Computational intelligence & modeling of crop disease data in Africa

Owomugisha, Godliver

DOI:
10.33612/diss.130773079

Publication date:
2020

Chapter 8

Summary and Outlook

This thesis presents the application of machine learning techniques to solve a real world challenge related to pest and disease control in the agricultural sector. The research investigated methods for early disease diagnosis with a novel approach of identifying diseases before they became symptomatic and visible to the human eye.

In Chapter 2, we provided the background on prototype based classification that has mostly been used in our studies. We found GMLVQ suitable to address most of our research questions due to its competitive or superior performance. The analysis of relevances provided additional insights and facilitated the identification of most important features.

In Chapter 3, we tackled the problem of crop disease detection using an image dataset captured with a mobile phone camera. As an initial step towards early disease diagnosis, we investigated on disease incidence and severity measurements from cassava leaf images. We applied computer vision techniques to extract visual features of color and shape combined with classification techniques.

In Chapter 4, we considered disease diagnosis using spectral data. We compared two datasets: spectral data collected from leaves of the plant and leaf image data captured with a mobile phone camera. We analysed data from visibly affected parts of the leaf and parts that appear to be healthy, visibly. We analysed the obtained data by prototype based methods and standard classification models in a three-class classification problem. Results point towards significant improvement in performance using spectral data and the possibility of early detection of disease before the crops become symptomatic, which for practical reasons is highly significant.

In Chapter 5, we answered several of our research questions. By nature, spectral data come with thousands of dimensions, therefore different wavelengths are analyzed in order to identify the most relevant spectral bands. To cope with the nominally high number of input dimensions of data, functional decomposition of the spectra is considered. The outlined classification task was addressed using GMLVQ and compared with the standard classification techniques performed in the space of expansion coefficients.

The challenge of early detection is not fully answered until this stage. In cassava crop, once disease symptoms are visible in the aerial part of the plant, a lot of damage has been caused especially in the root of the plant which is majorly used as food. The novelty and usefulness of this research is evidenced in Chapter 6. The chapter presented results in using visible and near infrared spectral information to detect diseases in cassava crops before symptoms can be seen by the human eye. To test this hypothesis, we grew cassava plants in a screen house where they were inoculated with disease viruses and we monitored the plants over time collecting both spectral and plant tissue for wet chemistry analysis at each time step until the plants show disease. Our models in our case GMLVQ were able to detect cassava diseases one week after virus infection can be confirmed by wet lab chemistry, but several weeks before symptoms manifest on the plants.

Although the analysis of spectral data proved successful in our experiments, spectrometry devices are not commonly found on the market, ready to do automated diagnosis of crop diseases. Also, most spectrometry devices require technical knowledge to operate them, thus making them inapplicable for our end users (smallholder farmers). In our case, we purchased one expensive spectrometer (in 1000 USD) to achieve our research goals. In Chapter 7, we presented initial steps towards the development of a low-cost 3-D printed smartphone add-on spectrometer that can be used to diagnose crop diseases in the fields. The contribution of this chapter can be seen in the design of a diagnostic tool that is cheap and easy to use by smallholder farmers in developing countries in monitoring their crop status. The performance of the first prototype was not favourable, however, requirements for an improved version were stated.

8.1 Future work

The research presented in this thesis builds from previous studies as stated in the literature. The present work was transitioning from previous methods of diagnosis into spectral data analysis. Our results and novel insights suggest the following points of investigation for future work:

- In Chapter 6, we carried out an experiment in a controlled environment (screen house). We grew healthy plants and inoculated them with CBSD disease virus. Future experiments in this area would include more cassava varieties as well as studying on other diseases e.g CMD and CBSD.

- In a similar setup, future work would consider how crop nutritional deficiency caused by stress effects affects plant growth. This was a common question raised by our different stakeholders. To tackle this problem, an additional class to handle data from this group would be required during training.

- Our research should also be expanded by considering other crops, e.g maize, beans and rice. Initially, the same methods could be applied on dataset from the mentioned crops.
- Chapter 7 was our first attempt to the construction of a low-cost diagnostic device based on spectrometery data. We have identified several areas of potential improvements in our discussion.
- In some of our chapters we experimented with CNNs as a baseline. Being an area that has gained much popularity in recent studies, we envisage future studies in applicability of the neural networks.

This thesis serves as a basis for putting forward the efficient early detection of crop diseases using spectral information. Our research can contribute to an improved livelihood of a smallholder farmer in the Sub-Saharan Africa through increased crop yields and food security.