STUDY ON CONTECT SENSOR-BASED RIDGE TRACKING TECHNOLOGY FOR PRECISION GARLIC SEEDING

Jumyeong Lee[1,2], Yong-Hyun Kim[1,2], Chulwhan Yoon[1,2], Jungun Lee[1,2], Hak Jin Kim[1,2*]

[1] Department of Biosystems Engineering, College of Agriculture and Life Sciences, Seoul National University, Seoul, 08826, Republic of Korea. [2] Integrated Major in Global Smart Farm, College of Agriculture and Life Sciences, Seoul National University, Seoul, 08826, Republic of Korea.

*Corresponding Author: Hak Jin Kim(kimhj69@snu.ac.kr)

Abstract

Ridges are an important part of field operations in agriculture. From soil tillage and sowing to harvesting, ridges serve as the foundation throughout the entire crop production cycle. However, in practical application, ridges are often irregular and poorly maintained. Irregular ridge can disrupt consistent seeding which can result in uneven crop growth and a decline in overall productivity. In the case of garlic, seeding uniformity is directly related to yield. Therefore, addressing the uneven ridges is crucial for ensuring seeding consistency and high productivity. To effectively manage ridge irregularity, this study proposes a contact sensor-based ridge tracking method using a feeler arm. Feeler arms were installed on the inner sides at both ends of the platform, and offsets caused by a contact with the ridges were detected though torque sensor so that the garlic seeder could automatically follow the ridges accordingly. Field experiments were conducted at the Seoul National University Farm to investigate the feasibility of the developed system for use in arable fields.

Keywords: Auto-guidance, Garlic seeder, Precision agriculture

INTRODUCTION

For the context of Precision Agriculture, Ridges serve as an effective structure that contributes to the stabilization of seeding depth. However, irregular ridges are frequently observed in farmland, and the current lack of research on automation under such irregular conditions [1] remains a constraint on yield optimization. In particular, the conventional three-point hitch system of tractors couples the implement's steering to that of the tractor, [2] which can lead to unintended performance when operating along non-linear ridges. Despite precise ridge tracking by the tractor, the attached implement can cause damage to the ridge due to the spatial offset between the tractor and the implement. The encroachment beyond the ridge boundary results in crop injury and a reduction of arable land, both of which are directly impact on overall yield. In contrast to studies using tractor-mounted stereo cameras or LiDAR, placing a camera on the implement introduces inconsistencies due to variations in working height and ground condition, while exposing the sensor to potential damage. Mounting vision sensors on the tractor's rear also entails the issue that much of the sensed area is blinded by the

implement. [3] In such cases, contact sensors can provide navigation support. Torque sensors can measure the shear stresses resulting from contact with the ridge, making them effective for preventing ridge failure. To minimize ridge damage from implement, this study proposes a contact sensor-based ridge tracking method using feeler arm.
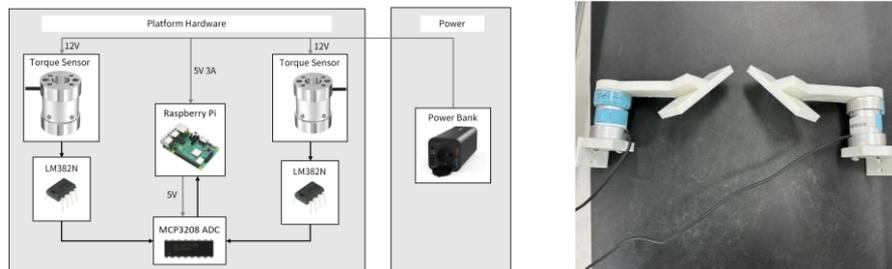
MATERIALS AND METHODS

Fig.1 Flowchart of the Proposal Study and Sensor installed on platform

A Non-rotating torque sensor, CYJN-2 was mounted on a Daedong DRP80 rice transplanter. The feeler arm connected to torque sensor was installed with a clearance from the ridge. Considering the shape of the ridge, the arm's ridge-contacting surface was designed with a 45° slope angle and covered with a high density, high elasticity sponge. The rice transplanter equipped with the implement was driven so that the sponge-covered arm could contact the sides of the ridge. During operation, the transplanter continuously applied stress to the ridge, while voltage and torque signals were measured. Through data processing with a Savitzky-Golay filter, peak values were extracted, and an algorithm was developed to produce signals aimed at preventing ridge failure.

RESULTS & DISCUSSION

Using the sensor, voltage data were collected as shown in Fig.2. The data were obtained by manually pressing the ridge as consistently as possible instead of using transplanter. After smoothing the data with a filter and measuring the peak value, approximately 0.677V was obtained. From the shape of graph, it was possible to identify a threshold value. Additional study using transplanter and the design for ridge-tracking algorithm are planned for future work.
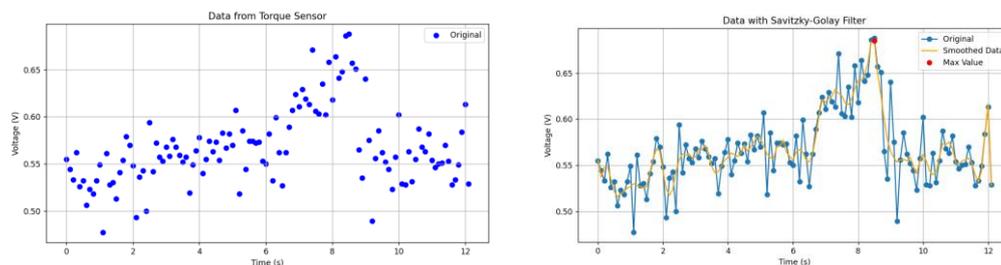

Fig.2 Original and Filtered Voltage Data from Torque Sensor

CONCLUSIONS

Using contact torque sensors on the ridge, it was observed that stress increased with displacement, reach a peak, and then dropped out. Based on these observations, it is expected that a ridge-tracking algorithm can be developed to minimize ridge deformation.