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Retrieving spatial-temporal dynamics of hydrology from scanned historical maps

Sidi Wu Institute of Cartography and Geoinformation (IKG) 23.09.2022

#### Background: HistoRICH project

Historical river change – Planning for the future by exploring the mapped past





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Task	Research interest				
Feature extraction	Segmentation uncertainty and its applications				
Temporal feature extraction	Domain adaptation				
Temporal feature alignment	Map image registration				







# Segmentation uncertainty and its applications Background

- 1. Challenges in segmenting historical maps:
  - Diversity and inconsistency in map designs and symbolic representations
  - Confusion in similar symbolic representations between different feature classes
  - Incompleteness of legends and documentations
  - Graphical flaws from original painting, scanning and aging process



- 2. Types of uncertainty:
  - Aleatoric uncertainty: noise inherent in observations (e.g., sensor noise, data noise), which can't be reduced with more training data
  - Epistemic uncertainty: imperfectness in model parameters (lack of knowledge), which can be reduced with more training data



# Segmentation uncertainty and its applications Previous work



Q1

02

[Wu et al (2022). A Closer Look At Segmentation Uncertainty Of Scanned Historical Maps  $\overline{0}$ 

[Wu et al (2022). Leveraging Uncertainty Estimation and Spatial Pyramid Pooling for Extracting Hydrological Features from Scanned Historical Topographic Maps]

Q1: 60%, Q2: 80%, Q3: 90%

0

01

02

Q3

0

Q1

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Q2 Q3 1

## Segmentation uncertainty and its applications Previous work

			Dice					F1					Precision					Recall		
Refine	avg	stream	wetland	river	lake	avg	stream	wetland	river	lake	avg	stream	wetland	river	lake	avg	stream	wetland	river	lake
-	0.829	0.942	0.752	0.906	0.718	0.871	0.954	0.830	0.912	0.783	0.829	0.940	0.747	0.895	0.734	0.917	0.968	0.933	0.929	0.838
Entropy	0.843	0.965	0.789	0.893	0.726	0.878	0.963	0.853	0.899	0.792	0.872	0.967	0.808	0.873	0.841	0.884	0.958	0.902	0.928	0.748
Variance	0.843	0.965	0.793	0.890	0.721	0.876	0.963	0.857	0.897	0.786	0.850	0.969	0.810	0.866	0.757	0.903	0.956	0.910	0.930	0.816
LCE	0.858	0.965	0.840	0.894	0.731	0.886	0.963	0.883	0.900	0.795	0.864	0.967	0.855	0.876	0.759	0.908	0.958	0.913	0.925	0.834

Refinement using different uncertainty quantifiers









#### Segmentation uncertainty and its applications Future work – contextual uncertainty



green – river, blue – lake, resolution – 1.25m/pixel, input size – 256\*256, output size – 128\*128

#### Segmentation uncertainty and its applications Future work – contextual uncertainty





### Segmentation uncertainty and its applications Future work – contextual uncertainty





- Detect unfavorable context?
- Determine the best context?
- Adaptative context?

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#### Map image registration Background

• Temporal misalignment after being geo-referenced using the same method



Possibly because of:

- Surveying
- Generalization
- Painting
- Production
- Map distortions



Proposed method





[Wu et al (2022). Unsupervised Historical Map Registration by a Deformation Neural Network]



• Performance

	Average Misalignment (m)				
Method	Small(<=10)	Medium (10,20]	Large (>20)		
Unregistered	5.89	15.15	26.43		
Deformation + Translation [16] (image-based loss)	5.21	15.15	26.43		
Deformation + Translation [16] (DF-based loss)	13.45	10.93	21.51		
Proposed (image-based loss)	5.55	15.15	26.43		
Proposed (DF-based loss)	2.72	7.73	16.81		



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• Potential applications – apply deformation directly to the vector features



- Vector of the source image
- Deformed vector to align with the target image (base map)



#### Map image registration Future work – Refining the deformation network

- Investigate a multi-layer deformation network to separate objects with different deformations
- Add change detection to separate features to be / not be changed







#### Domain adaptation Current work

Method Overview





#### Domain adaptation Current work

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#### Domain adaptation Future work

- Domain adaptation in the input space (image-to-image translation)
  - **D** Paired images
  - Unpaired images









### Other potential research – evaluating extracted features

- Compare temporal data
- Compare with external sources (aerial images) -> "if" but not "where"? (location error and map generalization)





