Proceedings of the 12th International Conference of Control Dynamic Systems, and Robotics (CDSR 2025)
July 13, 2025 - July 15, 2025 | Imperial College London Conference Center, London, United Kingdom
DOI: 10.11159/cdsr24.003

Automating Forming Processes

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Small batch production and repair of components having complex geometries is often done most effectively by hand. Forming processes for these components are very complex and, unlike traditional manufacturing processes like machining, require multiple steps where each step requires knowledge of the results of the previous step. Essentially, the operation must be replanned at each step. Indeed, the metal workers and scientific glassblowers that perform these operations in industrial setting are also often artists. These workers are leaving the workforce at a greater rate than they are being replaced, driving the need to automate these complex fabrication processes. This talk will begin with our work in Incremental Sheet Forming (ISF) where a thin sheet of material, secured inside a clamping frame, is formed as a CNC mill or robot moves a hemispherical tipped tool along a programmed path. We will discuss our use of Iterative Learning Control (ILC) to automatically adjust the process plan based upon part errors measured with a digital image correlation system. The talk will then transition to our work in Digital Metal Forming (DMF) and Digital Glass Forming (DGF). These processes seek to provide automation capabilities to metal workers and scientific glass blowers similar to how CNCs provides automation capabilities to machinist. The DMF process consists of 1) selective spatial heating of the part to improve formability, 2) applying a load to the part to reshape it, 3) measuring the final part morphology, and 4) making decisions on how to process the part in subsequent iterations. In DGF a filament or fiber is fed into a molten pool of glass formed by a laser energy source. The process can be used to fabricate fully dense transparent free-form parts for gradient index optics, complex structures for embedded optics and waveguides, and freeform structures. The interesting sensing and control challenges found in DMF and DGF processes will be discussed. The discussion will be highlighted with results of an automated bending process in a DMF process to achieve precision angles and the thermal control of a DGF process to increase productivity while avoiding bubble formation.