Assessing the Effectiveness of an Automatic Controller for the Fertilization Application on Agriculture Drones

Polaiah Bojja[1(✉)], Asadi Srinivasulu[2], Pamula Raja Kumari[1], and Jaladi Rajendra Kumar[3]

[1] Institute of Aeronautical Engineering, Hyderabad, Telangana, India
polaiahbojja@gmail.com
[2] Data Science Research Lab, Blue Crest University, Monrovia, Liberia
[3] Koneru Lakshmaiah Education Foundation, Vijayawada, Andhra Pradesh, India

Abstract. Drone technology is rapidly advancing in the field of robotics automation engineering. One of the main purposes of designing robots is to eliminate the risks associated with hazardous work that requires human involvement. The objective of this paper is to create an autonomous agricultural drone that uses a drone guidance system to selectively fertilize, weed, plough, sow seeds, plant saplings, water plants, and spray insecticides and pesticides. This is accomplished using a conventional controller that search for the optimal solution in the field. In recent years, the use of drones has become increasingly popular in the field of agriculture due to their potential for enhancing crop management and productivity. One of the most important applications of drones in agriculture is their ability to fertilize crops, which requires precise and accurate movements to ensure the effective distribution of fertilizers. The results of the study demonstrate that the automatic controller can effectively regulate the drone's movements, leading to more precise and efficient fertilization.The results are carried out for assessing the effectiveness of an automatic controller for the fertilization on agriculture drones.

Keywords: Autonomous Agricultural drone · plant saplings · water the plants and spray insecticides and fertilization

1 Introduction

A general concept for a field crops robotic machine is to selectively fertilizer easily weed the desired drone of agriculture such as to plough the field, saw the seeds, plantsaplings, water the plants and spray insecticides and fertilizer. It uses several particles (agents) that constitute a swarm moving around in the search space, to perform for the best solution [1].This proposed technology seeks to evaluate the effectiveness of an automatic controller for fertilization on agriculture drones [2].The proposed controller will be assessed using a drone guidance system and a swarm of particles, to determine its accuracy and efficiency under different environmental conditions [3].The study's findings will provide valuable insights into the potential advantages of automatic controllers

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B. Raj et al. (Eds.): ICETE 2023, AER 223, pp. 430–437, 2023.
https://doi.org/10.2991/978-94-6463-252-1_46

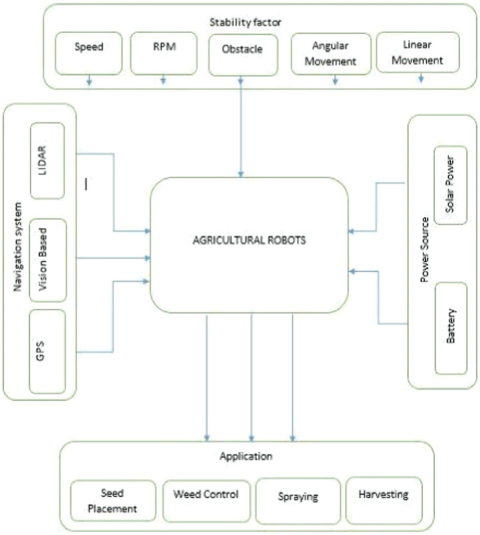


Fig. 1. Block diagram ofthedrone of agriculture

for agriculture drones, leading to more efficient and effective farming practices as shown in Fig. 1[3]-[5].

2 Scope of the Research Objective

The study will focus on determining the accuracy and efficiency of the proposed controller under varying environmental conditions, including wind and other factors that may influence the drone's movements during fertilization.

The objective concentrates on the specific domain of agricultural drone technology and its potential to improve fertilization processes, specifically through the application of an automatic controller. Automatic controllers can help address this issue by regulating the drone's movements to ensure optimal fertilization.

3 The Mathematical Model of the Desired Robot of Agriculture

The problem of designing a multi-objective agricultural drone can be formulated as an attempt to minimize all objectives, assuming that such a formulation is generally applicable in the formation of state model as shown in Eq. (1) as input [6]-[7]. Therefore, Z, h, g are vector functionsis the number of objectives mn1 and mn2 are inequality and inequality constraints, respectively.

$$\min Z(x) = \begin{bmatrix} z1(x) \\ z2(x) \\ . \\ . \\ . \\ zk(x) \end{bmatrix} \quad (1)$$

Differential Evolution (DE) is a type of evolutionary algorithm proposed by Storn and Price for optimization of problems in a continuous domain. is used for solving a problem[8]. The main motivation of this approach is to adapt the search steps as follows and obtain the with Eq. (1).

4 Proposed Methodology

1. Generate a set of particles (agents) in a uniformly distributed manner across a given domain X.

2. Evaluate the fitness of each particle's position based on an objective function as given Y, such as the one provided below as relation X and Y for Z in Eq. (2).

$$Z = f(x, y) + \sin(x) + \sin(y) + \sin(x * y) \tag{2}$$

3. If a particle's current position is superior to its previous best position, update the particle's record.

4. Determine the best particle based on the particle's best position from previous iterations to quickly controller.

5. Update the velocities of each gain in accordance with a set of Eq. (3) paramenters that take into account the drone position, velocity, and best known position[9]-[12].

$$u(t) = Kpe_t(t) + Ki \int e_t(t)dt + Kdde_t/dt \tag{3}$$

6. Move drone to their new positions by u(t).

7. Go to step 2 until the stopping criteria are satisfied.

To enhance the efficiency of a conventional controlled system, the Eq. (3) gains of the system are modified to optimize a specific performance index based on the response of the system, as illustrated in Fig. 2[13]. This performance index is calculated over a specified time interval T, typically within the settling time of the system, where $0 \leq T \leq t$. The performance indices utilized in this study are described in Fig. 3[14].

The MATLAB algorithm toolbox was used to design and simulate the system.

optimization process [15]-[20]. The optimization process utilized scattered crossover and selection based on stochastic uniform, with migration direction of velocity implemented in both directions of agriculture drone [21].

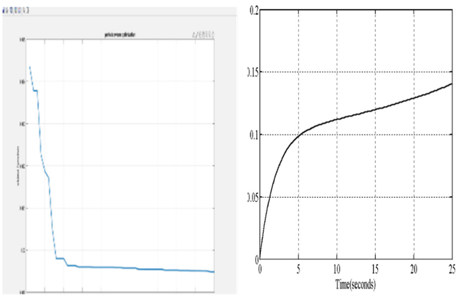
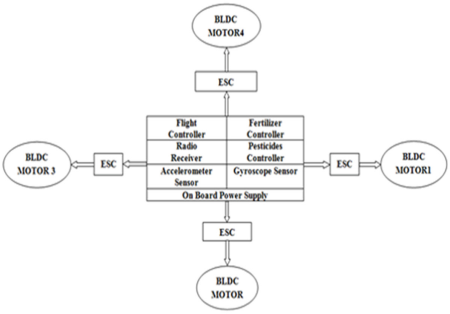


Fig. 2. The drone poor responsewithout controller

(a)



(b)

Fig. 3. (a) & (b): Design of Controller to drone system

5 Experimental Results

Implementation of conventional controller for evolution algorithm using Multi—Objective Optimization is done successfully as shown in Fig. 4.

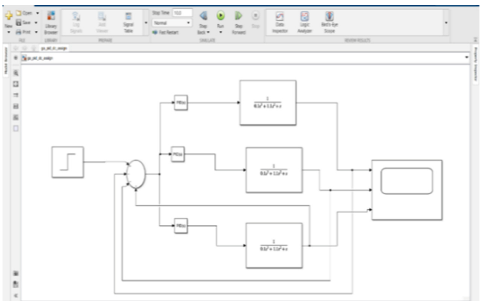
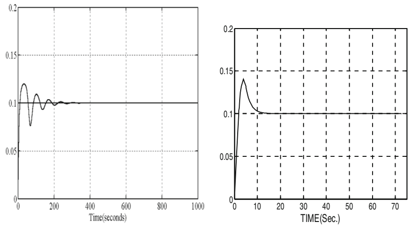
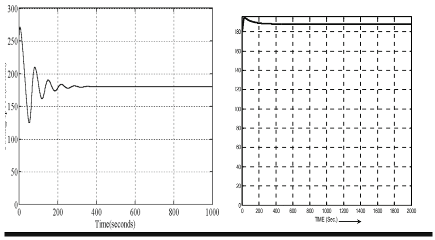


Fig. 4. Implementation of the controller with drone system



(a)



(b)

Fig. 6. (a) & (b): Response of the controller with drone system which tuned parameters

Simulation is carried out in MATLAB software to compare the performance between Ziegler-Nicholas method based on desired gain controller with other optimized methods [22], System response is shown in Fig. 6. Which shows the outcome of the table below displaysthe transient and steady state parameters in the form of motion of the drone [23].

The proposed proposes an optimized method for tuning the PID controller parameters, which is more efficient than the traditional Ziegler Nichols tuning method. Simulation results demonstrate that this approach results in lower overshoot, rise time, and settling time compared to the Ziegler Nichols method as shown in Fig. 6 [25]-[30]. Moreover, the use of genetic algorithms in tuning the PID controller has been shown to be effective in achieving desirable transient and steady-state response parameters, as presented in Table1[31]-[32].

Table 1. Performance index of the controller response based on proposed methodology.

Tuning Method	**MP(%)**	**TP(Sec)**	**TR(Sec)**	**TS(Sec)**
ZN Method	62.87	1.21	0.40	8.39
Modified	48.87	1.65	0.63	7.13
GA-ITAE as fitness	29.6	0.6	0.265	1.63

6 Conclusion

In order to eliminate the risks associated with dangerous work by the findings of important insights into the potential benefits of using automatic controllers for agriculture drones and their possible impact on farming practice.Ithas evaluated an algorithm that adjusts the parameters of a drone-based route controller to account for changes in wind intensity and direction, as well as other factors that can impact the controller's performance. Based on the results obtained from Fig. 2 and Fig. 6, there is a noticeable difference between the performance of the controller with and without the algorithm.The performance of an evaluate the effectiveness of an automatic controller for fertilization on agriculture drones. The results indicate that the automatic controller can successfully regulate the drone's movement, resulting in more accurate and efficient fertilization. The benefits of using automatic controllers in agriculture drones, which can enhance the precision and efficiency of crop management processes. The use of drones in agriculture has gained significant momentum, and the application of automatic controllers can further improve farming practicesand contribute to the development of new technologies for crop management and productivity improvement.

References

1. Kerle, N. and Oppenheimer, C. Satellite remote sensing as a tool in Lahar disaster management. In: Disasters: The Journal of Disaster Studies Policy and Management, 26 (2002)2, 140–160.
2. RajeshwarDass, Priyanka, Swapna Devi, "Image Segmentation Techniques", International Journal on Electronics & Communication Technology (IJECT), Vol. 3, Issue 1, pp. 66–70, Jan—March 2012.
3. D.Siva, Polaiah Bojja,SVM-Based Detection of Miniature Area of LCLU: A False-Damage Assessment Index for Disaster Management Application, International Journal of Recent Technology and Engineering (IJRTE),Volume-8, Issue-4, November 2019.
4. Polaiah etail., A Novel Method To Solve Visual Tracking Problem: Hybrid Algorithm of Grasshopper Optimization Algorithm And Differential Evolution Evolutionary Intelligence, 2022, 15(1), PP. 785–822.
5. Shivangi S. Somvanshi, Oshin Bhalla, Comparision of Classification Methods On Remote Sensed Satellite Data: An Application In Gautam Buddha Nagar, India", Page 1 of 9, 19th Esri India User Conference 2018.
6. LI et al, SVM-Based sea surface small target detection, IEEE Geo science and Remote sensing letters,vol.16,No.8, 1226–1229, August 2019.
7. Polaiah Bojja Etal; Experimental Analysis And Improvements Of A Visible Spectro Photometer For detection Of Nano Materials", International Journal Of Chemical Engineering, April, 22.
8. Shivangi S. Showmanship, Oshin Bhalla2, Comparison Of Classification Methods On Remote Sensed Satellite Data: An Application In Gautam Buddha Nagar, India, Page 1 of 9, 19th Esri India User Conference 2018.
9. Rajeshwar Dass, Priyanka, Swapna Devi, "Image Segmentation Techniques", International Journal on Electronics & Communication Technology (IJECT), Vol. 3, Issue 1, pp. 66–70, Jan—March 2012.
10. K. Sakthivel, R. Nallusamy, C. Kavitha,Color Image Segmentation Using SVM Pixel Classification Image,World Academy of Science, Engineering and Technology,International Journal of Computer and Information Engineering,Vol:8, No:10, 2014.

11. Ya'nan Zhou, Jun Li, Li Feng, Xin Zhang, and Xiaodong Hu, Adaptive Scale Selection for Multiscale Segmentation of Satellite Images, IEEE Journal of Selected Topics In Applied Earth Observations And Remote Sensing, 1939–1404 © 2017 IEEE.
12. Polaiah Bojja Etal; Industrial Iot Enabled Fuzzy Logic Based Flame Image Processing For-Rotary Kiln Control, Springer Wireless Personal Communications ,April 06, 22.Org/https://doi.org/10.1007/S11277-022-09677-Z.
13. B RokniDeilmai, B Bin Ahmad, H Zabihi, Comparison of two classification methods (MLC and SVM) to extract land use and land cover in Johor Malaysia, IOP Conf.series: Earth and Environmental Science 20012052, 2014.
14. Guo, Y., Cheng, T., & Zhu, Y. (2020). Development and evaluation of a multifunctional agricultural drone for precision farming. IEEE Access, 8, 136535–136545.
15. Yuan, Z., Cao, Y., & Wang, J. (2020). Research on application of drones in agricultural fertilization based on navigation technology. Applied Sciences, 10(4), 1384.
16. Li, Y., Shi, Y., Chen, X., & Wang, H. (2020). Research on intelligent control system of agricultural drone based on artificial intelligence. Journal of Physics: Conference Series, 1707(1), 012016.
17. Liu, Q., Wang, H., Yan, Z., & Sun, X. (2020). Research on the application of the agricultural drone in crop protection. In 2020 2nd International Conference on Control Engineering and Artificial Intelligence (ICCEAI) (pp. 187–190). IEEE.
18. Wang, J., Cao, Y., & Yuan, Z. (2020). Study on the application of unmanned aerial vehicle in intelligent agriculture. Applied Sciences, 10(11), 3828.
19. Zhang, K., Xu, J., Zhu, J., & Zhang, H. (2019). Research and application of agricultural UAV automatic control technology based on UAV cloud platform. In 2019 5th International Conference on Control, Automation and Robotics (ICCAR) (pp. 510–514). IEEE.
20. Feng, L., Zuo, X., & Wang, X. (2019). Application of artificial intelligence in agricultural drone. In 2019 2nd International Conference on Computer Science and Artificial Intelligence (CSAI 2019). Atlantis Press.
21. He, X., Liu, H., & Zhang, S. (2019). A UAV fertilization system for precision agriculture. In 2019 11th International Conference on Measuring Technology and Mechatronics Automation (ICMTMA) (pp. 615–620). IEEE.
22. Feng, H., Xie, X., Liu, X., & Wu, X. (2018). Development and research on a multi-functional intelligent agricultural drone. In 2018 International Conference on Control, Automation and Information Sciences (ICCAIS) (pp. 358–363). IEEE.
23. Miao, Y., Zhang, L., Gu, H., & Wu, X. (2018). Research on an agricultural drone for crop disease detection based on machine learning. In 2018 3rd International Conference on Robotics and Automation Sciences (ICRAS) (pp. 96–100). IEEE.
24. Huang, Y., Chen, C. Y., & Yu, S. (2020). A Comprehensive Review of Applications of Drone in Agriculture. Computers and Electronics in Agriculture, 173, 105430. https://doi.org/10.1016/j.compag.2020.105430
25. Kim, K., Lee, K., Lee, K. Y., & Kim, D. (2018). Application of Drones in Agriculture: A Comprehensive Review. Sensors, 18(11), 3555. https://doi.org/10.3390/s18113555
26. Osuna-Enciso, T., López-Granados, F., García-Ferrer, A., & Peña, J. M. (2018). Automatic Flight Control System for Unmanned Aerial Vehicles in Agriculture. Precision Agriculture, 19(1), 175–194. doi: https://doi.org/10.1007/s11119-017-9532-9.
27. Puri, A., & Bharti, R. (2020). A Review of Agricultural Drone Technologies. International Journal of Mechanical and Production Engineering Research and Development, 10(5), 489–500. doi: https://doi.org/10.24247/ijmperdmay202078
28. Saari, H., Kaivosoja, J., Hyyppä, J., Vaaja, M., & Holopainen, M. (2017). A Low-Cost GNSS-Aided INS System for a Small Unmanned Aerial Vehicle to Support Precision Agriculture. Sensors, 17(5), 1095. doi: https://doi.org/10.3390/s17051095.

29. C.J. Van Westen, 3.10 Remote Sensing and GIS for Natural Hazards Assessment and Disaster Risk Management, In Treatise on Geomorphology, edited by John F. Shroder, Academic Press, San Diego, 2013, Pages 259–298.
30. Quan-guo Li, Ling Kang, Dong-qi Tang, Yun-long Zhu, Applications on Spatial Information Technology in Natural Disasters, Procedia Environmental Sciences, Volume 10, Part B, 2011.
31. Kazuya Kaku, Alexander Held, Sentinel Asia: A space-based disaster management support system in the Asia-Pacific region, International Journal of Disaster Risk Reduction, Volume 6, December 2013, Pages 1–17
32. D.Siva, Polaiah Bojja, Performance Evaluation on Comparison of two Classification methods ofMachine Learning Techniques to extract DAI of LCLU for Disaster Management Applications, International Journal of Advanced Science and Technology, Vol. 29, No. 4, (2020), pp. 1014–1019, 2002.

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