The 11th Asian-Australasian Conference on Precision Agriculture (ACPA 11)
October 14-16, 2025, Chiayi, Taiwan

Development of an Autonomous Navigation and Obstacle Avoidance Robot for Poultry Sheds

Hao-Ting Lin, Jung-Hsuan Chang*

Department of Bio-industrial Mechatronics Engineering,National Chung Hsing University, Taiwan.

*Corresponding Author: 7113040012@smail.nchu.edu.tw

ABSTRACT

Traditional poultry sheds in Taiwan are mostly open-structured, resulting in low efficiency for manual inspection and egg collection, and increased risks of labor fatigue and injuries. This study develops an autonomous obstacle avoidance system for unmanned agricultural vehicles tailored to poultry shed environments, focusing on dynamic path planning and obstacle evasion for safe, efficient navigation.A tracked vehicle chassis enhances stability and adaptability on soft litter floors and narrow aisles typical of poultry sheds. The control system dynamically plans paths and adjusts speed to handle static obstacles (elevated platforms, feeding lines, perches) and dynamic obstacles (moving laying hens).Implemented on Ubuntu with Python, the system integrates LiDAR-based navigation and SLAM. Although originally designed to include depth cameras and image recognition, this study focuses on LiDAR data fusion for robustness in challenging environments. The system also records dynamic obstacle trajectories for behavioral analysis.Experiments show the system significantly improves poultry shed automation efficiency, reduces labor demand, and lowers occupational risks, contributing to smart agriculture and poultry industry modernization.

Keywords: unmanned agricultural vehicle, poultry shed, tracked vehicle, path planning, obstacle avoidance

INTRODUCTION

Traditional poultry sheds in Taiwan are typically open and simple in design, leading to inefficient manual inspection and egg collection, high labor intensity, and increased risks of worker fatigue and injury. Unmanned agricultural vehicles offer a viable automation solution for these environments, which are characterized by narrow aisles, soft litter floors, and dynamic obstacles such as moving poultry.

Driven by the need for greater efficiency and biosecurity, research has focused on robotic systems with autonomous navigation and obstacle avoidance. Conventional human-based inspections are inefficient and easily affected by environmental variability, particularly in confined housing with numerous obstacles. Thus, autonomous systems capable of adapting to complex, dynamic conditions are essential for intelligent poultry management.

Recent advances in LiDAR and vision sensors have enabled real-time path tracking and obstacle avoidance. Building on methods such as the pure-pursuit approach with 2D laser scan data (Morales et al., 2009), this study develops an autonomous navigation system tailored to poultry sheds, integrating real-time range data for adaptive path planning and robust obstacle avoidance.

MATERIALS AND METHODS

This study develops an autonomous navigation system for unmanned agricultural vehicles in poultry sheds, addressing static obstacles (feeding lines, perches) and dynamic ones (moving poultry). A tracked chassis enhances stability and maneuverability on soft litter and narrow aisles. Real-time SLAM with LiDAR data fusion improves perception and navigation performance.

System Architecture and Methods

The system integrates a Hokuyo UST-10LX 2D LiDAR sensor with an embedded computing platform running the Ubuntu operating system. Control software is developed in Python. SLAM algorithms enable synchronized localization and environmental map construction, coupled with dynamic path planning and obstacle avoidance strategies to realize autonomous and safe navigation.

LiDAR Sensor Specifications and Data Processing

Table 1 specifications of the Hokuyo UST-10LX sensor

Parameter	Specification
Scanning Angle	270°
Angular Resolution	0.25°
Measuring Range	0.06 m to 10 m
Distance Accuracy	±40 mm

LiDAR sensors employ various principles to measure distance. The most common methods are summarized as follows:

Time-of-Flight (ToF) Principle

The ToF method measures the distance d by calculating the round-trip travel time t of emitted laser pulses, according to the equation:.

$$d = \frac{C \times t}{2}$$

where

- d is the measured distance,
- c is the speed of light (~3×10^8 m/s)
- t is the round-trip time of the laser pulse.

The LiDAR point cloud data is converted into millimeter-scale distance values and combined with scanning angle information to localize obstacles in the surrounding environment.

Triangulation Method

This method calculates the distance based on the known baseline length between the laser emitter and receiver, as well as the disparity angle, using similar triangle geometry. The distance D is given by：

$$D = \frac{f \times (L + d)}{d}$$

where

- D is the distance to the target
- f is the focal length of the lens
- L is the baseline offset between the emitter and receiver
- d is the displacement on the image sensor

Phase Shift Measurement

Utilizing a modulated continuous-wave laser, this method derives distance from the phase difference Δϕ between emitted and received signals：

$$d = \frac{c \times \Delta_\phi}{4\pi f_m}$$

Where

- f_m is the modulation frequency.

Frequency Modulated Continuous Wave (FMCW)

This method estimates distance by measuring the frequency difference Δf between transmitted and reflected signals:

$$d = \frac{c \times \Delta f}{2 \times} S$$

where

- S is the frequency modulation slope.

RESULTS & DISCUSSION

Experimental validation shows that the autonomous navigation and obstacle avoidance system achieves high precision and stability in poultry housing. The Hokuyo UST-10LX LiDAR provided distance measurements closely matching ground truth, with an average error of 18.7 mm and a maximum deviation within ±40 mm. These results align with the manufacturer's specifications, confirming the sensor's reliability for agricultural distance measurement.

CONCLUSIONS

This research develops and validates an autonomous navigation and obstacle avoidance system for poultry sheds, improving efficiency while reducing labor and injury risk. Using the Hokuyo UST-10LX LiDAR with SLAM and dynamic path planning, the system demonstrates adaptability to complex agricultural environments, advancing smarter and safer poultry farming.

REFERENCES

Morales, J., Martínez, J. L., Martínez, M. A., & Mandow, A. (2009). Pure-pursuit reactive path tracking for nonholonomic mobile robots with a 2D laser scanner. EURASIP Journal on Advances in signal Processing, 2009(1), 935237..

Nguyen, P. T. T., Yan, S. W., Liao, J. F., & Kuo, C. H. (2021). Autonomous mobile robot navigation in sparse LiDAR feature environments. Applied Sciences, 11(13), 5963.

Dong, H., Weng, C. Y., Guo, C., Yu, H., & Chen, I. M. (2020). Real-time avoidance strategy of dynamic obstacles via half model-free detection and tracking with 2d lidar for mobile robots. IEEE/ASME transactions on mechatronics, 26(4), 2215-2225.