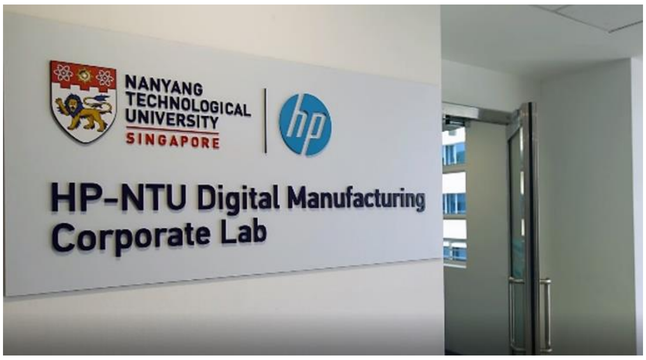
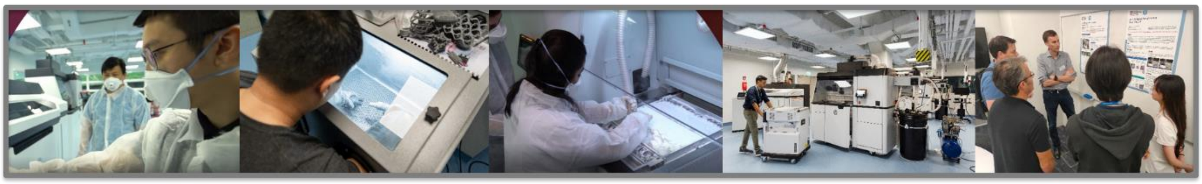
HP-NTU Digital Manufacturing Corporate Lab



The HP-NTU Digital Manufacturing Corporate Lab, which has commenced on 1 November 2018, is a collaboration between NRF, HP Inc. and NTU. It is the 13th corporate lab supported by NRF and HP's largest university research collaboration worldwide. The lab supports Singapore's push toward industry transformation – in the areas of digital manufacturing and 3D printing technologies.



The Corporate Lab's main research themes focuses on advancing 3D Printing, specifically around artificial intelligence, machine learning, new materials and applications, cybersecurity and customisation. The lab has 3 major programmes:

- 3D Printing
- Digital Systems, Artificial Intelligence & Machine Learning
- Cybersecurity

The multidisciplinary Corporate Lab involves more than 20 NTU PIs across different schools and colleges, as well as from HP, and aims to recruit up to 100 researchers and staff. In addition to specific research milestones within each project, the Corp Lab aims to support innovation and research through creating technical disclosures, patents, papers and new products. The areas covered will close the loop on all the necessary requirements to bring innovative products to market in the digital age, incorporating both hardware & software (including data analytics for machine learning & also security features). In essence, the collaboration will plant the first seeds of innovative research for the incoming tsunami of advanced manufacturing technologies and expand Singapore and NTU's capabilities in this large and emerging space.

For more information, visit our website at http://hp-ntucorplab.ntu.edu.sg.

Project Highlights:

Project 1: Multi-scale, multi-physics of the polymer powder bed fusion process in additive manufacturing

The attention to additive manufacturing techniques has increased tremendously in the past decade, which causes a shift in the manufacturing industry. Rapid mass production, reduction of material wastage and low energy consumption proves that such techniques give economic advantages to businesses. Defects in manufactured parts are inevitable and these will affect the quality of the print job, causing delay to the production. Pore defects generated during the powder bed fusion process can be studied through simulation modelling shown in Figure 1. Crystallization is one of the factors for the polymer part to change in geometry, with cooling rate as the main factor for the shrinkage behaviour to vary. Phase field model (Figure 2) provides information of crystallization and gives necessary details for constitutive model for accurate prediction. Constitutive model is used to simulate the warpage of printed part during the cooling process and the strength of final printed part, shown in Figure 3.

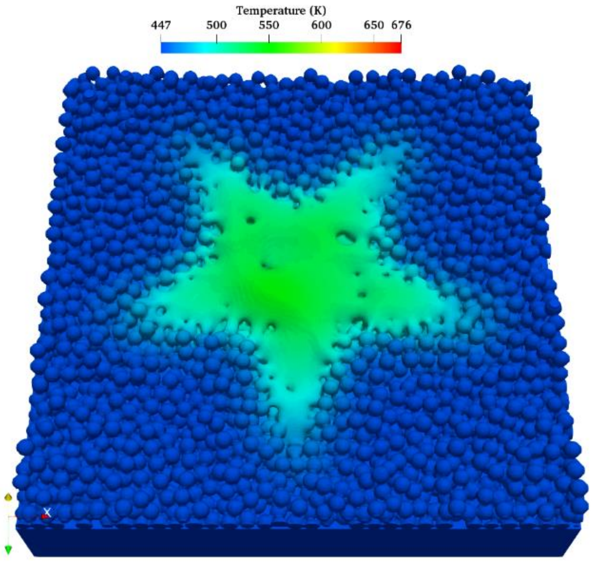


Figure 1: FVM simulation of sintering of polyimide powders

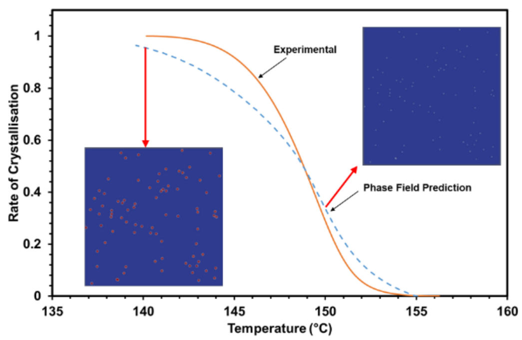


Figure 2: Phase field prediction for crystallization process

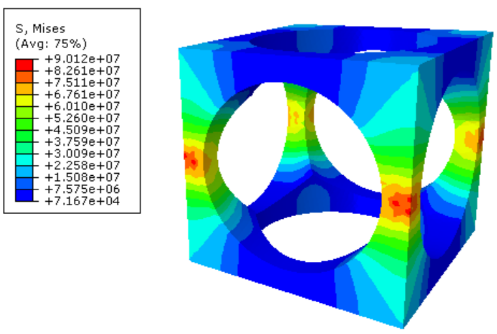


Figure 3: FEM simulation for the deformation of printed part

Project 2: Edge-Assisted Smart Wireless Cameras for Industrial Computer Vision Systems

We aim to design and implement a cordless and energy-efficient industrial computer vision system. The designed system uses wireless cameras to achieve benefits such as easy deployment, mobility support, and unobtrusiveness to the ongoing industrial processes. Additionally, wall-powered wireless edge node with sufficient computing resources is used to support the camera in facilitating deep learning (DL)-based image processing with short jitters and delays.

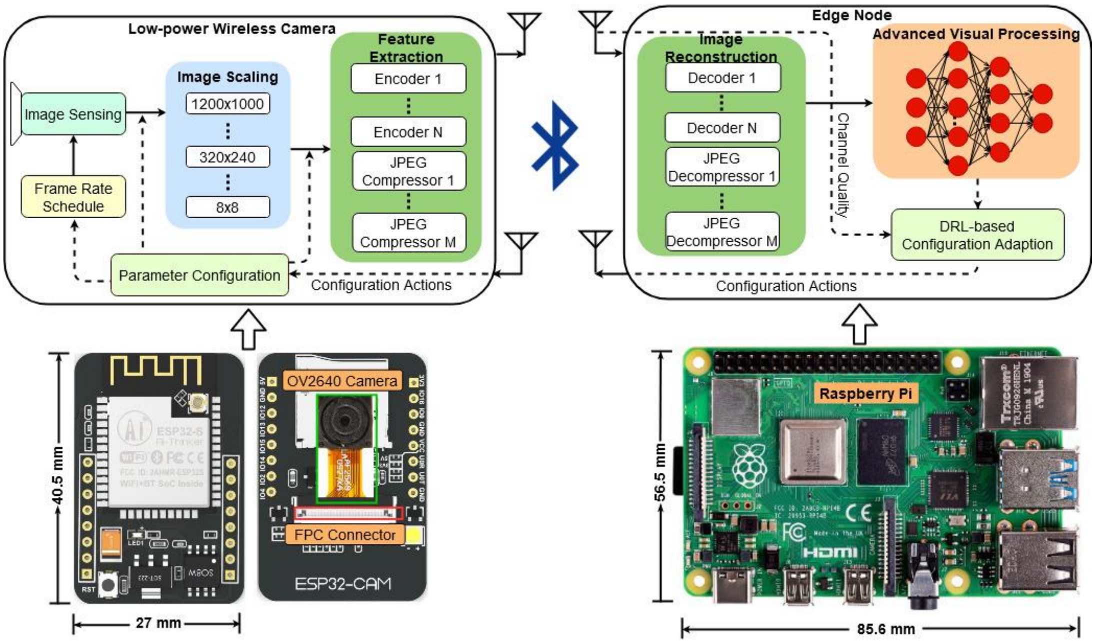


Figure 1: An overview of edge-assisted industrial wireless computer vision system.

Figure 1 overviews the designed computer vision system, in which a battery-powered wireless camera performs image pre-processing and transmits the data to a resourceful edge device for advanced DL-based visual processing. The developed system is prototyped by one off-the-shelf camera, called ESP32-CAM and one Raspberry Pi 4.

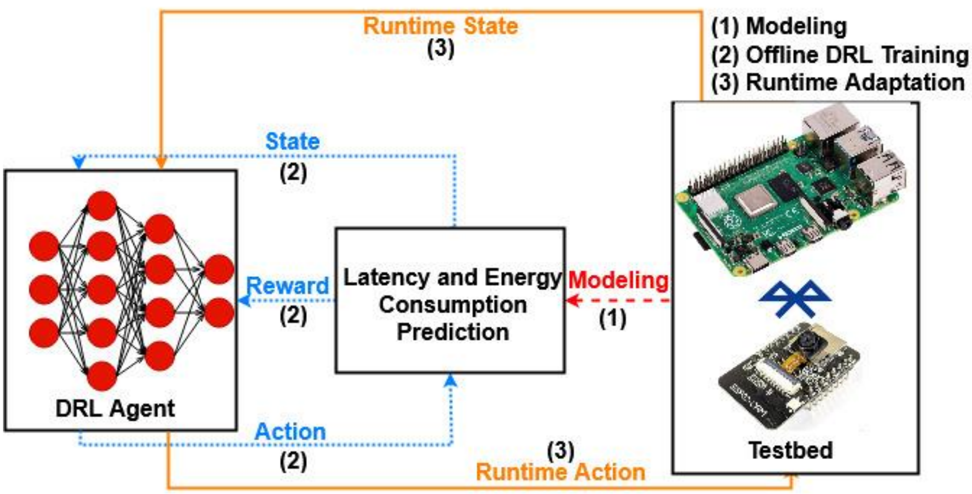


Figure 2: Deep reinforcement learning (DRL)-based configuration adaptation framework.

Our system applies deep reinforcement learning (DRL) to adapt the camera configuration to maintain the desired visual sensing performance with the minimum energy consumption under dynamic variations of application requirement and wireless channel conditions. Figure 2 illustrates the DRL-based configuration adaptation framework.

Project 3: Intelligent Part Design, Optimization and Simulation for Voxel Type AM

Part design is an important component in the product development cycle. Artificial intelligence provides powerful techniques and new possibilities for part design. This project aims to develop intelligent algorithms and tools for part designers to take advantage of voxel type additive manufacturing. The research focuses on 3D geometric modeling, material optimization and part fabrication, with the goal of realizing the concept: “3D printing starts from design and design keeps 3D printing in mind”.

The team has developed new geometric processing algorithms to support volumetric representation for part design. For example, an inversion-free, topology compatible algorithm was developed for tetrahedral mesh deformation driven by displacement of partial vertices of the mesh (see Figure 1). New computational framework and intelligence optimization techniques were proposed for part design and fabrication, which include intuitive elastic material design for parts and micro-structure design for 3D printing. The team is currently working on intelligent algorithms to enable automated digital design workflow for molded fiber products (see Figure 2).

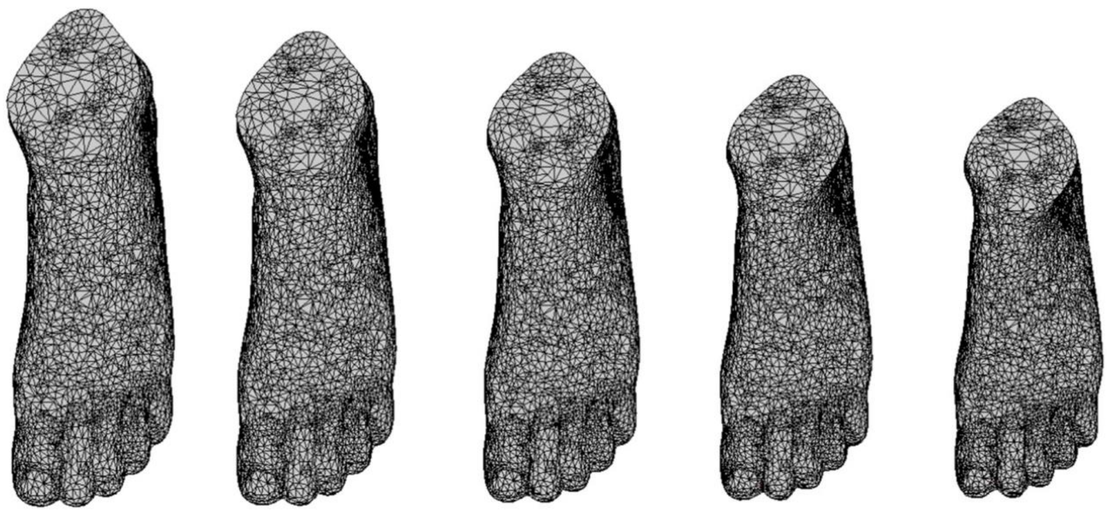


Figure 1: Gradual warping (from left to right) of a foot model.

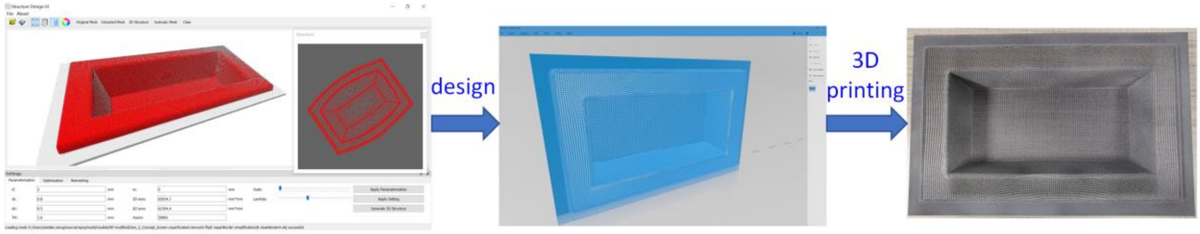


Figure 2: The workflow from a CAD model to the fabricated screen.