On the acoustic difference of metal and glass when falling on an impact plate

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We are interested in the separation of metal and mirror/glass components in recycling operations. Conventional optical separation of glass/mirror and metal parts lacks accuracy due to the reflective properties of glass/mirror. This is especially true for metal-coated mirrors, where even hyperspectral imaging fails. A cheap and effective way to separate these materials is to drop the parts onto an impact plate and record the resulting sounds with microphones. In this paper, we analyze the acoustic emissions from the impact of the materials mirror and metal. The results should provide a basis for further processing of the data via machine learning.

Introduction

Optical material characterization is often expensive and some materials are difficult to classify. With the goal of a multi-sensor separation system, we investigate here the possibilities of acoustic material characterization of mirrors and metals. Pearson et al (2007) investigated the feasibility of using impact acoustic emissions to detect damaged wheat kernels. Guo *et al* (2019) detected damaged wheat kernels using an impact acoustic signal processing technique based on Gaussian modeling and an improved extreme learning machine algorithm. Huang *et al* (2017) use acoustic impact emission to sort ELV plastic materials. Kalkan *et al* (2007) classifies hazelnut kernels using the time-frequency patterns of their acoustic impacts. Omid (2011) sorts pistachio nuts using decision tree and fuzzy logic classifier.

Material and Methods

We chose the materials glass/mirror and metal to investigate their suitability for acoustic characterization. The impact plate is made of steel and has the dimensions 400 mm x 400 mm x 8 mm. The inclination of the plate is 30 degrees. Three microphones were used: (i) a measurement microphone with a linear frequency response up to 20 kHz, (ii) a measurement microphone with a linear frequency response up to 100 kHz, and (iii) a contact microphone placed in the center of the underside of the plate. The measurement microphones recorded at a distance of 8 cm from the steel plate. Figure 1 shows a picture of the measurement setup.

Figure 1: Measurement Setup

To investigate the reproducibility of the signals generated, we recorded each piece 10 times. The measurement campaign consists of 10 mirror pieces and 10 metal pieces, all of similar size. Figure 2 and Figure 3 show the recorded metal and mirror pieces.

Figure 2: Metal Pieces

Figure 3: Mirror Pieces

Results and Discussion

A typical spectrogram of a metal piece shows a clear difference to a typical spectrogram of a glass piece, as shown in Figure 4 and Figure 5. Note that the maximum value of the spectrogram is normalized to 1, i.e., 0 dB.

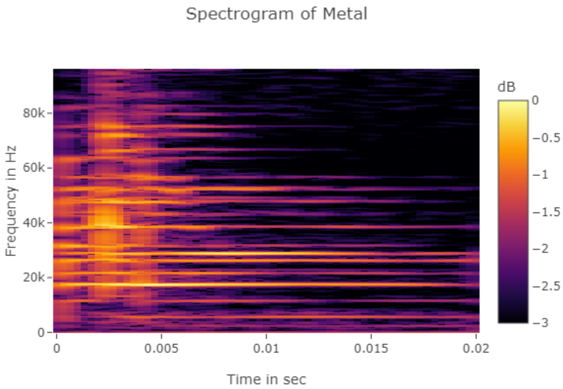

Figure 4: Spectrogram of a metal piece

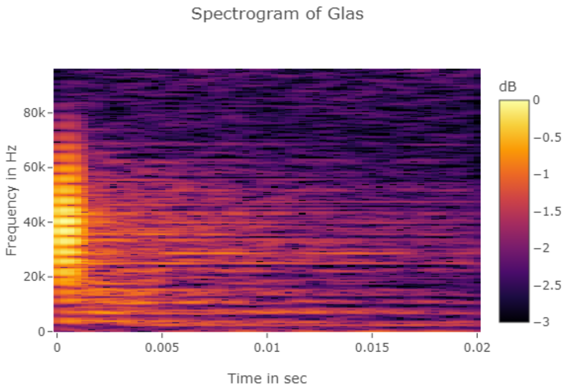

Figure 5: Spectrogram of a mirror piece

Conclusion

We have demonstrated the ability to discriminate between pieces of metal and glass/mirror based on the spectrogram of their acoustic emissions. Repeated measurements on the same pieces showed the value of cascaded impact plates. Future steps include the investigation of other materials and the use of machine learning for characterization.

References

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