between one or more evenly distributed feature points in the test sample and one or more evenly distributed feature points in the reference sample; obtaining a count of consecutive unlinked feature points in the test sample; and outputting a handwriting verification result, wherein the handwriting verification result is based at least in part on the feature matching and the count of consecutive unlinked feature points in the test sample.

In another aspect, a handwriting verification method executed in a computer system comprises obtaining a test sample and a reference sample each containing a plurality of feature points, wherein each of the feature points includes: (i) geometric features including an x-coordinate value and a y-coordinate value, and (ii) a non-geometric feature; finding mappings between feature points of the test sample and feature points of the reference sample based on the geometric features of the test sample and reference sample, wherein the finding mappings comprises finding mappings between one or more of evenly distributed feature points in the test sample and one or more evenly distributed feature points in the reference sample; and after the finding mappings, comparing the non-geometric features of each of the mapped feature points of the test sample and the reference sample.

In another aspect, a handwriting verification method executed in a computer system comprises performing feature matching between geometric features of a handwriting test sample and geometric features of a reference sample, wherein the feature matching comprises defining one or more links between one or more feature points in the test sample and one or more feature points in the reference sample; obtaining a count of consecutive unlinked feature points in the test sample; and outputting a handwriting verification result based at least in part on the feature matching and the count of consecutive unlinked feature points in the test sample.

In another aspect, a handwriting verification method executed in a computer system comprises obtaining a test sample and a reference sample each containing a plurality of feature points, wherein each of the feature points includes: (i) geometric features including an x-coordinate value and a y-coordinate value, and (ii) a non-geometric feature, wherein the non-geometric feature comprises pen pressure, elapsed time, speed, or acceleration; finding mappings between feature points of the test sample and feature points of the reference sample based on the geometric features of the test sample and reference sample, wherein the finding mappings is done by an algorithm

utilizing a pseudo-random value; and after the finding mappings, comparing the non-geometric features of each of the mapped feature points of the test sample and the reference sample.

In another aspect, a handwriting verification method executed in a computer system comprises obtaining a test sample and a reference sample each containing a plurality of feature points, wherein each of the feature points includes: (i) geometric features including an x-coordinate value and a y-coordinate value, and (ii) a non-geometric feature; finding mappings between feature points of the test sample and feature points of the reference sample based on the geometric features of the test sample and reference sample, wherein the finding mappings is based on a count of unlinked feature points of the test sample; and after the finding mappings, comparing the non-geometric features of each of the mapped feature points of the test sample and the reference sample.

In another aspect, a handwriting verification method executed in a computer system comprises obtaining a test sample and a reference sample each containing a plurality of feature points, wherein each of the feature points includes: (i) geometric features including an x-coordinate value and a y-coordinate value, and (ii) a non-geometric feature; finding mappings between feature points of the test sample and feature points of the reference sample based on the geometric features of the test sample and reference sample, wherein the finding mappings comprises determining, based on a pseudo-random value, whether to (a) remove a mapping from a selected feature point in the reference sample, or (b) define a new mapping between the selected feature point in the reference sample and a selected feature point in the test sample; and after the finding mappings, comparing the non-geometric features of each of the mapped feature points of the test sample and the reference sample.

In another aspect, a user authentication method executed in a computer system comprises receiving test signature data and a user device identifier (ID) from a user device; searching for a name or user ID associated with the test signature data; obtaining the name or user ID; searching for a reference device ID associated with the name or user ID; comparing the reference device ID with the user device ID; and providing authentication information (e.g., an authentication result) to the user device based on the comparing. The device IDs may be, for example, pen or stylus IDs associated with a pen or stylus.

In another aspect, a user authentication method executed in a computer system comprises receiving test signature data (e.g., encrypted test signature data), a device identifier, and a service identifier from a user device, wherein the service identifier relates to a service executing on the user device; comparing the test signature data with reference signature data to determine whether the test signature data is consistent with the reference signature data; based on a result of the comparing, obtaining authentication information (e.g., a user ID and a password) associated with the service executing on the user device; and providing the authentication information to the user device. If the test signature data is consistent with the reference signature data, the test signature data may be added to the reference signature data (e.g., as supplemental information for future authentications).

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1A is a high-level diagram of an illustrative cloud computing arrangement configured to verify authenticity of sample handwriting data;

FIGURE 1B is a functional block diagram of an illustrative handwriting data processing section;

FIGURE 2A is an illustration of a handwritten signature comprising a plurality of pen events;

FIGURE 2B is a diagram of rotation, altitude, and azimuth parameters that can be detected for a pen device;

CLAIMS

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A handwriting verification method executed in a computer system, the method comprising:

obtaining a test sample and a reference sample each containing a plurality of feature points, wherein each of the feature points includes:

(i) geometric features including an x-coordinate value and a y-coordinate value, and

(ii) a non-geometric feature;

finding mappings between feature points of the test sample and feature points of the reference sample based on the geometric features of the test sample and reference sample, wherein the finding mappings comprises finding mappings between one or more of evenly distributed feature points in the test sample and one or more evenly distributed feature points in the reference sample; and

after the finding mappings, comparing the non-geometric features of each of the mapped feature points of the test sample and the reference sample.

2. The method of claim 1, wherein the non-geometric feature comprises pen pressure, elapsed time, speed, or acceleration.

3. The method of claim 1, wherein the comparing is performed in the case that the mapping is determined to be a sufficient match.

4. The method of claim 1, wherein the finding mappings is done by an algorithm utilizing a pseudo-random value.

5. The method of claim 1, wherein the finding mappings is based on a count of unlinked feature points of the test sample.

6. The method of claim 1, wherein the finding mappings is based on a count of consecutive unlinked feature points in the test sample.

7. The method of claim 1, wherein the finding mappings comprises:

determining, based on a pseudo-random value, whether to (a) remove a mapping from a selected feature point in the reference sample, or (b) define a new mapping between the selected feature point in the reference sample and a selected feature point in the test sample.

8. The method of claim 1, the geometric features further include direction (D) and curvature (C) derived from the x-coordinate values and y-coordinate values.

9. A handwriting verification method executed in a computer system, the method comprising:

performing feature matching between geometric features of a handwriting test sample and geometric features of a reference sample, wherein the feature matching comprises defining one or more links between one or more feature points in the test sample and one or more feature points in the reference sample;

obtaining a count of consecutive unlinked feature points in the test sample; and

outputting a handwriting verification result based at least in part on the feature matching and the count of consecutive unlinked feature points in the test sample.

10. The method of claim 9, further including comparing non-geometric features of each of the linked feature points of the test sample and the reference sample.

11. The method of claim 9, wherein the feature matching includes:

initializing a pseudo-random value generator to generate a sequence of pseudo-random values, wherein the feature matching is based on a pseudo random value generated by the pseudo random value generator; and

if matching is not sufficient, performing another feature matching by the using another pseudo random value generated by the same uniform random value generator.

12. A handwriting verification method executed in a computer system, the method comprising:

obtaining a test sample and a reference sample each containing a plurality of feature points, wherein each of the feature points includes:

(i) geometric features including an x-coordinate value and a y-coordinate value, and

(ii) a non-geometric feature, wherein the non-geometric feature comprises pen pressure, elapsed time, speed, or acceleration;

finding mappings between feature points of the test sample and feature points of the reference sample based on the geometric features of the test sample and reference sample, wherein the finding mappings is done by an algorithm utilizing a pseudo-random value; and

after the finding mappings, comparing the non-geometric features of each of the mapped feature points of the test sample and the reference sample.

13. The method of claim 12, wherein the comparing is performed in the case that the mapping is determined to be a sufficient match.

14. The method of claim 12, wherein the finding mappings is based on a count of unlinked feature points of the test sample.

15. The method of claim 12, wherein the finding mappings is based on a count of consecutive unlinked feature points in the test sample.

16. The method of claim 12, wherein the finding mappings comprises:

determining, based on the pseudo-random value, whether to (a) remove a mapping from a selected feature point in the reference sample, or (b) define a new mapping between the selected feature point in the reference sample and a selected feature point in the test sample.

17. The method of claim 12, wherein the finding mappings comprises finding mappings between one or more of evenly distributed feature points in the test sample and one or more evenly distributed feature points in the reference sample.

18. The method of claim 12, wherein the geometric features further include direction (D) and curvature (C) derived from the x-coordinate values and y-coordinate values.

19. A handwriting verification method executed in a computer system, the method comprising:

obtaining a test sample and a reference sample each containing a plurality of feature points, wherein each of the feature points includes:

(i) geometric features including an x-coordinate value and a y-coordinate value, and

(ii) a non-geometric feature;

finding mappings between feature points of the test sample and feature points of the reference sample based on the geometric features of the test sample and reference sample, wherein the finding mappings is based on a count of unlinked feature points of the test sample; and

after the finding mappings, comparing the non-geometric features of each of the mapped feature points of the test sample and the reference sample.

20. The method of claim 19, wherein the non-geometric feature comprises pen pressure, elapsed time, speed, or acceleration.

21. The method of claim 19, wherein the comparing is performed in the case that the mapping is determined to be a sufficient match.

22. The method of claim 19, wherein the finding mappings is done by an algorithm utilizing a pseudo-random value.

23. The method of claim 19, wherein the finding mappings is based on a count of consecutive unlinked feature points in the test sample.

24. The method of claim 19, wherein the finding mappings comprises:

determining, based on a pseudo-random value, whether to (a) remove a mapping from a selected feature point in the reference sample, or (b) define a new mapping between the selected feature point in the reference sample and a selected feature point in the test sample.

25. The method of claim 19, wherein the finding mappings comprises finding mappings between one or more of evenly distributed feature points in the test sample and one or more evenly distributed feature points in the reference sample.

26. The method of claim 19, wherein the geometric features further include direction (D) and curvature (C) derived from the x-coordinate values and y-coordinate values.

27. A handwriting verification method executed in a computer system, the method comprising:

obtaining a test sample and a reference sample each containing a plurality of feature points, wherein each of the feature points includes:

(i) geometric features including an x-coordinate value and a y-coordinate value, and

(ii) a non-geometric feature;

finding mappings between feature points of the test sample and feature points of the reference sample based on the geometric features of the test sample and reference sample, wherein the finding mappings comprises determining, based on a pseudo-random

value, whether to (a) remove a mapping from a selected feature point in the reference sample, or (b) define a new mapping between the selected feature point in the reference sample and a selected feature point in the test sample; and

after the finding mappings, comparing the non-geometric features of each of the mapped feature points of the test sample and the reference sample.

28. The method of claim 27, wherein the non-geometric feature comprises pen pressure, elapsed time, speed, or acceleration.

29. The method of claim 27, wherein the comparing is performed in the case that the mapping is determined to be a sufficient match.

30. The method of claim 27, wherein the finding mappings is done by an algorithm utilizing a pseudo-random value.

31. The method of claim 27, wherein the finding mappings is based on a count of unlinked feature points of the test sample.

32. The method of claim 27, wherein the finding mappings is based on a count of consecutive unlinked feature points in the test sample.

33. The method of claim 27, wherein the finding mappings comprises finding mappings between one or more of evenly distributed feature points in the test sample and one or more evenly distributed feature points in the reference sample.

34. The method of claim 27, wherein the geometric features further include direction (D) and curvature (C) derived from the x-coordinate values and y-coordinate values.