Towards a Real Time Analysis of a Deep Drawing Process by using Persistence Diagrams

Ivan Peinado-Asensi[1,2,*], N. Montés[1], E. Garcia[2], L. Hilario[1], E. Pérez[1], H. Andreu[1], D. Alonso[1], E. López[1] and A. Falcó[1]

(1) Mathematics, Physics and Technological Sciences Department, Cardenal Herrera CEU University, C/ San Bartolomé 55, 46115, Alfara del Patriarca, Valencia, Spain.
(2) Ford Motor Company, Polígono Industrial Ford S/N, 46440, Almussafes, Valencia, Spain.

Abstract

In the industry, there is an increasing need for the automatic detection and prediction of unwanted events that may occur during the manufacturing process. This is either to understand the state of the final product or the state of the equipment used to manufacture the product. The goal is to automate the process as much as possible to save costs and increase competitiveness. In the age of Industry 4.0, with the use of Internet of Things (IoT) and Big Data Analytics technologies, it is possible to obtain a large amount of information about the process in real time. Currently, 5400 data points are obtained for the most critical variables of the press for each stamping cycle. From the available information, several tools have been developed to better understand what happens during the stamping process [1]. However, it is often difficult to find relevant information in the data set due to measurement noise caused by equipment tolerances. In the search for new tools to obtain additional process information, the application of Topological Data Analysis (TDA) is proposed due to its potential to classify and extract information from populations of data. One of the most important features of TDA is its ability to obtain very precise information about the shape of data [2], and to classify data accurately even in the presence of noise. In this work the Ripser library has been used to obtain topological features in the persistent homology of a point distribution of the most critical variables of the press during the forming of the steel sheet. Multiple persistence diagrams have been obtained from different parts throughout the production process. By considering to the geometry of the measured data, we aim to obtain a pattern of the topological characteristics of stamping and classify the manufacturing state of the part. The objective of this study is to relate the information obtained from deformation models that provide plastic characteristics of the material with the topological characteristics of the data obtained from the process.

References

[1] Peinado-Asensi, I., Montes, N., & García, E. (2022). In Process Measurement Techniques Based on Available Sensors in the Stamping Machines for the Automotive Industry. In *Key Engineering Materials* (Vol. 926, pp. 853–861). Trans Tech Publications, Ltd. https://doi.org/10.4028/p-gvqkd4

[2] Riihimäki, H., Chachólski, W., Theorell, J., Hillert, J., & Ramanujam, R. (2020). A topological data analysis based classification method for multiple measurements. *BMC bioinformatics*, 21(1), 1-18.

* Corresponding author ivpeias@gmail.com