Data processing II: objects tracking challenge

Looking into predictive single-particle tracking techniques

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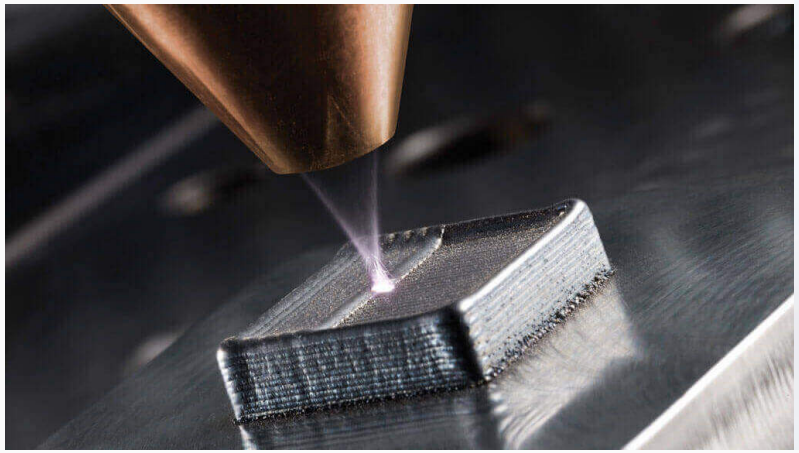
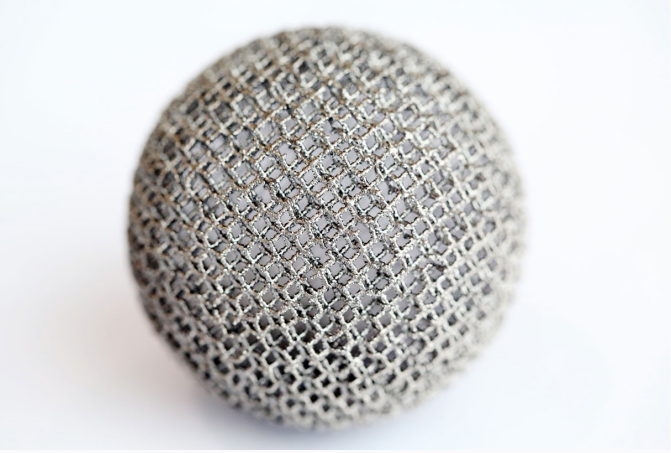
What is additive manufacturing

- **Additive manufacturing** is a transformative approach to industrial production that enables the creation of lighter, stronger parts and systems[1].
- Additive manufacturing uses data computer-aided-design (CAD) software or 3D object scanners to direct hardware to deposit material, layer upon layer, in precise geometric shapes[2].
- The terms '3D printing' and 'rapid prototyping' are the subsets of additive manufacturing.



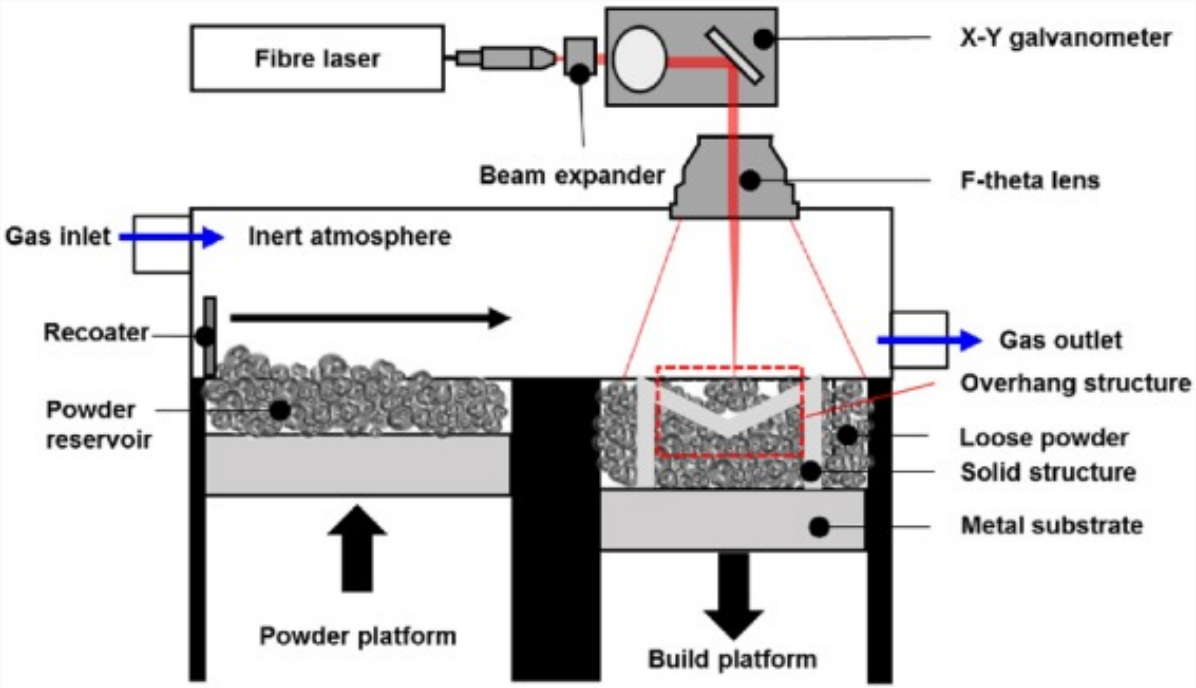


[1] https://www.ge.com/additive/additive-manufacturing

[2] https://www.youtube.com/watch?time_continue=71&v=kKQ5KwFwW_s

How the data have been collected

- I12 beamline [3] of DLS is used for very fast radiographic and tomographic imaging



[3] https://www.diamond.ac.uk/Instruments/Imaging-and-Microscopy/I12.html

[4] https://www.diamond.ac.uk/Science/Research/Highlights/2018/laser-additive-manufacturing.html

How the data have been collected

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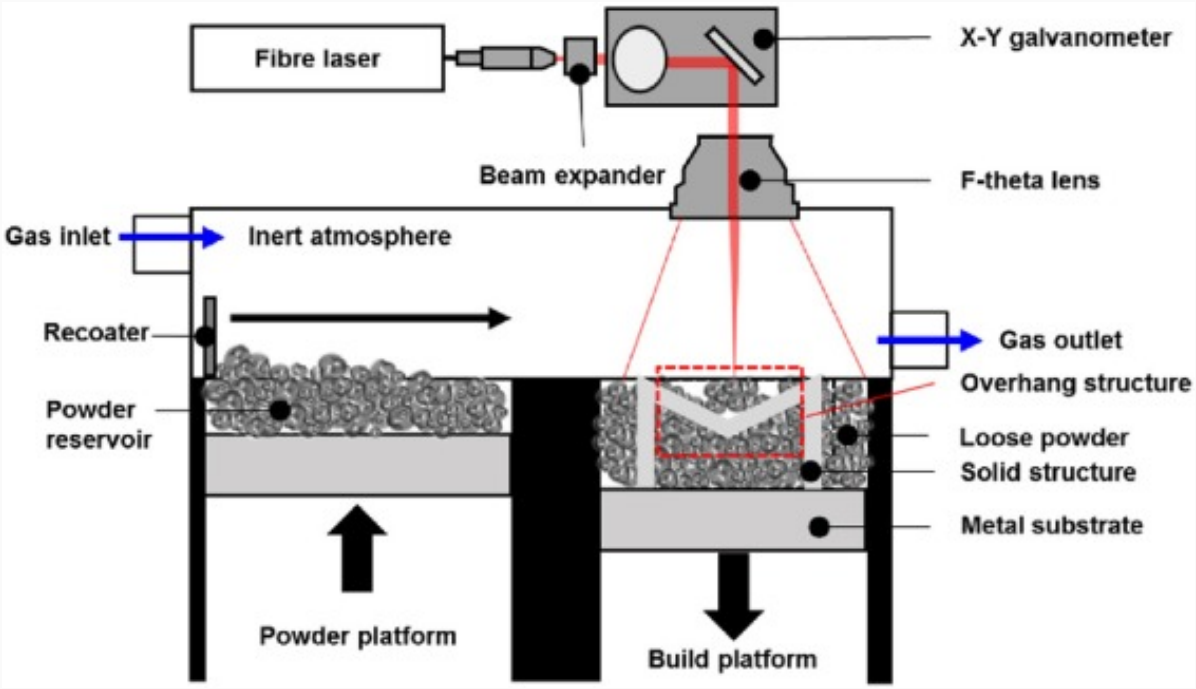
- The series of radiographs were collected resulting in a 3D dataset (x,y + time), i.e. 3D process captured in 2D[4]



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Laser melting process in details

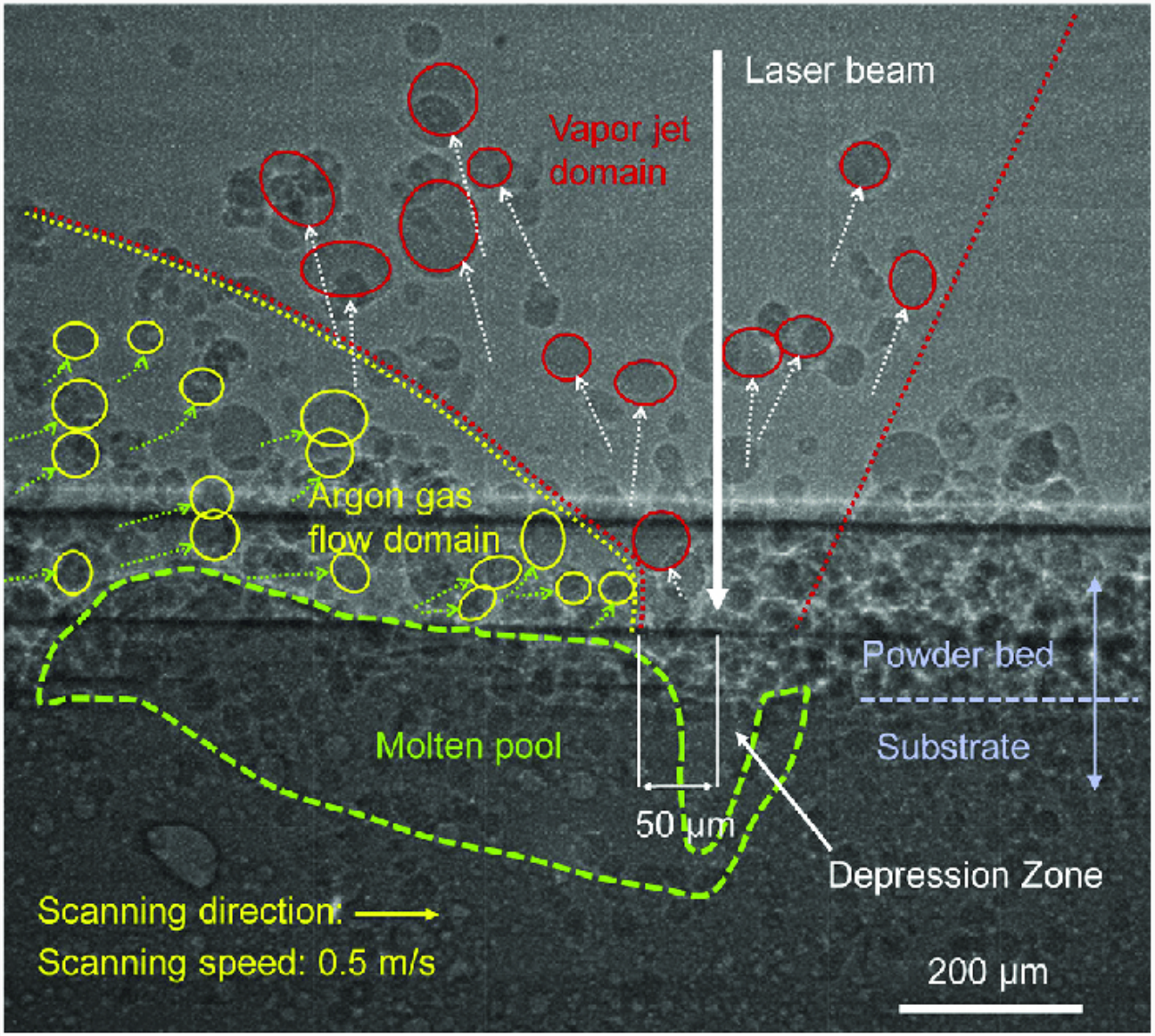

Image is taken from [1]

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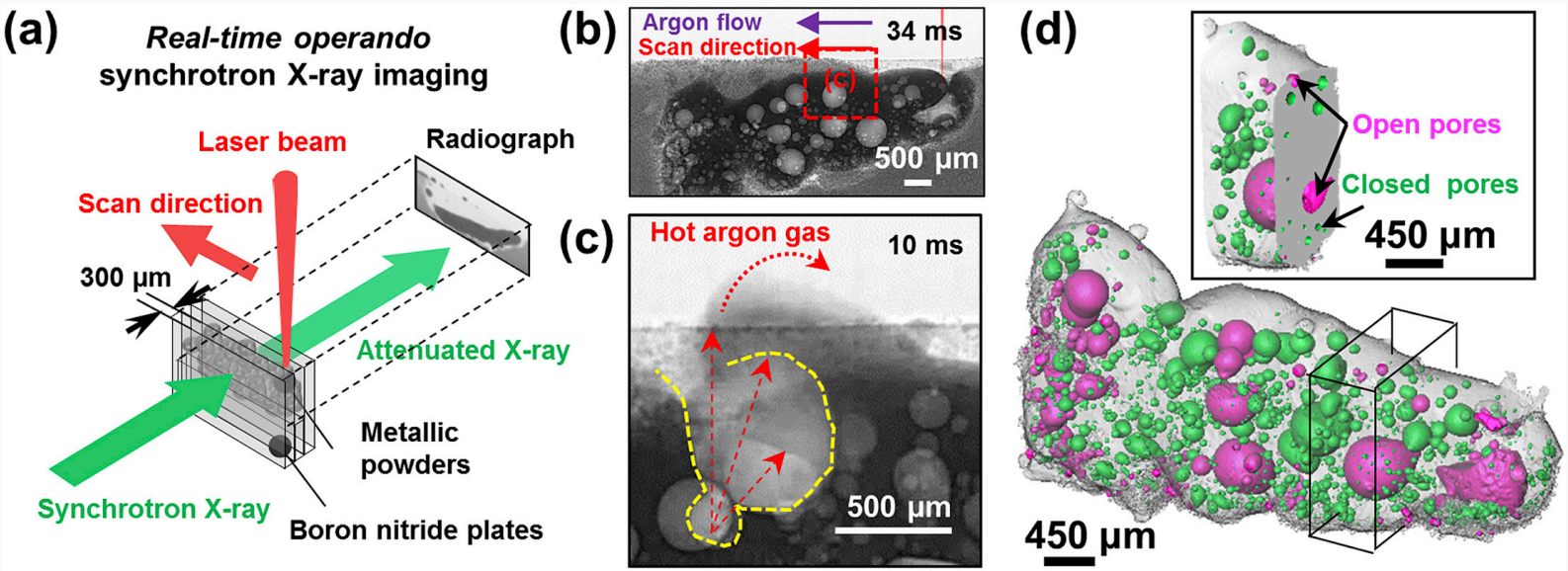

See videos here:
`https://www.sciencedirect.com/science/article/pii/S1359645418309698`

One data analysis pipeline

The image processing pipeline was performed by Dr. *Alex Leung* et al. (UCL) [1, 3, 2] and it contains the following steps:

1. **Denoising** of time-series using state-of-the-art video block matching algorithm[5]

[5] http://www.cs.tut.fi/~foi/GCF-BM3D/

[6] https://arxiv.org/abs/1701.05940

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2. Custom background **subtraction** and image **thresholding** techniques to extract the evolution of melt features, which enables the quantification of the molten pool geometries over time, including the length, width, and area.

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3. Manual **tracking** plugin from ImageJ[6] and also TrackMate software[4].

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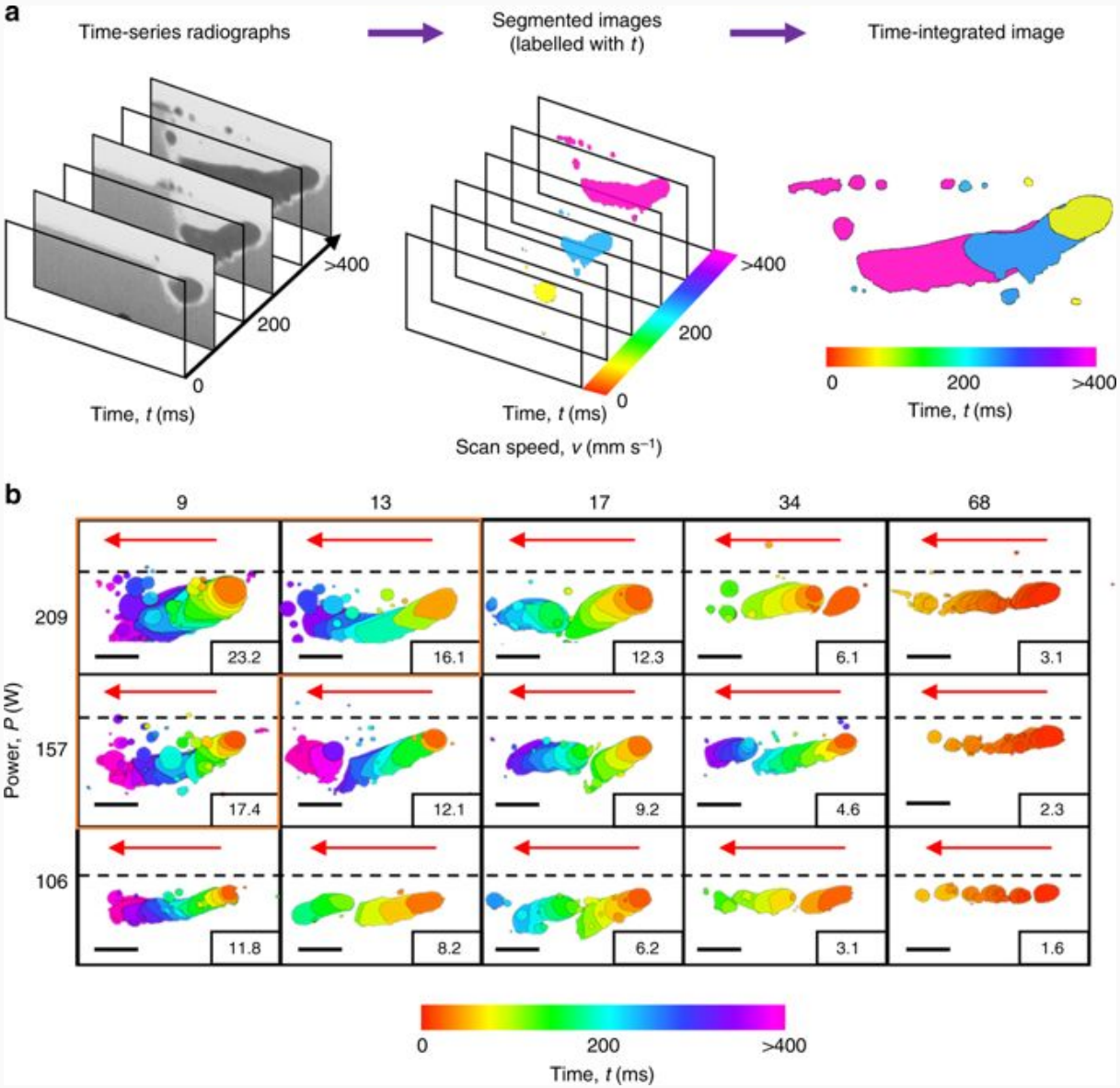
Some data processing stages



Challenges and methodology

1. Very low signal-to-noise ratio and poor contrast of the radiographs
2. Particles are small and intensity-wise at the noise level
3. Particles disappearing/appearing in frames
4. Particles overlay each other while flying in 3D space

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2. Better background subtraction and segmentation methods
3. Objects classification and tracking
4. Predictive models robustly estimating the path

Access to the data and software dependencies

- The raw I12 data are accessible at `ITT_BATH_DLS/DataP_I_AdditiveManufact_tracking/rawdata`
- Python script to read data (stack of tiffs) into Numpy 3D array `ITT_BATH_DLS/DataP_I_AdditiveManufact_tracking/ITT_AM.py`
- Python wrapper for Block-Matching denoiser `https://github.com/ericmjonas/pybm3d`
- Regularisation (denoising) package `https://github.com/vais-ral/CCPi-Regularisation-Toolkit`

All data are kindly provided by Dr. **A. Leung** alex.leung@ucl.ac.uk and Prof. **P. D. Lee** peter.lee@ucl.ac.uk

References i

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In situ x-ray imaging of defect and molten pool dynamics in laser additive manufacturing.

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