Coral*Lite*: µCT Reconstruction of Coral Colonies from Individual Corallites

website

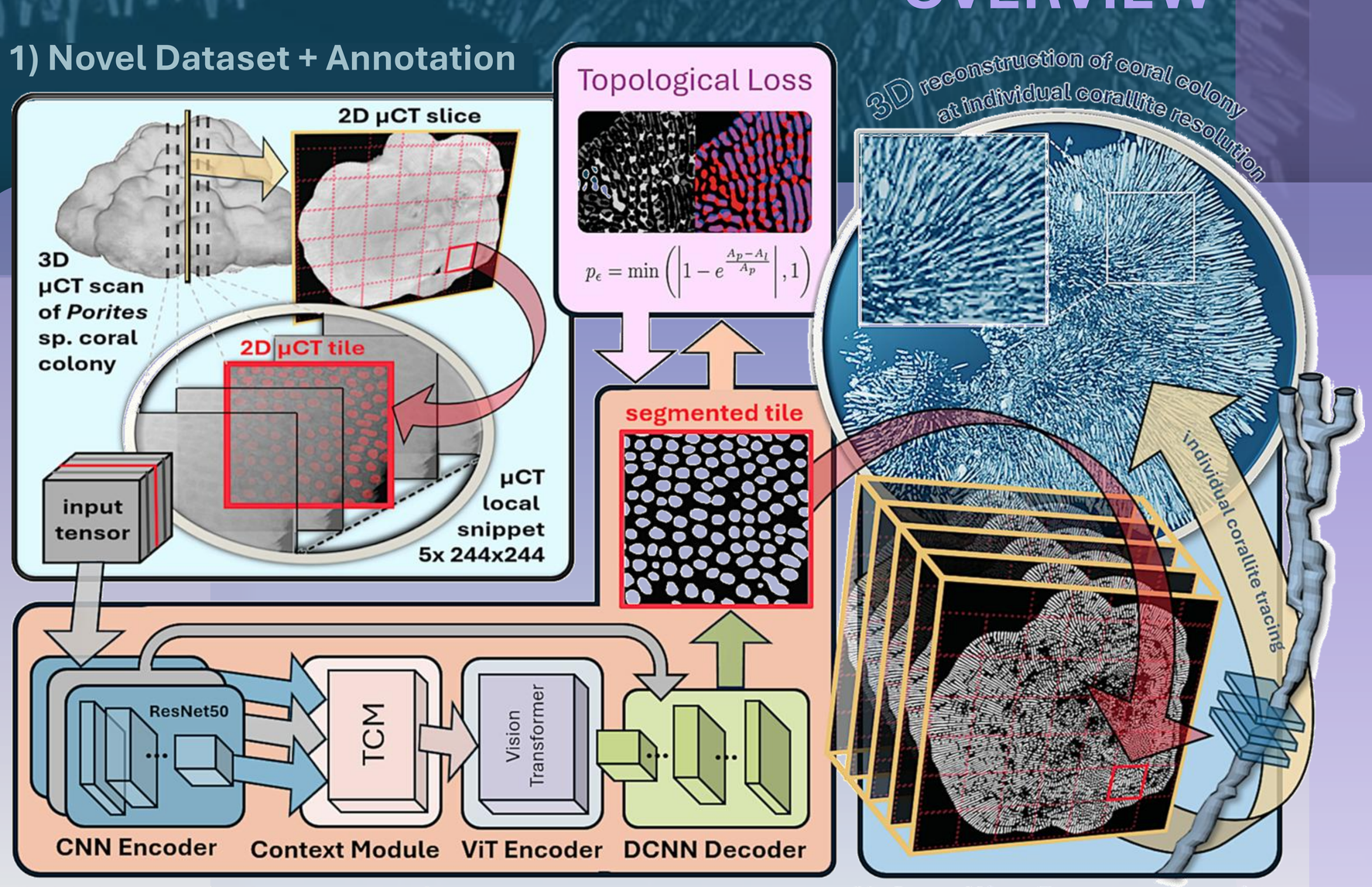
University of Bristol

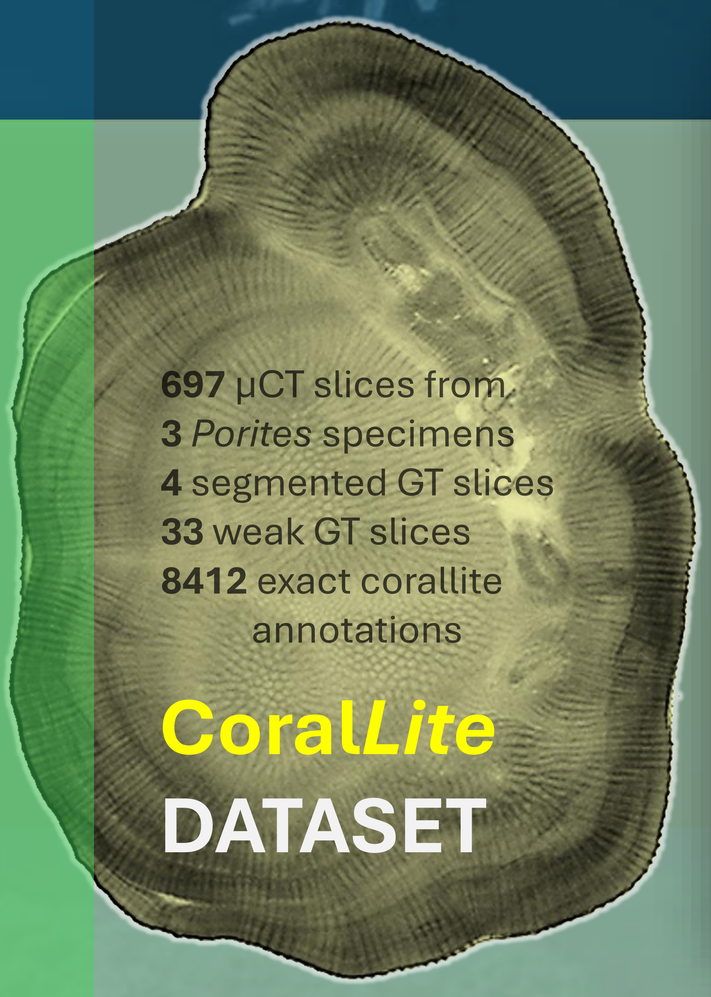
University of Liverpool

Natural History Museum

Jess Jones, Leonardo Bertini, Kenneth Johnson, Erica Hendy, Tilo Burghardt

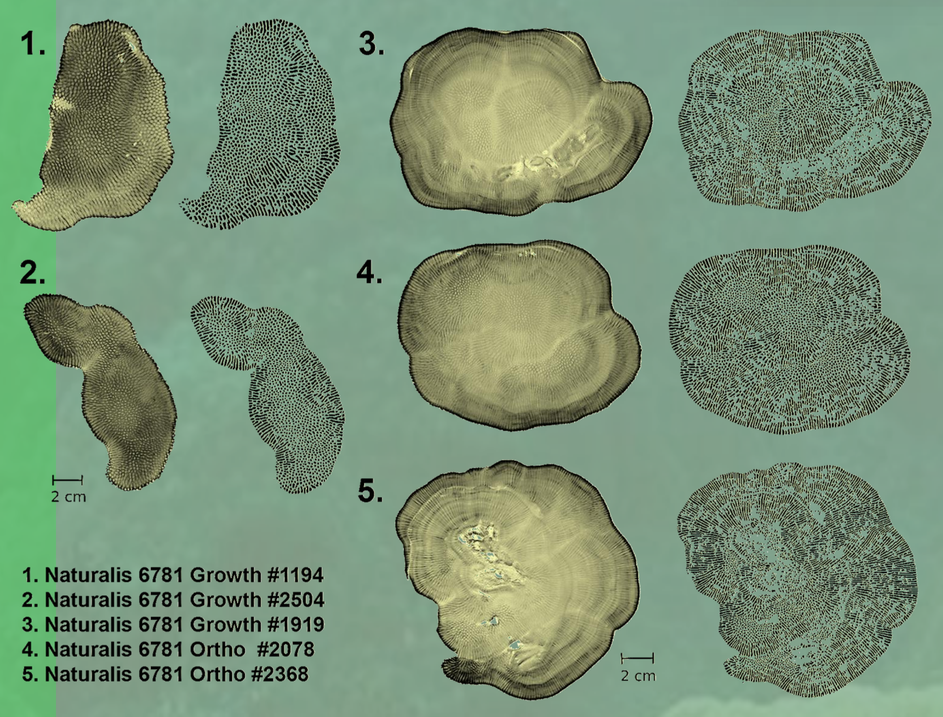
Coral*Lite* OVERVIEW





697 µCT slices from
3 *Porites* specimens
4 segmented GT slices
33 weak GT slices
8412 exact corallite annotations

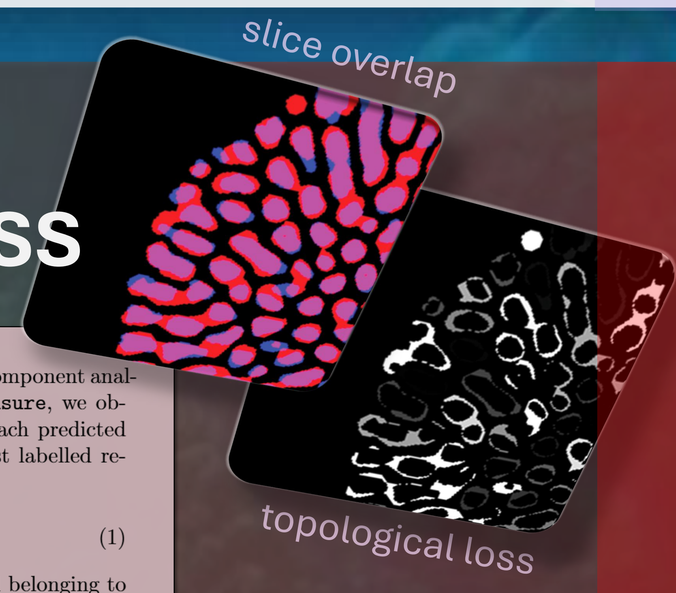
Coral*Lite* DATASET



1. Naturalis 6781 Growth #1194
2. Naturalis 6781 Growth #2504
3. Naturalis 6781 Growth #1919
4. Naturalis 6781 Ortho #2078
5. Naturalis 6781 Ortho #2368

Dataset Sample Slices
+ Segmentation Results

Coral*Lite* TOPOLOGICAL LOSS



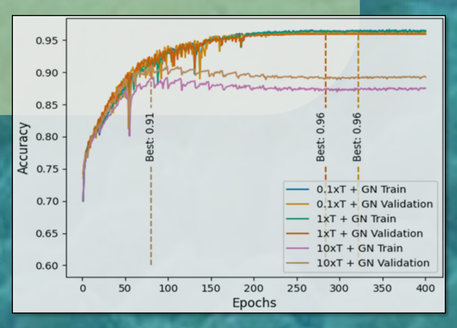
Component Penalty Formulation. Using basic connected-component analysis on binary annotation and prediction maps via `skimage.measure`, we obtain the set of predicted regions P and labelled regions L. For each predicted connected component $p \in P$ with area A_p, we identify its nearest labelled region $l \in L$ with area A_l and define the component penalty:

$$p_\epsilon = \min\left(\left|1 - e^{\frac{A_p - A_l}{A_p}}\right|, 1\right). \quad (1)$$

Error Map and Topological Loss Stipulation. Each pixel belonging to a region p is assigned the corresponding penalty if it does not belong to the matched ground-truth region l. This yields an error map $\mathcal{E}(n)$ that highlights for each pixel n its contribution towards incorrect corallite connections, false positive corallites and over-expanded regions (see Figure 5). This map is used to calculate a topological loss by averaging evidence over all N pixels of a tile during training as:

$$\mathcal{L}_{\text{Topo}} = \frac{1}{2N} \sum_{n=1}^{N} \sigma\left(\mathcal{E}(n)\right) - 0.5. \quad (2)$$

Coral*Lite* EVALUATION



Model	Parameters	Task A (same axis) Naturalis 6781 Growth #2499 mDSC	Task A Topo	Task B (same species) Naturalis 6781 Ortho #1003 mDSC	Task B Topo	Task C (diff. species) *Astraeiformis* mDSC	Task C Topo
Pre-training only	n/a	0.008	0.66	0.01	0.75	0.01	0.68
FT (fine-tuned)	$k = 224$	0.75	0.93	0.67	0.92	0.61	0.88
FT + $\mathcal{L}_{Topo}$	$T = 0.01$	0.76	0.94	0.70	0.92	0.61	0.87
max tile overlap (k = 50)	$T = 0.1$	**0.77**	**0.94**	**0.71**	**0.93**	**0.63**	0.87
plus noise augmentation	$T = 1$	0.77	0.94	0.70	0.93	0.60	0.86
	$T = 10$	0.77	0.94	0.70	0.93	0.63	**0.89**

3D Coral*Lite* RECONSTRUCTION

Basic Cross-Slice Tracing. In order to turn 2D corallite segmentation into 3D corallite tube reconstructions suitable for visualisation of entire colonies and for manual inspection, for each connected region R_i in slice S_n we search for a matching counterpart region R_j in the previous slice S_{n-1}. A match is accepted based on centroid distance and intersection-over-union (IoU) satisfying $d(R_i, R_j) < \gamma$ and $\text{IoU}(R_i, R_j) > \beta$. Thresholds can be altered for task-specific visualisations – visuals in this paper are generated with $\gamma = 0.3$ and $\beta = 0.3$. If a match is found, R_i is assigned to the same corallite object as R_j; otherwise, a new object trace is started.