Anomaly Detection System for Disaster Prevention in an Industrial Setting

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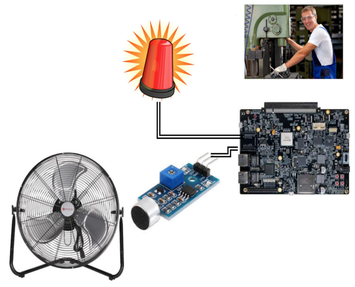
MOTIVATION AND REQUIREMENTS

- Industrial equipment degrades with time, making it hard to predict when a system failure will happen. System failure can cost big sums of money and in the worst case, loss of human lives.
- Usually, devices change their characteristic sounds when they degrade, but humans cannot monitor these changes without help from a digital system.



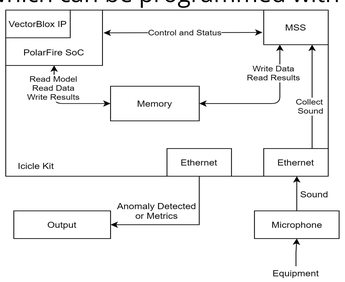
Our project consists of demonstrating the ability of Convolutional Neural Networks (CNNs) to potentially detect these anomalies:

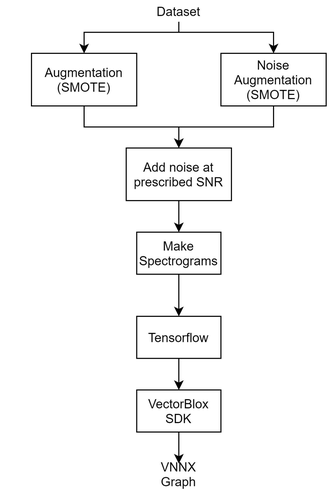
- The system shall use a Convolutional Neural Network supported by VectorBlox (Microchip's Inference Engine)
- The target hardware shall be the PolarFire SoC and the Icicle Kit
- The system shall be able to detect anomalies in an industrial setting

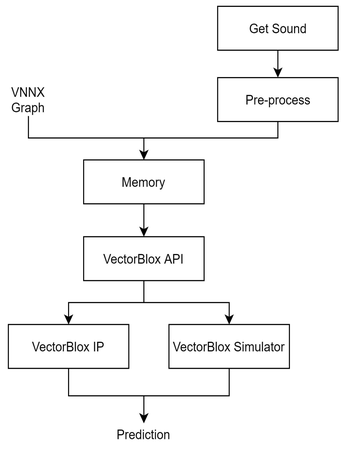
IMPLEMENTATION

Our design uses Microchip's Icicle Kit which hosts:

- Ethernet to collect data from one or more pieces of equipment, and to report predictions
- A processor system called the MSS to handle the logic and to simulate the VectorBlox IP
- The PolarFire SoC (an FPGA) which can be programmed with Microchip's VectorBlox IP

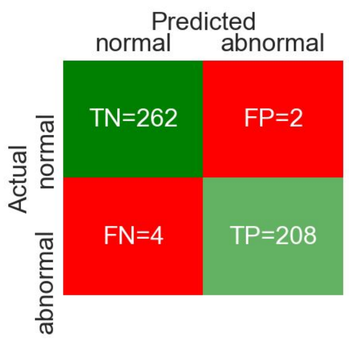






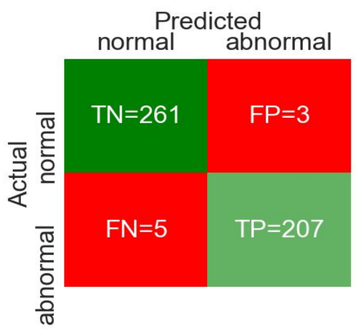
RESULTS AND DEMO

Tensorflow (Desktop)

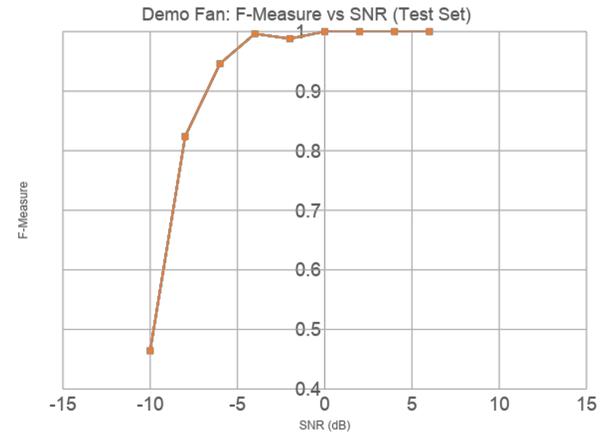


Recall	0.981
Precision	0.990
F-measure	0.986
FNR	0.019
FPR	0.008
Accuracy	0.987

VectorBlox (Icicle Kit)



Recall	0.976
Precision	0.986
F-measure	0.981
FNR	0.236
FPR	0.001
Accuracy	0.983



CONCLUSION

- Data and noise augmentation through SMOTE can improve performance metrics while providing better generalization
- Linear grayscale spectrograms are appropriate for anomaly detection on Industrial Equipment
- A 2D CNN can learn to detect anomalies from the sound of typical Industrial Equipment (fans, valves, pumps, and sliders)
- Microchip's VectorBlox can perform inference on an embedded system with only minimal impact from the float32 to 8 bit quantization

DISCUSSION/FUTURE WORK

- Speed up pre-processing in hardware
- Explore other models and pre-processing techniques
- Stress evaluation: How many pieces of equipment can be monitored with a single icicle kit
- Test the model in real-time
- Notification systems (web or mobile)

REFERENCES AND ACKNOWLEDGEMENTS

- Dr. Arindam Kumar Das (ML)
- Joe Edwards and Joel Vandergriendt (VectorBlox)
- Alden Doyle, Jamie Freed, Aaron Severance and Venki Narayanan (General)

[1] Harsh Purohit, Ryo Tanabe, Kenji Ichige, Takashi Endo, Yuki Nikaido, Kaori Suefusa, and Yohei Kawaguchi, "MIMII Dataset: Sound Dataset for Malfunctioning Industrial Machine Investigation and Inspection," arXiv preprint arXiv:1909.09347, 2019.

[2] Harsh Purohit, Ryo Tanabe, Kenji Ichige, Takashi Endo, Yuki Nikaido, Kaori Suefusa, and Yohei Kawaguchi, "MIMII Dataset: Sound Dataset for Malfunctioning Industrial Machine Investigation and Inspection," in Proc. 4th Workshop on Detection and Classification of Acoustic Scenes and Events

ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

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SPONSOR: Microchip