Mathematics pushes innovation in 4-D printing

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Recent advances in digital factory science make it possible to print more compliant objects across a wider range of length-scales than conventional engineering processes. A bottleneck for enabling the next technological progress resides in filling the gap in the comprehension of the unprecedented degree of complexity dominating this novel technology.

Mathematics plays a pivotal role in this contemporary industrial revolution: a study recently published by *Nature Communications* solves a problem of utmost importance for the development of 4-D printing, i.e. the possibility to fabricate objects with a programmable shape over time.

Professor Pasquale Ciarletta at the MOX Laboratory at Politecnico di Milano has provided fundamental insights into controlling the sudden nucleation of localised furrows, also known as creases, in soft solids. This theoretical understanding is of great interest not only for engineering sciences, especially for the possibility to fabricate devices with adaptive surface morphology at different length-scales, but also for developmental biology, in order to explain the spontaneous emergence of patterns during tissue morphogenesis, e.g., the convolutions of the brain, or metastasis in tumour development.

"Despite almost a century of thorough experimental investigation of the problem in engineering," he explains. "The physics behind creasing remained largely unexplained up to date, due to its formidable complexity. This study proposes a novel mathematical approach to accurately predict the experimental conditions triggering the onset and the morphology of creases, thus paving the way for controlling their appearance on-demand, down to nanometric scales."

These mathematical results are a potential breakthrough in the design and the fabrication of next-generation morphable materials, with additional applications in stretchable electronics, self-foldable machines, and lab-on-a-chip devices.

Provided by Politecnico di milano

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