Quantum-like Gaussian Mixture Model

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Abstract

A new concept of a quantum-like mixture model is introduced. It describes the mixture distribution with the assumption that a point is generated by each Gaussian at the same time. The decision boundary of a quantum-like mixture Gaussian corresponds as well to the separation of probabilities for the switching Kalman filter. The quantum-like mixture Gaussian can improve the classification accuracy in machine learning by indicating the uncertain points should not be assigned to any class. We will demonstrate the principle by the Gaussian mixture model for classification of the iris data set. The use of this data set in cluster analysis is not common, since the data set only contains two clusters with rather obvious separation.

Full Text

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Figures

Figure 1

(a) Two Gaussians with $\mu_1 = 3$, $\sigma_1 = 3$ and $\mu_2 = -3$, $\sigma_2 = 2$. (b) Gaussian mixture of the two Gaussians with equal mixture coefficients π .

Figure 2

(a) Quantum-like Gaussian mixture with the interference wave with the frequency $f = 10$ of the two Gaussians with $\mu_1 = 3$, $\sigma_1 = 3$ and $\mu_2 = -3$, $\sigma_2 = 2$ with equal mixture coefficients π . (b) Representation at a higher scale.

Figure 3

Please see the Manuscript PDF file for the complete figure caption.

Figure 4

Please see the Manuscript PDF file for the complete figure caption.

Figure 5

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Figure 6

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Figure 7

(a) Contour plot of Gaussian mixture of two Gaussians. (b) Contour plot of quantum-like Gaussian mixture of two Gaussians.

Figure 8

Please see the Manuscript PDF file for the complete figure caption.

Figure 9

(a) Contour plot of Gaussian mixture of four Gaussians. (b) Contour plot of quantum-like Gaussian mixture of four Gaussians.

Figure 10

(a) A bird is heading at a high speed for a tree trunk, the mean Gaussian as predicted by the Kalman filter will be centered on the obstacle. (b) A switching Kalman filter marginalizes the action of the bird, in our case two different movements described by Gaussians. However the resulting Gaussian mixture has a high probability values at the center of the obstacle if the two Gaussians. (c) The quantum-like Gaussian mixture with the interference wave separates the two Gaussians, the resulting probability value at the center of the obstacle is very low or zero.

Figure 11

Please see the Manuscript PDF file for the complete figure caption.

Figure 12

Classification of the first tow features sepal length and width of the Iris data set by the Gaussian mixture model.

Figure 13

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Figure 14

(a) Contour plot of Gaussian mixture of three Gaussians. As a result two clusters are present with rather obvious separation. One of the clusters contains Iris-Setosa, while the other cluster contains both Iris-Versicolor, and Iris-Virginica as indicated by the by the Gaussian mixture. (b) Contour plot of quantum-like Gaussian mixture of the three Gaussians. The quantum-like Gaussian mixture separates the two clusters Iris-Versicolor, and Iris-Virginica to some extend.