Abstract The traditional ellipsoid convex set is a kind of basic non-probabilistic model to measure uncertainties. However, it is difficult or inaccurate to quantify the uncertainties of variables with multimodal distributed samples. In this paper, a more generalized non-probabilistic ellipsoid model named multimodal ellipsoid model is proposed to effectively deal with the multimodal distributed samples. The samples with one or more similar properties are clustered together, and the principal directions of the samples and characteristic matrix are appropriately found through the Gaussian mixture model. Then, the multimodal ellipsoid model can be constructed by using the elliptical contour features of the Gaussian model to measure the uncertainties of variables. The proposed multimodal ellipsoid model can not only establish traditional ellipsoid model, but also establish multi-ellipsoid model for uncertain variables with multimodal samples. Furthermore, combining with the multimodal ellipsoid model and performance measure approach, the uncertain propagation results of system are obtained accurately. Three numerical examples and one engineering application are provided to demonstrate the effectiveness and accuracy of the proposed multimodal ellipsoid model.

Keywords Multimodal ellipsoid model, Gaussian mixture model, Uncertainty quantification, Uncertainty propagation, Performance measure approach.