Adjustments

An adjustment is specified by a **mode**, a **direction** and a **delta**. For each reference point and corresponding shift vector, the adjustment is computed and applied. The resulting shift vector is again cached in the warping library. This way of implementation allows incremental adjustments.

Mode defines the way of the distortion. Following modes are available:

- Parallelogram
- Trapezoid
- Pin balance
- Pincushion
- Shift
- Size
- Rotation (around bitmap image center point)

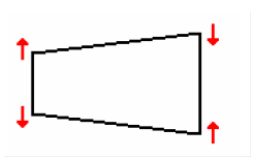
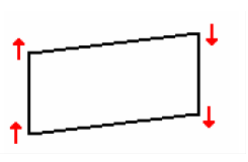
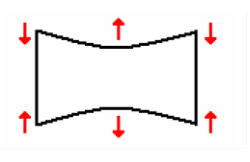
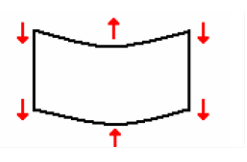
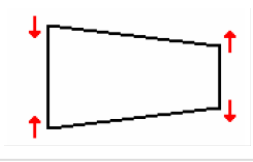
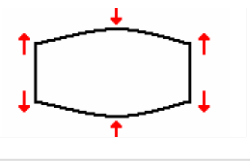
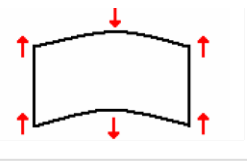
Direction specifies the direction in which the distortion is applied. Following directions are available:

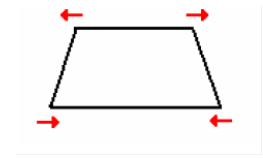
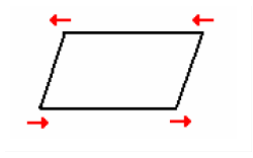
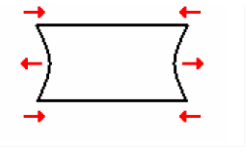
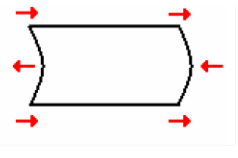
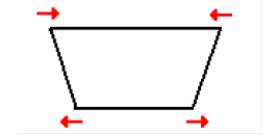
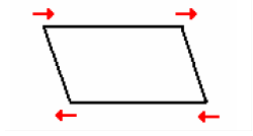
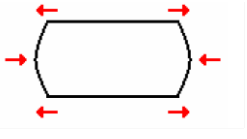
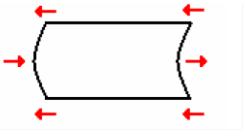
- Up
- Down
- Left
- Right

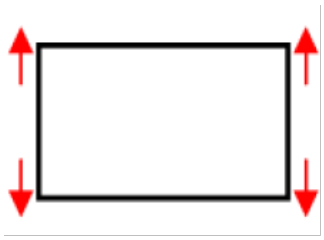
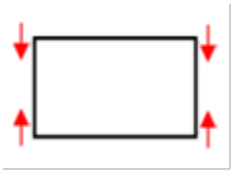
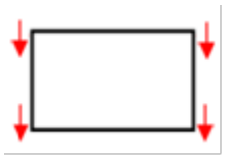
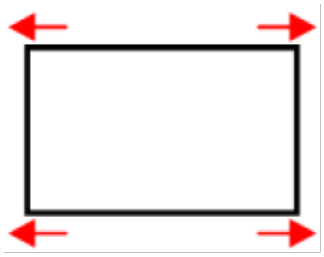
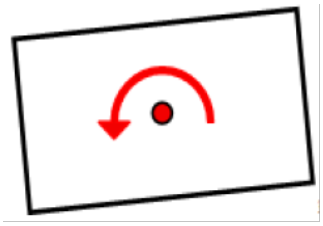
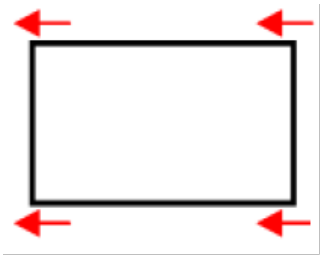
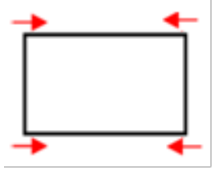
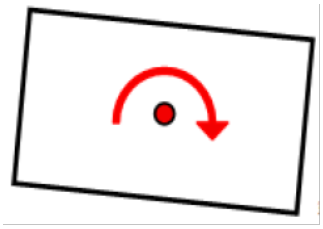
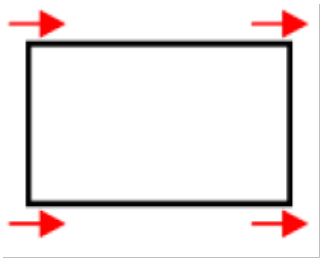
Delta specifies the amount of distortion that is applied. Delta is an unsigned integer value in range 0..255 (1 byte). The delta is added to the existing offset of the corresponding reference points.

Predefined Adjustments

Based on mode and direction, the following transformations are possible:

Mode Direction	Trapezoid	Parallelogram	Pincushion	Pin balance
Up				
Down				

Left				
Right				

Mode Direction	Size	Rotation	Shift
Up			
Down			
Left			
Right			

Formulas for adjustments

The following formulas describe the mathematically necessary adjustments of the reference points. If the requested adjustment exceeds the limit, no calculation shall be done and the previous status will be kept.

Trapezoid mode

***mode* = trapezoid transformation; *direction* = up**
condition: $TrapezoidY - delta \geq -TrapezoidLimitY$

$$y[i][j] = y[i][j] - delta \cdot \left(1 - \frac{2\,i}{NumOfRefPointsX - 1}\right) \cdot \left(1 - \frac{2\,j}{NumOfRefPointsY - 1}\right)$$

***mode* = trapezoid transformation; *direction* = down**
condition: $TrapezoidY + delta \leq TrapezoidLimitY$

$$y[i][j] = y[i][j] + delta \cdot \left(1 - \frac{2\,i}{NumOfRefPointsX - 1}\right) \cdot \left(1 - \frac{2\,j}{NumOfRefPointsY - 1}\right)$$

***mode* = trapezoid transformation; *direction* = left**
condition: $TrapezoidX - delta \geq -TrapezoidLimitX$

$$x[i][j] = x[i][j] - delta \cdot \left(1 - \frac{2i}{NumOfRefPointsX - 1}\right) \cdot \left(1 - \frac{2\,j}{NumOfRefPointsY - 1}\right)$$

***mode* = trapezoid transformation; *direction* = right**
condition: $Trapezoidx + delta \leq TrapezoidLimitX$

$$x[i][j] = x[i][j] + delta \cdot \left(1 - \frac{2i}{NumOfRefPointsX - 1}\right) \cdot \left(1 - \frac{2\,j}{NumOfRefPointsY - 1}\right)$$

Parallelogram mode

***mode* = parallelogram transformation; *direction* = up**
condition: $ParallelogramY - delta \geq -ParallelogramLimitY$

$$y[i][j] = y[i][j] - delta \cdot \left(1 - \frac{2i}{NumOfRefPointsX - 1}\right)$$

***mode* = parallelogram transformation; *direction* = down**
condition: $ParallelogramY + delta \leq ParallelogramLimitY$

$$y[i][j] = y[i][j] + delta \cdot \left(1 - \frac{2i}{NumOfRefPointsX - 1}\right)$$

***mode* = parallelogram transformation; *direction* = left**
condition: $ParallelogramX - delta \geq -ParallelogramLimitX$

$$x[i][j] = x[i][j] - delta \cdot \left(1 - \frac{2\,j}{NumOfRefPointsY - 1}\right)$$

***mode* = parallelogram transformation; *direction* = right**
condition: $ParallelogramX + delta \leq ParallelogramLimitX$

$$x[i][j] = x[i][j] + delta \cdot \left(1 - \frac{2\,j}{NumOfRefPointsY - 1}\right)$$

Pinbalance mode

***mode* = pin balance transformation; *direction* = up**
condition: $PinbalanceY - delta \geq -PinbalanceLimitY$

$$y[i][j] = y[i][j] - delta \cdot \left(\frac{-4i^2}{(NumOfRefPointsX - 1)^2} + \frac{4i}{NumOfRefPointsX - 1} - 0.5 \right)$$

***mode* = pin balance transformation; *direction* = down**
condition: $PinbalanceY + delta \leq PinbalanceLimitY$

$$y[i][j] = y[i][j] + delta \cdot \left(\frac{-4i^2}{(NumOfRefPointsX - 1)^2} + \frac{4i}{NumOfRefPointsX - 1} - 0.5 \right)$$

***mode* = pin balance transformation; *direction* = left**
condition: $PinbalanceX - delta \geq -PinbalanceLimitX$

$$x[i][j] = x[i][j] - delta \cdot \left(\frac{-4j^2}{(NumOfRefPointsY - 1)^2} + \frac{4j}{NumOfRefPointsY - 1} - 0.5 \right)$$

***mode* = pin balance transformation; *direction* = right**
condition: $PinbalanceX + delta \leq PinbalanceLimitX$

$$x[i][j] = x[i][j] + delta \cdot \left(\frac{-4j^2}{(NumOfRefPointsY - 1)^2} + \frac{4j}{NumOfRefPointsY - 1} - 0.5 \right)$$

Pincushion mode

***mode* = pincushion transformation; *direction* = up**
condition: $PincushionY - delta \geq -PincushionLimitY$

$$y[i][j] = y[i][j] - delta \cdot \left(\frac{-4i^2}{(NumOfRefPointsX - 1)^2} + \frac{4i}{NumOfRefPointsX - 1} - 0.5 \right) \cdot \left(1 - \frac{2j}{NumOfRefPointsY - 1} \right)$$

***mode* = pincushion transformation; *direction* = down**
condition: $PincushionY + delta \leq PincushionLimitY$

$$y[i][j] = y[i][j] + delta \cdot \left(\frac{-4i^2}{(NumOfRefPointsX - 1)^2} + \frac{4i}{NumOfRefPointsX - 1} - 0.5 \right) \cdot \left(1 - \frac{2j}{NumOfRefPointsY - 1} \right)$$

***mode* = pincushion transformation; *direction* = left**
condition: $PincushionX - delta \geq -PincushionLimitX$

$$x[i][j] = x[i][j] - delta \cdot \left(\frac{-4j^2}{(NumOfRefPointsY - 1)^2} + \frac{4j}{NumOfRefPointsY - 1} - 0.5 \right) \cdot \left(1 - \frac{2i}{NumOfRefPointsX - 1} \right)$$

***mode* = pincushion transformation; *direction* = right**
condition: $PincushionX + delta \leq PincushionLimitX$

$$x[i][j] = x[i][j] + delta \cdot \left(\frac{-4j^2}{(NumOfRefPointsY - 1)^2} + \frac{4j}{NumOfRefPointsY - 1} - 0.5 \right) \cdot \left(1 - \frac{2i}{NumOfRefPointsX - 1} \right)$$

Size mode

mode = **size**, ***direction*** = **up**
condition: *Height* + *delta* <= *HeightLimit*

$$y[i][j] = y[i][j] + delta \cdot \left(1 - \frac{2j}{NumOfRefPointsY - 1}\right)$$

mode = **size**, ***direction*** = **down**
condition: *Height* - *delta* >= - *HeightLimit*

$$y[i][j] = y[i][j] - delta \cdot \left(1 - \frac{2j}{NumOfRefPointsY - 1}\right)$$

mode = **size**, ***direction*** = **left**
condition: *Width* + *delta* <= *WidthLimit*

$$x[i][j] = x[i][j] + delta \cdot \left(1 - \frac{2i}{NumOfRefPointsX - 1}\right)$$

mode = **size**, ***direction*** = **right**
condition: *Width* - *delta* <= - *WidthLimit*

$$x[i][j] = x[i][j] - delta \cdot \left(1 - \frac{2i}{NumOfRefPointsX - 1}\right)$$

Rotation mode

mode = **rotation**, ***direction*** = **left**
condition: all warped reference points are inside the Illuminated TFT Area

$$x[i][j] = \cos(-delta) \cdot (x[i][j] - x\_center) + \sin(-delta) \cdot (y[i][j] - y\_center) + x\_center$$

$$y[i][j] = -\sin(-delta) \cdot (x[i][j] - x\_center) + \cos(-delta) \cdot (y[i][j] - y\_center) + y\_center$$

mode = **rotation**, ***direction*** = **right**
condition: all warped reference points are inside the Illuminated TFT Area

$$x[i][j] = \cos(delta) \cdot (x[i][j] - x\_center) + \sin(delta) \cdot (y[i][j] - y\_center) + x\_center$$

$$y[i][j] = -\sin(delta) \cdot (x[i][j] - x\_center) + \cos(delta) \cdot (y[i][j] - y\_center) + y\_center$$

Shift mode

***mode* = shift, *direction* = up**
condition: all warped reference points are inside the Illuminated TFT Area
$y[i][j] = y[i][j] - delta$

***mode* = shift, *direction* = down**
condition: all warped reference points are inside the Illuminated TFT Area
$y[i][j] = y[i][j] - delta$

***mode* = shift, *direction* = left**
condition: all warped reference points are inside the Illuminated TFT Area
$x[i][j] = x[i][j] + delta$

***mode* = shift, *direction* = right**
condition: all warped reference points are inside the Illuminated TFT Area
$x[i][j] = x[i][j] + delta$

> NumOfRefPointsX - number of reference points in horizontal direction
> NumOfRefPointsY - number of reference points in vertical direction
> x[i][j] - x-coordinate of reference point, a 2-dimensional array of floating point variables
> y[i][j] - y-coordinate of reference point, a 2-dimensional array of floating point variables

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Revision #2
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