An IoT-Based Autonomous Robot System for Maize Precision Agriculture Operations in Sub-Saharan Africa

Jibril Abdullahi Bala, Olayemi Mikail Olaniyi,
Taliha Abiodun Folorunso, and Emmanuel Daniya

Abstract

The importance of agriculture to the economic growth in sub-Saharan Africa suffers from several challenges. One of the major problems faced by the sector is the lack of suitable technology to optimize yield and profit to reduce the reliance of farmers on manual techniques of farming which is accompanied by drudgery, wastage, and low yields. Precision agriculture has been applied to maximize agricultural outputs while minimizing inputs. This study presents the design of an Internet of things (IoT)-based autonomous robot system that can be used for precision agricultural operations in maize crop production. The robot consists of a camera for remotely monitoring of the environment and a tank incorporated with a liquid level sensor which can be used for irrigation and herbicide application. The real-time feed from the camera as well as the output from the liquid level sensor is accessed from a cloud database via a Web application. This system can be adopted for improved crop production which in turn will increase crop yield, profit, and revenue generated from agriculture.

Keywords

Artificial intelligence · Fuzzy logic · Image processing · Internet of things · Precision agriculture · Robot navigation

J. A. Bala (✉) · T. A. Folorunso
Department of Mechatronics Engineering, Federal University of Technology, Minna, Nigeria
e-mail: jibril.bala@futminna.edu.ng

O. M. Olaniyi
Department of Computer Engineering, Federal University of Technology, Minna, Nigeria

E. Daniya
Department of Crop Production, Federal University of Technology, Minna, Nigeria

1 Introduction

1.1 Background of the Study

In the twenty-first century, there has been a rapid growth in the information and communication technology (ICT) sector. This development has influenced human operations and industrial services. One of the most important developments in the ICT sector is the introduction of the Internet (Yusuf et al., 2019). Internet of things (IoT) is a system of inter-connecting computing devices that are interrelated. These devices can transfer data over a network with the absence of human involvement (Iwayemi, 2018). The IoT is a network of physical devices, objects, buildings, people, animals, and other items that are embedded with sensors, software, electronic devices, and network connectivity that supports communication, collection, and exchange of data (Dubey et al., 2020; Nayyar and Puri, 2016a, 2016b; Padikkappa-rambil, 2020; Singh et al., 2020a, 2020b; Tanwar 2020a, 2020b). This technology allows devices to be remotely controlled and sensed using network infrastructure. This process allows the integration between the physical world and computer systems, which in turn, results in improved economic benefits, efficiency, effectiveness, and accuracy (Amadin et al., 2017). The IoT has a wide range of applications in various sectors including agriculture.

The Food and Agriculture Organization (FAO) estimated a 70% increase in global food production by the year 2050 (Ishengoma & Athuman, 2018). Also, the population of the African continent is projected to reach 2 billion by 2050 (Ishengoma & Athuman, 2018). Feeding this population would be quite challenging with limited farming methods. Currently, farmers in sub-Saharan Africa cultivate less area of land and harvest less due to a lack of technological development in the agricultural sector. Besides, traditional farming techniques predominantly used in the region results in low crop yield compared to mechanized farming methods. Africa has 25% of the world's arable land, yet it contributes