction) were purchased on their own and the process was carried out. Every frame was called from a small camera mounted on the Jetson Nano and saved as a video. A considerable amount of frames could be obtained by extracting frames from videos, and based on these, the work of drawing a bounding box was performed.

Originally, there was a class imbalance problem, that is, there were more data for Purplestone. For this reason, our trained model was skewed and outputted Purplestone more times than other class labels. We balanced the dataset and improved our trained model. In general, the amount of data for each class should be the same. If it is not the same, the data imbalance may be resolved by means such as oversampling (ex. SMOTH) or downsampling.

(Development Process)

First, we capture dataset using Jetson Nano with camera. Using roboflow, this dataset is managed and perform data augmentation and adding data annotation. When the dataset was prepared completely, we trained our model using Docker environment. The output of model training is .pth file. For optimization, this file is converted to .onnx file and this is converted to .engine file. Now using this optimized file, Jetson Nano can perform inference.

(The role of each member)

- Sooyoung Kim
  - Designed a robot for our project: ROS, control system,
  - Tested robot for accurate robot moving and demo
  - Parts selection
  - MobileNet model training with our dataset
- Gaon Choi
  - Learned how to use Roboflow, which is a dataset management methods, and how to interwork with Google Colab using API
  - Trained YoloV5 to measure the model's inference time. In the process, we use Roboflow to create a dataset of dog and cat pictures and build a model that can properly classify dogs/cats.
  - Labeled gemstone dataset with 70 classes, by drawing numerous bounding box for each data, with proper format.(Pascal VOC, pytorch YOLOV5 txt, ...)
  - Implemented "Video Capturer and Saver" for Jetson Nano.

Discussion and Conclusion

- We have designed a robot which explores for mineral resources and classify its category with ML methods.
- Data analysis is one of the important process in machine learning engineering.
- the purpose of data → classification? detection? or something else?
- the distribution of data → e.g. class data imbalance
- Optimization technique accelerates model inference speed.