Supplementary Material for CS-TRD: a Cross Sections Tree Ring Detection Method

1 Additional experiments

In this section, additional experiments are conducted to justify the decisions made during the algorithm design.

1.1 Artificial chains

One experiment concerns artificial chains (disk border and pith chain). Table 1 shows the method performance without including the Artificial Chains and using them. The average metric for the 64 images is presented for both experiments. Adding them improves the results: the F-Score increases from 72.1% to 89.1%.

Dataset	Image Size (pixels)	σ	P	R	F	RMSE
No Artificial Chains	1500x1500	3.0	82.7	66.7	72.1	2.85
Artificial Chains	1500x1500	3.0	92.6	86.3	**89.1**	3.81

Table 1: Method performance (average) including the artificial chains with the optimal σ and image resolution over the full UruDendro dataset (64 images).

This difference is because chain connections depend on having support in the vicinity. This condition is not met in disks with a strong presence of cracks and/or fungi. In Figure 1, cases are shown where chains are only completed after adding the artificial chains. Without them, no rings are completed.

1.2 Connectivity Goodness Condition

The Connectivity Goodness condition was defined as

$$\textbf{not}\, \mathit{ExistChainOverlapping} \wedge \mathit{RegularDeriv} \wedge (\mathit{SimilarRadialDist} \vee \mathit{RadialTol}).$$

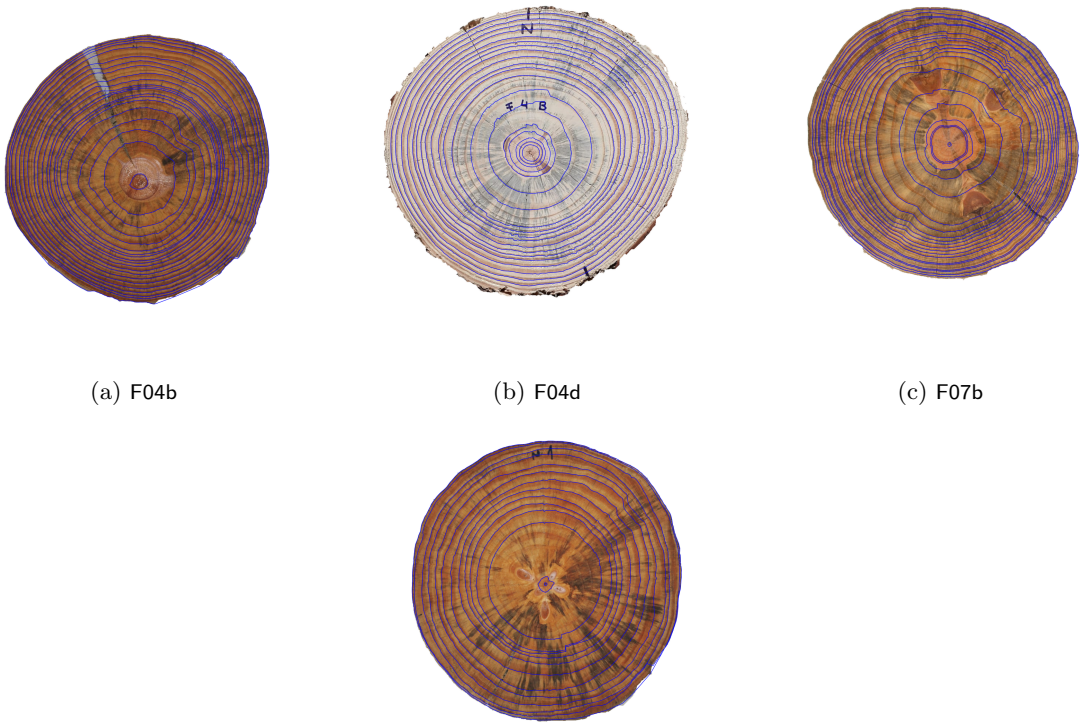
In this section, we explain why the condition $\mathit{SimilarRadialDist} \vee \mathit{RadialTol}$ was chosen over $\mathit{SimilarRadialDist} \wedge \mathit{RadialTol}$. Table 2 compares the method's performance on the full dataset under both conditions. The equation presented in the main article achieves the best performance, as measured by the F-Score metric.

1.3 Connectivity Parameters

As the main text explains, the connect stage iterates its parameters over nine configurations (Table 1 in the main text). Table 3 shows the results if the Algorithm 3 exits at iterations 1, 2, 7, or 9. In all the cases, artificial chains are included in the last iteration. With nine iterations, we achieve the best performance, characterized by the highest precision, recall, and F-Score.

Dataset	Image Size (pixels)	σ	P	R	F	RMSE
$\mathit{SimilarRadialDist} \vee \mathit{RadialTol}$	1500x1500	3.0	94.4	84.0	88.2	3.40
$\mathit{SimilarRadialDist} \wedge \mathit{RadialTol}$	1500x1500	3.0	92.6	86.3	**89.1**	3.81

Table 2: Method performance (average) comparing the $\wedge$ and $\vee$ conditions in Section 1.2 at the optimal σ and image resolution over the full UruDendro dataset (64 images).



(a) F04b (b) F04d (c) F07b

(d) L08b

Figure 1: Samples where closed ring chains are generated after adding the artificial chains.

Iteration (i)	P	R	F1	RMSE	TP	FP	FN
1	0.92	0.86	0.88	4.22	16.42	1.41	2.66
3	0.93	0.86	0.89	3.89	16.56	1.16	2.52
7	0.92	0.86	0.89	3.45	16.39	1.19	2.69
9	0.93	0.86	0.89	3.81	16.68	0.84	2.39

Table 3: Method overall performance over the full UruDendro dataset.

2 Showcasing CS-TRD examples

2.1 UruDendro

Some other examples of the ring delineation in the dataset are illustrated in Figure 2. Over these sets of disks, the results are really good. The CS-TRD algorithm generally works well, although it may encounter issues with specific images. Let's discuss several examples, such as images L02b, F07e, and L02d.

Figure 3 illustrates the results for disk L02b. Figure 3c, shows the detected rings in red and the GT in green. Four detections are closed curves and determined as correct (TP), while two are determined as incorrect (FP). Counting from the center to the border, the first detection is correct, and the next two are bad, corresponding to the second and third rings. Analyzing the chains step output shown in Figure 3a, it seems clear that there is not enough edge information to see the rings due to the fungus stain.

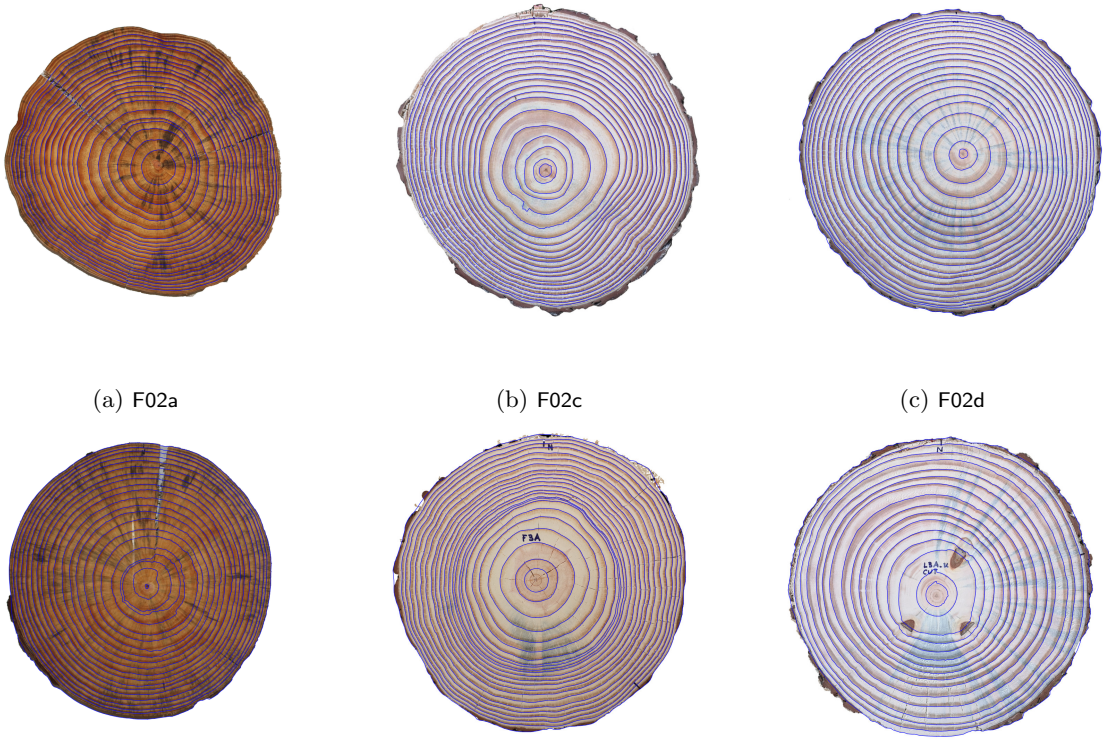
A similar situation happens for disk F07e, Figure 4. There is a strong presence of fungus stain, meaning that some rings do not have enough edges to form a closed curve.

The method results are slightly better for disk L02d with an F-Score of 50% in the presence of the same fungus stain issue as the former disks. Figure 5a illustrates this case and how the fungus perturbs the edge detection step in the middle of the disk.

Table 4 illustrates the metric result over all the disks presented in the article.

Name	P	R	F1	RMSE	TP	FP	TN	FN
F10b	0.952	0.909	0.93	1.49	20	1	0	2
F10a	0.889	0.727	0.8	0.842	16	2	0	6
F10e	1	0.95	0.974	1.01	19	0	0	1
F02c	1	0.955	0.977	1.17	21	0	0	1
F02b	0.955	0.955	0.955	0.719	21	1	0	1
F02a	0.952	0.87	0.909	0.682	20	1	0	3
F02d	0.952	1	0.976	0.664	20	1	0	0
F02e	0.95	0.95	0.95	1.16	19	1	0	1
F03c	0.957	0.917	0.936	1.16	22	1	0	2
F03b	1	0.913	0.955	0.548	21	0	0	2
F03a	0.957	0.917	0.936	1.81	22	1	0	2
F03d	1	0.952	0.976	3.21	20	0	0	1
F03e	0.913	1	0.955	0.619	21	2	0	0
F04c	1	0.905	0.95	1.73	19	0	0	2
F04b	0.955	0.913	0.933	2.96	21	1	0	2
F04a	0.957	0.917	0.936	1.58	22	1	0	2
F04d	0.9	0.857	0.878	0.771	18	2	0	3
F04e	0.952	0.952	0.952	1.37	20	1	0	1
F07c	0.87	0.87	0.87	0.757	20	3	0	3
F07b	0.667	0.522	0.585	3.41	12	6	0	11
F07a	1	0.833	0.909	2.23	20	0	0	4
F07d	0.952	0.909	0.93	0.432	20	1	0	2
F07e	0.727	0.364	0.485	7.19	8	3	0	14
F08c	0.955	0.913	0.933	0.846	21	1	0	2
F08b	1	0.957	0.978	0.804	22	0	0	1
F08a	1	0.958	0.979	1.49	23	0	0	1
F08d	1	0.955	0.977	1.21	21	0	0	1
F08e	1	1	1	1.23	22	0	0	0
F09c	1	0.833	0.909	1.27	20	0	0	4
F09b	0.955	0.913	0.933	0.635	21	1	0	2
F09a	1	0.875	0.933	0.681	21	0	0	3
F09e	0.909	0.909	0.909	2.9	20	2	0	2
L11b	0.938	0.938	0.938	0.591	15	1	0	1
L02c	0.917	0.846	0.88	0.776	11	1	0	2
L02b	0.8	0.533	0.64	7.02	8	2	0	7
L02a	0.938	0.938	0.938	5.62	15	1	0	1
L02d	0.667	0.429	0.522	2.93	6	3	0	8
L02e	1	0.714	0.833	2.04	10	0	0	4
L03c	0.933	0.875	0.903	1.24	14	1	0	2
L03b	1	0.938	0.968	1.19	15	0	0	1
L03a	1	0.882	0.938	1.63	15	0	0	2
L03d	1	0.933	0.966	1.63	14	0	0	1
L03e	1	1	1	1.43	14	0	0	0
L04c	1	0.875	0.933	1.21	14	0	0	2
L04b	0.938	0.938	0.938	0.9	15	1	0	1
L04a	1	0.882	0.938	1.85	15	0	0	2
L04d	1	0.812	0.897	0.705	13	0	0	3
L04e	0.917	0.733	0.815	1.39	11	1	0	4
L07c	0.875	0.824	0.848	1.01	14	2	0	3
L07b	1	0.812	0.897	1.13	13	0	0	3
L07a	1	0.882	0.938	1.57	15	0	0	2
L07d	1	0.875	0.933	0.745	14	0	0	2
L07e	0.923	0.857	0.889	4.82	12	1	0	2
L08c	1	0.938	0.968	1.11	15	0	0	1
L08b	1	0.75	0.857	2.31	12	0	0	4
L08a	1	0.882	0.938	1.19	15	0	0	2
L08d	1	0.929	0.963	1.72	13	0	0	1
L08e	1	0.867	0.929	2.45	13	0	0	2
L09c	0.833	0.938	0.882	0.834	15	3	0	1
L09b	0.889	1	0.941	1.07	16	2	0	0
L09a	1	0.882	0.938	1.41	15	0	0	2
L09d	0.867	0.867	0.867	0.68	13	2	0	2
L09e	1	0.867	0.929	2.15	13	0	0	2
F09d	1	0.957	0.978	1.1	22	0	0	1
Average	0.926	0.863	0.891	3.81	16.7	0.844	0	2.39

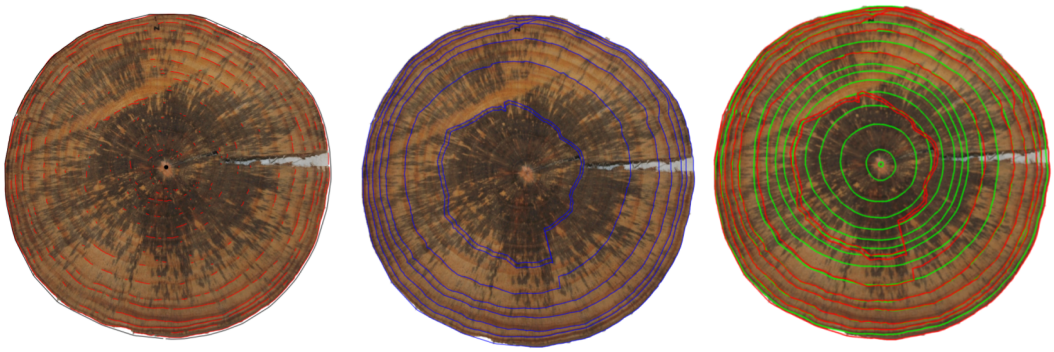
Table 4: Results over our dataset with $th\_pre = 60\%$. Images resized to 1500x1500 and edge detector parameter $\sigma = 3$.



(a) F02a (b) F02c (c) F02d

(d) F02e (e) F03c (f) L03c

Figure 2: Some results for the UruDendro dataset.

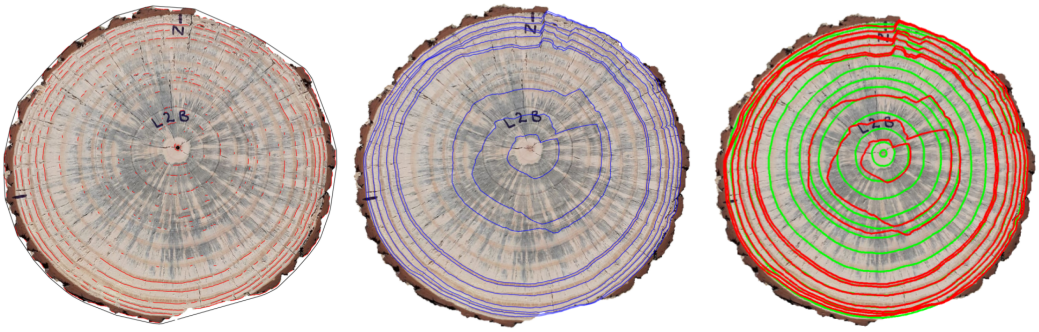


(a) Chains (b) Output (c) Gt and Detections

Figure 3: Method result for disk L02b. Note how the fungus stain perturbs the edge detection step.

(a) Chains (b) Output (c) Gt and Detections

Figure 4: Method result for disk F07e. Note how the fungus stain perturbs the edge detection step.



(a) Chains (b) Output (c) Gt and Detections

Figure 5: Method result for disk L02d. Note how the fungus stain perturbs the edge detection step.

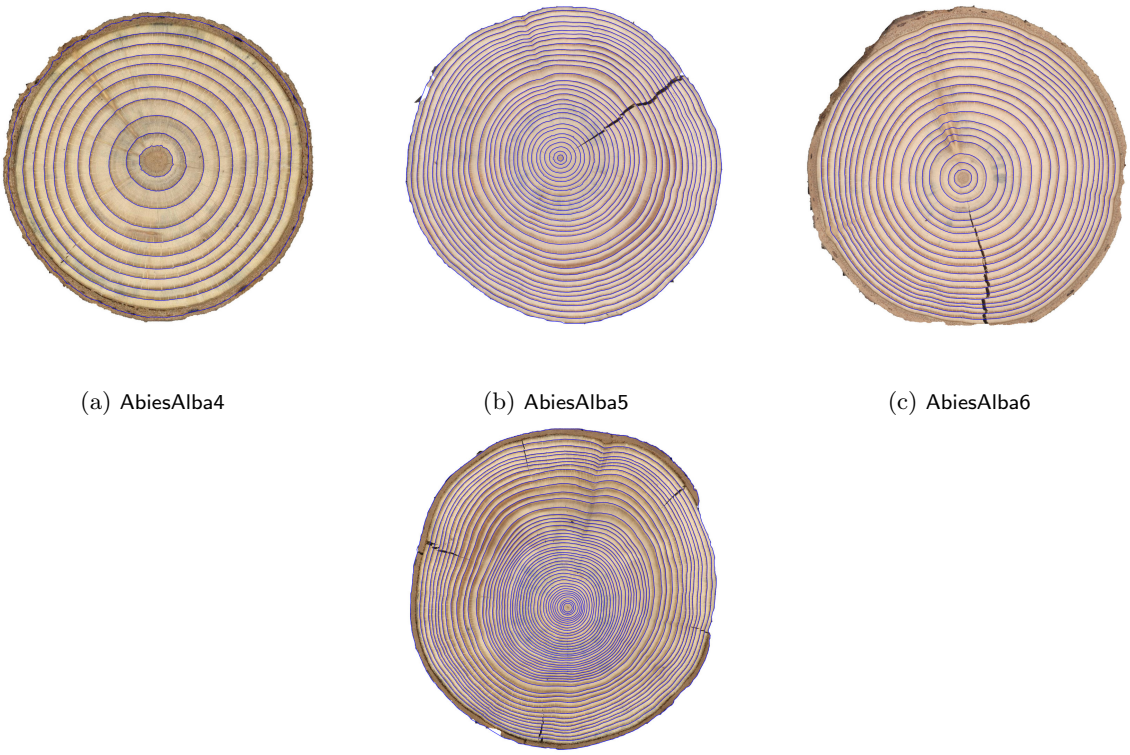
2.2 Kennel

In this section, we present the results of the CS-TRD method applied to the entire Kennel dataset. The first three disks of the dataset were shown in the main article, Figure 6 shows the results for the other four samples. The main difference between the UruDendro dataset and the UruDendro dataset is the age of the trees (number of annual rings); for example, the disk *AbiesAlba7* is 48 years old, while the oldest sample in the UruDendro dataset is 24 years old. As explained in the article, the results of the method in this dataset are really good, with an F-score of 97%.

Table 5 illustrates the metric result over all the disks presented in the article.

Name	TP	FP	TN	FN	P	R	F	RMSE	Time (sec.)
AbiesAlba1	49	1	0	3	0.98	0.94	0.96	3.66	18.01
AbiesAlba2	20	0	0	2	1.00	0.91	0.95	0.95	9.21
AbiesAlba3	26	1	0	1	0.96	0.96	0.96	1.30	8.93
AbiesAlba4	11	0	0	1	1.00	0.92	0.96	5.88	8.96
AbiesAlba5	30	1	0	0	0.97	1.00	0.98	1.29	9.06
AbiesAlba6	20	0	0	1	1.00	0.95	0.98	1.26	7.63
AbiesAlba7	45	0	0	3	1.00	0.94	0.97	3.58	13.78
Average					0.99	0.95	0.97	2.56	10.80

Table 5: Results on the Kennel dataset (size 1500x1500 and $\sigma = 2.5$) with $th\_pre = 60$.



(a) AbiesAlba4 (b) AbiesAlba5 (c) AbiesAlba6

(d) AbiesAlba7

Figure 6: Results over images from the Kennel dataset with 1500x1500 image size and $\sigma = 2.5$.