Towards stress measurement in thin metal plates using ultrasonic guided waves and supervised learning

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Guided waves in thin plates and shells are known to be highly sensitive to variations in mechanical properties of the plate. Due the multitude of wave modes and multi-path propagation through the sample, analysis of the received guided waves is, however, often quite challenging. The long-term goal of the research presented here is to monitor containers holding gases under pressure. As these containers are filled and emptied, the walls will be exposed to increasing and decreasing stress, respectively. Conventional stain gauges provide only local measurements, while guided ultrasonic waves are affected by both local and global changes in material properties. This paper provides a proof-of-concept of how complex ultrasound fingerprints based on multiple guided wave modes and edge reflections, can be used to predict bending forces applied to a thin metal sheet. Experiments were conducted for varying loads between 0 and 5 N and at varying temperatures between 0 °C and 50 °C. For each load-temperature combination, 100 ultrasound signals were collected. Features extracted from a subset of these were then used to train models for predicting the load and the remaining data was used for testing. Models assuming the temperature to be either known or unknown are the compared. The results show that it is indeed possible to predict the load. As expected, the result of changing the load is affected also by the temperature of the plate. This shows that the temperature either must be monitored separately or predicted by the model. Both approaches require the effect of temperature to be known.