Finding the Largest Unambiguous Component of Stereo Matching

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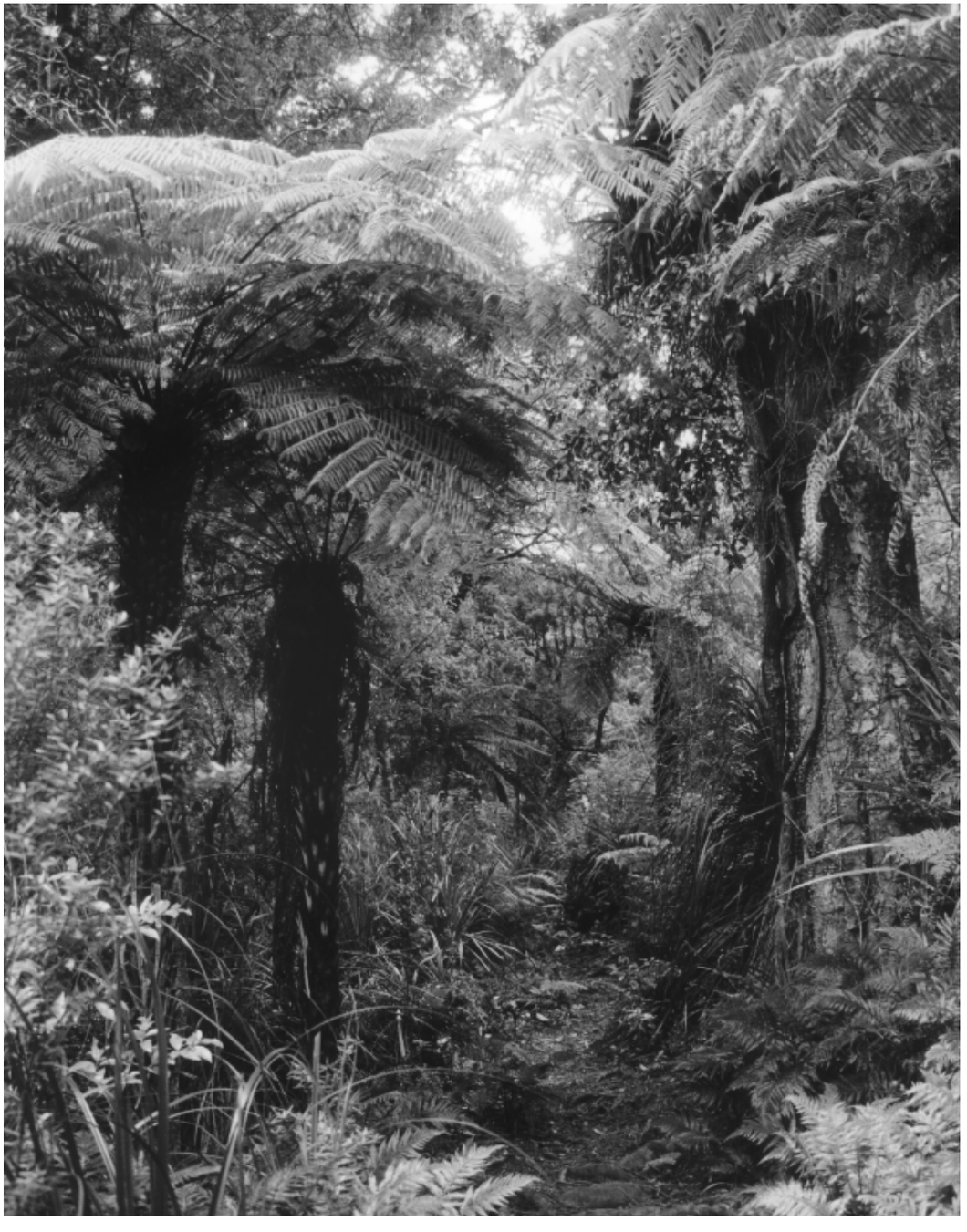
Talk overview

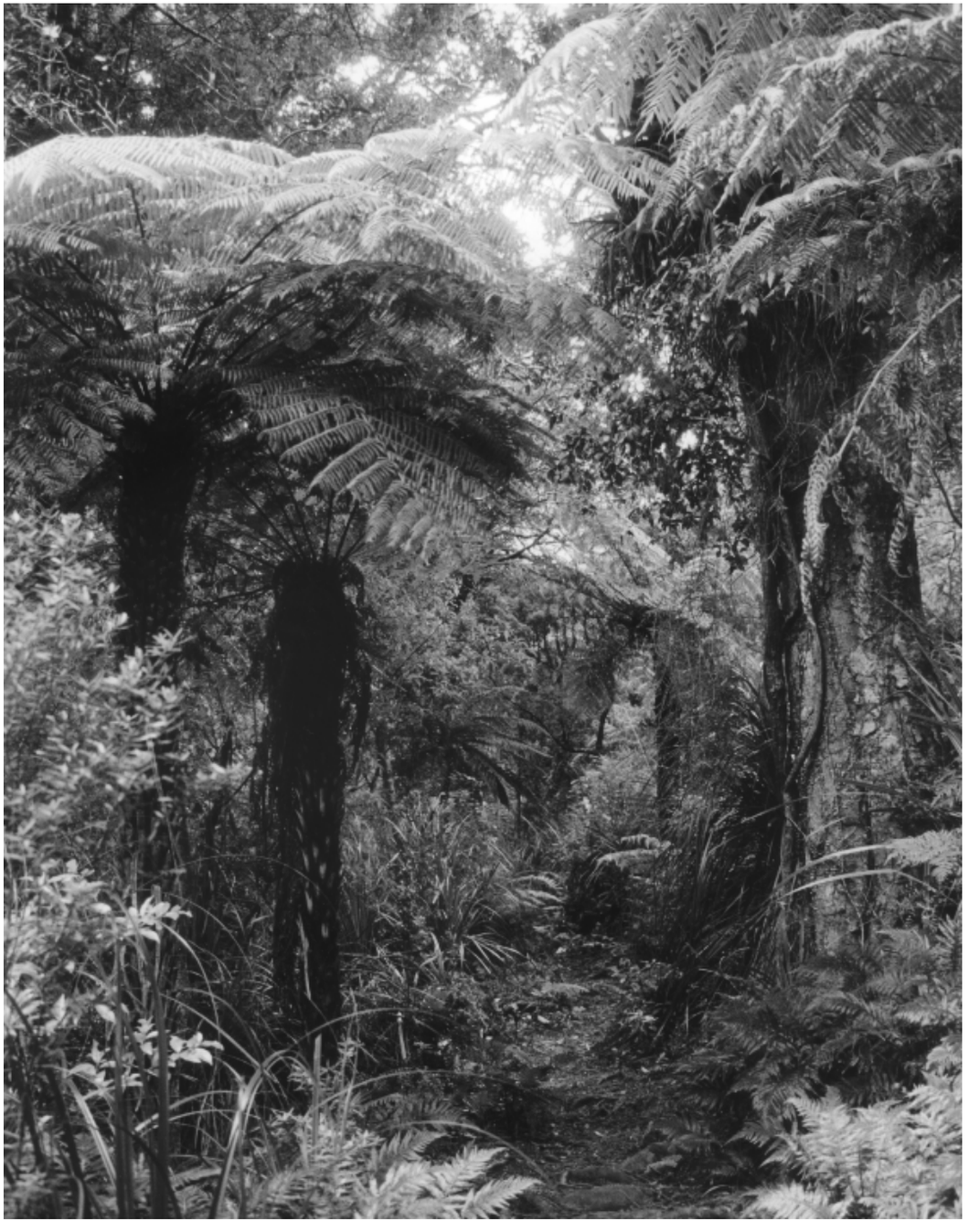
- Stability: A new principle in dense/sparse matching.
- Gives us: "**Matching at a given confidence level**" with ambiguous matches rejected.
- Simple.

Our programme



- complex scenes
- rich visual texture
- non-surfaces at camera resolution
- strong continuity model fails

Our programme

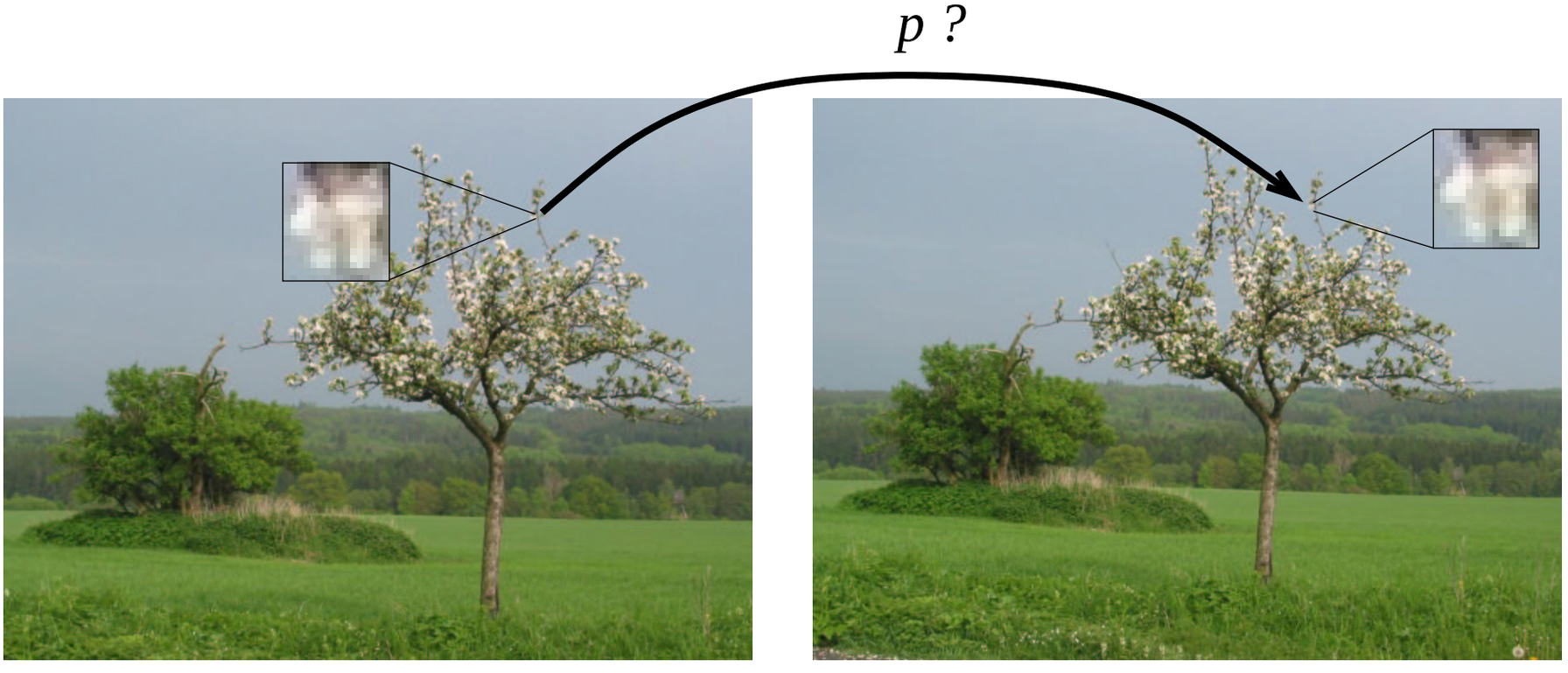


- complex scenes
- rich visual texture
- non-surfaces at camera resolution
- strong continuity model fails

- regularize differently:
  strong occlusion model
- reliable matches only

$\Rightarrow$ needs uncertainty representation

Signature-based (Area-based) matching



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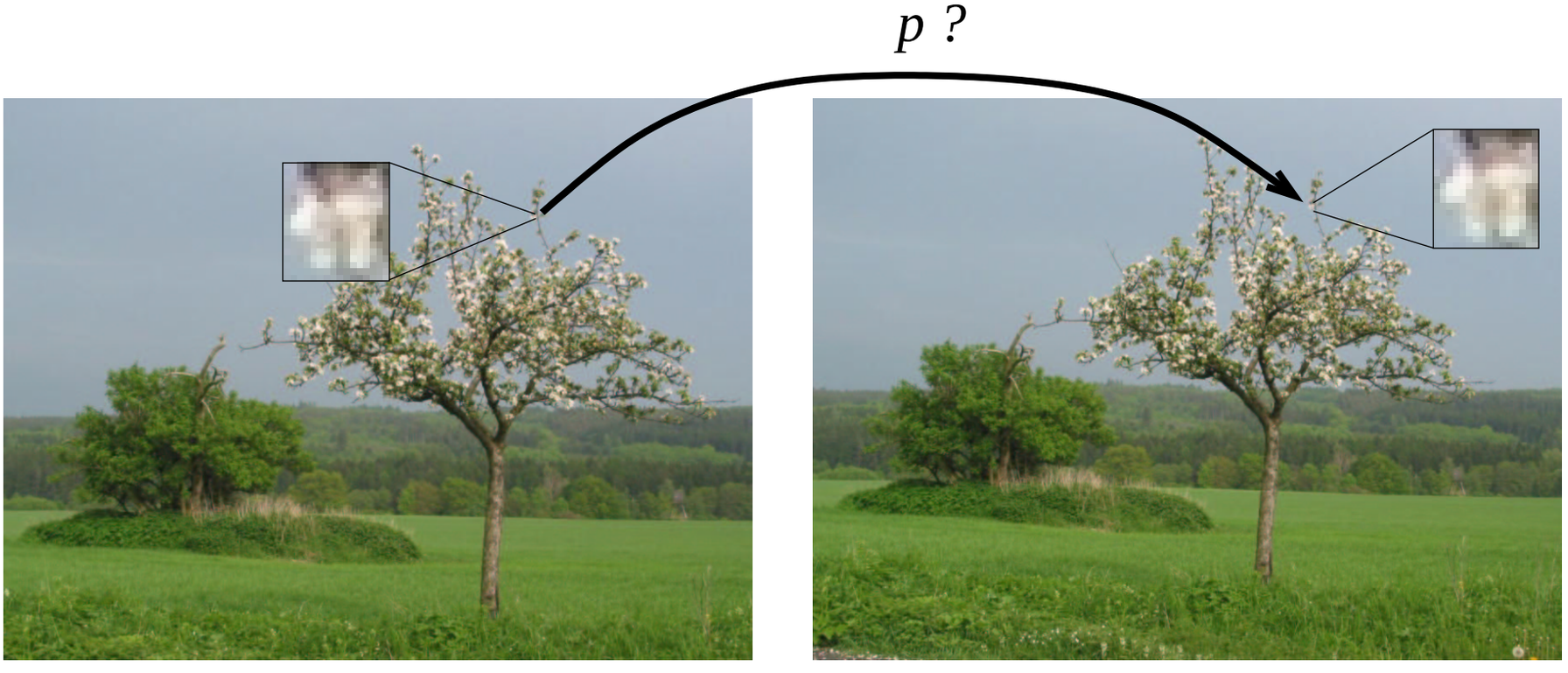

is match p good? : $c(p) = \text{similarity}\left(\quad , \quad \right)$

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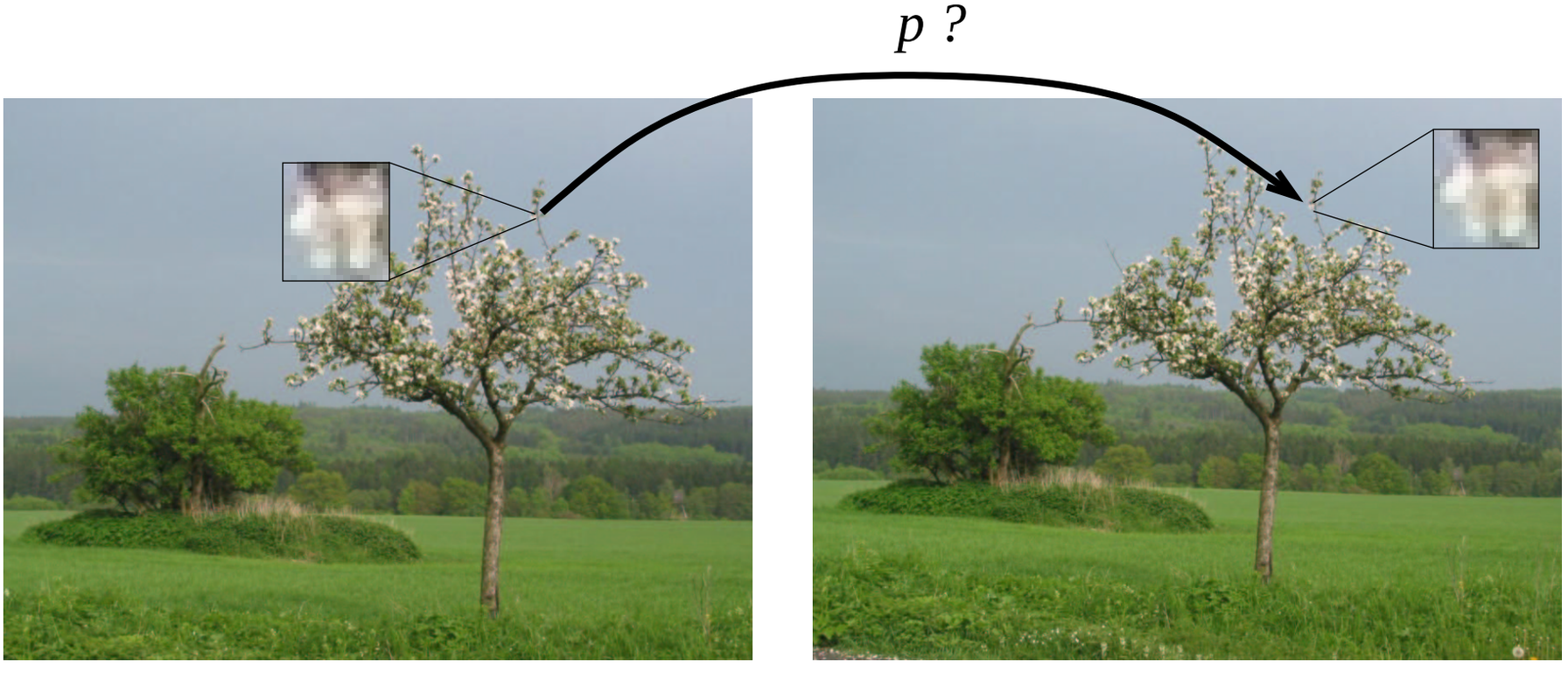
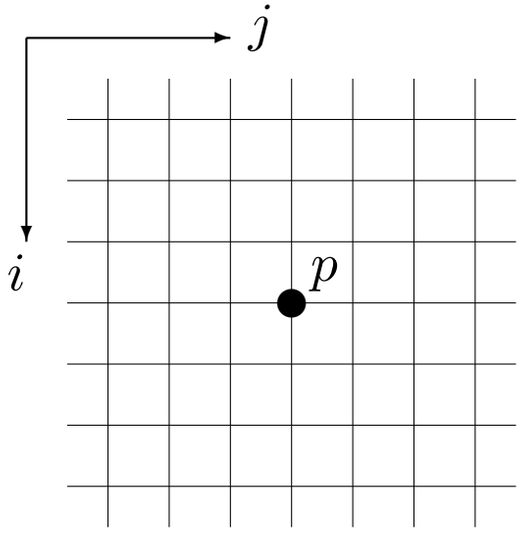


is match p good? : $c(p) = \text{similarity}\left(\quad , \quad \right)$

confidence interval $\left[c_{\min}(p),\, c_{\max}(p)\right]$

Inhibition relation over tentative matches



pair = tentative match

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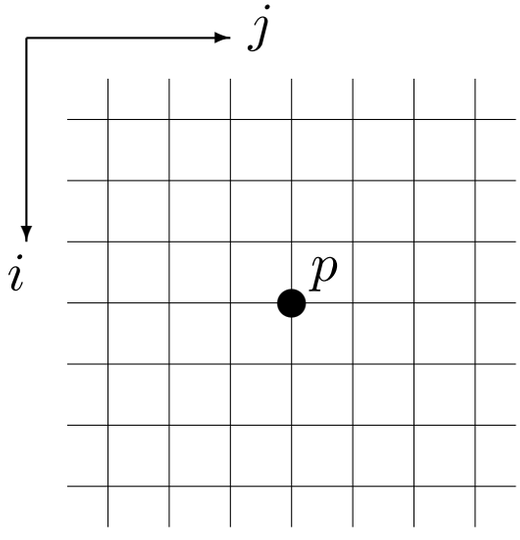
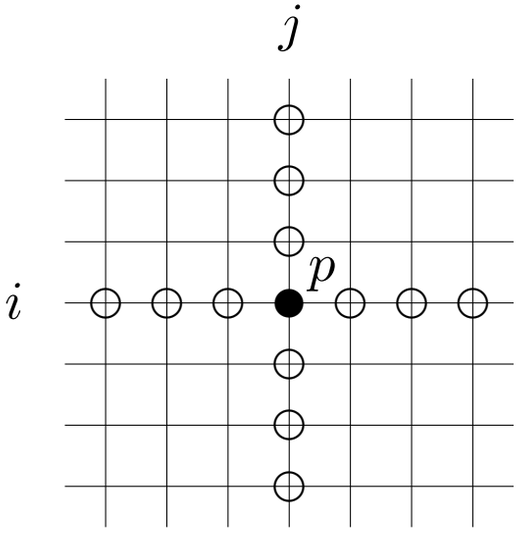


$p = (i, j) \in P$



$X(p) \subseteq P$

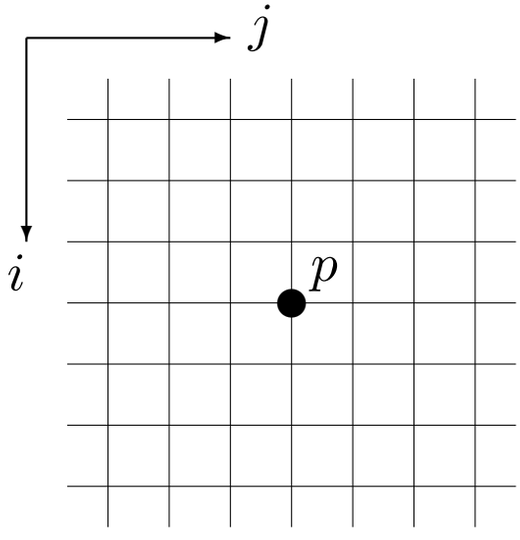
pair = tentative match

inhibition X-zone

uniqueness $\longrightarrow$ matchings

[Marr 74]

Inhibition relation over tentative matches



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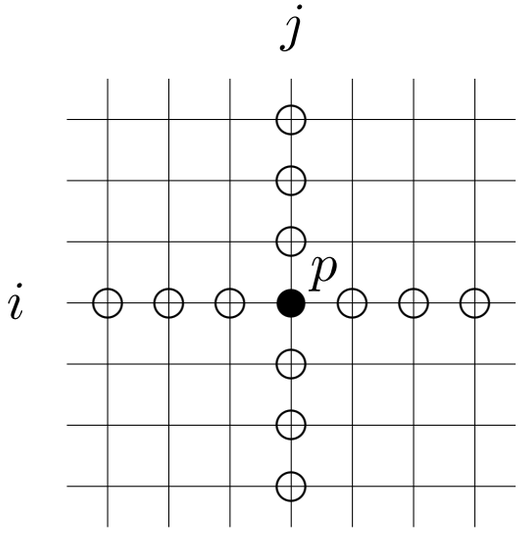

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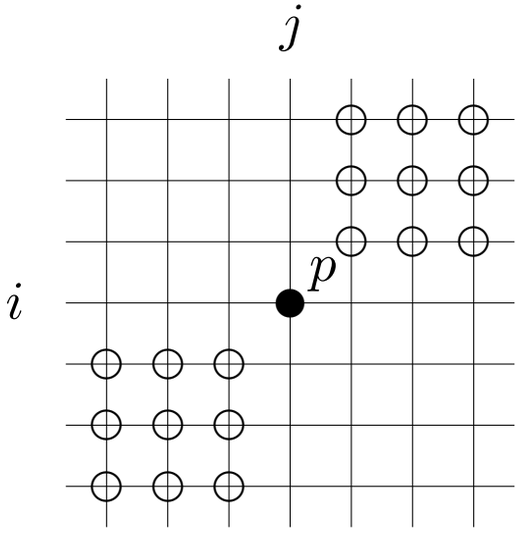


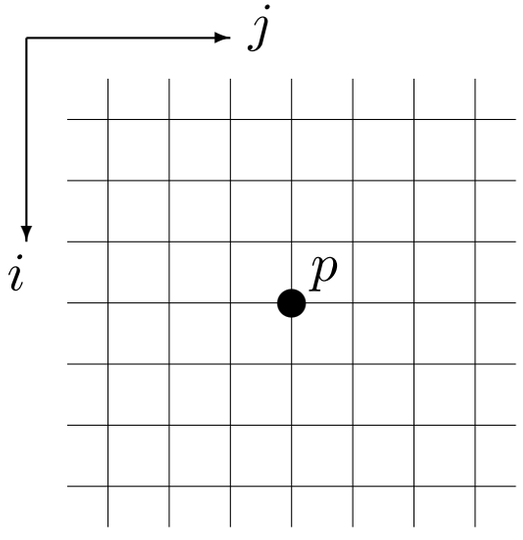
$F(p) \subseteq P$

inhibition F-zone

monotonicity $\longrightarrow$ ordering

[Yuille & Poggio 84]

Inhibition relation over tentative matches



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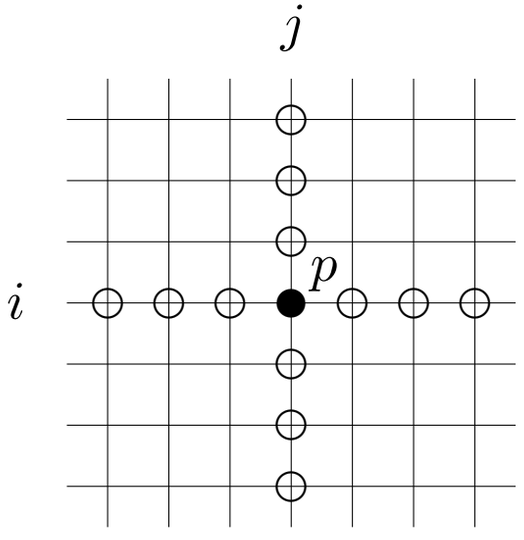

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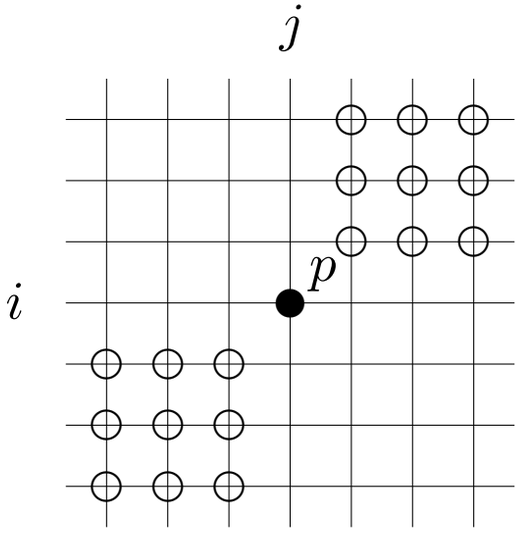

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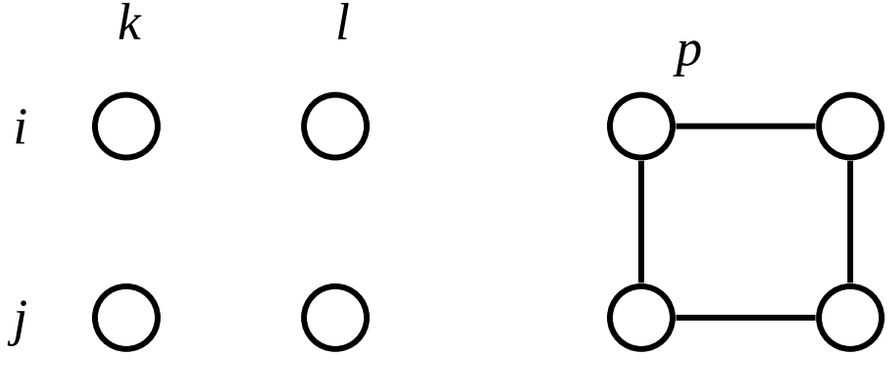
[Yuille & Poggio 84]

- $q \in Z(p) \Rightarrow p$, q mutually exclusive pairs (due to occlusion)
- their confidence intervals **overlap** $\Rightarrow$ **no preference** between the pairs
- their confidence intervals **disjoint** $\Rightarrow$ one pair **preferred** to the other

A new matching constraint: Stability

matching problem $\longrightarrow$ inhibition relation



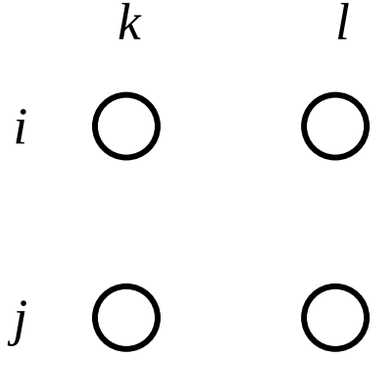
$$\forall p: \; Z(p)$$

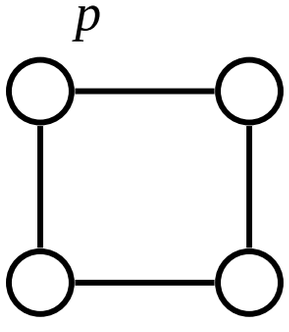
A new matching constraint: Stability

confidence level

↓

matching problem $\longrightarrow$ inhibition relation $\longrightarrow$ edge orientation





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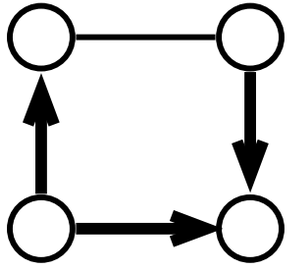


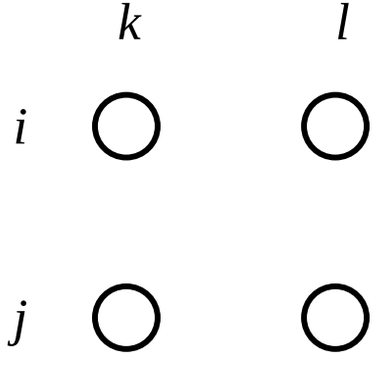
strong: oriented to the preferred pair
weak: unoriented

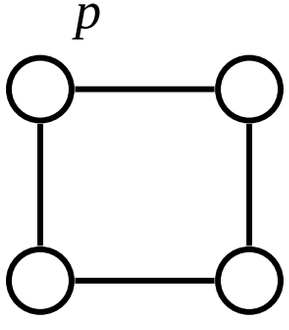
A new matching constraint: Stability

confidence level

↓

matching problem → inhibition relation → edge orientation → stable matching M





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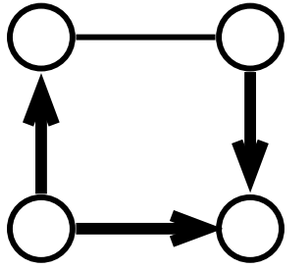

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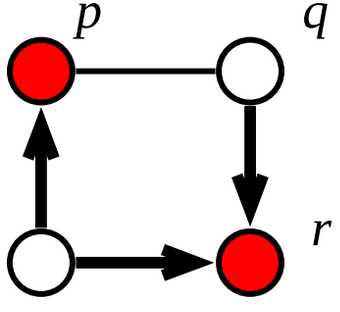

Def. 1. *Matching M is* **stable** *(at confidence level α) iff:*

For **every** *edge leaving M there is an* **oriented** *immediate successor returning to M.*

Stable matching properties

- **Existence:** For any given confidence level stable matching **exists uniquely**

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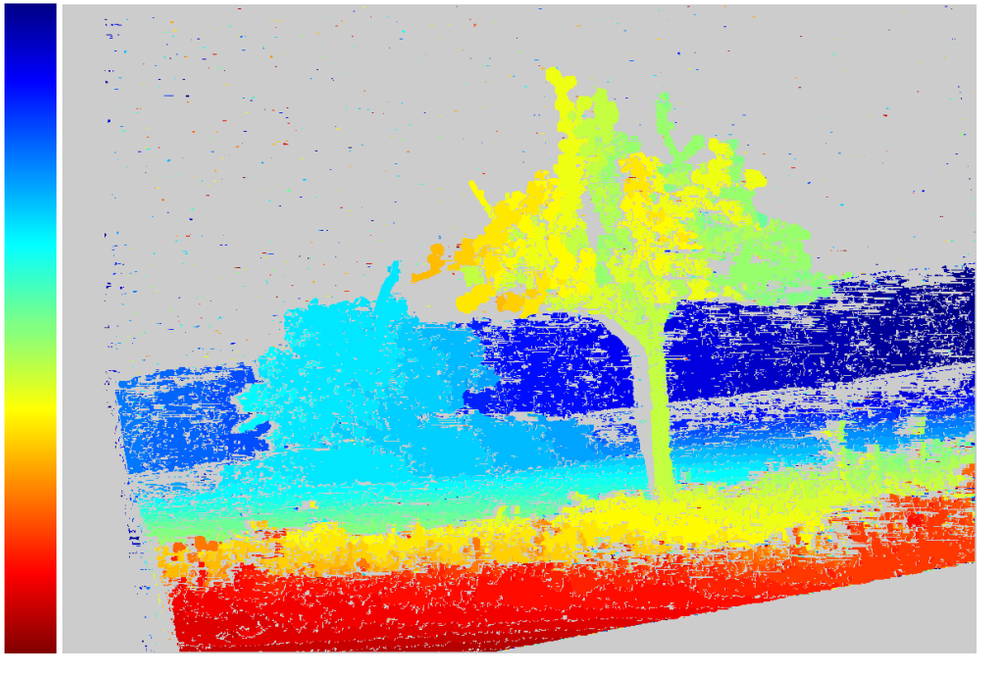
Stable matching properties

- **Existence:** For any given confidence level stable matching **exists uniquely**
- **Optimality:** Every occluded pair has has a strongly better matched pair in its inhibition zone.
- **Density:** Not complete (**rejects ambiguous matches**)
- **Algorithm:** is simple, $O(d^2 n)$ (see the paper)

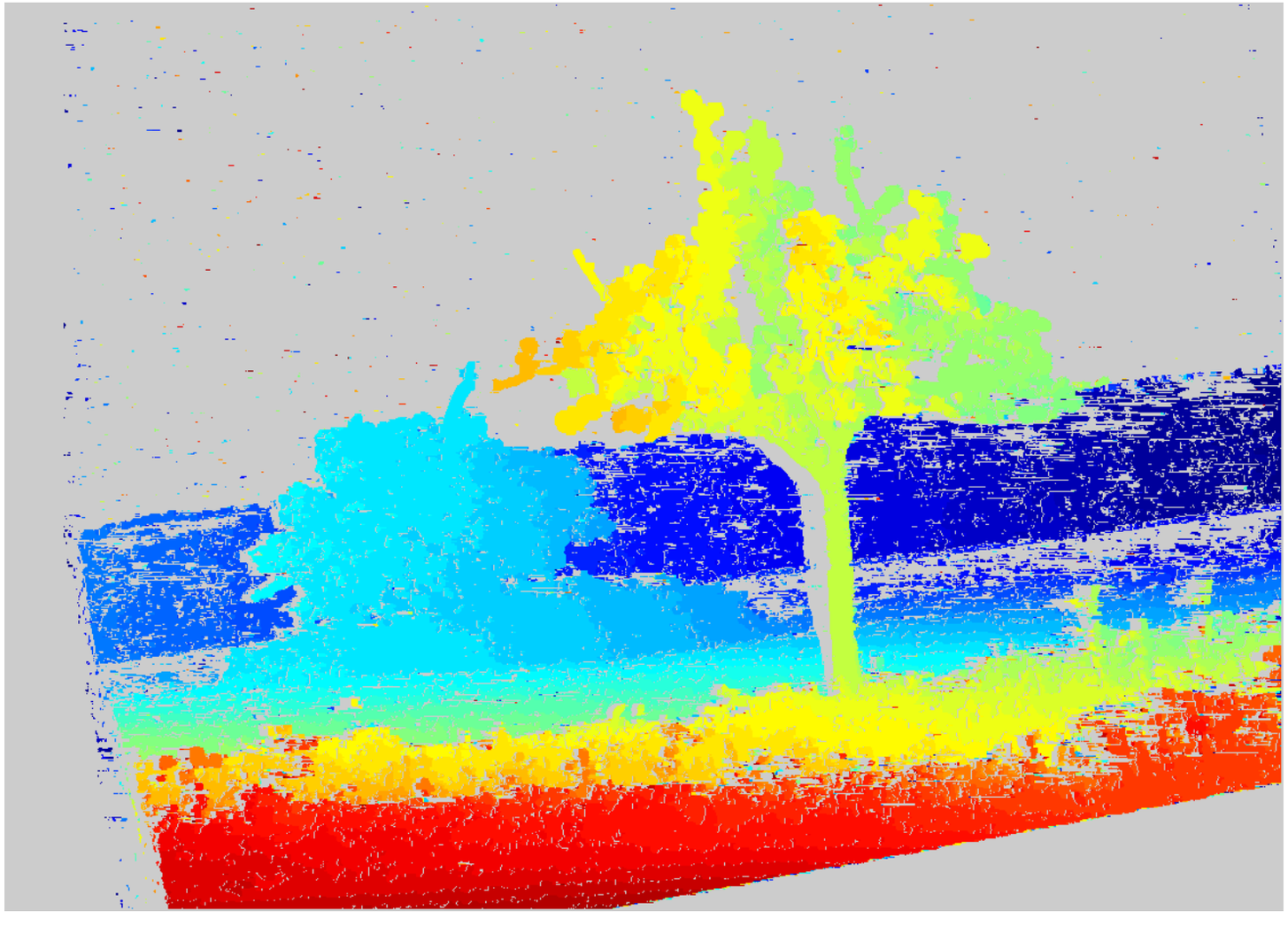
Results: Apple Tree



- 800×1100 image
- disparity range 50..100
- 5×5 correlation window + MNCC
- confidence interval width 0.5% of MNCC range

  (in the paper: $\alpha = 20$, $\beta = 0.01$)
- 1.5min 1GHz K7 CPU

Changing confidence level



confidence interval width 0% [of NCC range]

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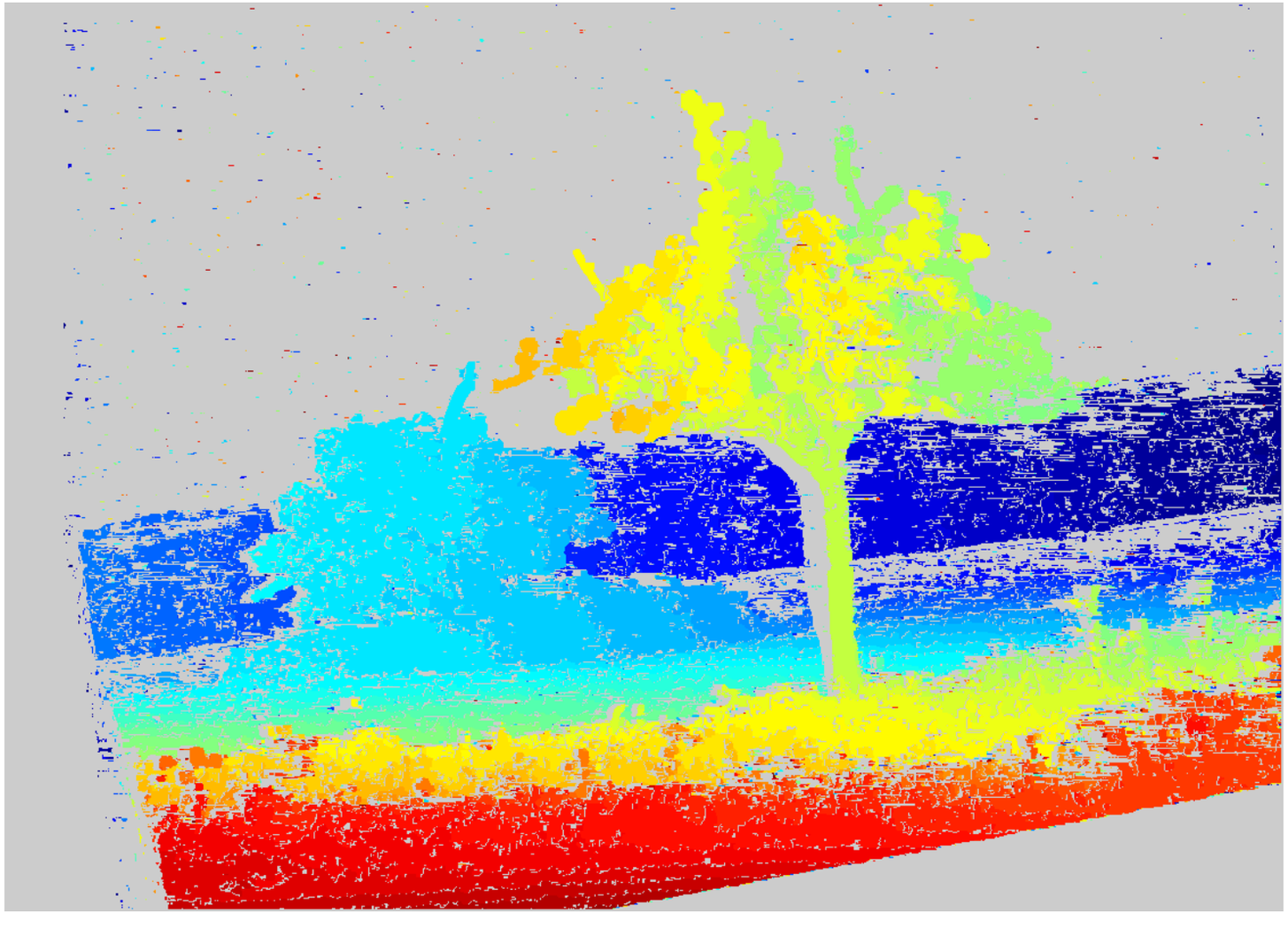

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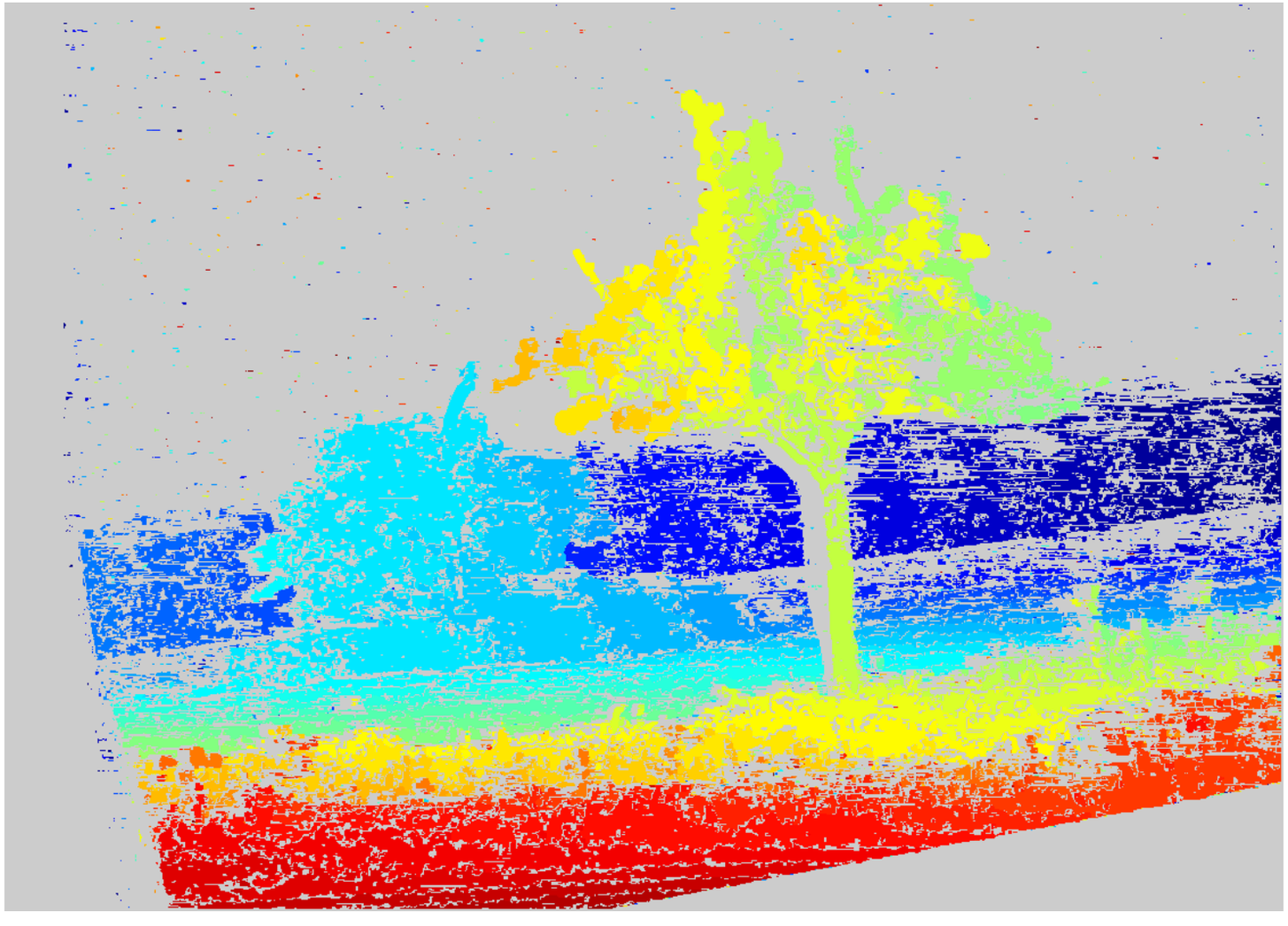

confidence interval width 1.5% [of NCC range]

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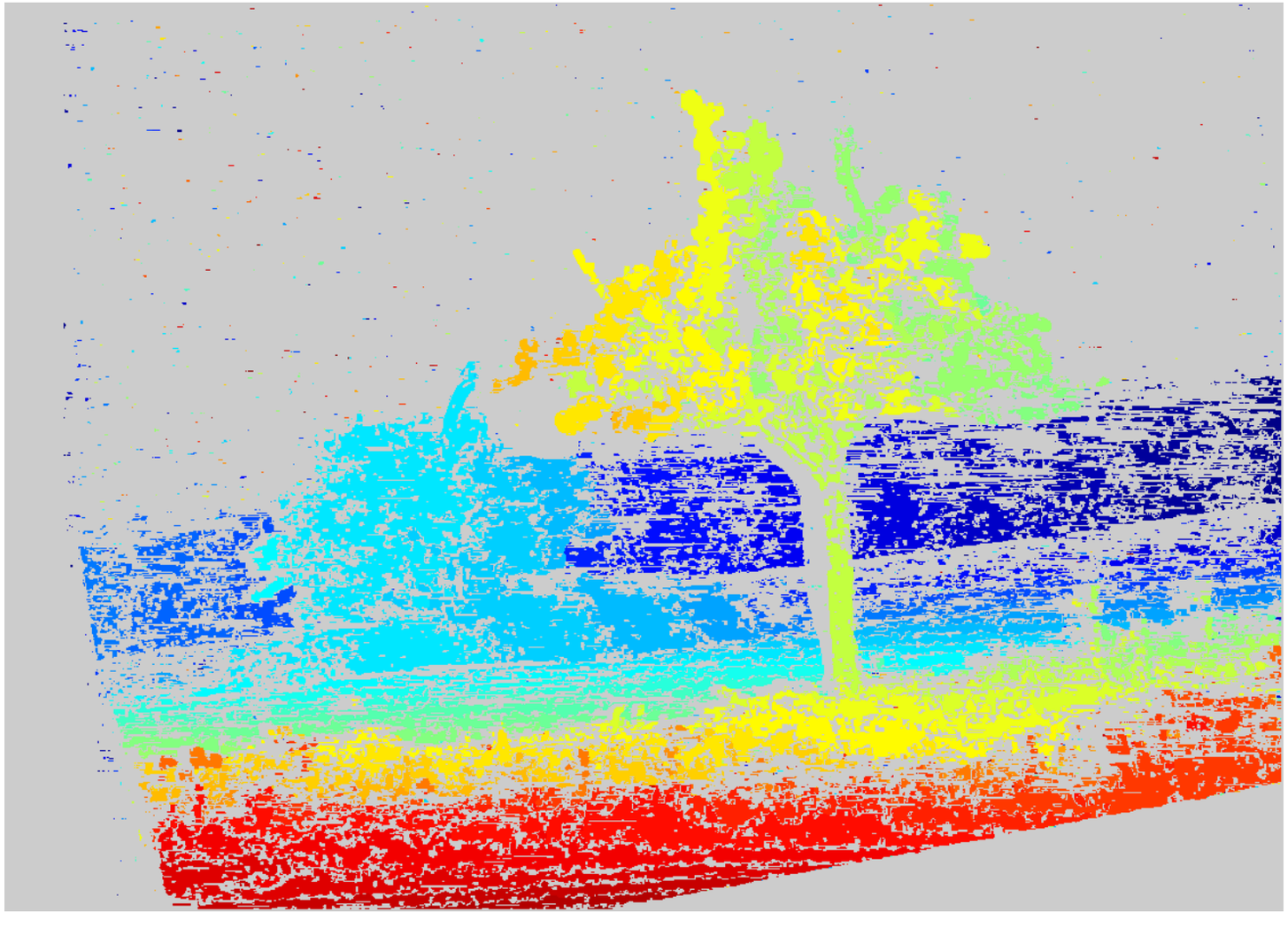
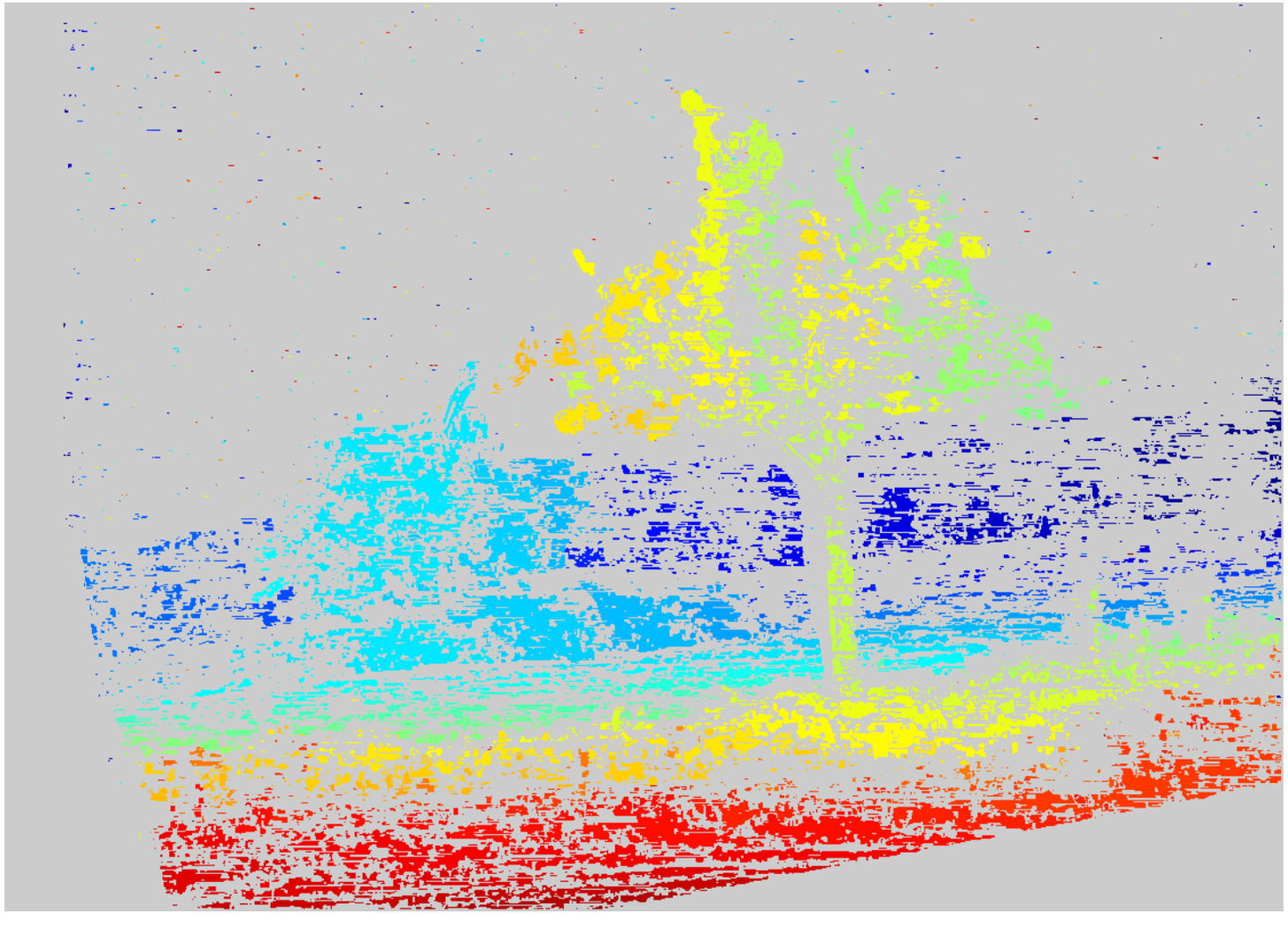
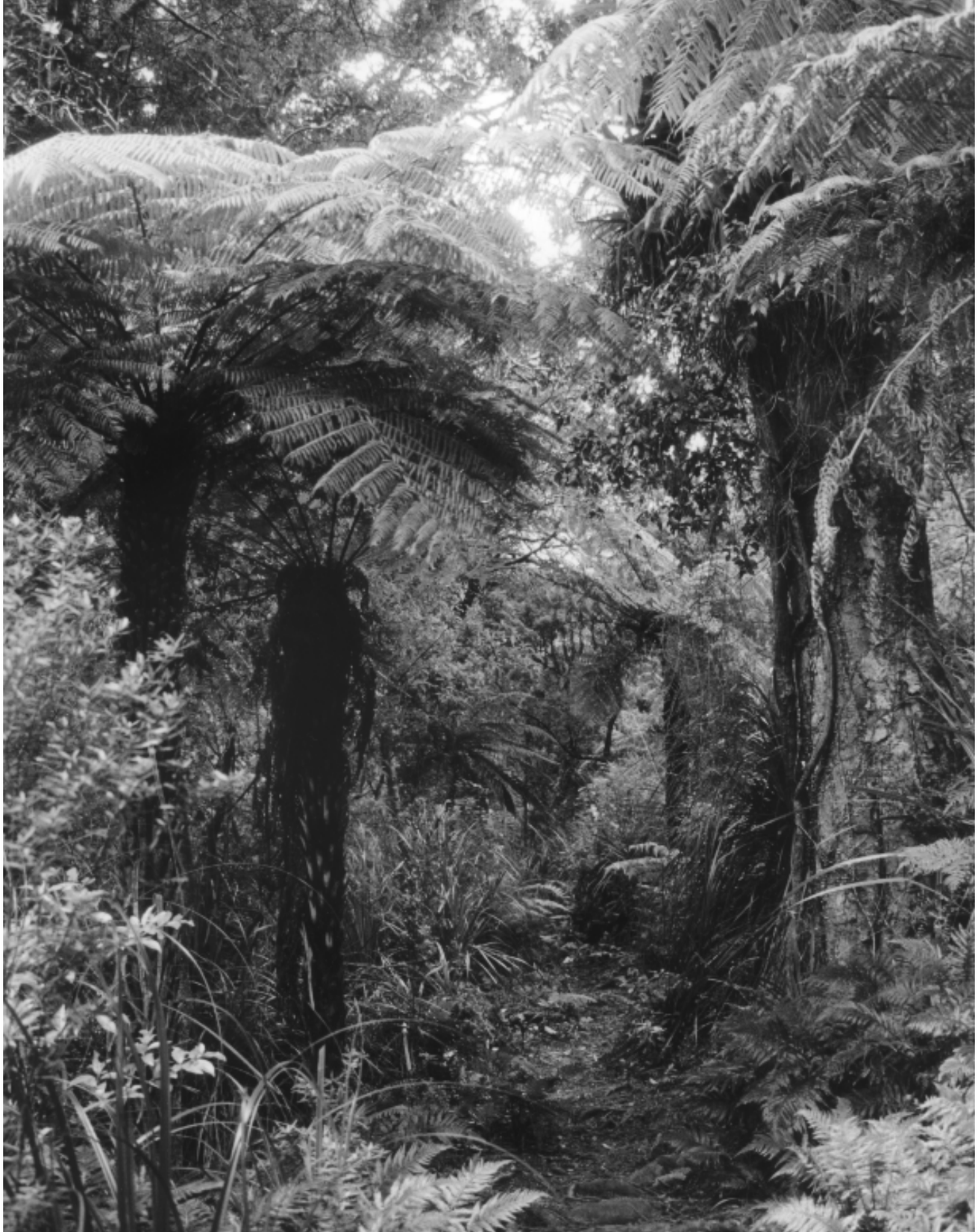
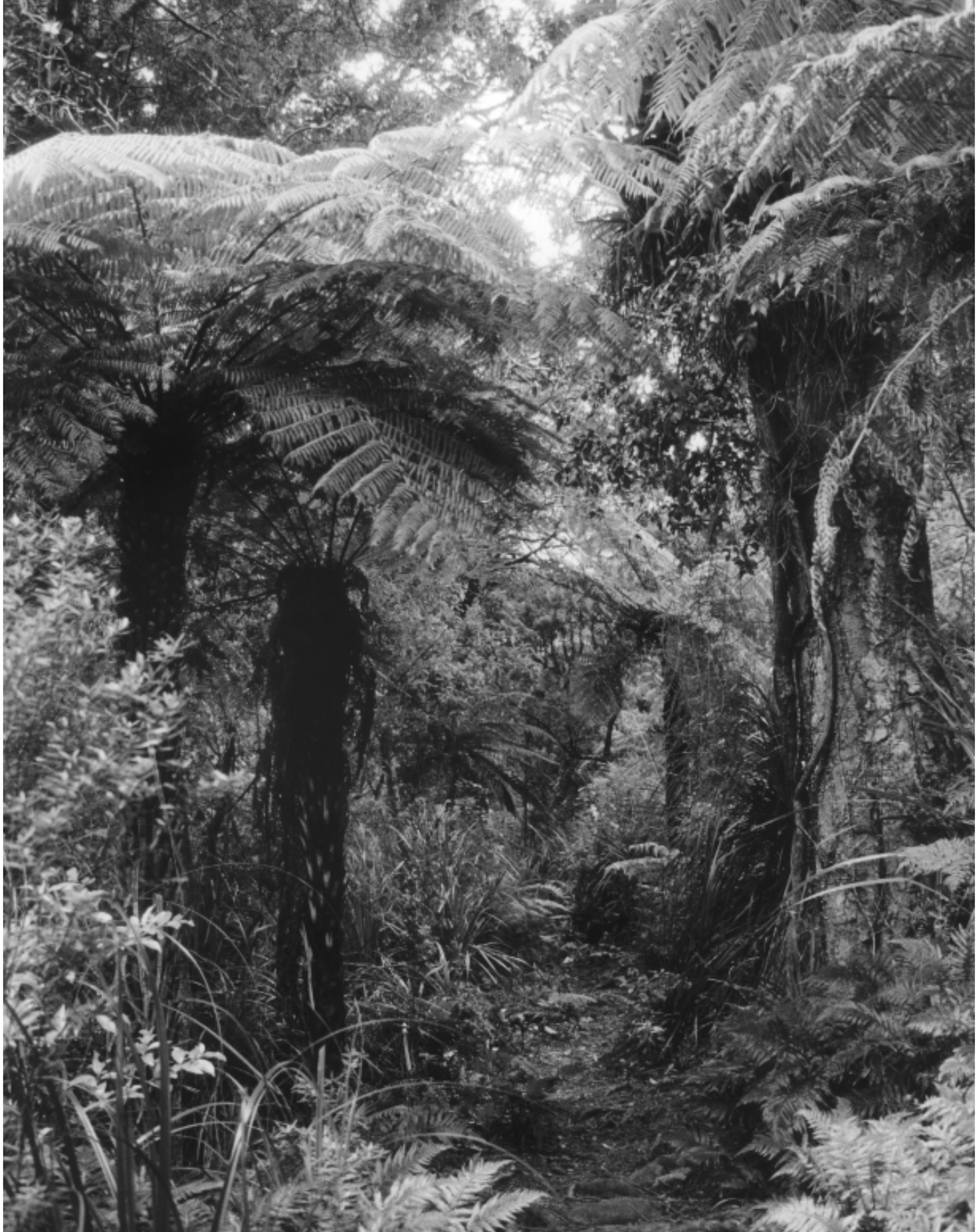
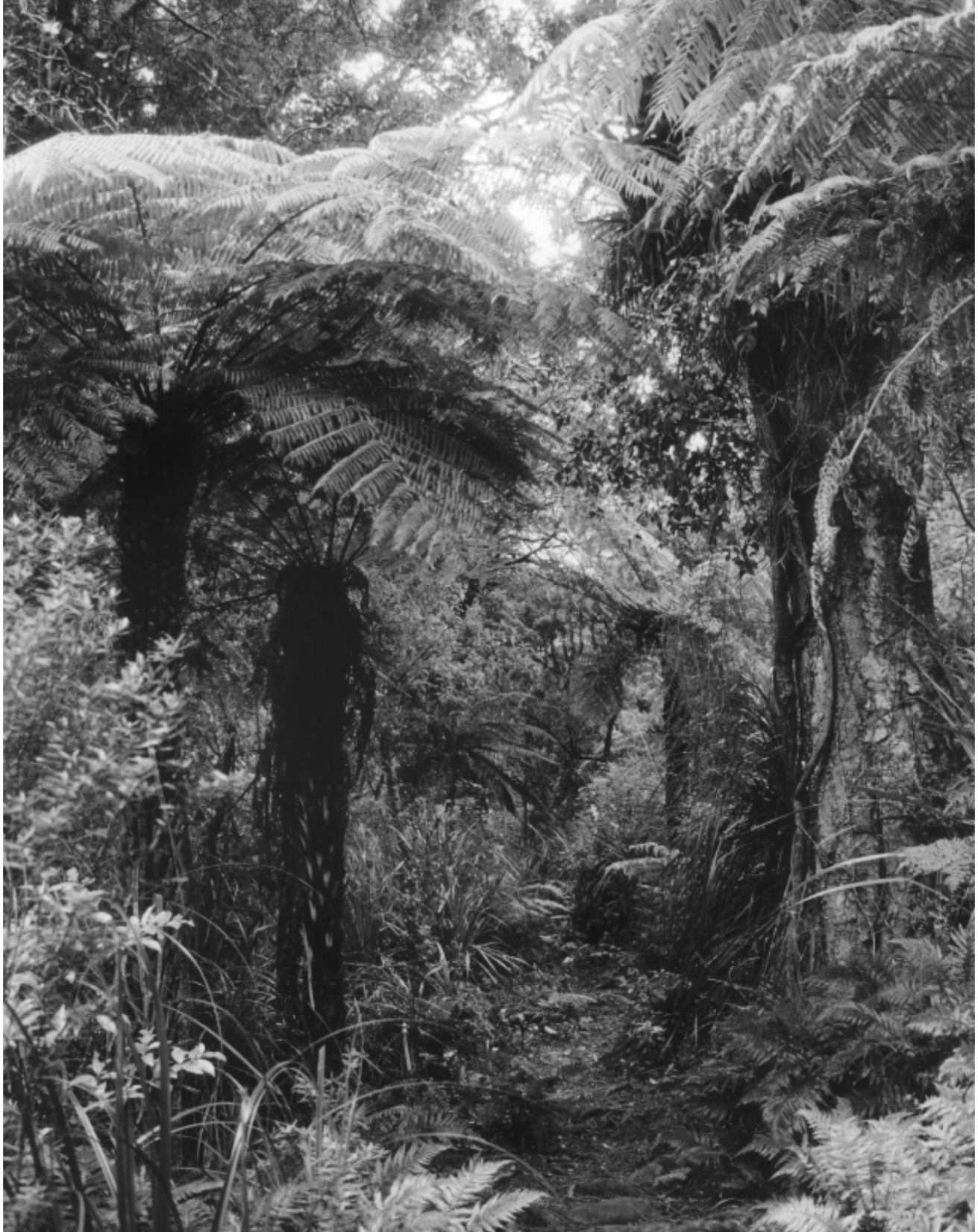
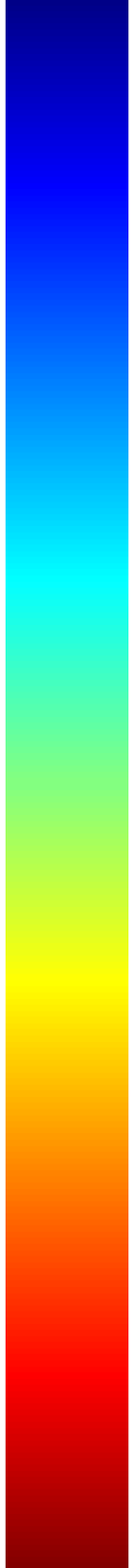
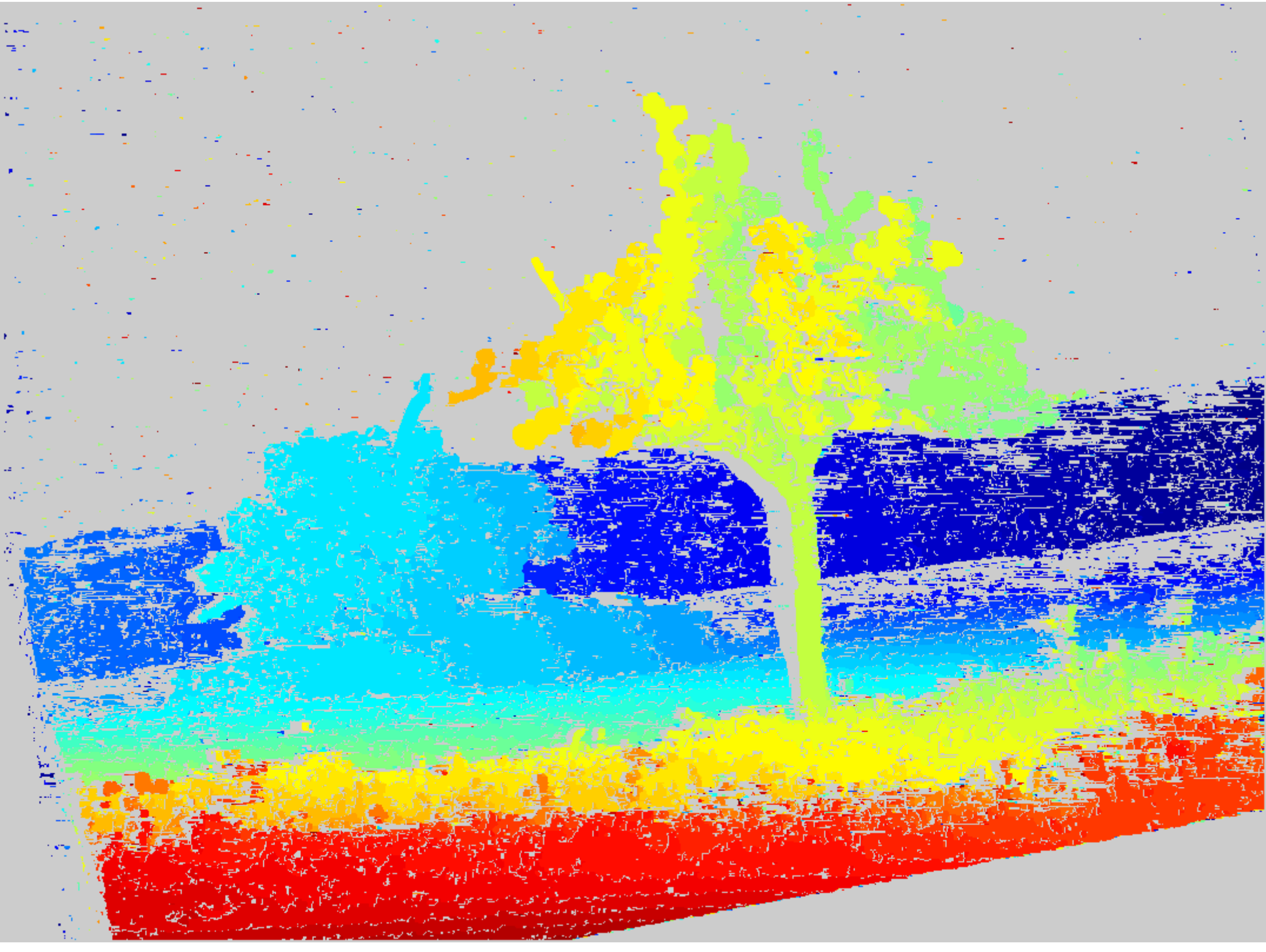


confidence interval width 2.5% [of NCC range]

Changing confidence level



confidence interval width 5% [of NCC range]

Conclusions

- **Stability is a property** of tentative match subsets / no cost functional
- **Ambiguous matches rejected** 'at given confidence level'
- **Low error rate:** would be ranked 1st–4th on the Middlebury Dataset
  http://www.middlebury.edu/stereo/
- **Flexible**: leaves space for many generalizations:
  - sparse matching ⇝ bootstrapped wide-baseline stereo
  - increasing matching problem dimension ⇝ tracking
  - graph orientation weakly constrained ⇝ multi-source evidence combination
- . . . opens many questions . . .