Swarm Optimization implementation. Each particle then evaluates its position's selected features and searches for a new position based on the change in velocity. This study employs BPSO with hyperparameters as follows: 100 particles, 25 iterations, 1.4 as c_1 and c_2 values, with 0.5 inertia.

For comparison, the barebone KNN and KNN with PCA without BPSO are further evaluated. For comparison purposes, the k number of neighbors used are 3, 5, and 7. Additionally, the proposed model's performance is then assessed by its accuracy rate.

4.2 Result Analysis

From Table 4, the results obtained for the four confusion matrix measures without BPSO demonstrate an adequate performance with the highest accuracy of 82.31% and a minimum accuracy of 79.23%. However, PCA can be found to somewhat impair the model's performance for K = 5 and K = 7. This is because PCA greatly reduces the number of features, while only decreasing the performance by a maximum of 3.08

The proposed feature selection implementation employing BPSO resulted in an improved performance with accuracy possessing higher scores than those without BPSO as shown in Table 4. BPSO improved the proposed model obtaining the highest accuracy of 93.08% for K = 3 with a 10.77% increase over the highest accuracy without BPSO.

Table 4. Model performance

Model	**Accuracy**		
	K = 3	**K = 5**	**K = 7**
KNN	82.31	82.31	81.54
KNN+PCA	82.31	79.23	80
KNN+PCA+BPSO	93.08	92.31	91.54

5. Conclusion

The experiments show that using BPSO as a feature selection method to revolutionize date fruit categorization provides excellent results. The results of this study reveal that BPSO is effective at optimizing the influential features employed in the KNN training phase. KNN can now build an upgraded model with a promising accuracy of 93.08% thanks to BPSO. Even though BPSO is an optimization approach, the experimental findings indicate that it is suitable for feature selection. BPSO may be a beneficial technique for improving model performance in other situations as well. Furthermore, this study emphasizes the need to correctly analyze and select helpful and influential attributes while also determining the trade-off between performance and data loss. Our findings also reveal that even without dimensionality reduction or feature selection, the method and techniques used for feature extraction give a minimum accuracy of 81.54%. Additionally, the findings of this study show the use of color, shape, and texture features for date fruit image classification employing standard KNN produces an adequate performance above 80%. Furthermore, the results indicate that by including additional information and classes, an improved date fruit classification model can be made.

Bibliography

[1] A. A. Abi Sen, N. M. Bahbouh, A. B. Alkhodre, A. M. Aldhawi, F. A. Aldham, and M. I. Aljabri. A classification algorithm for date fruits. In *2020 7th International Conference on Computing for Sustainable Global Development (INDIACom)*, pages 235–239. IEEE, 2020.

[2] S. Abouzahir, M. Sadik, and E. Sabir. Bag-of-visual-words-augmented histogram of oriented gradients for efficient weed detection. *Biosystems Engineering*, 202:179–194, 2021.

[3] H. Altaheri, M. Alsulaiman, and G. Muhammad. Date fruit classification for robotic harvesting in a natural environment using deep learning. *IEEE Access*, 7:117115–117133, 2019.

[4] F. Anowar, S. Sadaoui, and B. Selim. Conceptual and empirical comparison of dimensionality reduction algorithms (pca, kpca, lda, mds, svd, lle, isomap, le, ica, t-sne). *Computer Science Review*, 40:100378, 2021.

[5] F. Chalik and W. F. Al Maki. Classification of dried clove flower quality using convolutional neural network. In *2021 International Conference on Data Science, Artificial Intelligence, and Business Analytics (DATABIA)*, pages 40–45. IEEE, 2021.

[6] A. Farhanah and W. F. Al Maki. Hops plants disease detection using feature selection based bpso-svm. In *2022 9th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI)*, pages 389–393. IEEE, 2022.

[7] Y. Ferdinand and W. F. Al Maki. Broccoli leaf diseases classification using support vector machine with particle swarm optimization based on feature selection. *International Journal of Advances in Intelligent Informatics*, 8(3):337–348, 2022.

[8] Food and A. O. of the United Nations. Food and agriculture commodities production 2020.

[9] D. M. Hibban and W. F. Al Maki. Classification of ornamental betta fish using convolutional neural network method and grabcut segmentation. In *2021 International Conference on Data Science and Its Applications (ICoDSA)*, pages 102–109. IEEE, 2021.

[10] A. Humeau-Heurtier. Texture feature extraction methods: A survey. *Ieee Access*, 7:8975–9000, 2019.

[11] M. Iqbal, G. M. Putra, N. Puspitasari, H. J. Setyadi, F. A. Dwiyanto, A. P. Wibawa, R. Alfred, et al. A performance comparison of euclidean, manhattan and minkowski distances in k-means clustering. In *2020 6th International Conference on Science in Information Technology (ICSITech)*, pages 184–188. IEEE, 2020.

[12] V. P. Kour and S. Arora. Particle swarm optimization based support vector machine (p-svm) for the segmentation and classification of plants. *IEEE Access*, 7:29374–29385, 2019.

[13] L. Kumar and K. K. Bharti. An improved bpso algorithm for feature selection. In *Recent Trends in Communication, Computing, and Electronics: Select Proceedings of IC3E 2018*, pages 505–513. Springer, 2019.

[14] X. Liu, D. Zhao, W. Jia, W. Ji, and Y. Sun. A detection method for apple fruits based on color and shape features. *IEEE Access*, 7:67923–67933, 2019.

[15] A. K. Mishra, P. Roy, and S. Bandyopadhyay. Binary particle swarm optimization based feature selection (bpso-fs) for improving breast cancer prediction. In *Proceedings of International Conference on Artificial Intelligence and Applications: ICAIA 2020*, pages 373–384. Springer, 2021.

[16] M. Muhathir, T. T. S. Sibarani, and A.-K. Al-Khowarizmi. Analysis k-nearest neighbors (knn) in identifying tuberculosis disease (tb) by utilizing hog feature extraction. *Al'adzkiya International of Computer Science and Information Technology (AIoCSIT) Journal*, 1(1), 2020.

[17] A. Nasiri, A. Taheri-Garavand, and Y.-D. Zhang. Image-based deep learning automated sorting of date fruit. *Postharvest biology and technology*, 153:133–141, 2019.

[18] F. J. Pratama, W. F. Al Maki, F. Sthevanie, et al. Big cats classification based on body covering. *Jurnal RESTI (Rekayasa Sistem dan Teknologi Informasi)*, 5(5):984–991, 2021.

[19] G. T. Reddy, M. P. K. Reddy, K. Lakshmanna, R. Kaluri, D. S. Rajput, G. Srivastava, and T. Baker. Analysis of dimensionality reduction techniques on big data. *Ieee Access*, 8:54776–54788, 2020.

[20] A. K. Singh, S. Sreenivasu, U. Mahalaxmi, H. Sharma, D. D. Patil, and E. Asenso. Hybrid feature-based disease detection in plant leaf using convolutional neural network, bayesian optimized svm, and random forest classifier. *Journal of Food Quality*, 2022:1–16, 2022.

[21] F. R. Siregar and W. F. Al Maki. Hybrid method for flower classification in high intra-class variation. In *2020 3rd International Seminar on Research of Information Technology and Intelligent Systems (ISRITI)*, pages 73–78. IEEE, 2020.

[22] A. Younas, S. A. Naqvi, M. R. Khan, M. A. Shabbir, M. A. Jatoi, F. Anwar, M. Inam-Ur-Raheem, N. Saari, and R. M. Aadil. Functional food and nutra-pharmaceutical perspectives of date (phoenix dactylifera l.) fruit. *Journal of food biochemistry*, 44(9):e13332, 2020.

[23] X. Zenggang, T. Zhiwen, C. Xiaowen, Z. Xue-min, Z. Kaibin, and Y. Conghuan. Research on image retrieval algorithm based on combination of color and shape features. *Journal of signal processing systems*, 93:139–146, 2021.

[24] P. Zhang and Z.-Y. Yin. A novel deep learning-based modelling strategy from image of particles to mechanical properties for granular materials with cnn and bilstm. *Computer Methods in Applied Mechanics and Engineering*, 382:113858, 2021.

[25] W. Zhou, S. Gao, L. Zhang, and X. Lou. Histogram of oriented gradients feature extraction from raw bayer pattern images. *IEEE Transactions on Circuits and Systems II: Express Briefs*, 67(5):946–950, 2020.