# Multi-perspective Multi-modal Trajectory Descriptions for Handwritten Strokes


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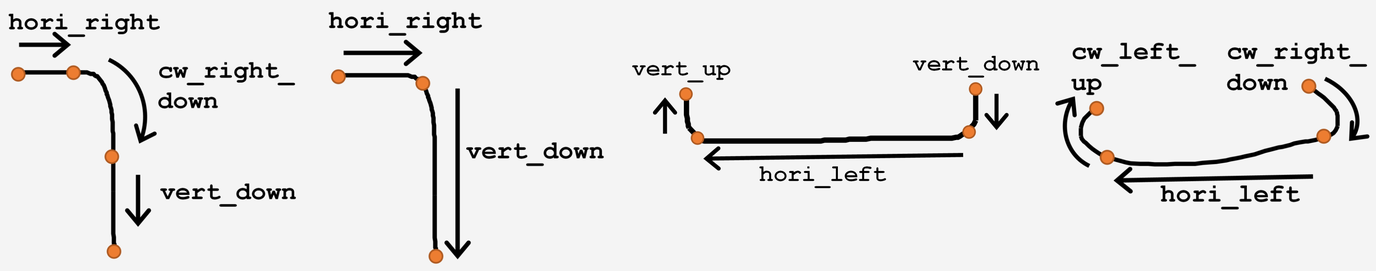
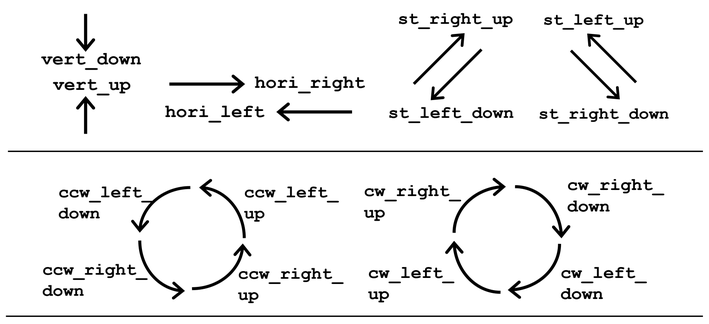
## Requirements for Stroke Descriptions

- Handling how a handwritten stroke can be '***viewed***'

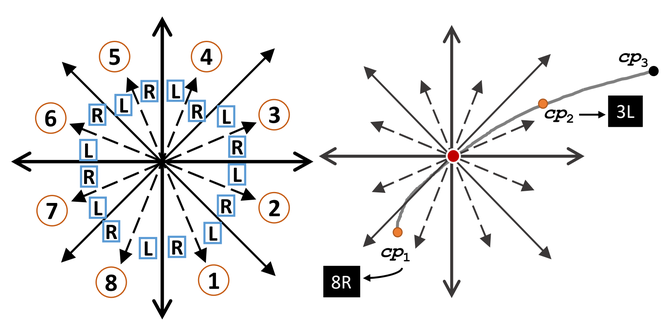
### Issue of Perspective




### Issue of Modality




**Shape Descriptors**



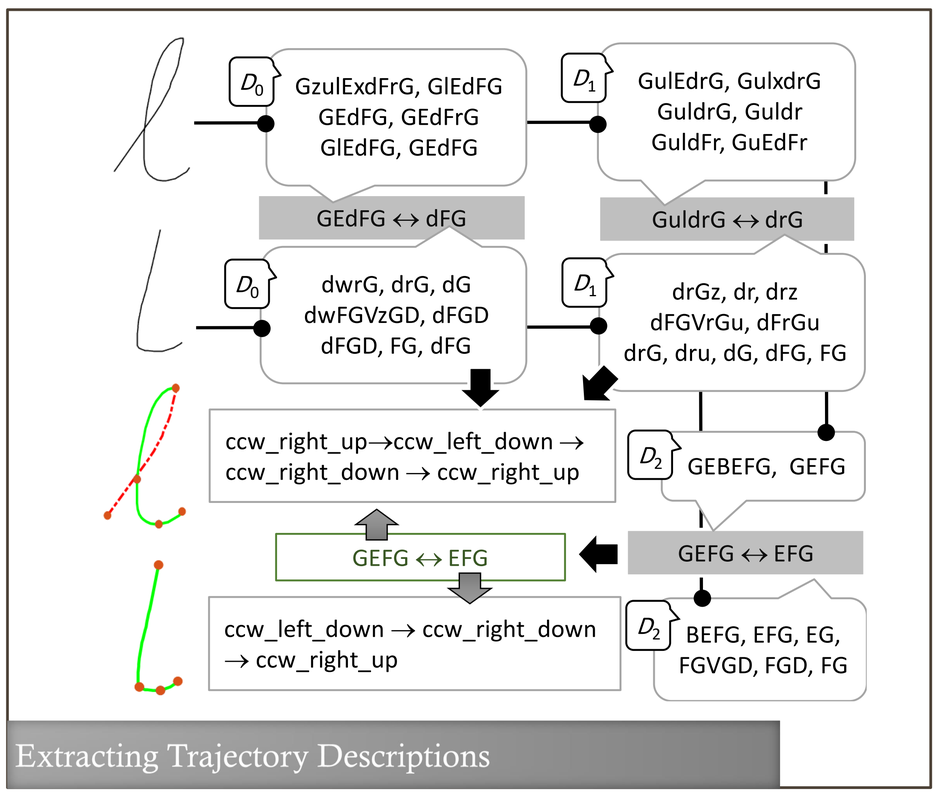

**Segment to Descriptor Mapping**

## Descriptors and Mapping

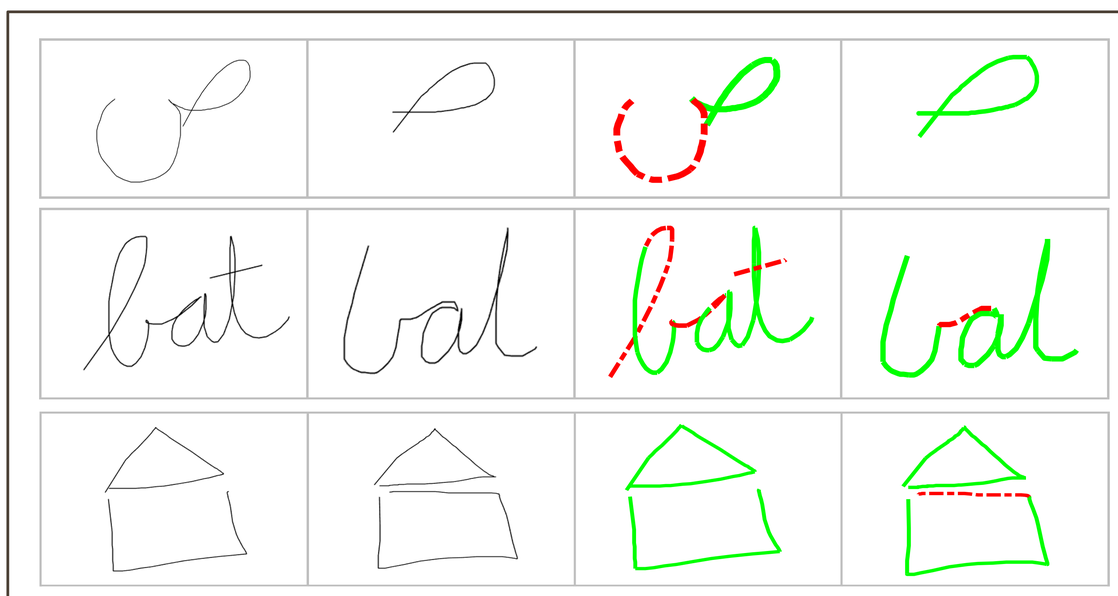
## Shape Descriptor Fitting Criteria

| Descriptor | Rigidness Level | Fitting Criteria | |
|---|---|---|---|
| ↓ | Strict | (pos($cp_1$) = 4L ∨ 5R) ∧ (pos($cp_2$) = 1R ∨ 8L) | |
| | Relaxed | (pos($cp_1$) = 4 ∨ 5) ∧ (pos($cp_2$) = 1 ∨ 8) | |
| ↑ | Strict | (pos($cp_1$) = 1R ∨ 8L) ∧ (pos($cp_2$) = 4L ∨ 5R) | |
| | Relaxed | (pos($cp_1$) = 1 ∨ 8) ∧ (pos($cp_2$) = 4 ∨ 5) | |
| → | Strict | (pos($cp_1$) = 6L ∨ 7R) ∧ (pos($cp_2$) = 2L ∨ 3R) | |
| | Relaxed | (pos($cp_1$) = 6 ∨ 7) ∧ (pos($cp_2$) = 2 ∨ 3) | |
| ← | Strict | (pos($cp_1$) = 2L ∨ 3R) ∧ (pos($cp_2$) = 6L ∨ 7R) | |
| | Relaxed | (pos($cp_1$) = 2 ∨ 3) ∧ (pos($cp_2$) = 6 ∨ 7) | |
| ↘ | Strict | ($\neg$H ∧ $\neg$V) ∧ ($cp_{1x} < cp_{2x}$ ∧ $cp_{1y} > cp_{2y}$) | $\alpha_{1,2} < \alpha_{low}$ |
| | Relaxed | | $\alpha_{1,2} < \alpha_{high}$ |
| ↘ | Strict | | $\neg$ ↘ ∧ $loc(mid_{1,2})$ = 'right' |
| | Relaxed | | override ↘ ∧ $loc(mid_{1,2})$ = 'right' |
| ↘ | Strict | | $\neg$ ↘ ∧ $loc(mid_{1,2})$ = 'left' |
| | Relaxed | | override ↘ ∧ $loc(mid_{1,2})$ = 'left' |
| ↙ | Strict | ($\neg$H ∧ $\neg$V) ∧ ($cp_{1x} > cp_{2x}$ ∧ $cp_{1y} > cp_{2y}$) | $\alpha_{1,2} < \alpha_{low}$ |
| | Relaxed | | $\alpha_{1,2} < \alpha_{high}$ |
| ↙ | Strict | | $\neg$ ↙ ∧ $loc(mid_{1,2})$ = 'right' |
| | Relaxed | | override ↙ ∧ $loc(mid_{1,2})$ = 'right' |
| ↙ | Strict | | $\neg$ ↙ ∧ $loc(mid_{1,2})$ = 'left' |
| | Relaxed | | override ↙ ∧ $loc(mid_{1,2})$ = 'left' |
| ↗ | Strict | ($\neg$H ∧ $\neg$V) ∧ ($cp_{1x} < cp_{2x}$ ∧ $cp_{1y} < cp_{2y}$) | $\alpha_{1,2} < \alpha_{low}$ |
| | Relaxed | | $\alpha_{1,2} < \alpha_{high}$ |
| ↗ | Strict | | $\neg$ ↗ ∧ $loc(mid_{1,2})$ = 'left' |
| | Relaxed | | override ↗ ∧ $loc(mid_{1,2})$ = 'left' |
| ↗ | Strict | | $\neg$ ↗ ∧ $loc(mid_{1,2})$ = 'right' |
| | Relaxed | | override ↗ ∧ $loc(mid_{1,2})$ = 'right' |
| ↖ | Strict | ($\neg$H ∧ $\neg$V) ∧ ($cp_{1x} > cp_{2x}$ ∧ $cp_{1y} < cp_{2y}$) | $\alpha_{1,2} < \alpha_{low}$ |
| | Relaxed | | $\alpha_{1,2} < \alpha_{high}$ |
| ↖ | Strict | | $\neg$ ↖ ∧ $loc(mid_{1,2})$ = 'left' |
| | Relaxed | | override ↖ ∧ $loc(mid_{1,2})$ = 'left' |
| ↖ | Strict | | $\neg$ ↖ ∧ $loc(mid_{1,2})$ = 'right' |
| | Relaxed | | override ↖ ∧ $loc(mid_{1,2})$ = 'right' |

## Applications – Handwriting Learning




Extracting Trajectory Descriptions




Handwritten Shapes with Feedback

| | Trajectory Representation (from top-left) | Parameter Settings |
|---|---|---|
|  | | |
|  | vert_down<br>ccw_right_up<br>vert_up<br>vert_down<br>ccw_right_down<br>vert_up | $\tau$ = 2, $\alpha_{low}$ = 10<br>maxSegLen = 0.4,<br>$D_0$ = ↓s,↑s,→s,←s,↘s,↘s,↘s,↙s,↙s,↖s,↗s,↗s,↗s,↖s,↖s,↖s |
|  | vert_down<br>ccw_right_up<br>ccw_right_down<br>vert_up | $\tau$ = 3, $\alpha_{low}$ = 10<br>maxSegLen = 0.4,<br>$D_0$ = ↓s,↑s,→s,←s,↘s,↘s,↘s,↙s,↙s,↖s,↗s,↗s,↗s,↖s,↖s,↖s |
|  | vert_Down<br>vert_up<br>vert_down<br>vert_up | $\tau$ = 3, $\alpha_{high}$ = 20<br>maxSegLen = 0.6,<br>$D_1$ = ↓r,↑r,→r,←r,↘r,↘s,↘s,↙r,↙s,↖s,↗r,↗s,↗s,↖r,↖s,↖s |
|  | ccw_right_down<br>ccw_right_up<br>ccw_right_down<br>ccw_right_up | $\tau$ = 3, maxSegLen = 0.8,<br>$D_2$ = ↘r,↘r,↙r,↙r,↗r,↗r,↖r,↖r |

## An Example