Non-Ideal Part Generation at Early Design Phase for Assembly Process Optimisation Using a Conditional Random Field Approach

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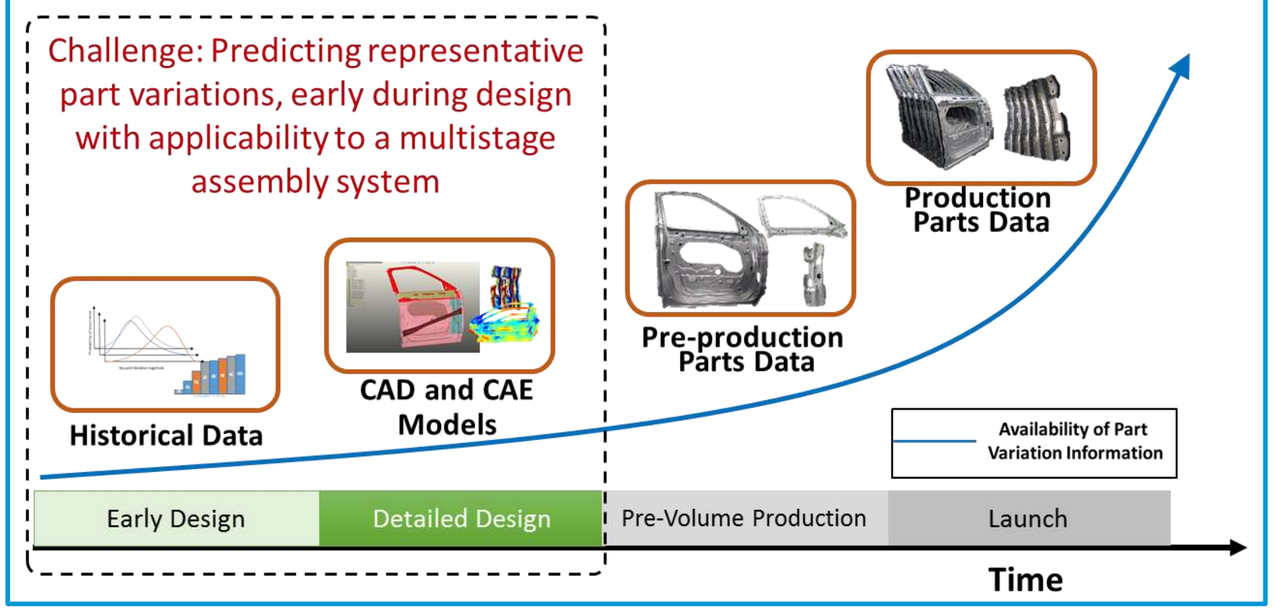
1.Motivation and Challenges

Current CAD/CAM/CAE tools lack abilities to model geometric and dimensional stochastic variation of deformable parts during early design phase. These stochastic parts variation manifest due to inherent manufacturing imprecision. Additionally, to simulate multi-station assembly systems with large number of components and increasing complexity, there is need for a methodology which requires minimum number of parameters expressing high energy compaction to represent the parts variation; a quality absent in existing methods.

2.Objective

To develop a methodology with capability to generate representative part geometric variations during early design phase with minimum number of necessary parameters expressing high energy compaction.

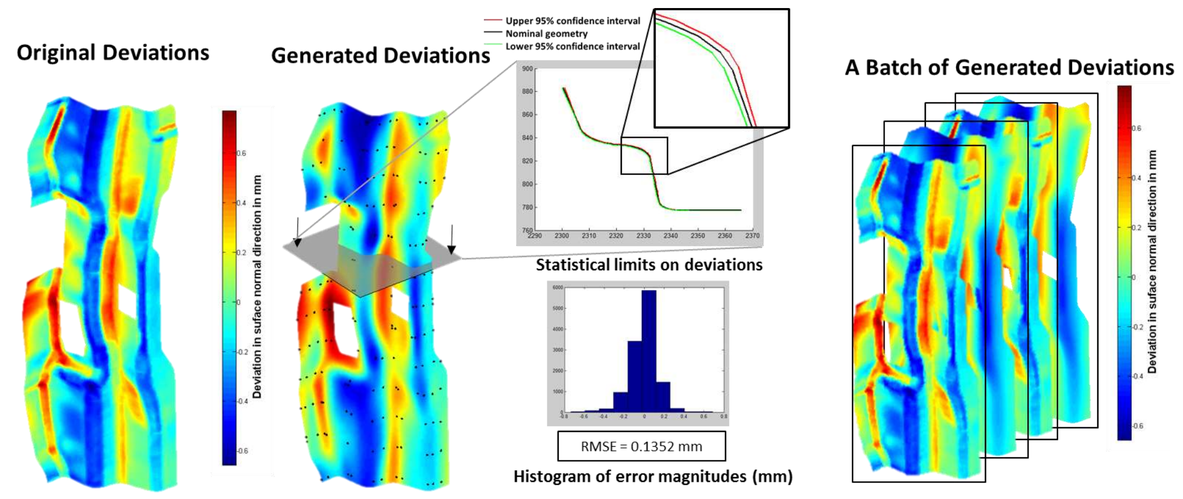
Available part variation information during new product introduction



3.Methodology and Results

The methodology emulates stochastic variation of the manufacturing process and its impact on part geometric variation by incorporating the covariance function, which defines how points on the part surface interact with their neighbours. The parameters of the covariance function which characterise the part geometric variations are learned from historical data or CAE simulations. This enables the prediction of the range of possible variations, estimation of their confidence limits and also parameterisation of parts variation.

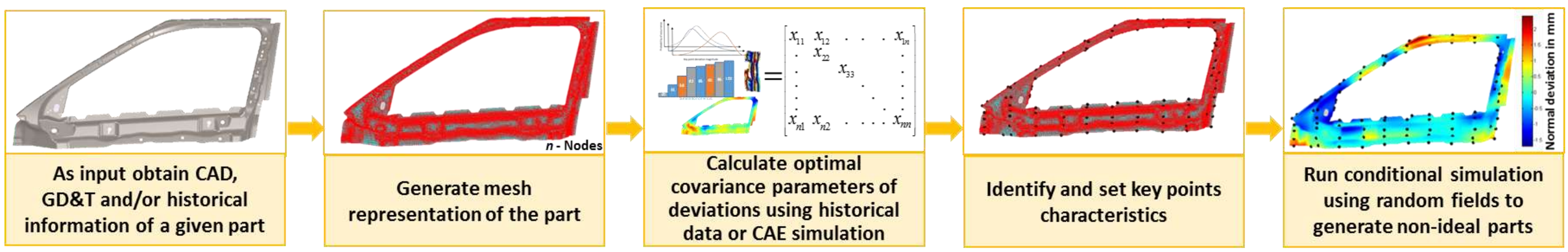
Variational geometry generated for door hinge reinforcement



4.Novelty

- Ability to generate the range of most probable part geometric variations that can occur during manufacturing.
- A single methodology applicable at various stages of design, increasing in accuracy with the increase of available data.
- Has smaller number of parameters (2-6) to describe the parts variation than existing methodologies (50-200).

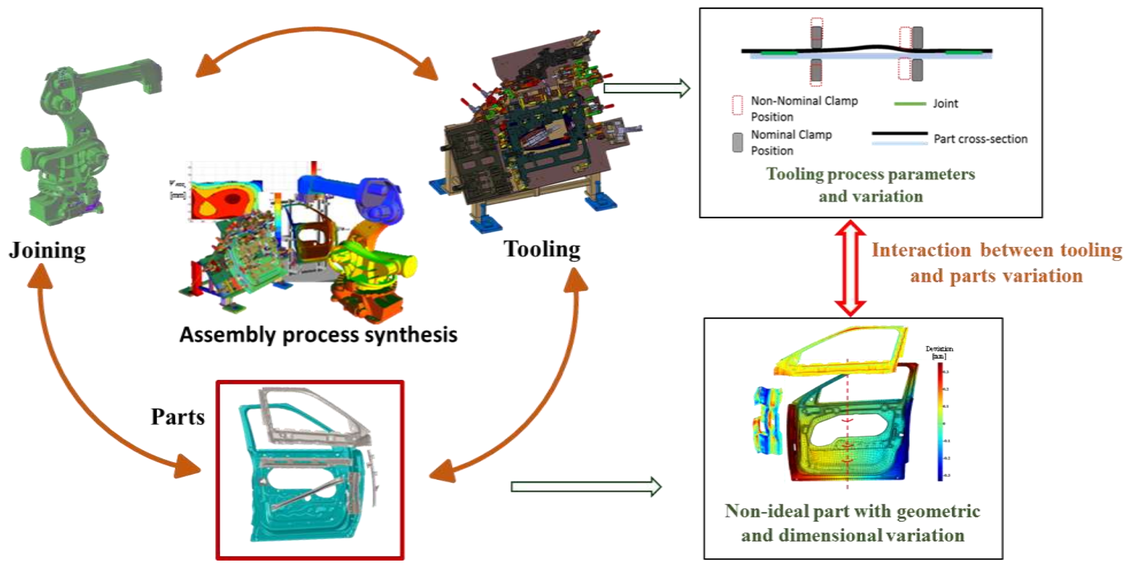
Proposed non-ideal part generation methodology



5.Impact: (i) Assembly Process Synthesis

Generation of non-ideal parts plays a vital part in Right-First-Time design of the automotive body assembly by minimizing unnecessary design changes required before or during production. This is achieved by taking into account the stochastic geometric and dimensional variations imparted into the part by the manufacturing process before the parts are manufactured, leading to the design of an optimal assembly system.

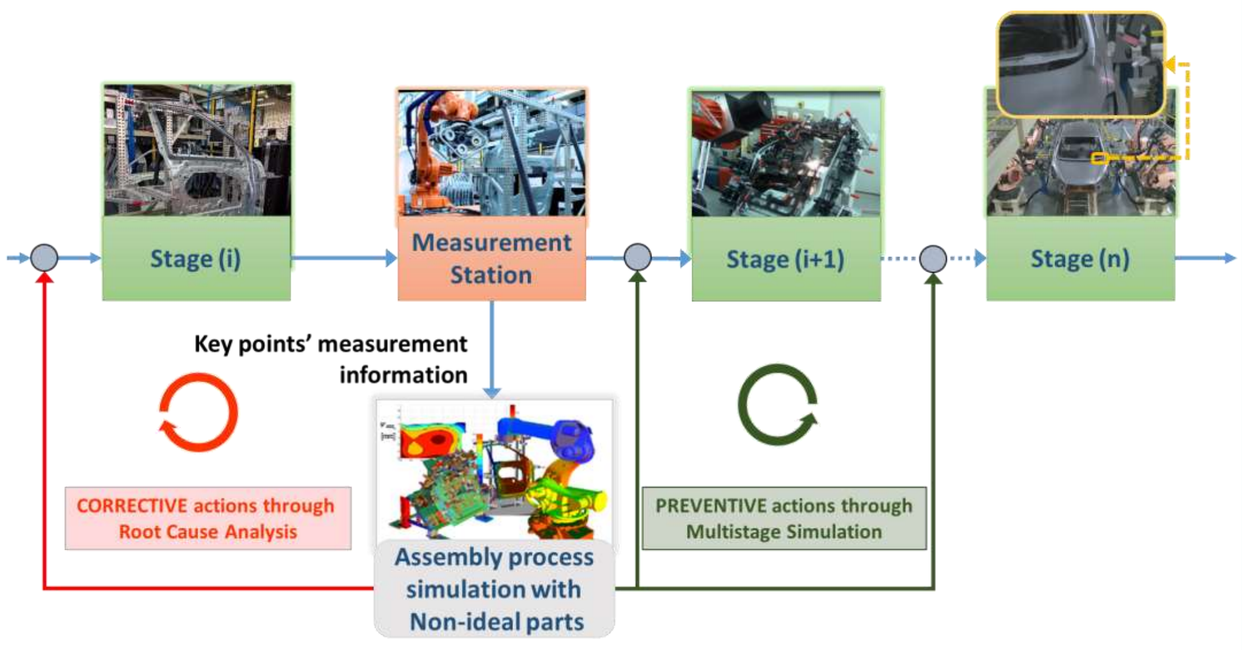
Assembly process synthesis



(ii) In-line Closed-loop Quality Control

The developed methodology used together with measurements from the assembly line can be used to drive the modelling of variational parts in the Assembly Process Simulator leading to:
(1) **CORRECTIVE** actions through Root Cause Analysis
(2) **PREVENTIVE** actions through Multistage Simulation.

In-line closed-loop quality control



[1] Babu MK, Franciosa P and Ceglarek D, Conditional Random Field Kernel for Generation of Non-Ideal Part at Early Design Phase with Application to Assembly Process Optimisation, *Working Paper*, WMG, University of Warwick.
[2]Samper, Serge, and Fabien Formosa. 2007. "Form Defects Tolerancing by Natural Modes Analysis." *Journal of Computing and Information Science in Engineering* 7 (1): 44. doi:10.1115/1.2424247

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