Data processing I: objects tracking challenge

Looking into predictive single-particle tracking techniques

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Diamond Light Source

- **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.
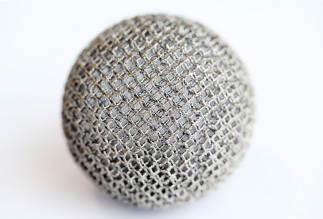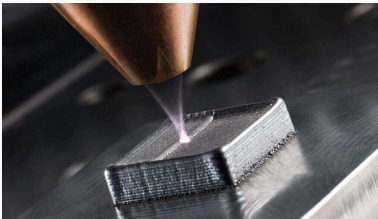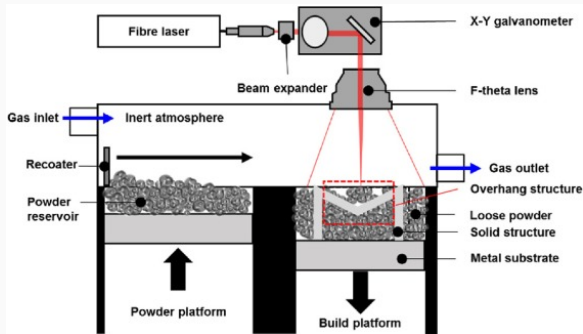

[1] https://www.ge.com/additive/additive-manufacturing
[2] https://www.youtube.com/watch?time_continue=71&v=kKQ5KwFwW_s

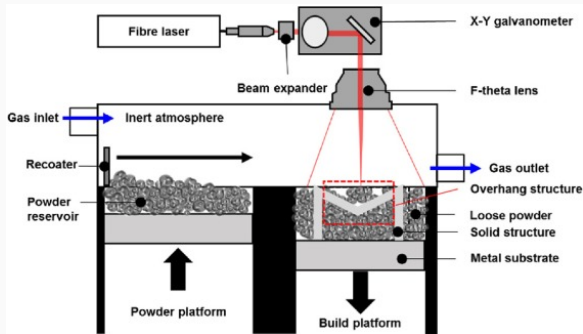- I12 beamline [3] of DLS is used for very fast radiographic and tomographic imaging

[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
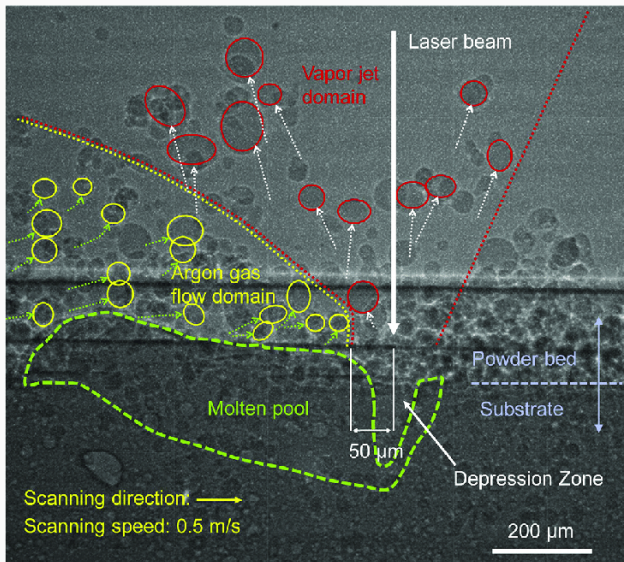
- I12 beamline [3] of DLS is used for very fast radiographic and tomographic imaging
- The series of radiographs were collected resulting in a 3D dataset (x,y + time), i.e. 3D process captured in 2D[4]

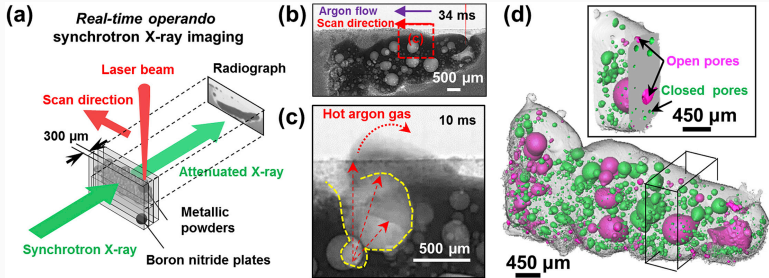[3] https://www.diamond.ac.uk/Instruments/Imaging-and-Microscopy/I12.html
[4] https://www.diamond.ac.uk/Science/Research/Highlights/2018/laser-additive-manufacturing.html

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]

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[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
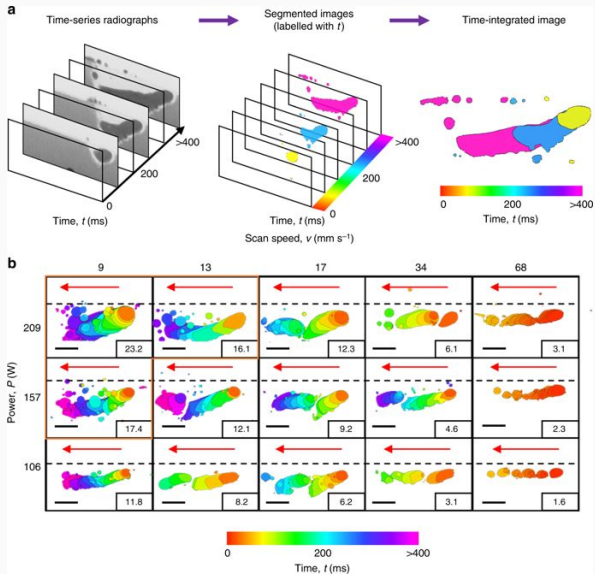
Challenges and methodology

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 are disappearing/appearing in frames
4. Particles overlay each other while flying in 3D space

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

📄 C. L. A. Leung, S. Marussi, R. C. Atwood, M. Towrie, P. J. Withers, and P. D. Lee.
In situ x-ray imaging of defect and molten pool dynamics in laser additive manufacturing.
Nature communications, 9(1):1355, 2018.

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The effect of powder oxidation on defect formation in laser additive manufacturing.
Acta Materialia, 2018.

C. L. A. Leung, S. Marussi, M. Towrie, J. del Val Garcia, R. C. Atwood, A. J. Bodey, J. R. Jones, P. J. Withers, and P. D. Lee.
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