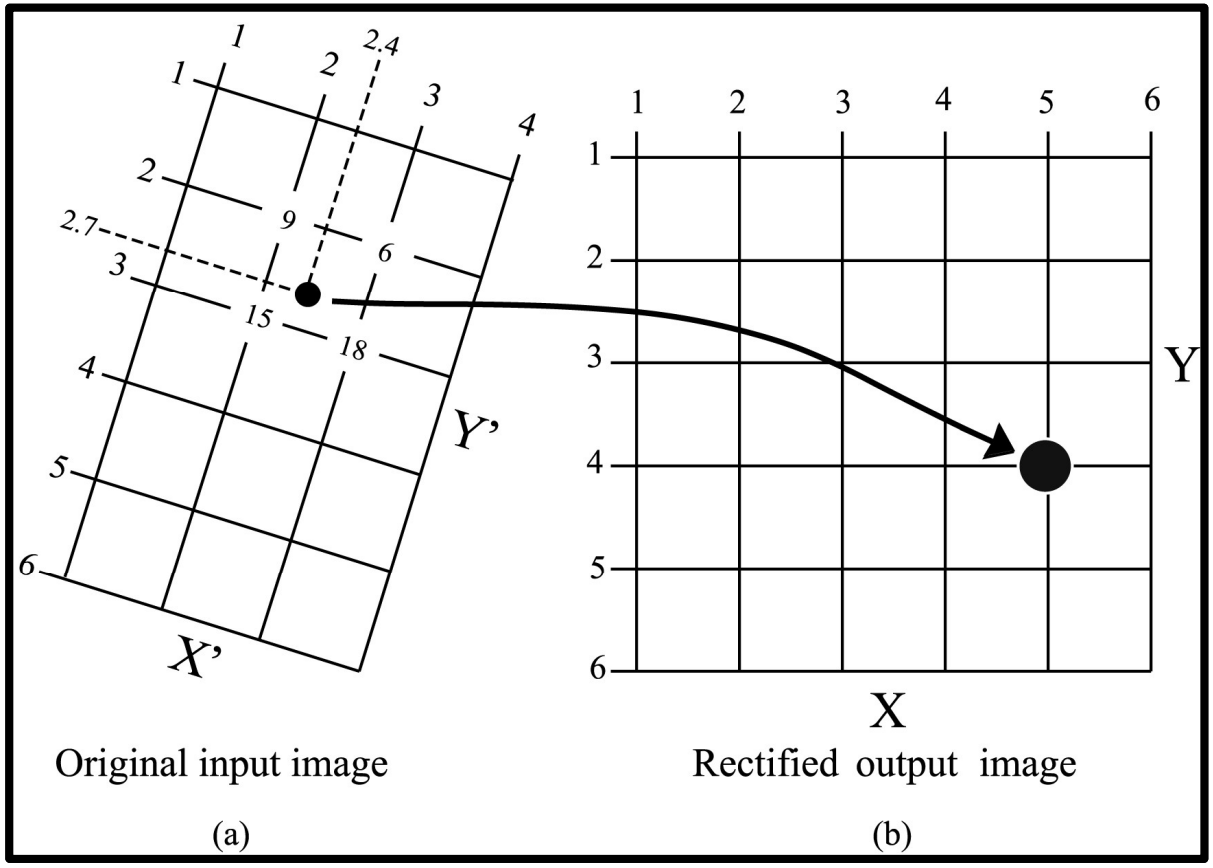
Georeferencing Process

- Create Links
- Look at the link table for acceptable RMS on each Point.
- Remove links with error that is to high
  - It is better to keep a link that you are sure is correct. If a link has a high RMS but is correctly located on the image removing it will improve the reported RMS but add error to the map.
- Select the order of transformation
- Rectify the map selecting the resample method

Resampling or Intensity interpolation

- Once an image is warped, **how do you assign DNs to the "new" pixels?**
- Unfortunately, there is **no direct one-to-one relationship** between the movement of input pixel values to output pixel locations.
- a pixel in the rectified output image **often requires a value from the input pixel grid that does not fall neatly on a row-and-column coordinate.** When this occurs, there must be some mechanism for determining the brightness value (*BV*) to be assigned to the output rectified pixel. This process is called ***intensity interpolation.***
- Since the grid of pixels in the source image rarely matches the grid for the reference image, the pixels are resampled so that new data file values for the output file can be calculated.
- ***This process involves the extraction of a brightness value from a location in the input image and its reallocation in the appropriate coordinate location in the rectified output image***

THE LOGIC



- The goal is to fill a matrix that is in a standard map projection with the appropriate values from a non-planimetric image.

$$X' = a_o + a_1 X + a_2 Y$$

$$Y' = b_o + b_1 X + b_2 Y$$

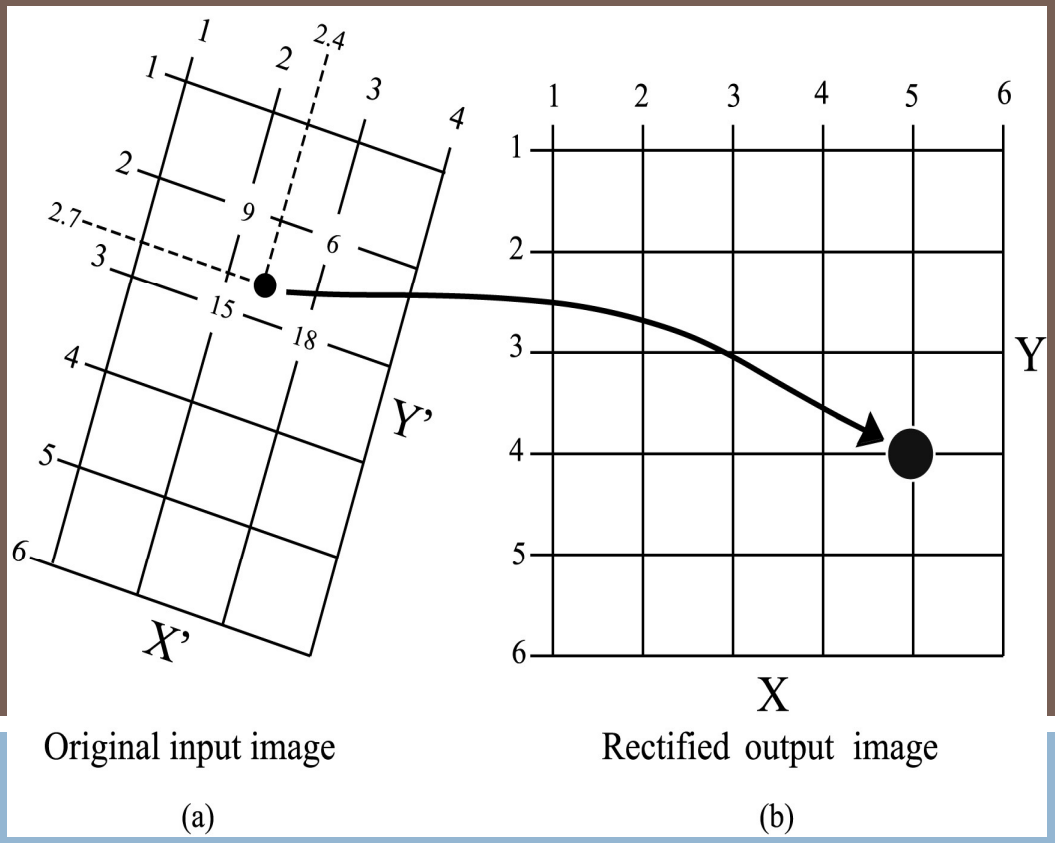
- This *pixel-filling logic* is used to produce the output image line by line, column by column. Most of the time the x' and y' coordinates to be sampled in the input image are floating point numbers (i.e., they are not integers). For example, in the Figure we see that pixel **5, 4 (*x*, *y*) in the output image** is to be filled with the value from coordinates **2.4, 2.7 (x', y') in the original input image.** When this occurs, there are several methods of brightness value (*BV*) *intensity interpolation* that can be applied, including:

  - *nearest neighbor,*
  - *bilinear interpolation,* and
  - *cubic convolution.*

- The practice is commonly referred to as ***resampling***.

Nearest-Neighbor Resampling

The brightness value closest to the predicted *x'*, *y'* coordinate is assigned to the output *x*, *y* coordinate.



Nearest Neighbor

ADVANTAGES:

- Output values are the original input values. Other methods of resampling tend to average surrounding values. This may be an important consideration when discriminating between vegetation types or locating boundaries.
- **Since original data are retained, this method is recommended before classification.**
- Easy to compute and therefore fastest to use.

DISADVANTAGES:

- Produces a choppy, "stair-stepped" effect. The image has a rough appearance relative to the original unrectified data.
- Data values may be lost, while other values may be duplicated.

Bilinear Interpolation

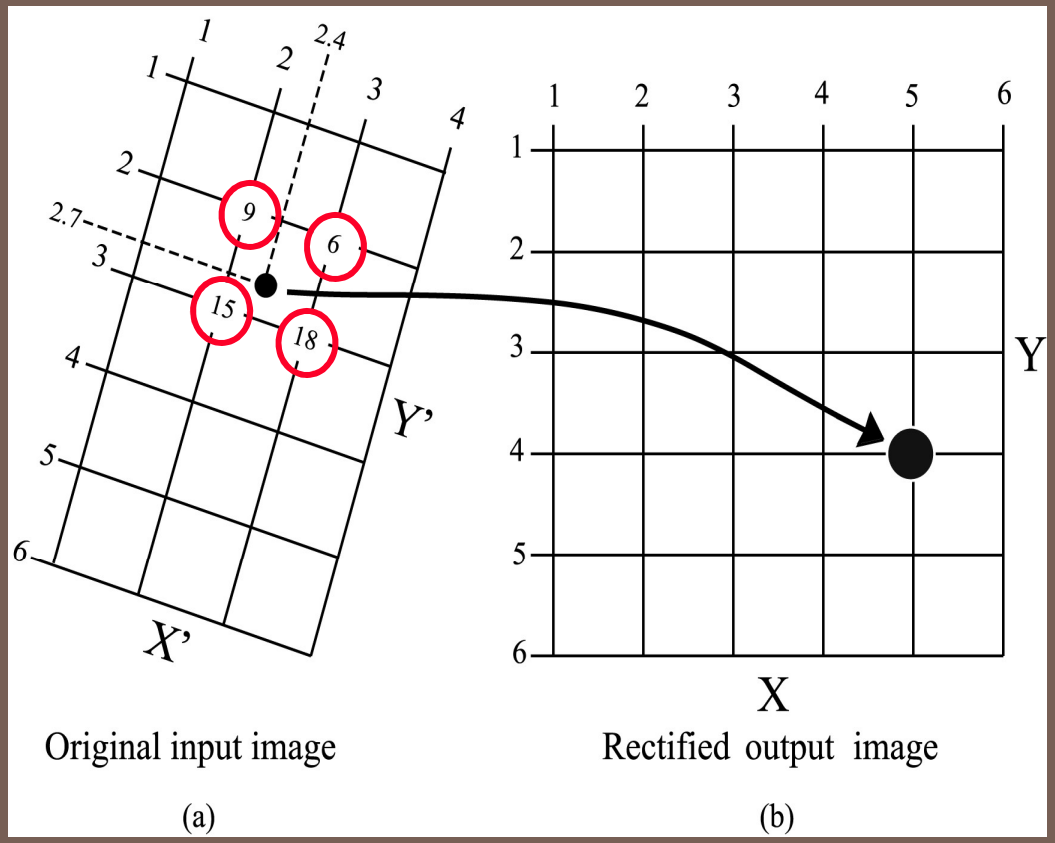
Assigns output pixel values by interpolating brightness values in two orthogonal direction in the input image. It basically fits a plane to the ***4*** pixel values nearest to the desired position (***x'***, ***y'***) and then computes a new brightness value based on the weighted distances to these points. For example, the distances from the requested (***x'***, ***y'***) position at 2.4, 2.7 in the input image to the closest four input pixel coordinates (2,2; 3,2; 2,3;3,3) are computed . Also, the closer a pixel is to the desired x',y' location, the more weight it will have in the final computation of the average.

$$BV_{wt} = \frac{\sum_{k=1}^{4} \frac{Z_k}{D_k^2}}{\sum_{k=1}^{4} \frac{1}{D_k^2}}$$

where Z_k are the surrounding four data point values, and D^2_k are the distances squared from the point in question (*x'*, *y'*) to the these data points.

Jensen, 2004

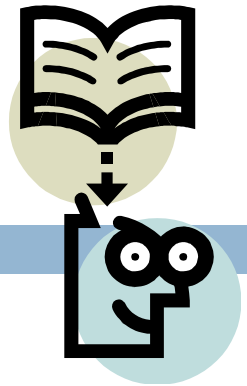
Bilinear Interpolation



Nothing to worry we'll try it ourselves

Sample point location (I,j)	Value at sample point Z	Distance from x' , y' to the sample point D	D_k^2	$\frac{Z_k}{D_k^2}$	$\frac{1}{D_k^2}$
2,2	9				
3,2	6				
2,3	15				
3,3	18				

Wasn't it easy !!!!!



Sample point location (I,j)	Value at sample point Z	Distance from x' , y' to the sample point D	D_k^2	$\frac{Z_k}{D_k^2}$	$\frac{1}{D_k^2}$
2,2	9	0.806	0.65	13.85	1.539
3,2	6	0.922	0.85	7.06	1.176
2,3	15	0.500	0.25	60.00	4.000
3,3	18	0.670	0.45	40.00	2.222
				∑ 120.91	**∑ 8.937**

BV_{wt} **= 120.91/8.937 = 13.53**

Bilinear

- **ADVANTAGES:**
  - Stair-step effect caused by the nearest neighbor approach is reduced. Image looks smooth.
- **DISADVANTAGES:**
  - Alters original data and reduces contrast by averaging neighboring values together.
  - Is computationally more extensive than nearest neighbor.

Cubic Convolution

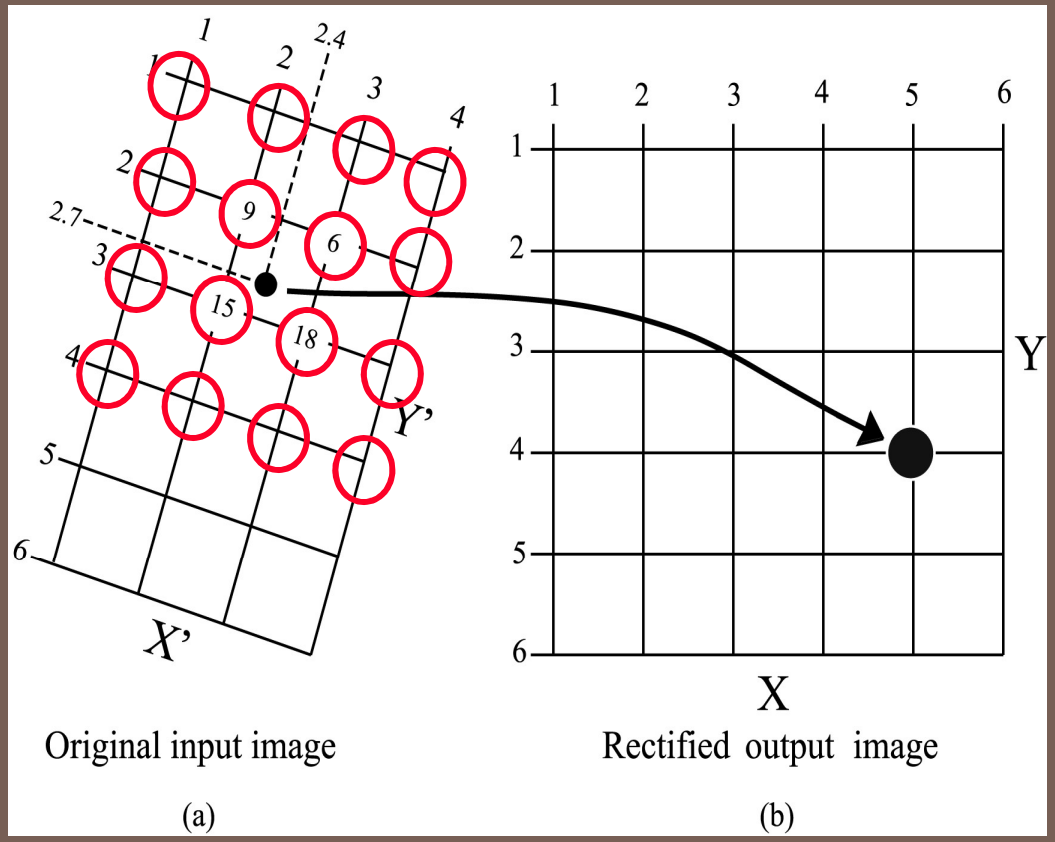
Assigns values to output pixels in much the same manner as bilinear interpolation, except that the weighted values of ***16*** pixels surrounding the location of the desired ***x'***, ***y'*** pixel are used to determine the value of the output pixel.

$$BV_{wt} = \frac{\sum_{k=1}^{16} \frac{Z_k}{D_k^2}}{\sum_{k=1}^{16} \frac{1}{D_k^2}}$$

where Z_k are the surrounding four data point values, and D^2_k are the distances squared from the point in question (*x'*, *y'*) to the these data points.

Jensen, 2004

Cubic Convolution



Jensen, 2004

Cubic Convolution

- **ADVANTAGES:**

– Stair-step effect caused by the nearest neighbor approach is reduced. Image looks smooth.

- **DISADVANTAGES:**

– Alters original data and reduces contrast by averaging neighboring values together.

– Is computationally more expensive than nearest neighbor or bilinear interpolation.

General Steps for Georeferencing an Image in ArcGIS

1. Obtain a digital or scanned imagery/map .
2. Obtain base data (a data layer with a known coordinate system) or control points that represent locations/objects visible in image.
3. Create displacement links (links), clicking first on RASTER, then on base layer.
4. Look at the link table for acceptable residual on each point and total RMS error.
5. Select transformation method.
6. Rectify the map by selecting a resampling method (optional in ArcMap). Rectifying will create a new image file

WHAT DOES ALL THIS MEAN???

- Careful attention must be paid to the projection, datum and coordinate system for every piece of GIS data used.
- Failure to use data from the same system OR change the data (re-project) it to the desired system will result in overlay errors
  - Can range some small to SIGNIFICANT
  - Real danger is when the errors are small (possibly unnoticed)
- Shapefiles, images, grids all have this data inherent in their very creation.
  - Usually included in a system of files known as "metadata" or xxxxxx.PRJ file.