

Machine Vision and AI Algorithms for Sorting Grading and Quality Analysis in Post Harvest Processing

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Autonomous Agricultural Robotics for Crop Harvesting and Weed Detection Using AI

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Abstract

The integration of autonomous robotics in agriculture, particularly for crop harvesting and weed detection, is revolutionizing modern farming practices. This chapter explores the critical role of Artificial Intelligence (AI), machine learning, and advanced sensor technologies in enabling autonomous systems to optimize agricultural processes with unprecedented precision. By focusing on key applications such as precision herbicide application, real-time crop harvesting, and environmental adaptation, this work highlights the transformative potential of autonomous agricultural robots in enhancing productivity, sustainability, and operational efficiency. Through advanced navigation systems, including GPS and geospatial technologies, robots can navigate complex terrains and adjust to varying weather conditions, ensuring seamless operation across diverse farming environments. The precision in weed detection and herbicide application offers a sustainable approach to pest control, significantly reducing the environmental impact of conventional farming practices. Furthermore, by improving the accuracy, timing, and speed of harvesting operations, autonomous robots contribute to higher crop yields while minimizing waste. Despite the significant advancements, challenges remain in scaling these technologies for widespread adoption, particularly concerning cost, infrastructure, and operational reliability in real-world conditions. This chapter provides a comprehensive overview of the current state of autonomous agricultural robotics, highlighting emerging trends, technological advancements, and future directions for research and development in this rapidly evolving field.

Keywords: Autonomous Robotics, Artificial Intelligence, Precision Agriculture, Crop Harvesting, Weed Detection, Environmental Adaptation.

Introduction

The agricultural industry is undergoing a dramatic transformation, driven by the need to feed a growing global population while minimizing environmental impact and ensuring sustainability [1]. Traditional farming methods, which rely heavily on human labor and non-automated processes, are increasingly insufficient to meet the demands of modern agriculture [2]. The rise of autonomous agricultural robots equipped with Artificial Intelligence (AI) and advanced sensor technologies presents a groundbreaking solution to these challenges [3]. These autonomous

systems are designed to perform a variety of tasks with high precision and efficiency, such as crop harvesting, weed detection, soil monitoring, and irrigation [4]. Their integration into agricultural operations can lead to significant improvements in productivity, resource management, and environmental sustainability [5].

The key advantage of autonomous agricultural robots lies in their ability to perform repetitive and labor-intensive tasks without the need for human intervention [6]. These robots are powered by AI algorithms and machine learning models that enable them to make real-time decisions based on environmental data [7]. For example, autonomous crop harvesters use AI-driven systems to determine the optimal time for harvesting, ensuring that crops are picked at their peak quality [8]. Similarly, weed detection and management systems can accurately identify and target weeds, allowing for precision herbicide application [9]. This level of precision not only improves crop yields but also reduces the use of harmful chemicals, thereby benefiting the environment and the health of the surrounding ecosystem [10].

A crucial aspect of autonomous agricultural robotics is their ability to adapt to diverse and ever-changing environmental conditions [11]. Agricultural fields are not uniform, and factors such as terrain variations, weather conditions, and soil composition can all affect farming operations [12]. Autonomous robots equipped with advanced sensors, such as GPS, LiDAR, and cameras, can navigate through these variable conditions with ease. [13] GPS and geospatial technologies enable precise navigation, while sensor fusion allows robots to detect obstacles and adjust their movement in real time [14]. This adaptability ensures that robots can operate efficiently in different farming environments, from large monoculture fields to smaller, diversified plots, providing farmers with scalable solutions for a wide range of agricultural applications [15].