Historical Air Photo Digitization Project University of Waterloo Map Library

http://www.lib.uwaterloo.ca/locations/umd/project

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Abstract

The University Map Library (UML) at the University of Waterloo developed an online collection of digitized and georeferenced aerial photography of the Kitchener-Waterloo area from the 1930s and 1940s. Using GIS technology, the air photos were digitized with geographical coordinate tags for use in GIS software programs including online mapping applications such as Google Earth (GE). By creating and offering downloadable georeferenced images compatible with popular mapping tools, the air photos have gained significant popularity and utilization by not only regular library users but by community groups, organizations and corporations who have never used library resources before. The integration of modern technology with traditional paper mapping has proven to be both a method of preservation and a means of increasing and varying utilization of the collection.

Introduction

The University of Waterloo Map Library is a cartographic and GIS resource centre for academics, community organizations and interested members of the local community. With a collection of over 100,000 maps, 49,000 air photos and serving as the campus’ hub for geospatial data, the library is frequented by many user groups and individuals -- and serves a variety of interests and purposes. Until most recently, many of these users were only able to access the collection in person, during library hours. Now, one of the library’s most popular paper collections, the historical aerial photographs, has become available online for users to view and download from their home and business computers.

The Map Library’s air photo collection includes stereoscopic images of the Region of Waterloo taken from as early as 1930 to as recently as 1995. The air photos are widely used by students, business contractors, history buffs and home owners who like to study the air photos for land cover, property information, feature identification and changes in these over time. Due to several access limitations, the Map Library wanted to provide the community with easier access, available 24/7 and remotely via the Internet.

In October 2007, the University Map Library launched an archival air photo scanning and digitization project, in which approximately 1200 historical air photos of Kitchener-
Waterloo and surrounding areas for the years 1930 and 1945-47 were scanned, digitized, georeferenced and made available online for viewing and downloading. A number of image formats have been made available to the users, including both higher and lower resolution outputs as well as GeoTiffs for GIS purposes and the popular KML files for the utilization of the georeferenced images in Google Earth and Google Maps.

**Objectives**

The purpose of the project was to address several issues that have been associated with the use of archival air photos by library clients. The primary concerns have been the physical handling of the photos, which occasionally resulted in permanent markings, creased corners, and misfiling of photos. In a few instances, theft has occurred as well. Since the print collection is only available during limited library building hours, it is not conveniently accessible by off-campus clients. The library, therefore was interested in not only archiving and preserving original material, but it also wanted to expose the photos to a larger community and provide easier access. The library's interest in utilizing modern technology also had a large influence on the project's overall outcome.

**Preservation and Archiving of Photos**

The Map Library’s aerial photography collection is highly used by both academic scholars and the public community. One of the most important objectives for the library was to decrease the amount of handling of the original photographs. Images were often handled, scanned by the users and then filed in the cabinets by library staff. Occasionally photographs were placed inadvertently in the wrong cabinets, and a great deal of effort was spent trying to locate them again. It was expected that the digitization of the historical photos would significantly decrease the photos’ physical usage, as well as eliminate the redundant scanning.

Most clients who use the library’s air photo collection wish to have a copy of the image for off-site analysis. Approximately 95% of all air photo users either scan the image or take a photograph of it. Since the images have been made available on the Internet, the 1930s and 1940s paper collection has not been accessed by clients at all. For those individuals who are not aware of the online project, library staff inform them of the project before providing access to the locked air photo cabinets. When given the option of using paper air photos or the digitized images, clients always choose the digital format. Clients continue to handle and scan the remainder of the air photo collection that has not been digitized.

**Offer Easy Online Access to Photos**

With library users limited to the map library’s business hours, offering pre-scanned Images 24/7 on the internet was expected to increase the usage of the photos, offer convenience, and expose the photos to many individuals and groups who otherwise would not have known about them. In fact, for the first six months that the photos were made available on the Internet, statistics show that they were accessed 25,000 times,
by 10,000 unique users. This is an extraordinary increase in users, as the library
traditionally has had fewer than 50 individuals use the air photo collection in a four-
month period. The exact user groups are unknown, but based on some of the queries
received via email, they have consisted of individual members of the community,
businesses and local community organizations.

Due to the changing landscape over the last 80 years, using traditional paper flight line
indexes has proven to be very time consuming and ineffective. Many library users
struggle to find the photo they are interested in, and several collections are represented
on one flight index, adding to the confusion. Map Library staff created a clickable index
on the web that uses modern streets and municipal boundaries as navigational aids in
finding the user's photo of interest. Clicking on the area of interest on the index leads
the user to the actual photo. Patrons can now eliminate the time consuming step of
using paper air photo indexes. The online index serves the same purpose and only
takes the user a few seconds.

**Offer Georeferenced Photos for Easier Navigation, Interpretation and Map Making**

With the invaluable benefit of having spatial information associated with the
photographs, staff wanted to georeference every image and make it available in
Keyhole Markup Language (KML) format for Google Earth users. Using a third party
resource, such as Google's online mapping program, anybody can view the images,
place them accurately on the earth's surface and use Google’s street files and points of
interest to navigate around the photos.

**Methodology**

**Scanning Historical Air Photos**

The library's earliest photos consist of 670 aerial images from 1930 and 550 aerial
images from the 1940s. The library commenced the project using images from these
years and in the future will consider archiving photos from the 1950s and continue on
with years that are free of copyright. (The term of copyright on aerial photographs
published in Canada by federal and provincial governments is 50 years after the first
date of publication. Therefore, air photos published prior to 1958 are in the public
domain and may be freely copied). Before scanning and storing the images, library
staff researched the technical specifications of similar projects across multiple
institutions. After careful testing and analysis, the library learned that scanning images
at 600 dpi provided the best results. Scanning at a higher resolution didn't improve the
quality of the image but significantly increased the file size. Anything less than 600
reduced image quality. The library also decided to store the images on DVDs, a
portable media, so they can be used by others, if needed. The library also saved the
images on a computer server with a nightly back-up system. This archival and storage
procedure provides the library with an electronic duplicate in case any of the original
photos are misplaced or damaged. In order to reduce the amount of handling of the
original photos, the library needed to provide users with easy access to the electronic
images. Offering the images on the internet was deemed to be the most convenient and user-friendly way to view and access the imagery.

**Digitizing and Georeferencing the Imagery**

The scanned images were brought into the GIS program ArcMap 9.2 and were georeferenced by library staff. Georeferencing a photograph is the process of adding spatial coordinates to the image so that it has a relation to the earth's surface. Using paper indexes, the staff found the geographical location of the air photos and tagged each photo with latitude and longitude coordinates. This process took anywhere from 3 minutes to 25 minutes for each photo. It was the most time consuming element of the project, as staff had to study in detail all 1200 images and interpret any features present in order to accurately assign latitude and longitude coordinates to those features. The most challenging component was working with photos that represented geographical areas that have changed dramatically over the past 80 years. Staff were comparing 80 year old images to a map consisting of current streets and rivers, trying to find commonalities to define the location of the photo. Street intersections, river bends and unique terrain patterns on farm land were commonly used to orient the photographs. (see Figure 1). Figure 2 is an example of one of the more challenging photos from 1930 that required intensive interpretation and orientation. When compared to a 2008 image of the same area (Figure 3), one can begin to appreciate some of the difficulties present in historical air photo interpretation.

The combination of aerial photography and georeferencing technology brings traditional air photo interpretation to a higher level. A georeferenced image has the benefit of situating the location of the photo accurately on the earth's surface. A user can compare, for example, the past and the present with very close precision. If the user is interested in studying the loss of forestry, h/she can overlay a historical aerial photograph over a more recent one to study the changes and discover precisely where new trees have been planted.

Spatial location of a photo is only supported in a GIS program, however, so the images were made available in a geospatial format that the public could readily use. Since many internet users are familiar with Google Earth, compatible Keyhole Markup Language (KML) files were created for use in this free online mapping program. One of the advantages of using a GIS program is that one can overlay streets on the historical image to accurately interpret the photo's location. Figure 4 shows a 1930 image of a farmland in Waterloo. On its own, the photograph doesn't tell much of a story, but once placed spatially correctly in Google Earth (Figure 5), the overlaid streets provide the information necessary to identify the location as the University of Waterloo. When photos do not have any distinguishing features, errors in interpretation can easily be made -- for example, users may believe they are looking at an image of their grandparents' farm when in fact they are looking at their neighbours' across the way. Misinterpretation commonly occurs when working with landscape that has changed dramatically over many decades. Historical photos can therefore be unidentifiable - so using familiar landmarks, such as current streets and rivers, as clues, will assist the researcher in finding the exact area he/she is looking for.
Once the images were georeferenced, they were inspected for alignment and tonal quality. Stereoscopic imagery (3D viewing) is the result of overlap, which is the amount that one photograph includes an area covered by a neighbouring photograph. There is approximately 60% forward overlap between photographs and 40% lateral (side) overlap. This means that one geographical area may be covered by three or four air photos. Library staff didn't want to duplicate coverage, so instead of uploading all 1200 digitized images, they mosaicked most photos to create seamless coverage represented as hundreds of even tiles using a 2.5 x 2.5 km grid.

**Offering the Imagery Online**

A website was created to provide the public with access to the digitized air photos. Users can find their images by navigating to their geographical area of interest by clicking on a graphical index. The map-like index was created to assist users in locating an air photo of a geographical area of interest. Since street names have changed over the years, offering a spatial way to locate a piece of land was deemed the most appropriate for a locality-based resource. Staff created indexes for each municipality within the Region of Waterloo, offering streets as a navigational aid in locating the area of interest. Once the user finds the geographical area they are interested in, they have the option to view or download the image tile representing that specific area. Every tile has its own page and offers images from all the years that are available for the geographical area bounded by the tile. Image formats include high resolution Tiff (approximately 7 MB), for users who wish to work with higher quality images, low resolution jpg (approximately 150 kb), for users who wish to work with a small image file, PDF (approximately 1.5 MB) for users who wish to take advantage of Adobe's zoom tools, and KML (approximately 2 MB), for Google Earth users. Figure 6 is an example of a KML file downloaded from the site and opened in Google Earth. Other features were added to the map to display urban growth.

This website is available at: [http://www.lib.uwaterloo.ca/locations/umd/project](http://www.lib.uwaterloo.ca/locations/umd/project)

**Results and Conclusion**

Aerial photography captures moments in time, offering a pictorial preservation of history. This project offers convenient access to Kitchener-Waterloo's local history, and offers users the added value of combining the photos with GIS technology. Georeferenced aerial photography accurately places the photograph on the earth's surface, making the information richer, revealing hidden patterns and displaying informative results. When using mapping programs such as Google Earth, one can find one's home today and with a simple click, view the historical image to see how the land was used 70 years ago. Combining the old and the new, places coffee shops in the middle of farmer's fields, and highways over old stone school houses. GIS technology expands the usage capabilities of aerial photography and attracts interest to the library's collection and the Region's local history.
The online project was released to the public in July, 2008. Since then, the library has received countless testimonials from corporations, community organizations and individuals very pleased with the service. Organizations have linked the online project to their own list of links, and community users who have never visited our library are taking advantage of the online imagery. Web server statistics show that over 25,000 visitors used the site within the first four months of the project going live! The project has also attracted Google Inc., which has asked for a copy of all the images for an upcoming project they are working on. This project is successfully enabling the library to serve new community groups. The library receives correspondence from individuals interested in the history of their land, from local community groups such as genealogical and historical societies, as well as from business organizations looking for additional photos representing different years. The library's digital resources are much more popular than the paper ones, demonstrating that promotion and ease of access are the keys to resource usage.

**Acknowledgements**

Map Library staff have spent hundreds of hours on this project - both part-time and full time staff contributed to the scanning, cropping, georeferencing and tiling of a very large collection. Thank you to everybody for their dedication, attention to detail and for the many hours spent often working on repetitive tasks.
Figure 1: The shape of the road in this photo was used to identify its location.
Figure 2: Due to the lack of recognizable features, the location of this photo was very difficult to identify. When comparing this 1930 image to the 2008 image (Figure 3), the location is even harder to distinguish because the landscape has changed so much.
Figure 3: Image taken in 2008, courtesy of First Base Solutions
Figure 4: A georeferenced historical air photo overlaid in Google Earth's current aerial photography.
Figure 5: Using Google Earth's current streets to assist in interpreting the historical image.
Figure 6: 1930 Air photo with 2008 feature overlays