Path Planning Optimisation Utilising CNN and ANN for Direct Energy Deposition 3D Printing of Alloys with Low Residual Stress

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Rationale

Interest in additive manufacturing (AM) has expanded dramatically in recent years due to the numerous advantages that this process provides over traditional manufacturing [1]. Although the majority of recent work in AM has been focused on three-dimensional printing of polymers, AM techniques for fabricating metal alloys have been available for more than a decade [2, 3]. Direct Energy Deposition (DED) and in particular, Wire and Arc Additive Manufacturing (WAAM) attracts great interest due to its high deposition rate, environmental friendliness, and cost-competitiveness [4-8]. In particular, WAAM becomes a promising alternative to conventional subtractive methods for fabricating large aerospace alloy components that feature high buy-to-fly ratio [9, 10].

Generally, process planning for a WAAM system involves CAD modelling, 3D slicing, 2D path planning, weld bead modelling, weld setting, robot code generation, and post-process machining. Among these steps, proper 2D path planning and weld parameter selection for WAAM are crucial for achieving defect free deposition with high quality and high geometrical accuracy [11, 12].

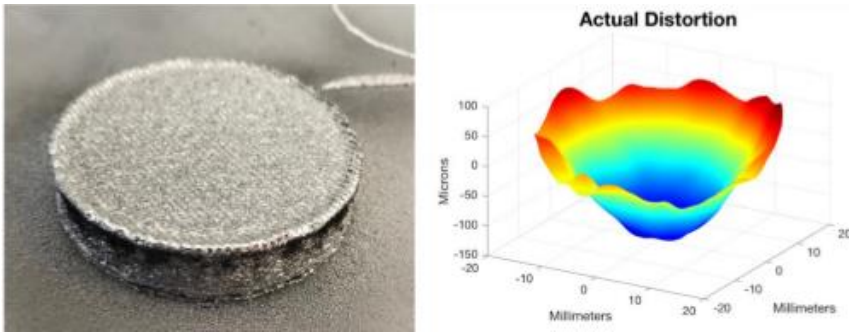
As an important step in process planning, 2D Path planning generates tool paths to fill the 2D sliced layers with full density deposits as required by the component design. Due to the large deposition size of WAAM as compared to powder-based AM, the deposited metal residual stress is high, which limits the ability to manufacture high integrity, large structures [13-15]. Some attempts at mitigating this stress have focussed on mechanical approaches, such as rolling [16], but this is an impractical solution and it is known that stress levels may be reduced by control of the deposition strategy.

Aim

The aim of this project is to utilise artificial intelligence approaches (such as the use of Artificial Neural Networks) to develop a model of the path-dependent development of residual stress in the Plasma Transferred Arc WAAM process and a subsequent methodology for the application of the approach.

Approach

The approach used will be at the discretion of the student, but will likely require the use of Convolutional Neural Network (for feature extraction in thermal image data) and ANN approaches (to identify parameter effects) to investigate thermal history images of the build process and process parameter influences in distortion to develop the approach.



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