Strabo:
A Complete System for Label Recognition in Maps

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USC spatial sciences

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Motivation

USC spatial sciences

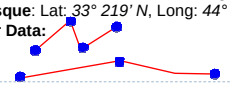
- Maps are a rich source of geospatial data:
  - Easily accessible - you can easily obtain printed maps for many places around the globe (volume)
  - Many different types of information (variety)
  - Often contains information that cannot be found elsewhere

Now I understand!

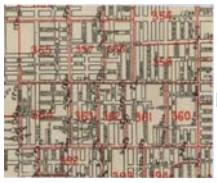
But the information is locked in the images

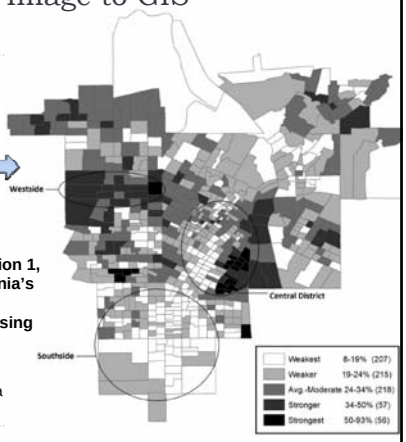
Strabo

Kadhi Tourist Hotel: Lat: *33° 2012' N*, Long: *44° 263' E*
Abdhali Mosque: Lat: *33° 219' N*, Long: *44° 228' E*
Road Vector Data:



From Scanned Image to GIS Usable Format

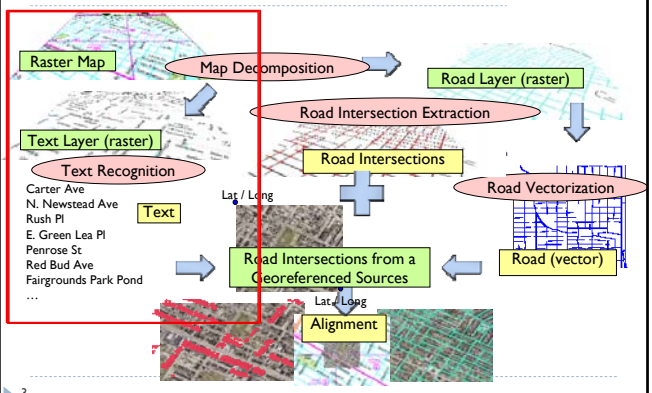




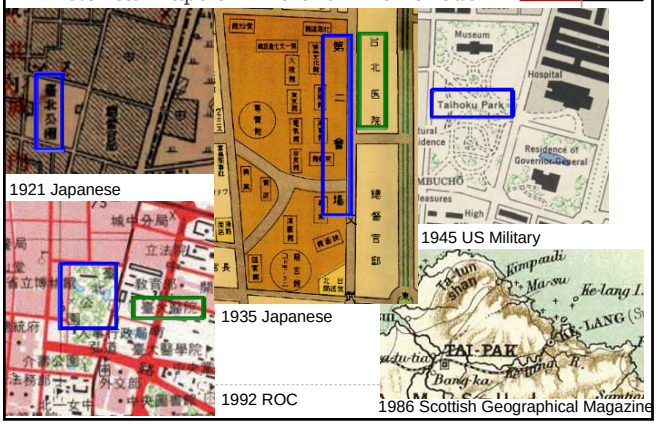
Opposition Vote for Proposition 1, the 1920 extension of California's alien land law that prevented Japanese from owning or leasing land (Los Angeles, 1920)

Lon Kurashige, Southern California Quarterly, 2013 by The Historical Society of Southern California.

Harvesting Geographic Features From Heterogeneous Raster Maps

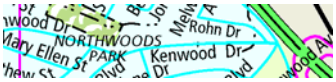


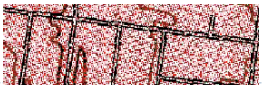
Various Toponym of the Same Place in Historical Maps of Different Time Periods

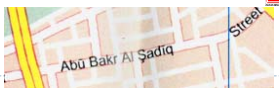


Map Processing Challenges

- It is difficult to unlock the geospatial information in raster maps:
  - There is limited access to the meta-data
  - They have overlapping features
  - They often have poor image quality
- Previous work is typically limited to a specific type of map and often relies on intensive manual work

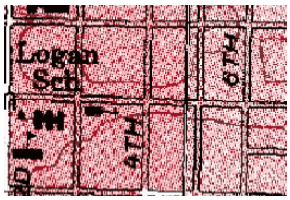


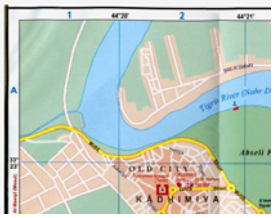




Scanning and Compression Noise

- Raster maps may contain noise from scanning and compression process

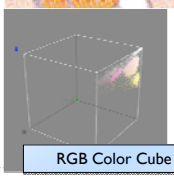




Numerous Colors in Scanned Maps

- Manually examining each color for extracting features is laborious

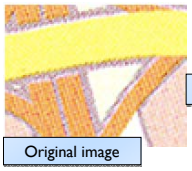
285,735 colors



RGB Color Cube

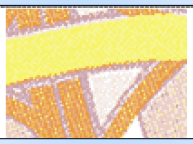
Color Segmentation by Analyzing Color Space

- Analyze only color space for color segmentation does not work for feature extraction purpose
  - Colors of individual features do not merge



Original image

After K-means (16 colors)

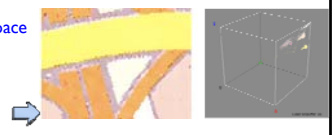


After Median-Cut (16 colors)

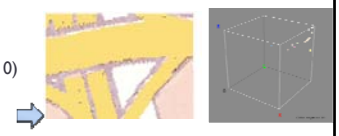
Each color is represented by a grayscale level

Color Segmentation with Spatial Information

- The Mean-shift algorithm
  - Consider distance in the color space and in image space
  - Preserve object edges
  - Reduce the colors by 50%

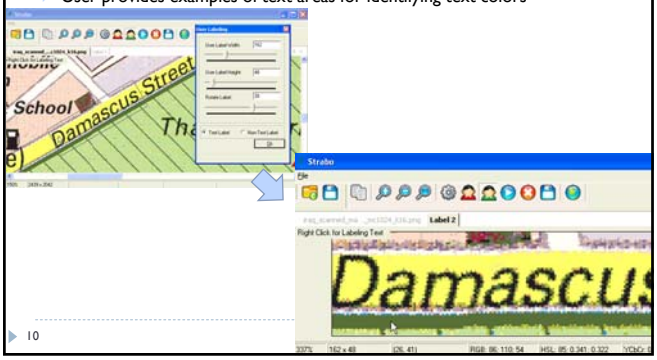


- The K-means algorithm
  - Limit the number of colors to K
  - From 155,299 to 10 colors (K=10)



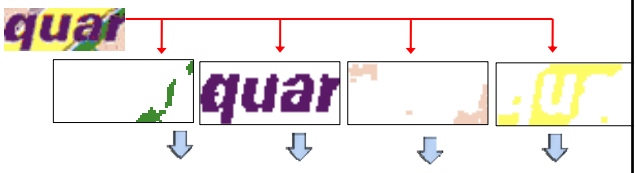
Supervised Extraction of Text Layers

- Use color segmentation to reduce the number of colors
- User provides examples of text areas for identifying text colors



Determine Text Colors

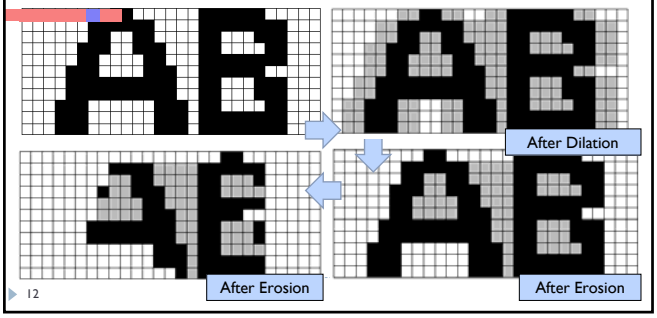
- Decompose a user label into images, each of the images contains one color
- Apply Run Length Smoothing algorithm (RLSA) to identify text colors



Run Length Smoothing Algorithm (RLSA)
->Next slide

RLSA Example

- A RLSA example using a 5x1-pixel window



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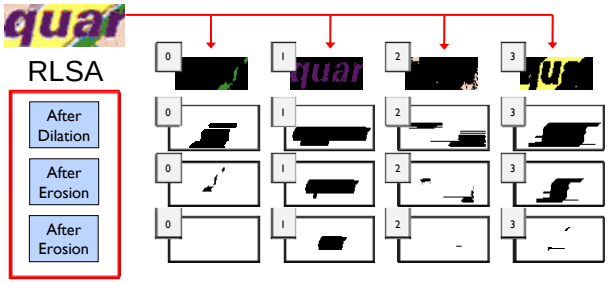
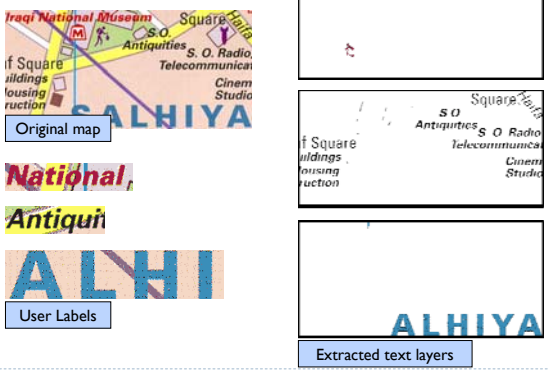


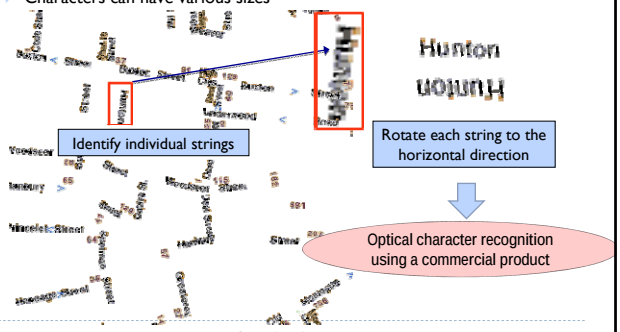
Extracted Text Layers



Fourth Contribution: Text Recognition

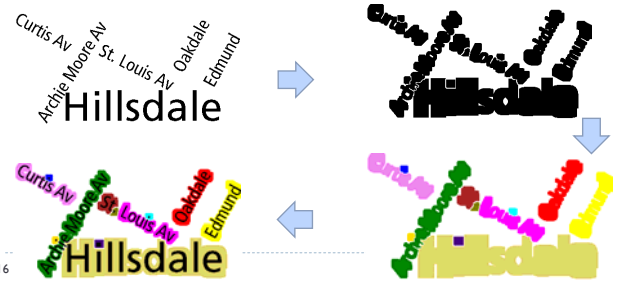
Text Recognition from Identified Text Layers

- Multi-oriented text labels
- Characters can have various sizes



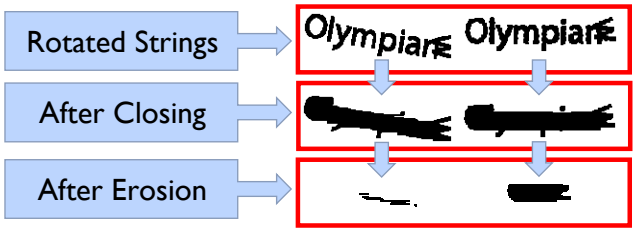
Identify Individual Strings

- Conditional Dilation Algorithm:
  - Expand the foreground area of the connected components (i.e., characters) when certain conditions meet
  - To determine the connectivity between the characters



Detect String Orientation

- Rotate a string from 0° to 180°
- Apply Run Length Smoothing algorithm

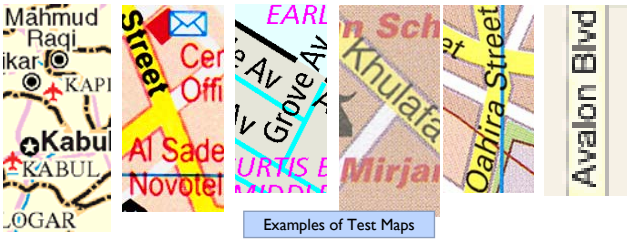


Recognize Characters in the Horizontal Text Strings

- Feed the horizontal text strings to a commercial OCR product
- Use the OCR returned confidence to determine the correctly oriented horizontal string
  - Number of suspicious characters
  - Number of recognized characters

Experiments

- Tested on 15 maps from 10 sources
- Tested the 15 test maps using an OCR product called ABBYY FineReader alone for comparison



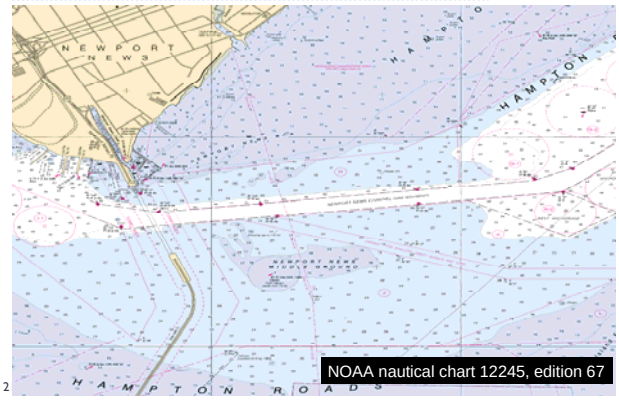
Examples of Test Maps

Experiments (Cont'd)

- Strabo extracted 22 text layers using 74 user labels (avg. 3.36)
- Strabo extracted 6,708 characters and 1,383 words
- ABBYY FineReader extracted 2,956 characters and 655 words

	Char. P.	Char. R.	Char. F.	Word P.	Word R.	Word F.
Avg. (Strabo)	92.77%	87.90%	90.32%	82.02%	77.58%	79.70%
Avg. (ABBYY)	71.99%	30.00%	42.44%	46.11%	20.64%	28.52%

In Practice: Text Recognition on Nautical Charts



Extraction Precision/Recall

Time Requirement

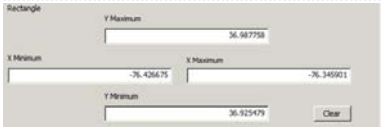
Strabo Steps	Time (H:MM:SS) User Time	Elapse Time
1. Color Segmentation	N/A	N/A
2. Providing Text Samples	0:01:04	0:01:04
3. Processing the Text Samples to Extract Text Layers	0:00:00	0:00:11
4. Processing Text Layers to Identify Individual Text Labels	0:00:00	0:16:17
5. Executing ABBYY FineReader to Recognize Text Labels	0:00:00	0:04:47
6. Saving ABBYY FineReader OCR Results	0:00:00	0:18:59
7. Generating Shapefiles	0:00:00	0:09:49
Total Time	**0:01:04**	**0:51:07**

Table 1. The required time for using Strabo for text recognition in the test map

ArcGIS Steps	Time (HH:MM:SS) User Time	Elapse Time
1. Post-editing to Delete Incorrect Results	0:12:46	0:12:46
2. Post-editing to Add Missing Results	0:20:39	0:20:39
3. Post-editing to Verify Results	0:23:13	0:23:13
Total Post-Editing Time	**0:56:38**	**0:56:38**

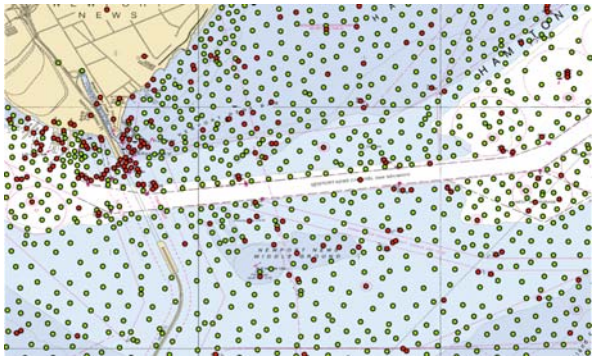
Table 2. The required time for post-editing in ArcGIS

Positional Accuracy

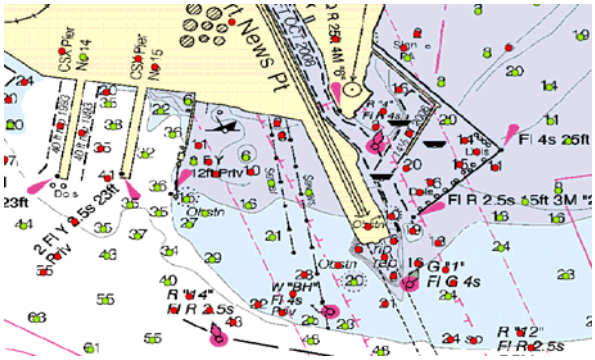


Label Count	917
Minimum Distance	0 (decimal degrees)
Maximum Distance	0.002296 (decimal degrees)
Distance Sum	0.01332 (decimal degrees)
Distance Mean	0.000015 (decimal degrees)
Distance Standard Deviation	0.000155 (decimal degrees)

Error Distribution



Error Distribution (Cont'd)



Related Work

- Work on one type of map (Fletcher and Kasturi,88; Bixler, 2000; Chen and Wang, 97)
- Require training for each input map (Adam et al., 00; Deseilligny et al., 95; Pezeshk and Tutwiler, 10)
- Require manual processing to prepare each string for OCR (Cao and Tan, 02; Li et al., 00; Pouderoux et al., 07; Velazquez and Levachkine, 04, ABBYY FineReader, 10)
- Require additional knowledge of the input map (Gelbukh et al., 04; Myers et al., 96)

Conclusion: Contributions

- A general approach to recognizing text labels in heterogeneous raster maps
- Not limited to a specific type of map
- Handle raster maps with varying map complexity, color usage, and image quality
- Require minimal user input
- Outperform state-of-art commercial products with considerably less user input

Discussion and Future Work

- Strabo is an open source library
- We are working with the TerraGo Technologies to build commercial package for text recognition on maps

terraGo TECHNOLOGIES

- Current Implementation Limitation and Research extensions:
  - Current user interface takes only 4k-by-4k maps
  - Recognize languages other than English
  - Handle monotone, B/W maps
  - Will incoperate additional knowledge of the map region to improve text recognition

Questions?

Thank You

- Acknowledgement

The U.S. National Committee (USNC) to the International Cartographic Association

University of Southern California, Spatial Sciences Institute