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# Supplemental Material for the Paper:

# ShipShape: A Drawing Beautification Assistant

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## 1. Introduction

In this document, we present extra material for the paper *ShipShape: A Drawing Beautification Assistant*. This addendum describes in greater detail the approach we used to evaluate the likelihoods of applications of the supported rules and constraints listed in the main paper. We agree that further investigation of tuning of these parameters would be beneficial.

## 2. Rules Evaluation

The rules are evaluated using a piecewise-linear ramp functions, both continuous and discontinuous. These functions transform the input values, such as angular differences or view-space distances, to likelihood values from the interval $[0,1]$ used to direct the tree expansion and final suggestion sorting described in the paper. For each rule listed in section 3.1 in the main paper, we show the exact scoring function we used in out implementation.

### 2.1. Line Detection

As in QuickDraw [CGL12], we calculate the deviation from straightness $D = |1 - \frac{|l_c|}{|l_l|}|$, where $|l_c|$ is length of sampled Bézier curve and $|l_l|$ length of line segment between its endpoints. If $D$ is lower than the threshold 0.05, we set the likelihood $\mathcal{L}_{LD}$ of the curve being a line segment to $1 - D$.

### 2.2. Arc Detection

We determine approximate curvature from the series of angles between tangents of successive path samples. We then sort them and select samples on 15th and 85th percentiles. If their signs match, we evaluate their angular difference (Figure 1 top) obtaining likelihood $\mathcal{L}_{dst}$ and span (to prevent treating imprecise bent line segments as circular arcs with short span) $\mathcal{L}_{spn}$ (Figure 1 bottom). Final likelihood value is then computed as their multiplication $\mathcal{L}_{AD} = \mathcal{L}_{dst}\mathcal{L}_{spn}$ and a suggestion is produced, if $\mathcal{L}_{AD} > 0$. If the input Bézier curve is closed or the span is larger than $1.95\pi$, we output the full circle.

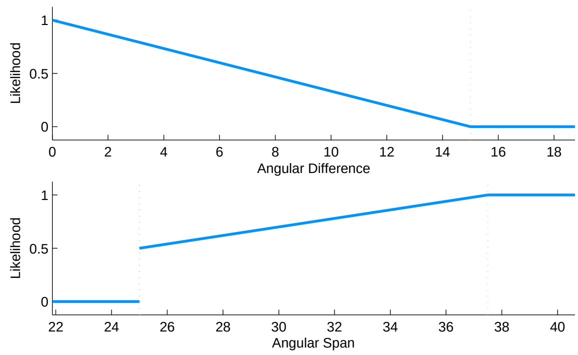


**Figure 1:** Angular difference evaluation (top) and angular span evaluation (bottom) in *Arc Detection* rule.

### 2.3. Endpoint Snapping

We measure the distances between the endpoint and the points of interest (other endpoints, arc centers, etc.) in view-space pixels and transform them to final likelihoods $\mathcal{L}_{ES}$ (Figure 2). As the users can end strokes relatively precisely even with devices such as mouse or touchpad, there is no tolerance zone in the scoring function.

### 2.4. End Tangent Alignment

The angular difference between the curve endpoint and the endpoint it is connected to is directly transformed to final likelihood $\mathcal{L}_{ETA}$ (Figure 3).

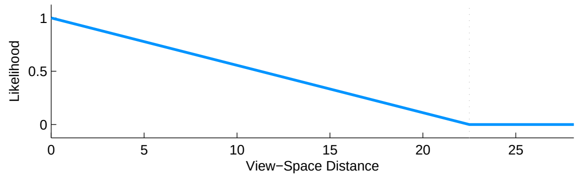


**Figure 2:** View-space distance evaluation in *Endpoint Snapping* rule.

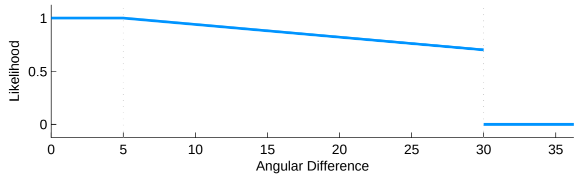


**Figure 3:** Angular difference evaluation in *Arc Detection* rule.

### 2.5. Line Parallelism and Perpendicularity

We measure the angular difference between the direction vectors of two line segments to obtain the likelihood $\mathcal{L}_{dff}$ (Figure 4 top). To increase the final likelihood of nearby line segments, we also score the view-space distance between tested line segments – $\mathcal{L}_{dst}$ (Figure 4 bottom). The output suggestion with likelihood $\mathcal{L}_{LP} = \mathcal{L}_{dff}\mathcal{L}_{dst}$ is produced, if $\mathcal{L}_{LP} > 0.7$.

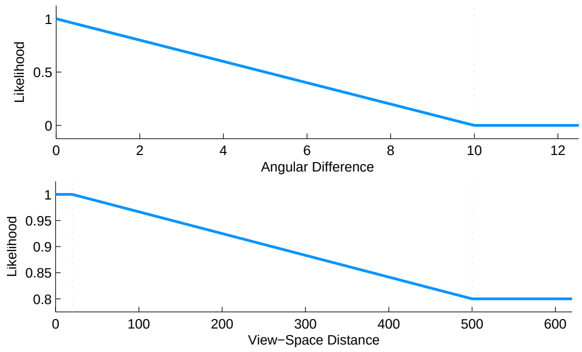


**Figure 4:** Angular difference evaluation (top) and view-space distance evaluation (bottom) in *Line Parallelism* and *Line Perpendicularity* rule.

### 2.6. Line Length Equality

We measure the line length difference relative to a tested line segment to get the likelihood $\mathcal{L}_{dff}$ (Figure 5 top) and also the likelihood $\mathcal{L}_{dst}$ (Figure 5 bottom) based on relative distances of existing line segments to the tested one. Similarly to line parallelism rule, the final likelihood is computed as $\mathcal{L}_{LLE} = \mathcal{L}_{dff}\mathcal{L}_{dst}$ and an output suggestion is produced, if $\mathcal{L}_{LLE} > 0.7$.

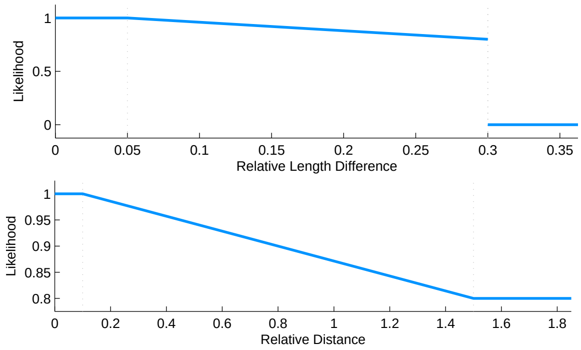


**Figure 5:** Relative length difference evaluation (top) and relative distance evaluation (bottom) in *Line Length Equality* rule.

### 2.7. Arc and Circle Center Snapping

We compute the final likelihood $\mathcal{L}_{ACCS}$ from the distance necessary to snap the arc center to some "interesting" point (line endpoint, other arc center, etc.) relative to the current radius of the arc (Figure 6).

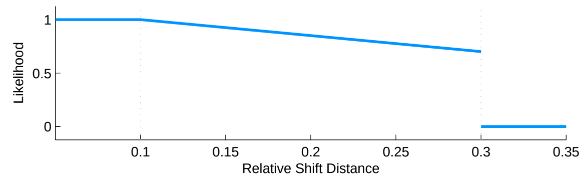


**Figure 6:** Relative shift distance evaluation in *Arc and Circle Center Snapping* rule.

### 2.8. Path Identity

We compute the discrete Fréchet distance between the tested path and the existing one, as described in Section 3.4 in the main paper. The absolute distance $\delta_F$ is then made relative to the length of the tested path and used to compute the likelihood $\mathcal{L}_{PI}$ (Figure 7).

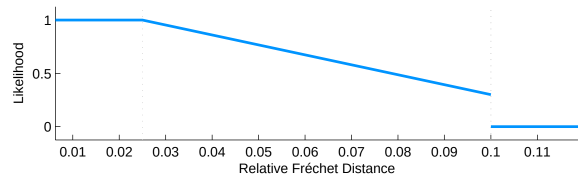


**Figure 7:** Relative discrete Fréchet distance evaluation in *Path Identity* rule.

### 2.9. Path Offset

The process to obtain samples along the tested path together with their signed distances to the existing path is described in the main paper in Section 3.5. To compute the likelihood $\mathcal{L}_{PO}$ we evaluate the relative distance difference between 25th and 75th quantile from the sorted hit data (Figure 8).

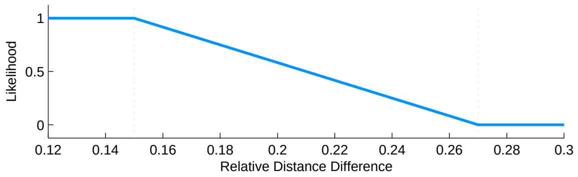


**Figure 8:** Relative distance difference evaluation in *Path Offset* rule.

### 2.10. Path Rotational Symmetry

As described in Section 3.1 of the main paper, we try to find the optimal transformation of a tested path $x$ of the "same shape" as some existing path $y$ to obtain a transformed path $y'$ that minimizes the displacement of endpoints of path $x$. We then make this displacement relative to the length of the tested path $x$ and use this value to compute the final likelihood $\mathcal{L}_{PRotS}$ (Figure 9).

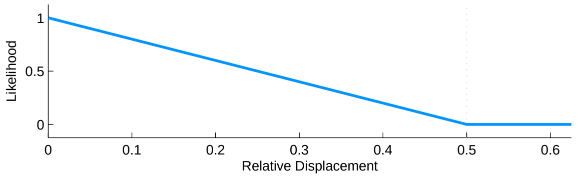


**Figure 9:** Relative displacement evaluation in *Path Rotational Symmetry* rule.

### 2.11. Path Reflection Symmetry

In similar spirit to path rotational symmetry, we evaluate the displacement of the endpoints of the tested path to get the final likelihood $\mathcal{L}_{PRefS}$ (Figure 10). We observed that with increasing number of paths in the canvas, the probability of finding suitable reflection axis for almost any input stroke rises, and thus we made this symmetry rule slightly less sensitive.

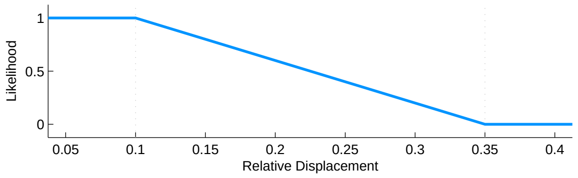


**Figure 10:** Relative displacement evaluation in *Path Reflection Symmetry* rule.



## References

[CGL12] Cheema S., Gulwani S., LaViola J.: Quickdraw: Improving drawing experience for geometric diagrams. In *Proceedings of SIGCHI Conference on Human Factors in Computing Systems* (2012), pp. 1037–1064. 1