
PhD thesis: **Digital Signal Processing and Artificial Intelligence Methods in Agricultural Production Technologies Using Innovative Biofertilizers**

Candidate: Aleksandra Konopka

Detailed Review Comments:

This PhD thesis presents a comprehensive study of digital signal processing and AI-based methods for production technology innovation using biofertilizers. It starts with a detailed background review of the key challenges to be addressed in the thesis in Chapter 1, followed by the summary and overview of the publications in Chapter 2. Chapter 3 lists all the major publications in different aspects of the research related to the main research topic of the doctoral dissertation. Some conclusions have been drawn in Chapter 4, whereas future research is briefly discussed in Chapter 5.

The main contributions of this thesis are multidisciplinary research, including the classification of microscopic soil bacteria images (over 3000 images) using deep learning techniques with a very good accuracy, improvements of methodologies such as extreme learning machine, classification of ploidy levels in plants, and application of vision transformers to stomata images. Based on the above research, the candidate has published seven research articles and other publications in international conference proceedings.

More specifically, Paper/publication #1 presents an effective classification methodology for soil bacteria using machine learning and image processing, which contains 128 images of five different bacteria genera. Methods compared included SVM, RF, KNN, ELM and others. Paper #2 studies the identification of bacteria genera based on their geometric and dispersion features, including 10 geometric features and 17 dispersion characteristics.

In addition, Paper #3 uses residual neural networks (NN) for microscopic image classification, which partitioned the datasets into 6:3:1 and images into sub-images. Paper #4 presents the analysis and classification performance of extreme learning machine with a hybrid of other methods such as k-means and k-medoids. Paper #5 summarizes the challenges and insights concerning automated imaging and machine learning in the context of soil bacteria classification.

Furthermore, Paper #6 uses deep learning-based methods for the classification of blackcurrent genotypes with extensive cross-validation, whereas Paper #7 explores this type of classification using convolutional neural networks and vision transformers.

All the above research outputs are quality publications, with publications in international journals and top conference proceedings, such as Engineering Applications of Artificial Intelligence and PloS One. This also shows that candidate can carry out quality, independent research for the chosen research area.

The candidate also participates various research projects, seminars and attending international conferences. The research outputs and presentations also show that the candidate has a broad knowledge of the subject area. Based on the research outputs and publications, I would like to recommend the candidate to be awarded of the PhD degree with distinction.

The main reason for the recommendation of PhD with Distinction is that the research outputs represent some unique, new contributions to the knowledge in the research field, and the results are convincing with the research methodologies well justified. Overall, the research portfolio in this thesis represents a very good set of quality research outputs and new results.

Some minor suggestions:

1. In the introduction chapter (Chapter 1), after the overview of the state-of-the-art in Section 1.4, it would be useful to summarize the key research questions and objectives this thesis. Then, these questions can be linked to the research outputs/publications in Chapter 3.
2. In Chapter 5, in the discussions of future work, it would be useful to explain what the possible limitations of the existing/proposed work is, and then try to investigate ways for improving the current research so that they can be linked to future work and extensions.

Reviewed by

Prof. Xin-She Yang



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