General Audience Abstract: Self-Supervised Anomaly Detection in Audio Spectrograms

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Anomalies are classes of samples that appear rarely or never in a dataset. My project this summer involved using constructing a neural network to detect anomalies in audio recordings consisting primarily of bird sounds from the Morton Arboretum in Lisle, IL, working independently and with mentorship from postdoctoral researcher Dario Dematties. Typically, neural networks learn using "labelled data"; for example, the network would be fed an audio spectrogram, along with a binary label: "normal" or "anomaly." After making a prediction, the network could use the label to update its parameters and improve its performance. However, producing labelled data requires time-consuming human annotation, and it may be difficult to provide a sufficiently comprehensive set of examples of anomalies to the network in training. Thus, to build the anomaly detector, we employed a type of neural network known as an "autoencoder," which requires no labels in training. An autoencoder reduces the dimensionality of its input and subsequently attempts to reconstruct the input from the low-dimensional representation. We can apply autoencoders to anomaly detection by exploiting the natural statistics of the data: normal samples appear frequently in the dataset, and the network thus learns how to reconstruct them with high accuracy; meanwhile, anomalies appear infrequently, and the network thus struggles to reconstruct them. We can detect anomalous samples, then, by monitoring the reconstruction error of the network on each sample. In completing this project, I learned about several techniques in deep learning and self-supervised learning, gained familiarity with the machine learning framework PyTorch, and constructed a neural network that was successfully able to detect anomalies in the dataset. This project supported the DOE mission to address challenges through transformative science by advancing our understanding of anomaly detection methods, which are widely applicable across several scientific domains.