Assessing Annotation Accuracy in Ice Sheets Using Quantitative Metrics

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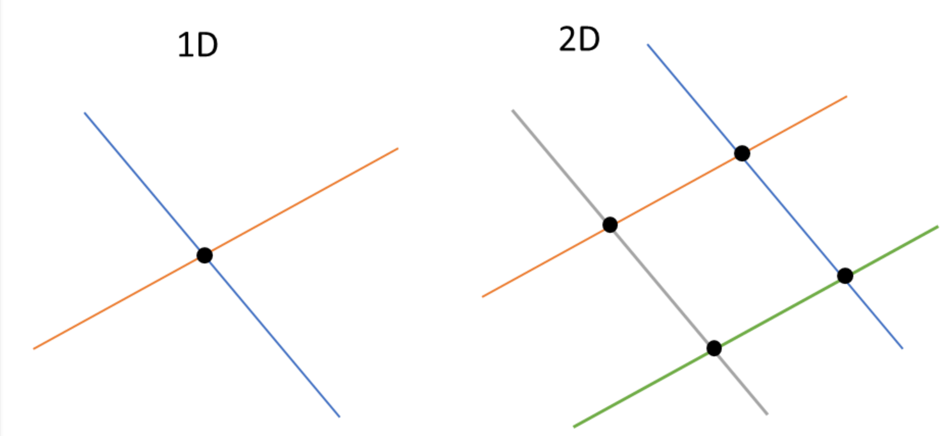
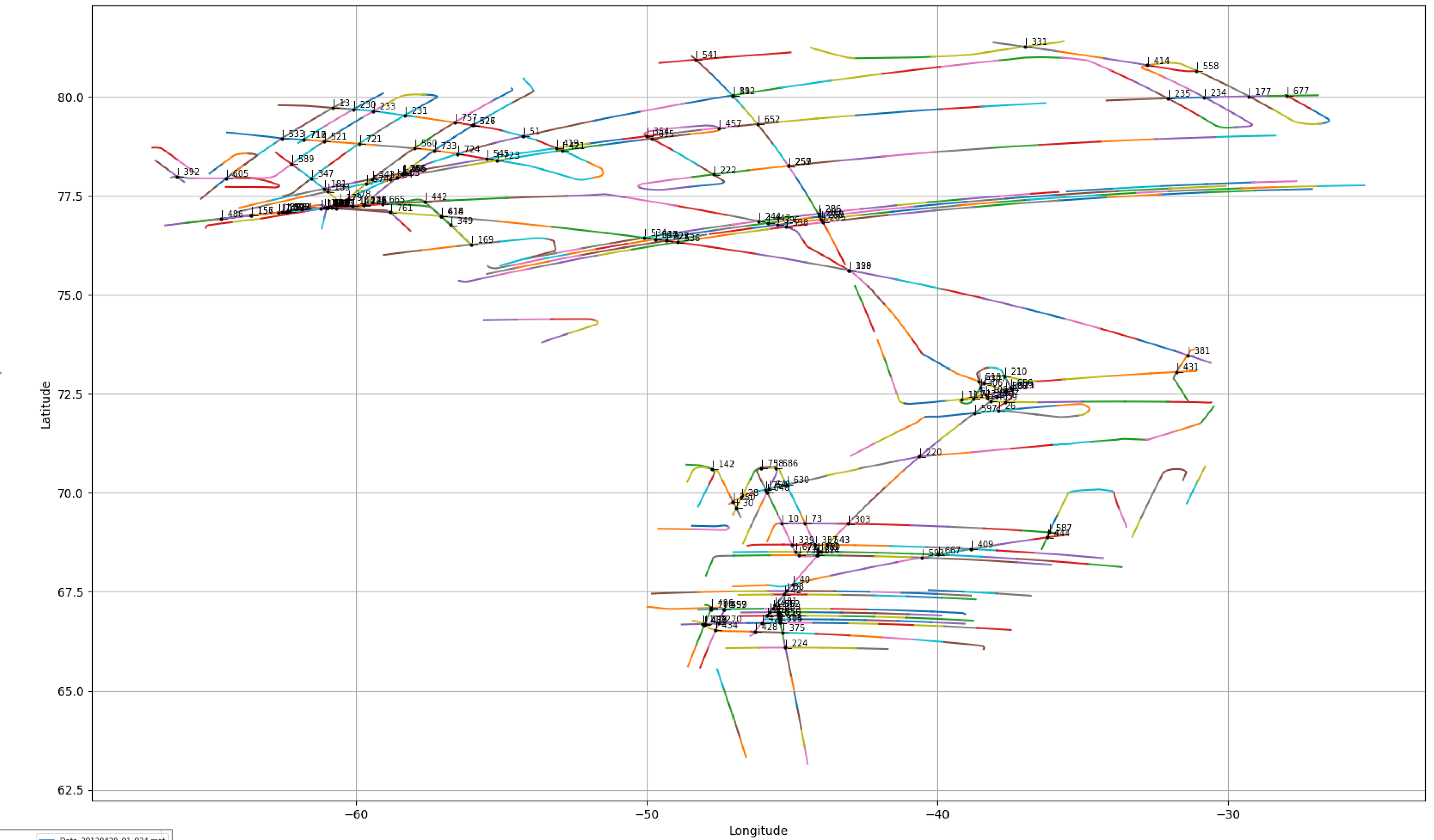
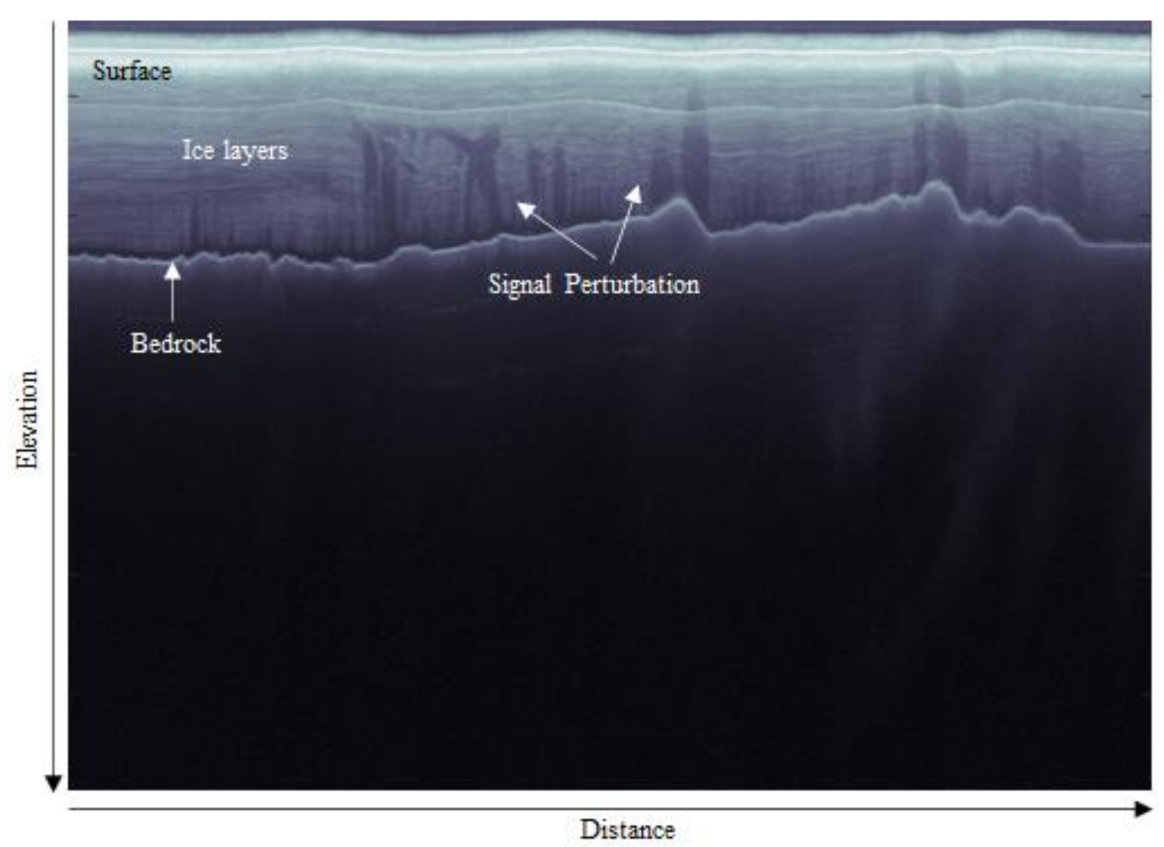
MOTIVATIONS

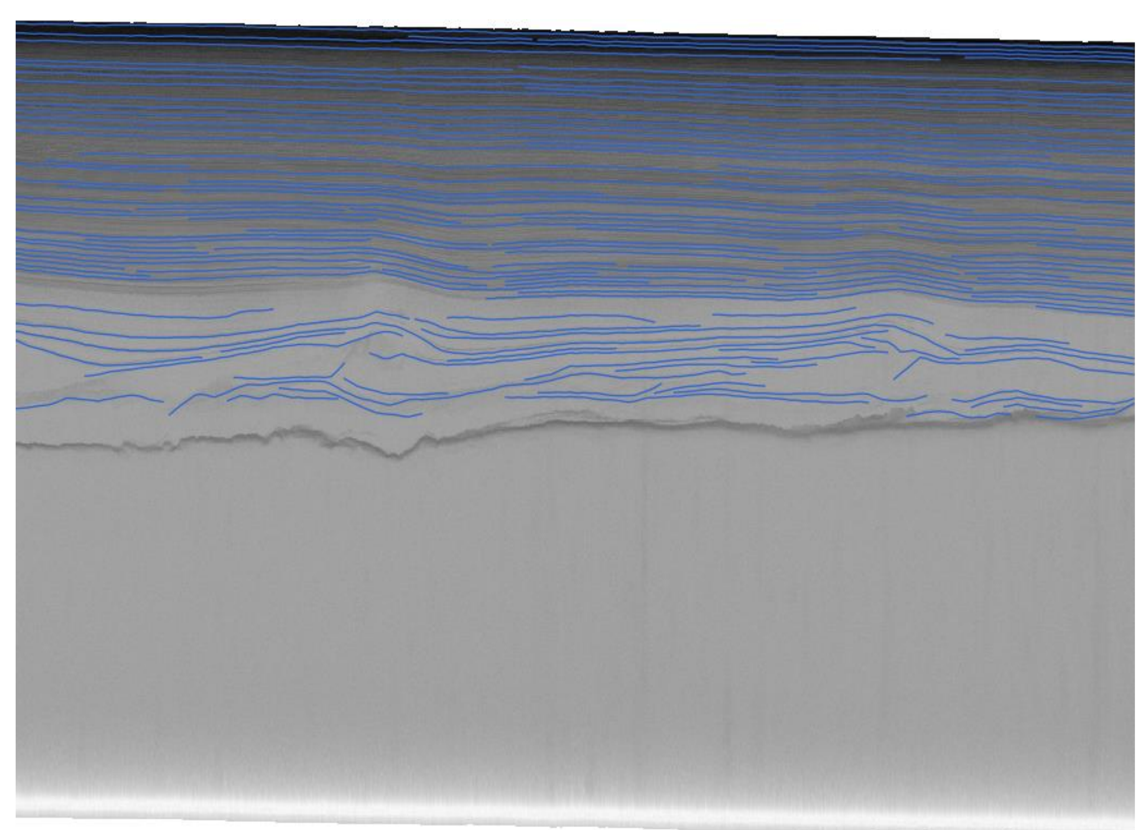
- The study of ice sheets through radargrams that capture layers of ice accumulation plays a crucial role in understanding climate, past snowfall trends, the impact of climate change, and sea level rise.
- Current ice layer-tracing algorithms encounter multifaceted challenges:
  - Manual annotation of ice layers by experts (i.e., glaciologists), although of high quality, requires considerable time and effort and may be incomplete.
  - The absence of a standardized automated approach leads to significant variability in annotation accuracy.
  - There is a lack of standardized evaluation metrics for assessing the reliability of annotations.



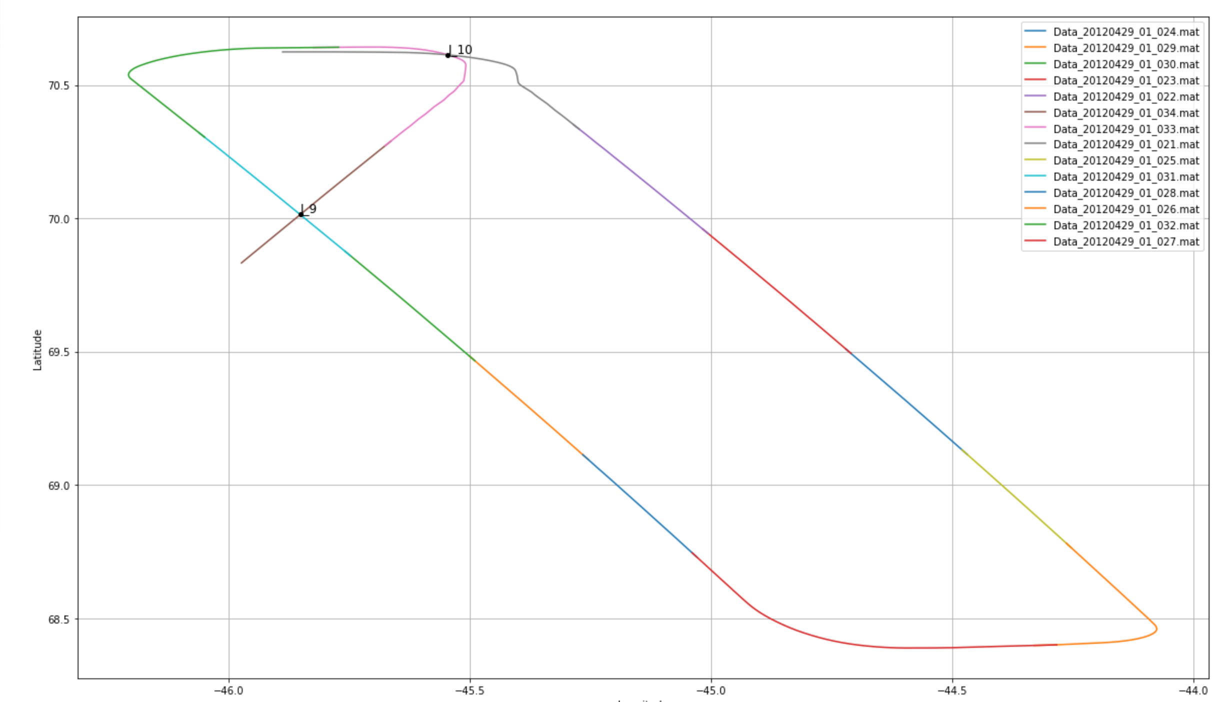


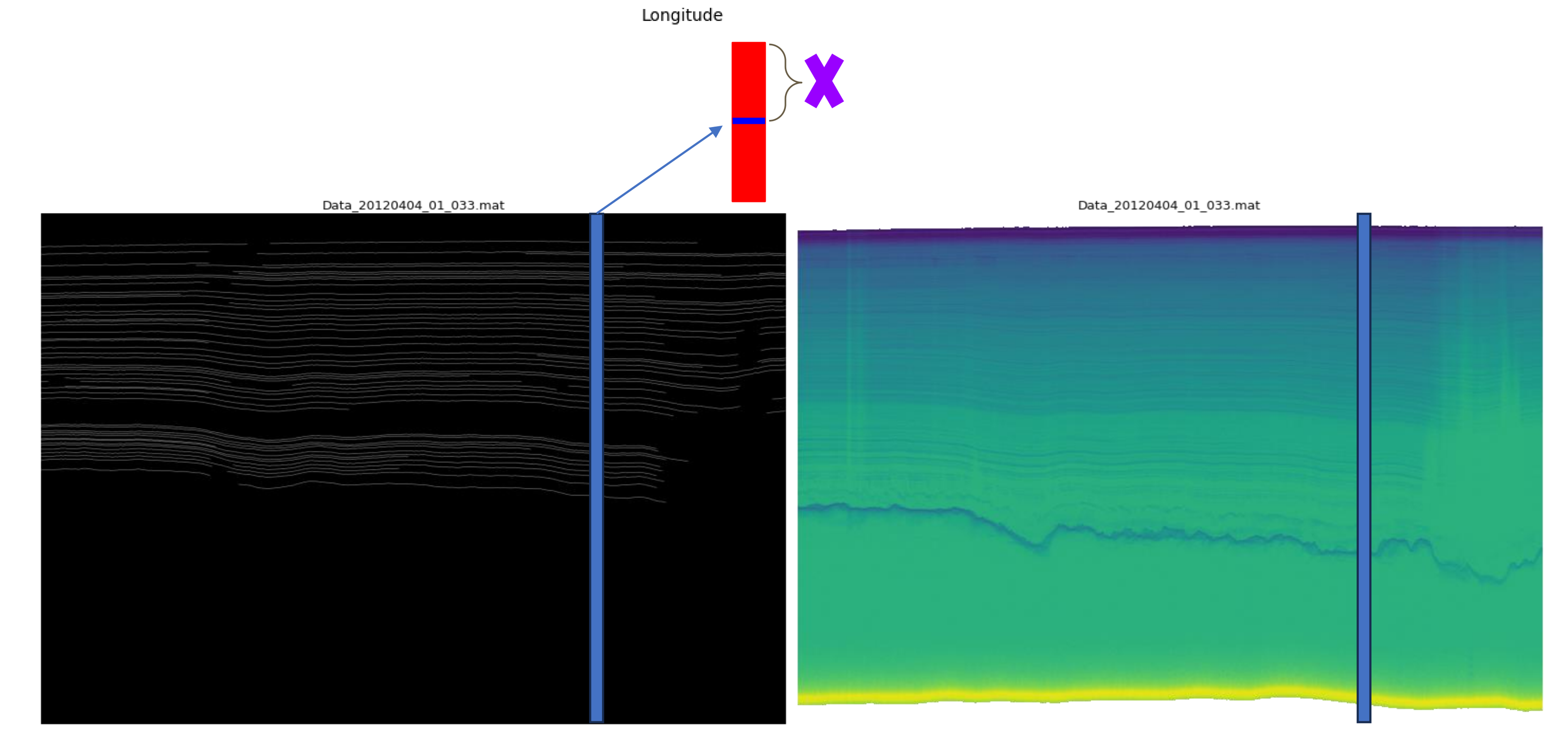


Raw Radargram



Annotated Radargram





Algorithm 1: Dip Estimation and Comparison

Require: $mask^a$, $mask^{gl}$, window_size
- Initialize dip_mask^a and dip_mask^{gl} as zero arrays with dimensions of $mask^a$ and $mask^{gl}$, respectively.

for each point in $mask^a$ and $mask^{gl}$
- Select a window_size.
- Compute transitions in the window.
- Calculate y and x differences of transitions.
- Compute angles using $arctan2$ of y and x differences.
- Calculate average dip as mean of angles.
- Assign average dip to the corresponding point in dip_results.

end for
- Calculate Pearson correlation coefficient between dip_mask^a and dip_mask^{gl}.

Return Correlation coefficient ρ.

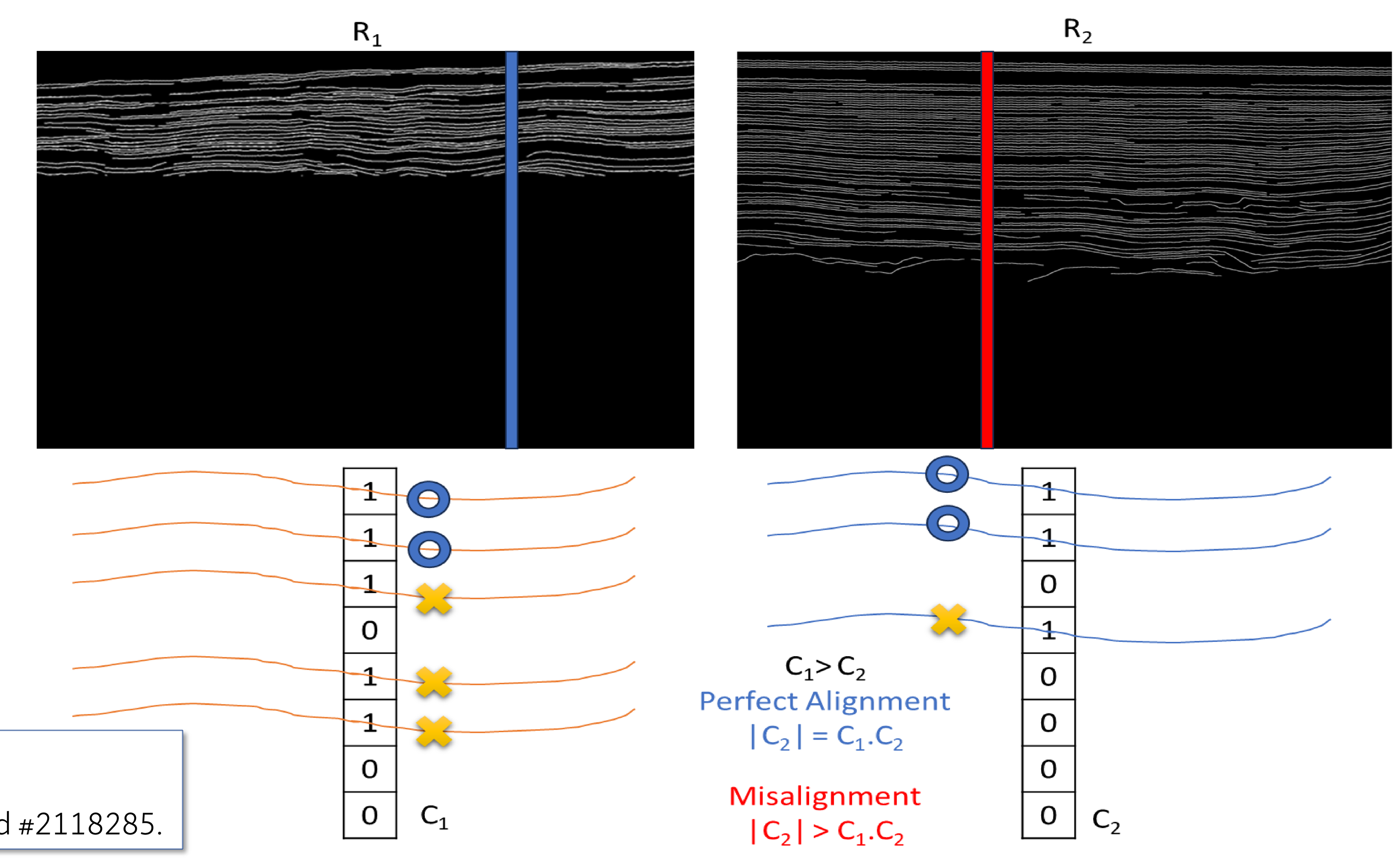
Algorithm 3: Recall Intersection over Union Calculation

Require: $mask^a$, $mask^{gt}$
- Compute the overlap as the sum of element-wise logical AND between $mask^a$ and $mask^{gt}$.
- Compute the total number of positive pixels in $mask^{gt}$.
- Calculate Recall IoU as the ratio of overlap to the total layers in $mask^{gt}$.

Recall IoU $= \frac{\text{Overlap}}{\text{Total Layers in } mask^{gt}}$.

Return Recall IoU.

Method	$\rho_{dip}\uparrow$	$rIoU^g\uparrow$
Baseline	0.527±0.190	0.633±0.185
MLT_1^h	0.478±0.153	0.636±0.164
MLT_2^h	0.504±0.190	0.669±0.165
MLT_3^h	0.489±0.185	0.693±0.158
MLT_1^d	0.459±0.149	0.650±0.159
MLT_2^d	0.454±0.153	0.663±0.160
MLT_3^d	0.482±0.158	0.670±0.134
MLT_4^d	0.547±0.184	0.692±0.154



ACKNOWLEDGEMENT

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