WHAT IS CLAIMED:

1. A computer-implemented method of using machine learning for identifying glass breakage events, comprising:

accessing or obtaining, by one or more processors, a machine learning model trained using training audio data that represent (i) training ambient sounds, (ii) training glass sounds, and (iii) training glass breakage sounds;

obtaining, by the one or more processors, audio data over a period of interest;

determining, by the one or more processors processing the audio data using the machine learning model, whether a glass breakage event has occurred during the period of interest; and

when determined that the glass breakage event has occurred, indicating, by the one or more processors, that the glass breakage event has occurred.

2. The computer-implemented method of claim 1, wherein:

the training audio data and the audio data each include one or more spectrograms; and

obtaining the audio data over the period of interest includes generating the spectrogram of the audio data from raw audio data using a Fourier Transform.

3. The computer implemented method of any one of the preceding claims, wherein:

(i) the training ambient sounds include sounds caused by operation of machinery,

(ii) the training glass sounds include sounds caused by a first glass surface contacting either a second glass surface or a non-glass surface, and

(iii) the training glass breakage sounds include sounds caused by either glass cracking or glass breaking.

4. The computer-implemented method of claim 3, wherein the machinery implements a biomanufacturing process and the training glass sounds and the training glass breakage sounds are produced by one or more containers of one or more drug products.

5. The computer-implemented method of either claim 3 or 4, further comprising:

after identifying the glass breakage event, automatically causing, by the one or more processors, the machinery to stop operation.

6. The computer-implemented method of any one of the preceding claims, further comprising:

iteratively adjusting, by the one or more processors, gain of amplification applied to one or both of training audio signals or audio signals until a performance threshold is satisfied, wherein the training audio signals and the audio signals respectively correspond to the training audio data and the audio data.

7. The computer-implemented method of any one of the preceding claims, wherein the machine learning model is a convolutional neural network.

8. The computer-implemented method of any one of the preceding claims, wherein:

the machine learning model is trained using a supervised learning technique, and

the audio data include (i) ambient sound labels, (ii) glass sound labels, and (iii) breakage sound labels.

9. A computer system of using machine learning for identifying glass breakage events, comprising:

one or more processors;

a program memory coupled to the one or more processors and storing executable instructions that, when executed by the one or more processors, cause the computer system to:

perform the method of any one of claims 1-8.

10. A computer-implemented method for training a machine learning model for identifying glass breakage events, comprising:

obtaining, by one or more processors, training audio data;

classifying, by the one or more processors, the training audio data into a plurality of subsets each corresponding to different actual outcome data, the subsets including (i) at least one subset representing training ambient sounds, (ii) at least one subset representing training glass sounds, and (iii) at least one subset representing training glass breakage sounds; and

generating, by the one or more processors, the machine learning model for identifying glass breakage events using the classified subsets of the training audio data.

11. The computer-implemented method of claim 10, wherein the training audio data include one or more spectrograms.

12. The computer implemented method of either claim 10 or 11, wherein:

(i) the training ambient sounds include sounds caused by operation of machinery,

(ii) the training glass sounds include sounds caused by a first glass surface contacting either a second glass surface or a non-glass surface, and

(iii) the training glass breakage sounds include sounds caused by either glass cracking or glass breaking.

13. The computer-implemented method of claim 12, wherein the machinery implements a biomanufacturing process and the training glass sounds and the training glass breakage sounds are produced by one or more containers of one or more drug products.

14. The computer-implemented method of any one of claims 10-13, further comprising:

iteratively adjusting, by the one or more processors, gain of amplification applied to training audio signals until a performance threshold is satisfied, wherein the training audio signals correspond to the training audio data.

15. The computer-implemented method of any one of claims 10-14, wherein the machine learning model is a convolutional neural network.

16. One or more tangible, non-transitory computer-readable media storing executable instructions for training a machine learning model for identifying a glass breakage event, when executed by one or more processors of a computer system, cause the computer system to:

perform the method of any one of claims 10-15.

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