ON MORPHOLOGICAL HIERARCHIES FOR IMAGE SEQUENCES

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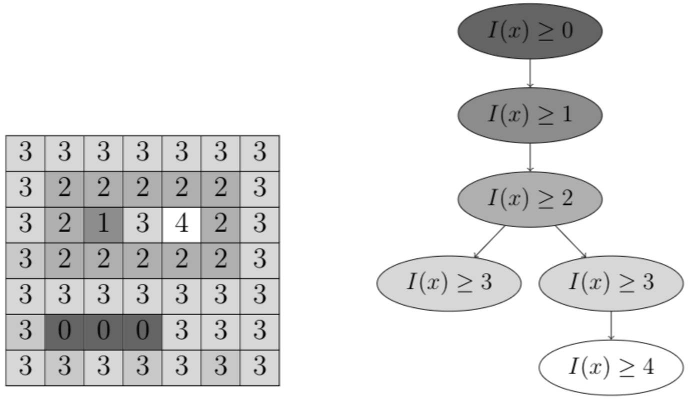
MOTIVATION

- Morphological hierarchies are efficient tools to process single frame remote sensing images
- In our previous work, we have proposed different hierarchical representation strategies for image sequences[1]
- Our goal is to select the most relevant and efficient hierarchical representation for subsequent studies.

1-Tuna, Caglayan, et al. "Component trees for image sequences and streams." *Pattern Recognition Letters* 129 (2020): 255-262.

TREE FOR AN IMAGE



- Tree representations can be used to extract object based feature from an image without needing prior information

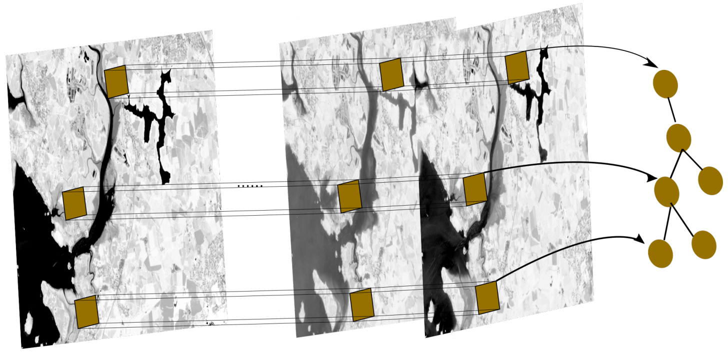
$$T = (V, E)$$

- Tree consist of set of nodes and set of edges

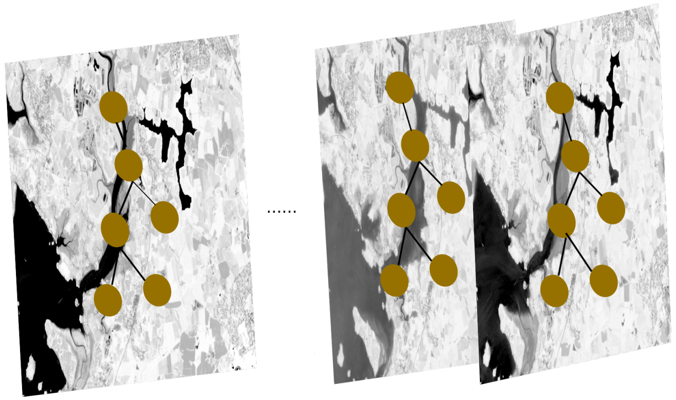
$$V = \cup\, (C_\lambda)$$

- Set of nodes are the union of connected components/nodes

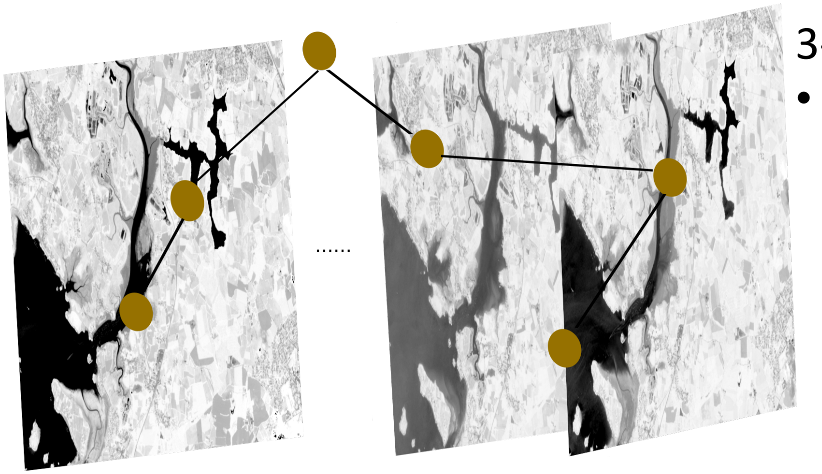
TREE FOR IMAGE SEQUENCES



1-Spatial Hierarchy
- Ordering
- Projection



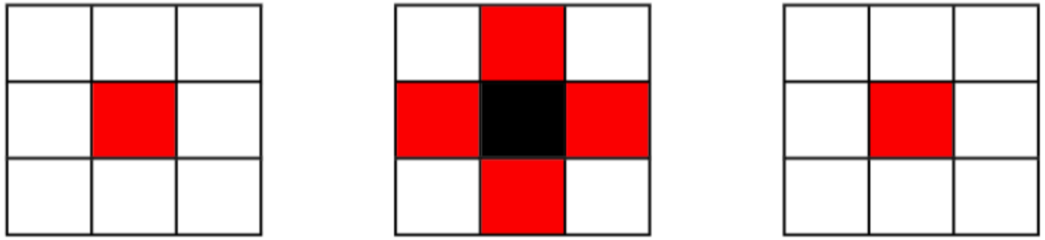
2-Temporal Hierarchy
- Building tree for each date



3-Spatio-temporal Hierarchy
- Building one tree from all

SPACE-TIME TREE

- Space-time tree is built using temporal connectivity



6 connectivity

- Another options is continuous connectivity (instead of 3x3x3, 3x3xn)
- Thus, spatio-temporal connected components are created

$$C_{\lambda,t} = \cup\,(C_{\lambda,1}, C_{\lambda,2}, \ldots, C_{\lambda,n})$$

- These connected components or nodes includes pixel from different time stamps

PROJECTION

Three strategies

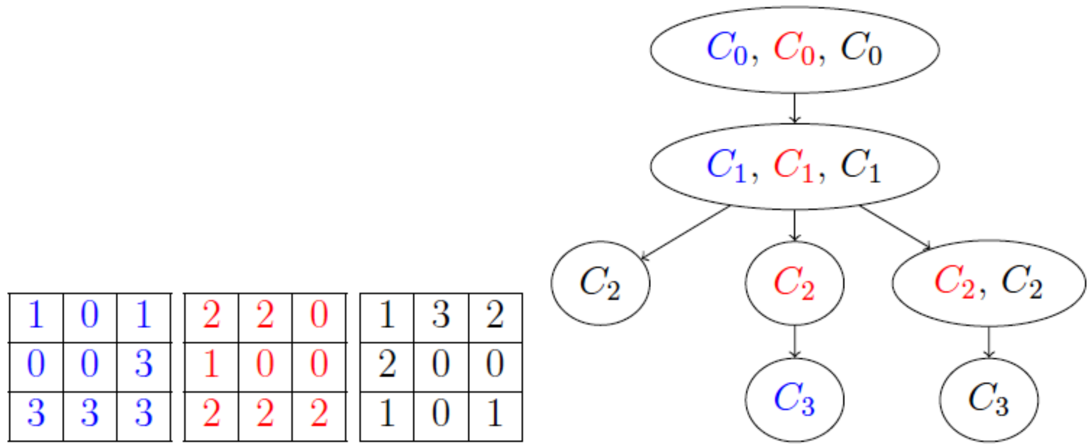
1. Spatial h. : Spatial domain
2. Temporal h.: Spatial domain
3. Spatio-temporal: Spatio-temporal

Tree projection from space-time tree to make them comparable

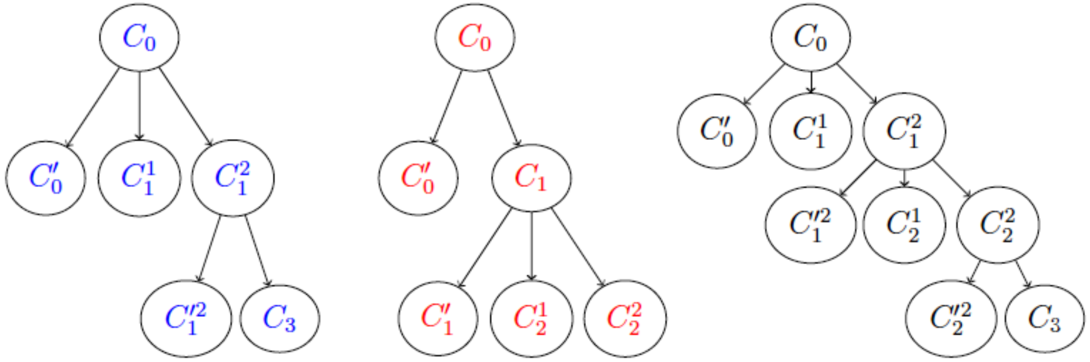
1. Spatial projection
2. Temporal projection

- Comparison can be made between temporally projected trees and temporal hierarchy trees or spatially projected trees or spatial hierarchy trees

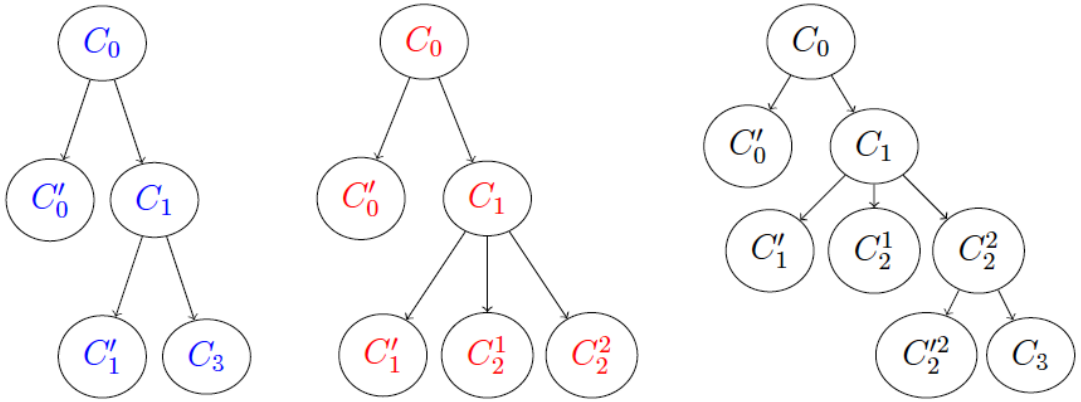
Space time tree example with 3 images



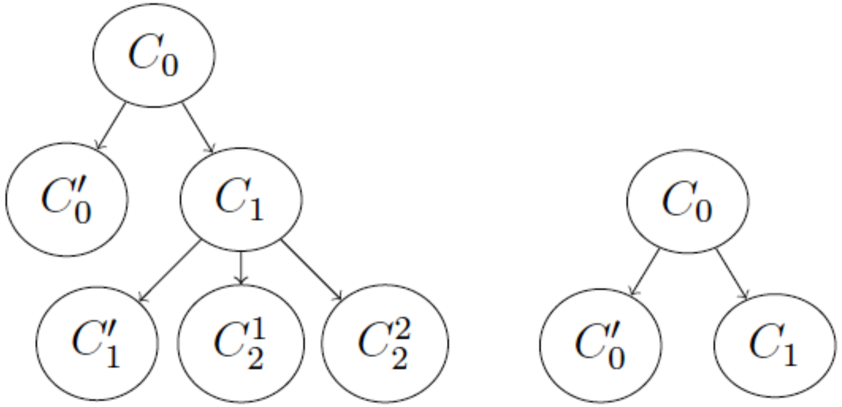
Each color represents different images



Tree for each date



Projected trees in temporal domain



SH tree and spatially projected tree

EXPERIMENTS

	$\mathcal{T}_t$		$\mathcal{T}^t$		$\mathcal{T}'^t$	
	Max	Min	Max	Min	Max	Min
$t=1$	13640	14274	6377	5874	4917	3481
$t=2$	13577	14231	4471	4523	3688	4007
$t=3$	14268	14002	2418	5726	2099	2924
$t=4$	13883	14178	5111	3067	3469	2626
$t=5$	12495	11592	6726	2966	6178	2862
$t=6$	15176	13943	4106	6789	1614	5838
avg.	13839	13703	4818	4824	3631	3623
std.	804	951	1445	1438	1558	1090
total	83039	82220	28909	28945	21789	21738

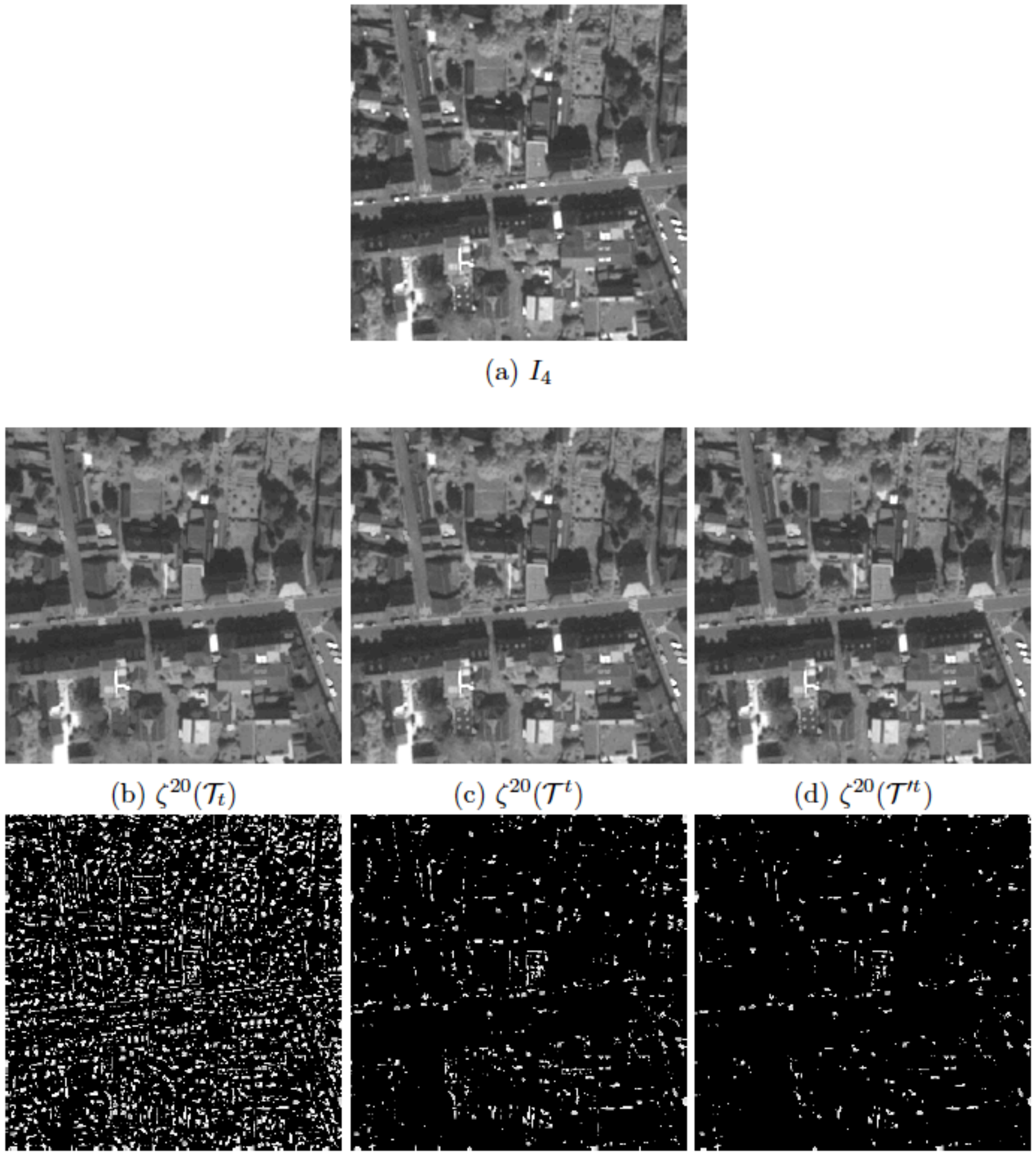
Amount of nodes: Complexity analysis

	$\mathcal{T}_t$		$\mathcal{T}^t$		$\mathcal{T}'^t$	
	Max	Min	Max	Min	Max	Min
$t=1$	57.2	93.5	23.8	10.4	6.4	5.8
$t=2$	41.7	82.2	4.4	12.8	3.2	9.9
$t=3$	54.7	86.5	2.1	10.9	**1.00**	4.4
$t=4$	58.6	86.0	12.8	4.5	5.2	2.42
$t=5$	66.9	70.2	25.6	1.2	23.1	**1.00**
$t=6$	70.6	98.4	7.2	20.6	1.3	14.1

	Max	Min
$\mathcal{T}_\varsigma$	500.00	1000.00
$\mathcal{T}^\varsigma$	15.00	3.00
$\mathcal{T}'^\varsigma$	**1.00**	**1.00**

Dasgupta's Cost (2016) is adapted

EXPERIMENTS



(a) I_4

(b) $\zeta^{20}(\mathcal{T}_t)$ (c) $\zeta^{20}(\mathcal{T}^t)$ (d) $\zeta^{20}(\mathcal{T}''^t)$

(e) $I-(b)$ (f) $I-(c)$ (g) $I-(d)$

Filtering result with TH strategy and projected trees with same threshold

CONCLUSION

- We have proposed projection methods for space-time trees in order to make them comparable with the trees obtained with spatial and temporal hierarchy
- We showed that space-time tree is more preferable compared to other strategies
- Among future works, we aim to explore capability of trees with continuous connectivity for real remote sensing based applications such as land-cover mapping, pattern recognition and change detection.