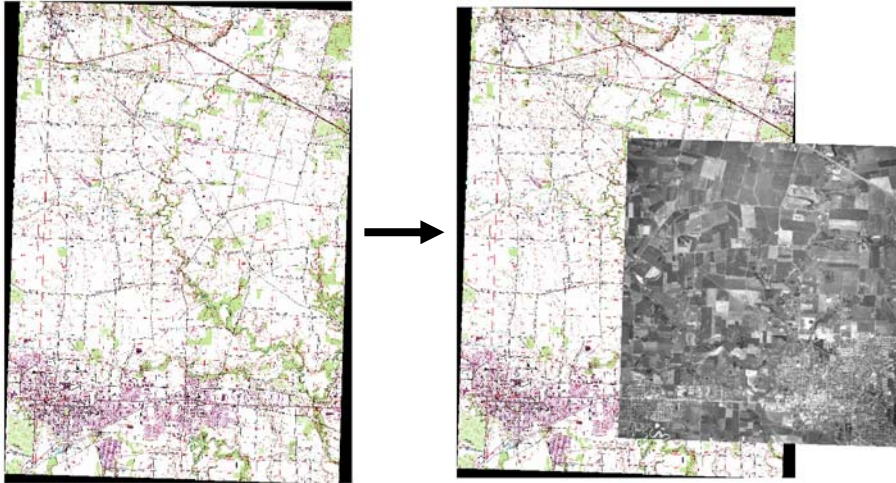


# Geometric Transformation

## RMS Error and Geometric Accuracy

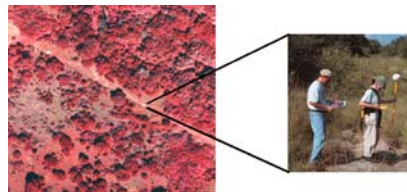


By Jon Franczyk



## Overview

- Accurately aligning multiple images (map, aerial photo, satellite image) of the same area
- Using similar objects found in both images
  - Buildings,
  - Road corners,
  - GPS locations
- Ground Control Points



## What is RMS Error?

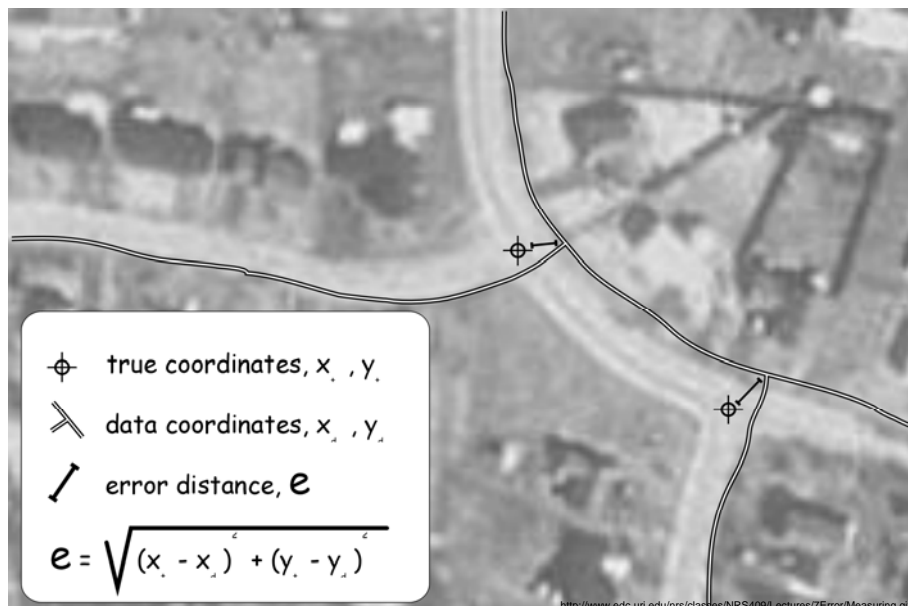
- Root Mean Squared (RMS) Error = difference btw. the desired output GCP coordinate (reference) & the actual output coordinate (source) for same point after transformation
- A quantitative measure of accuracy

$$\text{RMS error} = \sqrt{(x_r - x_i)^2 + (y_r - y_i)^2}$$

Where:

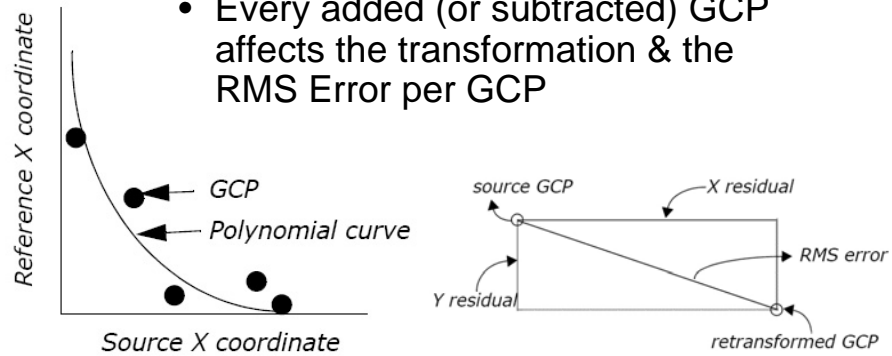
$x_i$  and  $y_i$  are the input source coordinates  
 $x_r$  and  $y_r$  are the retransformed coordinates

## RMS Error: In Action



# RMS Error per GCP

- “Good to Fit” line
- GCP distance from line = RMSE
- Every added (or subtracted) GCP affects the transformation & the RMS Error per GCP



# Total RMS vs. RMS per GCP

The screenshot shows a GIS application window. On the left is a map with several yellow dots representing GCPs. On the right is a 'Link Table' window with the following data:

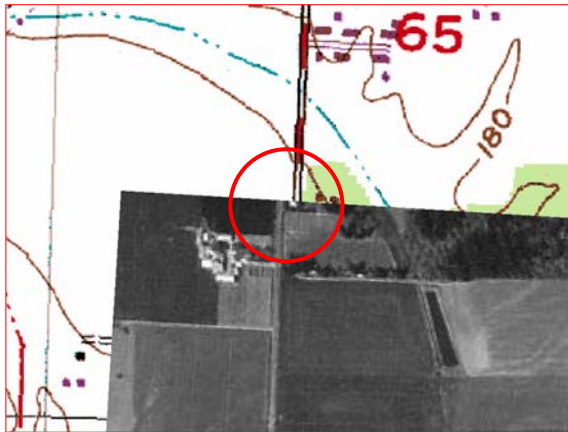
Link	X Source	Y Source	X Map	Y Map	Residual
1	432.477176	-6794.124279	589473.340821	68592.229044	1.37789
2	3839.366772	-814.666950	591246.666375	71689.064450	1.94416
3	6333.987834	-462.961336	592560.493095	71910.241034	0.94193
4	4679.058346	-6678.882660	591680.512752	68638.907020	1.22581
5	2581.198531	-4609.486850	590585.027019	69712.653174	3.76688
6	1747.190800	-2572.767800	590162.523030	70719.290194	2.11123
7	2639.256536	-7106.069594	590646.464959	69408.278445	2.49034
8	2784.187418	-4803.954426	590689.944117	69603.955280	3.47229

Below the table, the formula for Total RMS Error is shown:

$$\text{Total RMS Error} = \sqrt{\frac{1}{n} \sum_{i=1}^n X R_i^2 + Y R_i^2}$$

The 'Total RMS Error' field in the software interface is circled in red and shows the value 2.37777.

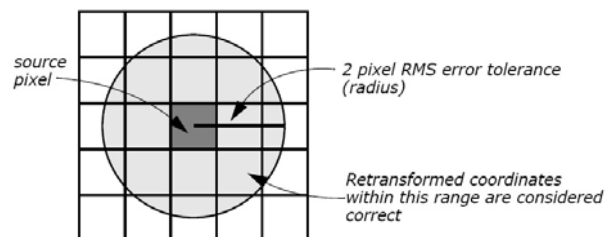
## Levels of Accuracy



The acceptable level of RMS Error is dependent on the necessary level of accuracy

## Acceptable RMS Error

- Measured in the source coordinate system (i.e. pixels). Therefore if accuracy must be within 30m on a 30m resolution image, the RMS Error value must be  $<1$
- Determined by:
  - End use of data base
  - Type of data being used
  - Accuracy of GCPs





## After Transformation

- Four Options:
  - Throw out GCPs with the highest RMS Error. A more accurate “best to fit” line should result
  - Tolerate the level of error
  - Use a higher order of transformation, but could cause high distortion in image
  - Select only high-confidence points