Classifying Scrap Metal On The Edge

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Trained Model Video Demo Inference Notes

The sample video is a demo of a scrap metal classification task made possible with a neural network trained from scratch on a custom data set. The data set is built using photos of 500 scrap metal samples from 5 classes: aluminum, brass, copper, stainless steel, and zinc. Augmentation was utilized to synthetically boost the size of the training set during model training.

The video clip was produced with webcam settings set to auto, except for exposure which was set to encourage a uniform/bright/white background.

However, varying exposure did not completely reduce the horizontal banding artifacts caused by the LED lights (a function of the power frequency (60 Hz)), so a center crop of the camera frame was used as input to the model to reduce the influence of this noise. (Note: the bands are moving very slowly in the videos; but they are still moving, which suggests that they are a product of the web cam frame rate and the LED lighting operating frequency)

The green box is just an overlay used to consistently center samples in the camera field of view during filming. It is not a bounding box: this is an image classification model, not an object detection model.

Finally, the “Unknown” classification is a simple decision rule based on the precision of the model prediction. Testing showed that a plain background yielded a “copper” class prediction with more than 3 digits of precision (e.g., Copper (0.9999). This is likely a product of not including negative samples in the data set. Without negative samples, the model must assign a majority probability to only one of the available classes even when the object is visually dissimilar to any image in the training set.

More model flexibility would likely correct these issues (e.g., more training data to reflect additional feature variability associated with each class).

Extra Details:

- **Webcam:** Logitech C920
- **Exposure:** Auto exposure altered background color which influenced classification decisions. Manually setting exposure (-8.0) ensured background had bright/white appearance.
- **Center Crop:** LED frequency induced horizontal patterns on background (e.g., “banding”). On professional cameras shutter speed can be changed to compensate for power supply frequency (e.g., 60 Hz). The closest option in OpenCV to “shutter speed” is the exposure setting. However, a setting could not be found to reduce the banding. To mitigate the influence of these bands during testing, a center crop was used as the input to the classification model.
- **Focus:** autofocus commanded via execution script; not always consistent

Sometimes when the script was run the webcam exposure setting would be changed, sometimes it would stay in auto mode. I was necessary to stop and re-run the script until it was obvious that the setting reflected the desired value in the code (settings revert to default once OpenCV video capture is released).

OpenCV Configurable Capture Parameters:
https://docs.opencv.org/master/d4/d15/group__videoio__flags__base.html#gaeb8dd9c89c10a5c63c139bf7c4f5704d

Metal Sample Photography/Filming Setup