

# CCPi Phase III

## The CCP in tomographic imaging

Constructing a Five Year Plan from September 2020

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# CCPi Phase 3: 2020 - 2025

	Year 1 (2020-2021)				Year 2				Year 3 (Mid-Term Review)				Year 4				Year 5 (-2025)			
Month	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	55		
<b>WP1 Community Engagement (MT)</b>																				
1.1 Organisation	TWs/QA	WG	QA	TWs/WG	TWs/QA	WG	QA	TWs/WG	TWs/QA	WG	QA	TWs/WG	TWs/QA	WG	QA	TWs/WG	TWs/WG	TW/WG		
1.2 Grow community	20 international imaging fellows																			
1.3 Collaboration	30 short exchanges each year - linked to quarterly coding hackathons, software user support and matchmaking																			
1.4 Roadmap alignment								RA									RA			
1.5 Network comms																				
1.6 SW training	H		ST		H		ST		H		ST		H		ST	H		ST		
<b>WP2 Facility Engagement (JW)</b>																				
2.1 Engage with NRF																				
2.2 Engage with...	NRF/DLS				ISIS				NRF				CLF							
2.3 Liaise: EPAC, DLS, ISIS																				
2.4 CIL dev with facilities																				
2.5 Data set curation		1st data set			2nd			3rd			4th			5th			6th		7th	
<b>WP3 Software Lead (JJ)</b>																				
3.1 Maintain CIL		AR				AR				AR				AR					AR	
3.2 Challenging data																				
3.3 New post-proc																				
3.4 Integrate code																				
3.5 Accelerate code																				
<b>WP4 Workflows and Industrial Links (LIE)</b>																				
4.1 Img based simulation																				
4.2 PE toolkit																				
4.3 Standards			BSI				BSI				BSI				BSI			BSI		
4.4 Industry links	IBSim				IBSim				IBSim											

WG – Working Group meeting

ST – Annual Spring Training Session

H – Hackathon proposal / QA – Quarterly activity

TW – Three tomography weeks; Jun, Jul and Sep

IBSim – Formal Image-based Simulation event to cross-link

RA – EPSRC Roadmap Alignment, including new community needs surveys

The monthly talks will continue and are held from October–July

AR – Annual major CIL software releases

# Past Successes

In particular the CCPi has:

- Helped to identify the needs and future directions for CT through support for the 2018 EPSRC X-ray CT (XCT) Roadmapping exercise including an academic questionnaire, an industry questionnaire, 2 town meetings (London and Manchester) involving over 210 academics, 72 users from industry and 20 from other organisations.
- Setup and promoted three major annual conference and workshop series based on supporting complementary groups within the CT community.
- Created and run regular developers' hackathons and collaboration series of quarterly events bringing together best practice and improved code delivery. In particular, supporting the community-driven CCPi Core Imaging Library ([www.ccp.i.ac.uk/CIL](http://www.ccp.i.ac.uk/CIL)).

# Future Links

On the basis of the evidence of the 2018 X-ray CT Roadmap,

- EPSRC is planning a £10m National Research Facility (NRF) for Lab. X-ray CT to start March 2020.
- The Central Laser Facility (CLF, STFC) is working towards a unique laser driven X-ray Facility in 2024 at the £80m Extreme Photonics Applications Centre (EPAC)
- ISIS has started offering neutron CT,
- Diamond is delivering further CT beamlines.

## Optimisation Framework

**Least Squares**  $\min_u \|Au - g\|_2^2$

**Tikhonov Regularisation**  $\min_u \alpha \|\nabla u\|_2^2 + \frac{1}{2} \|Au - g\|_2^2$

**Total Variation Regularisation**  $\min_{u>0} \alpha \|\nabla u\|_{2,1} + \int Au - g \log(Au)$

### Python Interface

```
1# Setup and run the CGLS algorithm
2cglts = CGLS(u_init, A, g)
3cglts.run(10)
4
5# Setup and run the FISTA algorithm
6f = alpha + Norm2Sq(Gradient)
7g = 0.5 * Norm2Sq(A, g)
8fista = FISTA(u_init, f, g)
9fista.run(2000)
10
11# Setup and run the PDHG algorithm
12operator = BlockOperator(Gradient, A)
13f = BlockFunction(alpha + MixedL21Norm(),
14                  KullbackLeibler(g))
15g = IndicatorBox(lower=0)
16pdhg = PDHG(f, g, operator, tau, sigma)
17pdhg.run(3000)
```



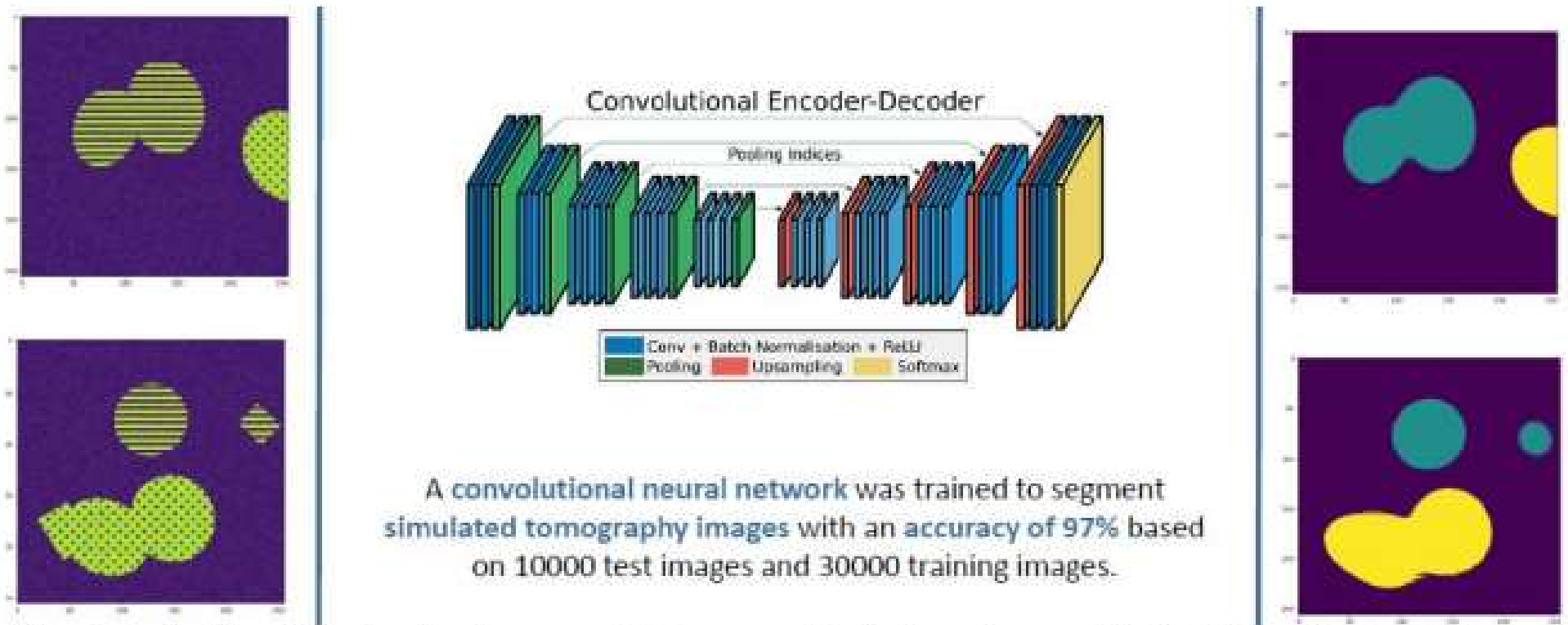
Fig. 1: Left: Example reconstruction variants offered within CIL. Centre: Python code snippet demonstrating modularity and ease of use. Right: Reconstructions of lizard head from multispectral data using conventional (top) and our code (below).



*Fig. 2: In the last five years, CCPi WG members have established 3 annual key symposiums/workshops involving combined over 300 attendees each year; as well as hosting a monthly seminar series (56 speakers & over 510 attendees so far).*



*Fig. 3: Training and outreach is an integral part of CCPI staging 45 days of software and analysis courses (attendance about 350) and having stands at 14 exhibitions, with 1,000s engaging with our VR displays and touchscreens at open days and public engagement events.*



*Fig. 4: Left: Simulated noisy tomographic images, featuring shapes filled with spotted and striped textures. Centre: Convolutional neural network architecture for segmentation learned from training data. Right: Resulting segmented images*



# Four Co-I leaders

## Jay Warnett

WP2: Facility engagement (Lead JW)

2.1 Engage with the new NRF for Lab. X-ray CT.

2.2 [CoSeC] Engage with Large Scale (Diamond, ISIS, CLF), Mid-scale (the NRF), and Small Scale Facilities (e.g. Manchester, WMG, Southampton, Swansea, Nottingham)

2.3 Work with EPAC, DLS and ISIS to ensure the UK community have the appropriate software

2.4 Ensure CCPi CIL developments are prioritised

2.5 [CoSeC] Establish and curate collection of datasets



# Four Co-I leaders

## Llion Evans

WP4: Workflows and industrial applications (Lead LIE)

4.1 [CoSeC] Establish open-source workflows connecting CT data to image-based modelling and finite element analysis

4.2 [CoSeC] Develop an open-source toolkit for public engagement involving touchscreen interactive displays and VR/AR

4.3 Establish “CT benchmarks”: with links to the emerging ISO standards

4.4 Seek to expand links from academic tomography community to industrial users



# Four Co-I leaders

## Jakob Jorgensen / Bill Lionheart

WP3: Software (Lead JJ)

3.1 [CoSeC] Maintain, unify and distribute a versatile open-source software framework

3.2 [CoSeC] Develop tomographic image processing tools for “suboptimal”, or non-standard, data arising from fast, in situ, multi-spectral, multi-modality or otherwise challenging...

3.3 [CoSeC] Develop new software for post processing, including registration, Digital Volume Correlation, segmentation, and 3D data visualisation as well as a GUI

3.4 [CoSeC] Establish an open interface for CIL -such as SIRE, TIGRE, ASTRA, tomopy and Castor

3.5 [CoSeC] Accelerate existing software base



# Four Co-I leaders

## Martin Turner

WP1: Community engagement (Lead MT)

1.1 Organise and support community engagement.

1.2 Grow the community by encouraging exchange visits and ...

1.3 Support collaborative and inter-disciplinary work through exchange visits, quarterly coding hackathons, software user support and match-making.

1.4 Work with the user community to ensure CCPi software roadmap aligns

1.5 [CoSeC] Manage network funding and communication

1.6 [CoSeC] Arrange annual user training session on CCPi software and encourage software development best practices

