ML Assisted Pipe Crack Detection

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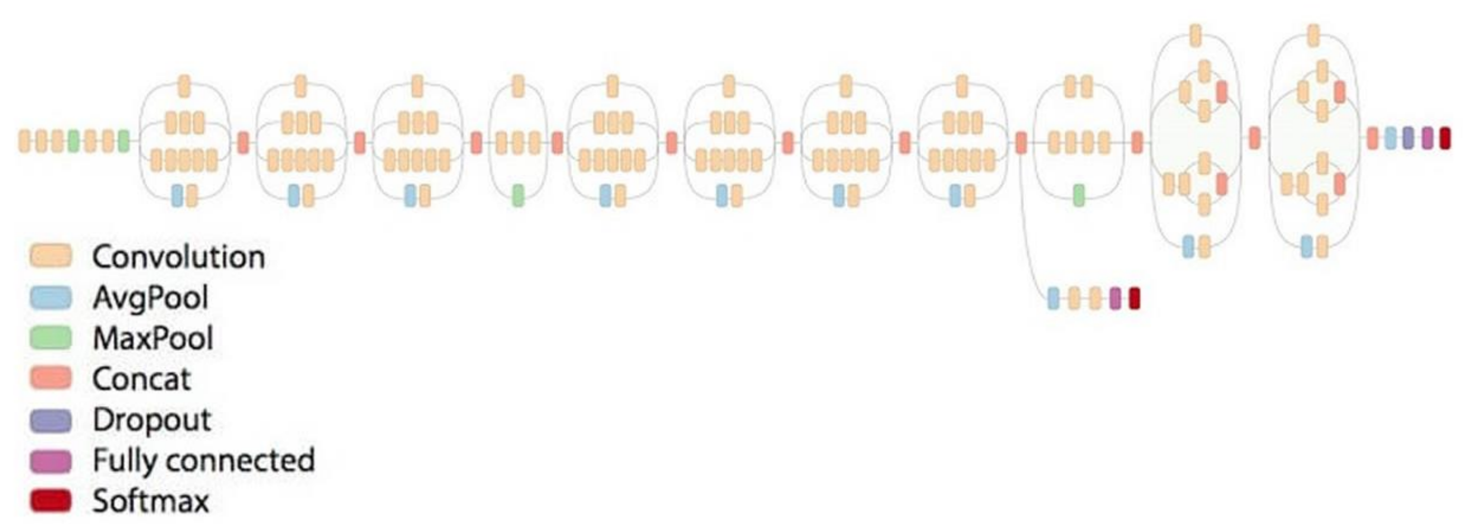
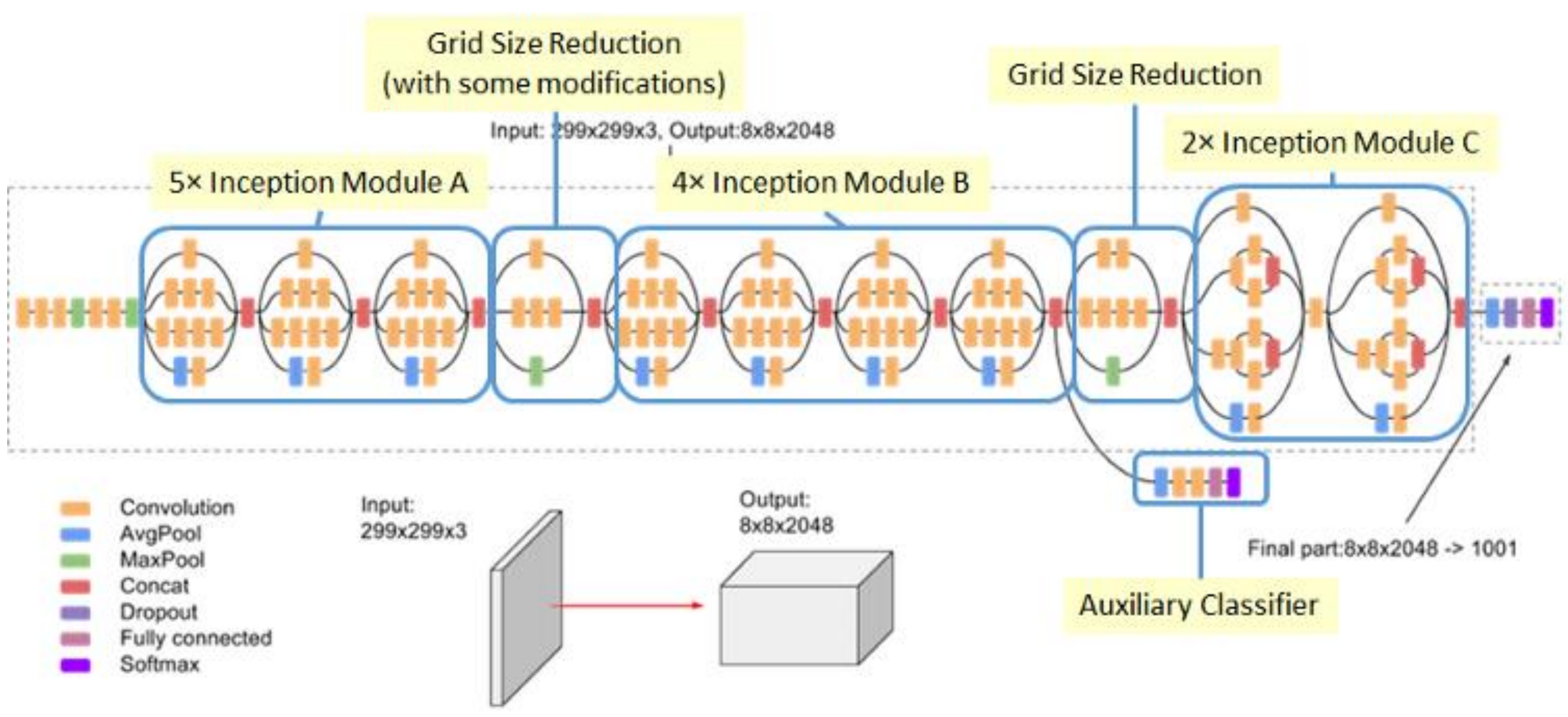
Abstract

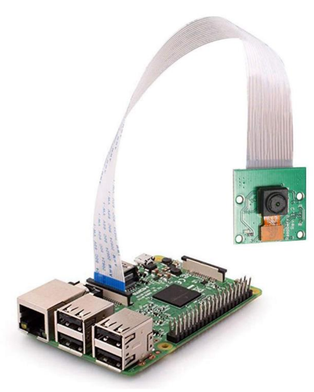
Machine learning is seeing greater and greater everyday use. As it becomes more common, there is a great demand for deploying ML in small, self contained packages. Embedded system performing ML functions hasn't been feasible until recent years, where a combination of technology miniaturization and ML model efficiency has allowed for the use of ML on tiny, low power devices. Many embedded systems will utilize a more powerful device connected to it over a network to perform computationally intensive operations, but this requires an existing network or the installation of expensive new infrastructure. In jobsites and many industrial locations, a reliable network is unavailable and not feasible, so there is a need for self-contained embedded systems that can perform not only inference, but also run training operations locally. This project utilized a TensorFlow framework and a retrained ImageNet deep learning model to perform pipeline damage and anomaly detection using a Raspberry Pi 3 B+. The design goal was to be capable of capturing it's own training dataset, run the training sessions, and perform inference with the new model, without outside processing aid.





Applications

- Automated pipeline inspection
  - Industry/Plants
  - Jobsites
  - New installations
  - Oilfields
- Inaccessible/Hazardous Locations
- 24/7 Monitoring of known trouble spots and critical components
- By nature, the device can be trained to perform computer-vision inference for any desired application



Local Modeling

Using an up to 8MP camera, the Pi can rapidly build it's own dataset to use in retraining. The images simply need to be organized in files with the label name. The retraining process takes roughly 4 hours for a 3000 image dataset.

Image Capture with Pi Camera (~2 images/second)
↓
File structure of training set determines labels
↓
Retraining script inserts new dataset in the final layer of the NN model
↓
Pi builds its own model in a matter of hours

Local Inference

The newly built model can be deployed on the Pi to perform inference. In it's current state, the Pi can classify 1 image every 3-4 seconds.

Camera and TensorFlow Intialized
↓
New model is loaded
↓
Image captured and processed
↓
Inference Performed
↓
Result Output with Label and % Confidence

Conclusions

+ The device was successfully able to create it's own datasets
+ The device successfully built it's own models
+ The device can accurately perform visual inference

— Inference is once every 3-4 seconds
— No resource headroom for additional processes such as live previews with information overlays