From Map Images to Geographic Names

Yao-Yi Chiang
Sima Moghaddam
Sanjauli Gupta
University of Southern
California
Spatial Sciences Institute
Los Angeles, CA 90089, USA
[yaoyic,khashkha,
sanjaulg]@usc.edu

Renuka Fernandes
University of Southern
California
Spatial Sciences Institute and
Department of Electrical
Engineering
Los Angeles, CA 90089, USA
rvfernan@usc.edu

Craig A. Knoblock
University of Southern
California
Department of Computer
Science and Information
Sciences Institute
Los Angeles, CA 90089, USA
knoblock@isi.edu

ABSTRACT

Map labels provide valuable geographic information by annotating geographic phenomenona with text descriptions. However, many interesting and useful maps are only available as images and hence this information is not readily accessible in a Geographic Information System (GIS). Previous work on text recognition in maps considers maps as a special type of image to be processed using Optical Character Recognition (OCR) techniques and does not pay attention to the typical workflows in a GIS. As a result, to convert map labels into machine-readable text, a user has to switch between OCR and GIS software, transform the detected text locations from the image coordinates (in OCR) to the map coordinates (in GIS), and apply data import/export procedures. This tedious process limits the opportunity to access text information in maps. This paper presents ArcStrabo, an integration of our previous text recognition work and a GIS, which uses a GIS user interface, workflows, and data types to enable efficient training of text recognition algorithms for converting map labels to a table of geographic names. We show that ArcStrabo facilitates map digitization processes, eliminates the need for GIS users to learn additional OCR tools, and does not require manual data export/import procedures between GIS and OCR software.

Categories and Subject Descriptors

H.4.m [**Information Systems Applications**]: Miscellaneous—*Geographic Information Systems*; H.2.8 [**Database Management**]: Database Applications—*Spatial Databases and Geographic Information Systems*

General Terms

Algorithms, Design, Human Factors

Keywords

OCR, GIS, digital map processing, text recognition

1. INTRODUCTION

Converting map labels into machine-readable geographic names provides a unique opportunity to index and search digital map archives and to compare and integrate geographic information in maps with other sources. Although many Optical Character Recognition (OCR) and map processing systems exist [1, 2], a major problem in automatic text recognition in maps is that the interface between GIS and these systems is cumbersome and difficult to use. For example, the normal process for text recognition in maps using a GIS and an OCR product includes: 1. Loading a map image into the OCR product to generate machine-readable text and their locations in the image coordinates (in general, the top-left corner of an image coordinate system is (0, 0) and the bottom-right corner is (image width, image height)), 2. Exporting the recognized text and the text locations into a format that the OCR product supports (e.g., Microsoft Word or comma-separated values), 3. Converting the OCR results into a common GIS vector data format (e.g., Esri shapefile), 4. Importing the OCR results into a GIS, 5. Georeferencing the OCR results, and 6. Reviewing and editing the OCR results, including adjusting the recognized text locations, adding undetected text locations, and revising incorrectly recognized text strings. These steps are laborious and highly map dependent.

This paper addresses the challenges of how to utilize the typical workflows (e.g., adding and editing vector layers) and data types (i.e., raster and vector data) in a GIS to build an easy-to-use system to generate machine-readable geographic names from map images. We present ArcStrabo, which bridges the gap between GIS and OCR techniques (Figure 1). ArcStrabo is an interactive digital map processing tool that tightly integrates our previous text recognition work [2] with the user interface, workflows, and data types supported by conventional GIS products (e.g., Esri ArcMap).

In the remainder of this paper, Section 2 describes the ArcStrabo text recognition algorithm, Section 3 presents the ArcStrabo user interface and workflow, Section 4 presents related systems, and Section 5 discusses the future work.
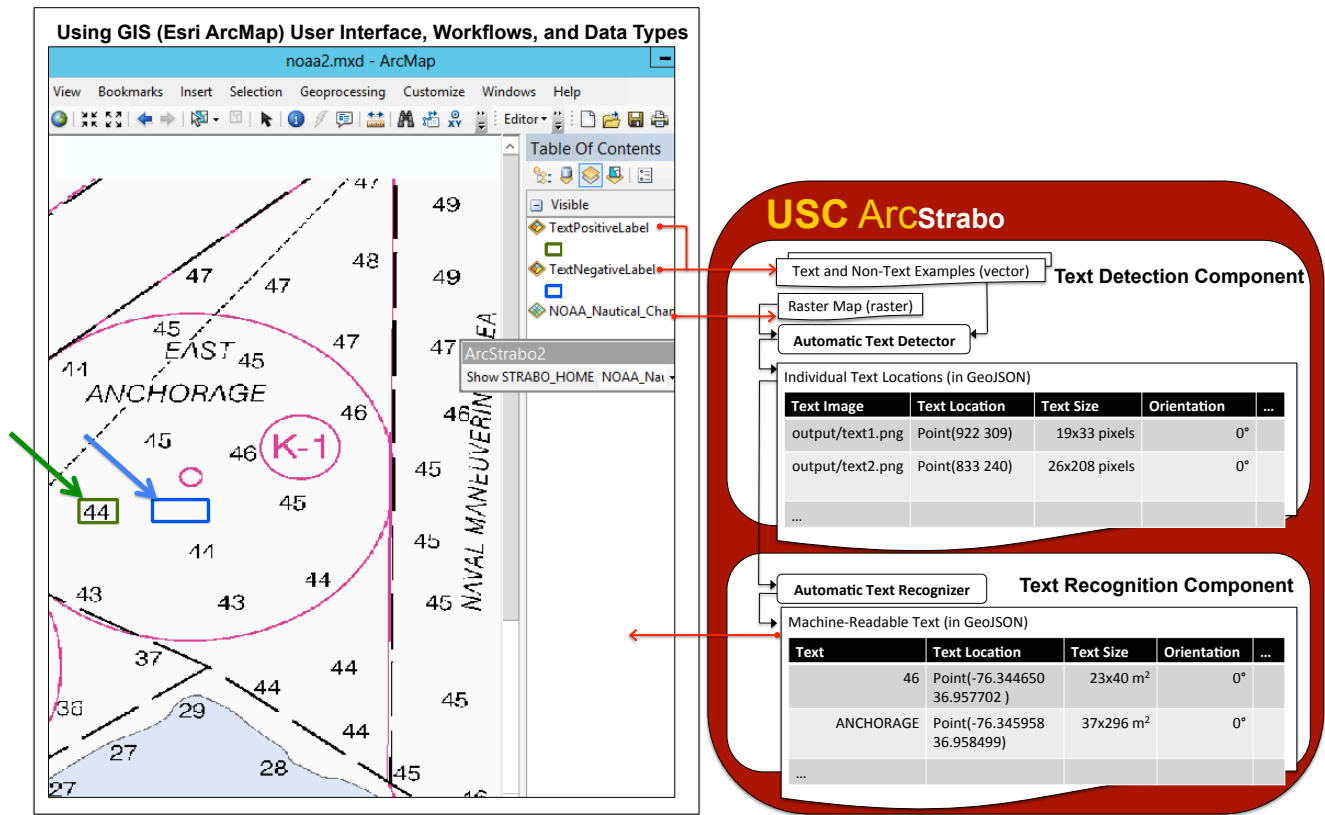
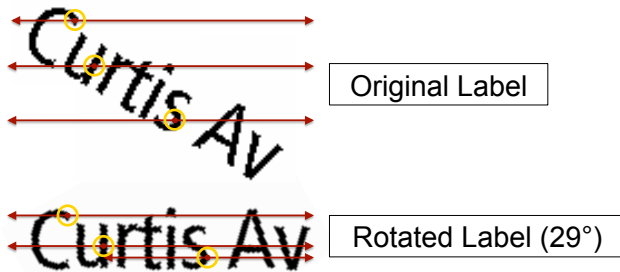**Figure 1: ArcStrabo architecture and an example use case**

Figure 2: Detecting label orientations

2. TEXT DETECTION AND RECOGNITION IN MAP IMAGES

In previous work, we developed a general approach that requires only a small amount of user effort to detect and recognize labels in map images [2, 3]. In our approach, the user utilizes a few examples of text and non-text areas to train the text detector for finding the text color(s) and extract the text pixels from an input map. A text example can be an area that contains one or more text strings and does not have to contain only text pixels, which makes the training process simple and user friendly. Once the text pixels are extracted, the text detector expands the pixel areas to group nearby pixels into characters and nearby characters into strings when certain conditions are satisfied. The conditions are based on cartographic labeling principles including

the rules that characters in one map label are similar in size and are closer than the characters in two separate labels.

Because map labels can be in various orientations, the text recognizer detects the label orientations to rotate every label to the horizontal direction so that they can be processed with OCR. The orientations are detected by first rotating each label at various angles. For each rotated label, the text recognizer draws a horizontal line from each text pixel and uses the number of pixels intersecting with the line to determine whether or not the characters in a string are aligned horizontally. Figure 2 shows that a horizontal line intersects with with more text pixels when the label is placed horizontally. Finally, the text recognizer uses an OCR package (e.g., Tesseract-OCR) to convert the text in the horizontal labels to machine-readable data.

3. ARCSTRABO WORKFLOW AND USER INTERFACE

Figure 1 shows the ArcStrabo architecture and an example use case. Figure 3 shows the ArcStrabo workflow and user interface. The input map is a nautical chart from the National Oceanic and Atmospheric Administration and the task at hand is to convert the black text layer (including soundings and place names) in the nautical chart into a GIS vector layer where the spatial component contains the geographic locations of map labels and the attribute component contains map labels in machine-readable format.

ArcStrabo employs a text detection component that detects individual label locations and a text recognition com-
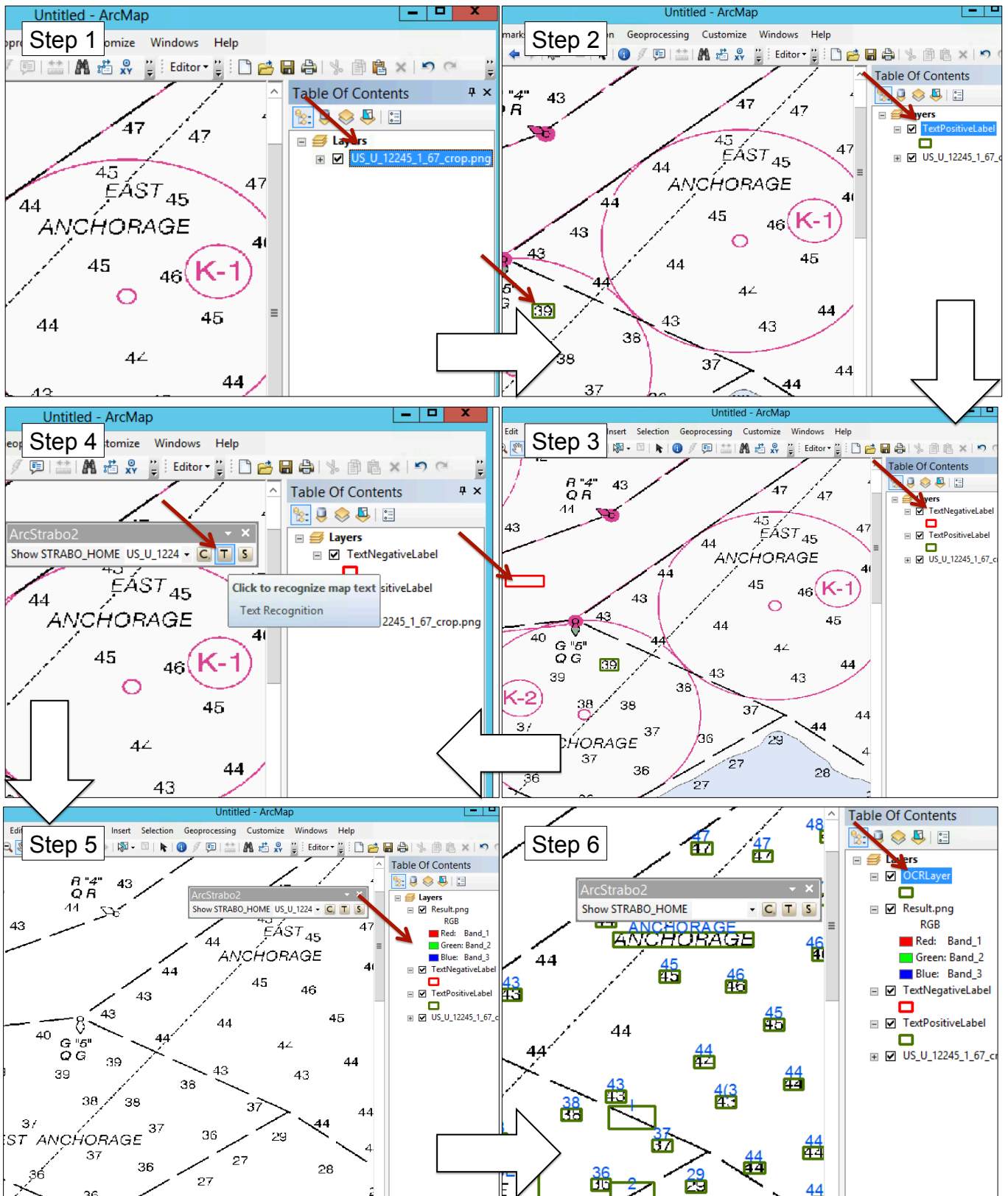
Figure 3: ArcStrabo user interface. Steps 1, 2, and 3: Providing examples of text and non-text areas in the map. Step 4: Invoking the ArcStrabo text detection and recognition processes. Steps 5 and 6: Reviewing the text recognition results in ArcMap (a raster layer of text pixels and a vector layer of the OCR results).

ponent that utilizes an open source OCR engine, Tesseract-OCR,[1] to convert individual text images (of map labels) into machine-readable text. (Both components are described in the previous section.) The GIS user trains the ArcStrabo text detection component by creating two polygon layers where one layer provides examples of text areas ("TextPositiveLayer") and the other one provides examples of non-text areas ("TextNegtiveLayer"). The green box in Figure 1 shows a sample feature of the text example layer ("44") and the blue box shows a sample feature of the non-text example layer (a white area). The features in these two layers are in the map coordinate system. Once the user finishes providing the text and non-text examples, ArcStrabo converts the features in both polygon layers and the entire raster layer to the image coordinates and sends these layers to the text detection component. The current implementation of ArcStrabo supports the linear transformation between map coordinates and image coordinates and additional transformations can be added. The text detection component detects the locations of individual labels and crops out the label images. The "Individual Text Locations" table in Figure 1 shows a sample of the detection results in the image space.

The text recognition component rotates the detected label images to the horizontal direction, recognizes text strings in the label images, transforms the recognition results back to the map coordinates (the "Machine-Readable Text" table in Figure 1), and sends the results back to the GIS as a new vector layer. Notice that the two intermediate tables are stored in the GeoJSON format and ArcStrabo is not fixed to specific functionalities in Esri ArcMap or Tesseract-OCR, which allows ArcStrabo to be easily integrated with other GIS or OCR products.

Within the Esri ArcMap environment (Figure 3), the user first adds the map layer (step 1), creates one polygon layer for text examples and one polygon layer for non-text examples (steps 2 to 3), and then clicks the "T" button on the ArcStrabo tool bar for text recognition (step 4). In this example, the user selects one text example (the sounding label "39") and provides a white area as the non-text example. ArcStrabo uses the map layer and the two polygon layers to find the map color(s) of the example text and then generates a new raster layer using the text color(s) (step 5). Then ArcStrabo processes the new raster layer to group text pixels into individual labels and recognizes the labels automatically. Finally, ArcStrabo adds the recognition results to ArcMap as a new vector layer with the label locations (bounding boxes) as rectangular polygons and the recognized text as an attribute value of each polygon (step 6). With the recognition results as a vector layer in the map coordinates, the user can use the vector data editing capabilities in ArcMap to start reviewing the results. For example, the user can include missing labels by adding new polygons in the vector layer or edit incorrectly recognized labels by modifying the attribute table. During the entire text recognition process, ArcStrabo hides the OCR process from the user and does not require the user to transform and import/export datasets.

4. RELATED WORK

Most existing map processing systems do not take GIS workflows into consideration (e.g., our previous work [2, 3]

and [4]) and present themselves as separate tools from a GIS (see [1] for a comprehensive review on map processing techniques and systems). For example, the United Nations Statistics Division presents MapScan [5] for manual map digitization. MapScan considers the input map as an image and includes an extensive set of image processing tools. To recognize map labels using MapScan, the user needs to mark each label manually and the label has to be in the horizontal direction.

There are some commercial map processing systems that can work with a GIS or work in a GIS. Esri ArcScan[2] represents the basic raster-to-vector conversion tools with minimal automatic processes (e.g., the user needs to manually select text regions and type in the text strings). AutoCAD RasterDesign[3] provides some automation to reduce manual digitization steps, such as automatically converting manually selected text labels into machine-readable text. In contrast, ArcStrabo is a complete system integrated with a GIS for text recognition in maps and is highly automated. ArcStrabo detects and recognizes map labels using only a few text examples.

5. DISCUSSION AND FUTURE WORK

We presented an easy-to-use system, ArcStrabo, which integrates GIS workflows and datatypes with our previous map processing work. ArcStrabo supports the end-to-end task of generating machine-readable geographic names from map images. We plan to develop and add additional capabilities for recognizing map symbol into ArcStrabo.

6. ACKNOWLEDGMENTS

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