Chapter 7
On the Use of Artificial Intelligence Techniques in Crop Monitoring and Disease Identification

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ABSTRACT

The use of technology for the purpose of improving crop yields, quality and quantity of the harvest, as well as maintaining the quality of the crop against adverse environmental elements (such as rodent or insect infestation, as well as microbial disease agents) is becoming more critical for farming practice worldwide. One of the technology areas that is proving to be most promising in this area is artificial intelligence, or more specifically, machine learning techniques. This chapter aims to give the reader an overview of how machine learning techniques can help solve the problem of monitoring crop quality and disease identification. The fundamental principles are illustrated through two different case studies, one involving the use of artificial neural networks for harvested grain condition monitoring and the other concerning crop disease identification using support vector machines and k-nearest neighbor algorithm.

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INTRODUCTION

Agricultural production and trade is a major contributor to the global economy, accounting for 1.6 trillion USD in 2016, based on data from the Food and Agriculture Organization (FAO) of the United Nations (FAO, 2018). Given this huge trade volume, it is clear that producers of agricultural products will need to offer high-quality products to the marketplace. In this context, one typically has to contend with two main problems.

The first problem is that there is typically a delay between the time agricultural products are harvested and the time they end up in the hands of consumers. This delay can be anywhere between a few days and a few months. This implies that the end products will need to be stored in special storage areas to ensure that the products will stay in peak quality prior to being shipped to end customers. Many kinds of agricultural products, such as grains, fruits and vegetables, are typically stored in this manner. While the products are being stored, it is possible that their quality will be degraded due to suboptimal storage conditions, the onset of disease-producing agents (such as bacteria and fungi), as well as insect and/or rodent infestation. It is critical that this possible degradation in product quality be monitored and detected. It is equally crucial that any products with degraded quality be immediately withdrawn from circulation, so as to avoid any danger to human health. The impact of this problem is profound, as illustrated by the fact that up to approximately 5.5% of the total weight of harvested grains, such as rice, can be lost due to pest damage, making the harvested product unfit for consumption, or even as seed(Togola et al., 2013). From a purely economic perspective, the impact is even more astounding, with some studies reporting that approximately one-third of the food produced (which amounts to some 1.3 billion tons) is lost globally during postharvest operations every year at an estimated cost of some 1 trillion USD (FOOD, 2016; Kumar & Kalita, 2017).

Another typical problem is that a disease-producing agent will attack agricultural products, prior to a harvest, making it unfit for consumption. Previous studies in the open literature indicate that approximately 25% of total harvested produce in the US alone is lost in this manner, with the loss figures in tropical areas reaching a staggering 50% (Wilson & Wisniewski, 1989),(Savary, Ficke, Aubertot, & Hollier, 2012). Again, it is critical that these agents be detected and that prompt action (such as the application of insecticides or fungicides) be taken in a prompt manner in order to avoid losing an entire harvest.

Today, both problems can be effectively addressed thanks to advances in a number of technological fields, namely sensor technology, low-power embedded systems, wireless networking, and artificial intelligence. Advances in sensor technology are enabling suboptimal storage conditions and disease-producing agents to be detected with a high-degree of precision (West, Canning, Perryman, & King, 2017), (M. Zhang, Qin, Liu, & Ustin, 2003). Advances in low-power embedded systems, particularly microcontrollers, are making it possible to integrate these sensors into powerful computing infrastructures that can effectively process the data collected by the sensors(Eisenhauer, Rosengren, & Antolin, 2010), (Atmojo, Salcic, Kevin, Wang, & Park, 2015). Advances in wireless networking, particularly wireless sensor networks and machine-to-machine (M2M) communications, are enabling storage infrastructures and agricultural fields typically spanning many square kilometers to be monitored at a distance in a cost-effective manner(Ojha, Misra, & Raghuwanshi, 2015), (Yu, Wu, Han, & Zhang, 2013). Finally, artificial intelligence techniques, particularly machine-learning algorithms, are enabling producers of agricultural products to make sense out of the vast quantities of data collected, to quickly arrive at conclusions and take corrective action where necessary(Park, Im, Jang, & Rhee, 2016).

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