1 APPENDIX

1.1 List of Digital Pen Features

In this section we provide the complete list of features from the various feature sets that we consider. For formal mathematical definitions please refer to the original publications. Please note that the feature sets are not necessarily distinct.

Our reference implementation is made publicly available on GitHub at:
`https://github.com/DFKI-Interactive-Machine-Learning/ink-features`

1.1.1 Rubine's Feature Set

These are the 13 features described by Rubine (Rubine, 1991):

1. Cosine of initial angle
2. Sine of initial angle
3. Length of bounding box diagonal
4. Angle of the bounding box diagonal
5. Distance between first and last point
6. Cosine of the angle between first and last point
7. Sine of the angle between first and last point
8. Total gesture length
9. Total angle traversed
10. Sum of the absolute value of the angle at each point
11. Sum of the squared value of the angle at each point
12. Maximum speed (squared) of the gesture
13. Duration of the gesture

1.1.2 Willems & Niels Feature Set

The feature set described by Willems and Niels (Willems and Niels, 2008) contains the following 89 features:

1. Length of the gesture
2. Area
3. Compactness
4. Eccentricity
5. Ratio between co-ordinate axes
6. Closure
7. Circular variance
8. Curvature
9. Average curvature
10. Standard deviation in curvature
11. Pen up/down ratio
12. Average direction

13. Perpendicularity

14. Average perpendicularity

15. Standard deviation in perpendicularity

16. Centroid offset

17. Length of first principal axis

18. Sine orientation of principal axis

19. Cosine orientation of principal axis

20. Rectangularity

21. Maximum angular difference

22. Average pressure

23. Standard deviation of pressure

24. Duration

25. Average velocity

26. Standard deviation of velocity

27. Maximum velocity

28. Average acceleration

29. Standard deviation of acceleration

30. Maximum acceleration

31. Minimum acceleration

32. Number of cups

33. Offset of the first cup

34. Offset of the last cup

35. Initial horizontal offset

36. Final horizontal offset

37. Initial vertical offset

38. Final vertical offset

39. Number of straight lines

40. Average length of straight lines

41. Standard deviation of straight line length

42. Straight line ratio

43. Largest straight line ratio

44. Number of pen down events

45. Octants 1

46. Octants 2

47. Octants 3

48. Octants 4

49. Octants 5

50. Octants 6

51. Octants 7
52. Octants 8
53. Number of connecting strokes
54. Number of crossings
55. Cosine of initial angle
56. Sine of initial angle
57. Length of the bounding box diagonal
58. Angle of the bounding box diagonal
59. Length between first and last point
60. Cosine of first to last point
61. Sine of first to last point
62. Absolute curvature
63. Squared curvature
64. Macro perpendicularity
65. Average macro perpendicularity
66. Standard deviation in macro perpendicularity
67. Ratio of principal axes
68. Average centroidal radius
69. Standard deviation of the centroidal radius
70. Sin chain code 1
71. Cos chain code 1
72. Sin chain code 2
73. Cos chain code 2
74. Sin chain code 3
75. Cos chain code 3
76. Sin chain code 4
77. Cos chain code 4
78. Sin chain code 5
79. Cos chain code 5
80. Sin chain code 6
81. Cos chain code 6
82. Sin chain code 7
83. Cos chain code 7
84. Sin chain code 8
85. Cos chain code 8
86. Average stroke length
87. Standard deviation in stroke length
88. Average stroke direction

89. Standard deviation in stroke direction

1.1.3 HBF49 Feature Set

The HBF49 feature set (Delaye and Anquetil, 2013) contains the following 49 features:

1. Horizontal position of first point
2. Vertical position of first point
3. Horizontal position of last point
4. Vertical position of last point
5. First point to last point vector length
6. Sine of first point to last point vector
7. Cosine of first point to last point vector
8. Closure
9. Sine of initial angle
10. Cosine of initial angle
11. Horizontal inflexion
12. Vertical inflexion
13. Downstroke proportion
14. Number of strokes
15. Angle of the bounding box diagonal
16. Trajectory length
17. Ratio between bounding box and trajectory length
18. Deviation
19. Average direction
20. Curvature
21. Perpendicularity
22. k-Perpendicularity
23. k-Angle
24. Dominant direction 1
25. Dominant direction 2
26. Dominant direction 3
27. Dominant direction 4
28. Local changes in direction 1
29. Local changes in direction 2
30. Local changes in direction 3
31. Local changes in direction 4
32. 2D histogram 1
33. 2D histogram 2
34. 2D histogram 3

35. 2D histogram 4

36. 2D histogram 5

37. 2D histogram 6

38. 2D histogram 7

39. 2D histogram 8

40. 2D histogram 9

41. Hu moment 1

42. Hu moment 2

43. Hu moment 3

44. Hu moment 4

45. Hu moment 5

46. Hu moment 6

47. Hu moment 7

48. Normalized convex hull area

49. Compactness

1.1.4 Sonntag et al. Feature Set

The 14 features described by Sonntag et al. (Sonntag et al., 2014) are:

1. Number of Strokes

2. Length

3. Area

4. Perimeter Length

5. Compactness

6. Eccentricity

7. Principal Axes

8. Circular Variance

9. Rectangularity

10. Closure

11. Curvature

12. Perpendicularity

13. Signed Perpendicularity

14. Angles after Equidistant Resampling

1.1.5 Cognitive Performance Feature Set

The set of 11 features defined in literature that focuses on the evaluation of cognitive performance (Cohen et al., 2014; Davis et al., 2015; Werner et al., 2006) consists of:

1. Number of strokes

2. Sketching time

3. Stroke distance

4. Duration

5. Average pressure

6. Average velocity

7. Variation of velocity

8. Number of pauses

9. Average pause duration

10. Ratio between sketching and pausing

11. Average lift duration

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