

Central Lancashire Online Knowledge (CLOK)

Title	IoTfaUAV: Intelligent remote monitoring of livestock in large farms using autonomous unmanned aerial vehicles with vision-based sensors
Type	Article
URL	https://clock.uclan.ac.uk/id/eprint/51346/
DOI	
Date	2024
Citation	Kuru, Kaya, Ansell, Darren, Jones, David, Watkinson, Benjamin, Pinder, John Michael, Hill, John Anthony, Muzzall, Eden, Tinker-Mill, Claire, Stevens, Kerry et al (2024) IoTfaUAV: Intelligent remote monitoring of livestock in large farms using autonomous unmanned aerial vehicles with vision-based sensors. Biosystems Engineering. (Submitted)
Creators	Kuru, Kaya, Ansell, Darren, Jones, David, Watkinson, Benjamin, Pinder, John Michael, Hill, John Anthony, Muzzall, Eden, Tinker-Mill, Claire, Stevens, Kerry and Gardner, Andrea

It is advisable to refer to the publisher's version if you intend to cite from the work.

For information about Research at UCLan please go to <http://www.uclan.ac.uk/research/>

All outputs in CLOK are protected by Intellectual Property Rights law, including Copyright law. Copyright, IPR and Moral Rights for the works on this site are retained by the individual authors and/or other copyright owners. Terms and conditions for use of this material are defined in the <http://clock.uclan.ac.uk/policies/>

IoTfaUAV: Intelligent remote monitoring of livestock in large farms using autonomous unmanned aerial vehicles with vision-based sensors

Kaya Kuru¹, Darren Ansel¹, David Jones¹, Benjamin Watkinson¹, John Michael Pinder¹, John Anthony Hill², Eden Muzzall², Claire Tinker-Mill¹, Kerry Stevens³ and Andrea Gardner³

¹ *School of Engineering and Computing, University of Central Lancashire, Preston PR1 2HE, U.K.*

² *Eden and Johns Farming, Deep Clough Farm, Littledale, Lancaster, LA2 9HB, U.K.*

³ *Myerscough College, St Michael's Rd, Preston PR3 0RY, U.K.*

Kkuru@uclan.ac.uk

Abstract

Precision farming (PF) (i.e. precision agriculture), equipped with automation and robotics, can provide the required tools to supply the global food demand by exploiting the limited global resources where the global food supply is dramatically affected by global warming, reduced numbers of farmers, and wars leading to high food inflation rates [1]. Precision Livestock Farming (PLF) aims to provide farmers with effective tools equipped with high technologies in livestock management while improving the welfare of the animals paving the way for satisfying the demands of consumers in a sustainable way. Vehicles are becoming increasingly automated by taking on more and more tasks [2], [3] under improving intelligent control systems equipped with enhancing low-power monitoring sensor technologies [4] and Artificial Intelligence (AI) techniques [5], [6], [7]. Unmanned Aerial Vehicle (UAV)-assisted smart farming, with high mobility, has gained momentum in managing large farms effectively, by avoiding high costs and increasing monitoring quality. Autonomous UAVs (A-UAVs), with a high level of autonomy, as flying autonomous robots, with self-learning and self-decision-making abilities by executing non-trivial sequences of events with decimetre-level accuracy based on a set of rules, control loops and constraints using dynamic flight plans involving autonomous take-off and landing are taking their indispensable parts with little or no human in the loop [8], [9], [10], [11] to accomplish various automated tasks [12], [13], [14], [15], [16], [17], [18]. In this research, an intelligent Internet of Things (IoT) drone solution, the so-called IoTfaUAV, has been developed with a cross-discipline approach within the concepts of Automation of Everything (AoE) and Internet of Everything (IoE) [19], [20] using several supervised and unsupervised AI techniques [21], [22], [23], [30]. Safe and cost-effective IoTfaUAV periodically surveys livestock in an automated manner by using vision-based sensor modalities involving both standard visual band sensing and a thermal imager. It provides prompt information about livestock's population size, their instant location and health-related issues [24], [25], [26], [27]. The implementation of IoTfaUAV in real use cases in two farms shows that the integration of AUAVs embedded with IoT and sensor-driven technologies into farming [28] can improve productivity with substantial cost savings. IoTfaUAV can help readily diagnose livestock diseases and reduce disease-related deaths significantly by measuring the indicators of stress levels and metabolic changes based on body temperature and behavioural factors.

Keywords: Precision Farming (PF); Precision Livestock Farming (PLF); livestock health monitoring; livestock management; autonomous unmanned aerial vehicles (UAV); thermal imagery; active RFID, Internet of Things (IoT), Internet of Everything (IoE)

REFERENCES

- [1] Kuru, K. *et al.* (2024) Automated airborne monitoring of livestock using autonomous uninhabited aerial vehicles with vision-based remote sensing. In: The 11th European Conference on Precision Livestock Farming, 09-12 September 2024, Bologna, Italy.
- [2] Kuru, K. *et al.* (2023). Toward Mid-Air Collision-Free Trajectory for Autonomous and Pilot-Controlled Unmanned Aerial Vehicles. In IEEE Access (Vol. 11, pp. 100323–100342). <https://doi.org/10.1109/access.2023.3314504>
- [3] Kuru, K. (2021). Planning the Future of Smart Cities With Swarms of Fully Autonomous Unmanned Aerial Vehicles Using a Novel Framework. In IEEE Access (Vol. 9, pp. 6571–6595). <https://doi.org/10.1109/access.2020.3049094>
- [4] Kuru, K. *et al.* (2021) Autonomous Low Power Monitoring Sensors. MDPI.
- [5] Kuru, K. (2023) Definition of Multi-Objective Deep Reinforcement Learning Reward Functions for Self-Driving Vehicles in the Urban Environment. IEEE Transactions on Intelligent Transportation Systems. (Submitted)
- [6] Kuru, K. (2023). Sensors and Sensor Fusion for Decision Making in Autonomous Driving and Vehicles. Sensors.
- [7] Kuru, K. (2022). TrustFSDV: Framework for Building and Maintaining Trust in Self-Driving Vehicles. In IEEE Access (Vol. 10, pp. 82814–82833). <https://doi.org/10.1109/access.2022.3196941>
- [8] Kuru, K. *et al.* (2021). A Framework for the Synergistic Integration of Fully Autonomous Ground Vehicles With Smart City. In IEEE Access (Vol. 9, pp. 923–948). <https://doi.org/10.1109/access.2020.3046999>
- [9] Kuru, K. (2021). Conceptualisation of Human-on-the-Loop Haptic Teleoperation With Fully Autonomous Self-Driving Vehicles in the Urban Environment. In IEEE Open Journal of Intelligent Transportation Systems (Vol. 2, pp. 448–469). <https://doi.org/10.1109/ojits.2021.3132725>
- [10] Kuru, K. *et al.* (2023). AITL-WING-HITL: Telemanipulation of autonomous drones using digital twins of aerial traffic interfaced with WING. In IEEE Access (Vol. 11).
- [11] Kuru, K. (2024) Human-in-the-Loop Teleoperation Modes for Autonomous Unmanned Aerial Vehicles. In: 4. Interdisciplinary Conference on Electrics and Computer (INTCEC 2024), 11-13 June 2024, Chicago-USA.
- [12] Kuru, K. (2022). Technical Report: Analysis of Intervention Modes in Human-In-The-Loop (HITL) Teleoperation With Autonomous Ground Vehicle Systems. Technical Report
- [13] Kuru, K. *et al.* (2023). Intelligent airborne monitoring of irregularly shaped man-made marine objects using statistical Machine Learning techniques. In Ecological Informatics (Vol. 78, p. 102285). <https://doi.org/10.1016/j.ecoinf.2023.102285>
- [14] Kuru, K., & Ansell, D. A. (2023). Vision-Based Remote Sensing Imagery Datasets From Benkovac Landmine Test Site Using An Autonomous Drone For Detecting Landmine Locations [dataset]. IEEE DataPort. <https://doi.org/10.21227/PTSA-QJ43>
- [15] Kuru, K. *et al.* (2023). Intelligent, automated, rapid and safe landmine and Unexploded Ordnance (UXO) detection using Maggy. IEEE Transactions on Geoscience and Remote Sensing.
- [16] Kuru, K. *et al.* (2023). Intelligent automated, rapid and safe landmine and Unexploded Ordnance (UXO) detection using multiple sensor modalities mounted on autonomous drones. IEEE Transactions on Geoscience and Remote Sensing.
- [17] Kuru, K. *et al.* (2019). Analysis and Optimization of Unmanned Aerial Vehicle Swarms in Logistics: An Intelligent Delivery Platform. In IEEE Access (Vol. 7, pp. 15804–15831). <https://doi.org/10.1109/access.2019.2892716>
- [18] Kuru, K. *et al.* (2023). WILDetect: An intelligent platform to perform airborne wildlife census automatically in the marine ecosystem using an ensemble of learning techniques and computer vision. In Expert Systems with Applications (Vol. 231, p. 120574). <https://doi.org/10.1016/j.eswa.2023.120574>
- [19] Kuru, K., & Yetgin, H. (2019). Transformation to Advanced Mechatronics Systems Within New Industrial Revolution: A Novel Framework in Automation of Everything (AoE). In IEEE Access (Vol. 7, pp. 41395–41415). <https://doi.org/10.1109/access.2019.2907809>
- [20] Kuru, K. (2021). Management of geo-distributed intelligence: Deep Insight as a Service (DINSaaS) on Forged Cloud Platforms (FCP). In Journal of Parallel and Distributed Computing (Vol. 149, pp. 103–118). <https://doi.org/10.1016/j.jpdc.2020.11.009>

- [21] Kuru, K., & Khan, W. (2018). Novel hybrid object-based non-parametric clustering approach for grouping similar objects in specific visual domains. In *Applied Soft Computing* (Vol. 62, pp. 667–701. <https://doi.org/10.1016/j.asoc.2017.11.007>
- [22] Kuru, K. *et al.* (2012) *A novel report generation approach for medical applications: The SISDS methodology and its applications. International Journal of Medical Informatics*, 82 (5). pp. 435-447.
- [23] Kuru, K. *et al* (2024) Treatment of Nocturnal Enuresis using miniaturised smart mechatronics with Artificial Intelligence. *IEEE Journal of Translational Engineering in Health and Medicine*, 12 . pp. 204-214.
- [24] Kalmukov, Y., & Evstatiev, B. (2022). Methods for Automated Remote Sensing and Counting of Animals. In 2022 8th International Conference on Energy Efficiency and Agricultural Engineering (EE&AE). 2022 8th International Conference on Energy Efficiency and Agricultural Engineering (EE&AE). IEEE. <https://doi.org/10.1109/eeae53789.2022.9831239>
- [25] Kuru, K., Ansell, D. Jones, D. Watkinson, B., Pinder, J. M., Hill, J. A., Muzzall, E., Tinker-Mill, Cl., Stevens, K., and Gardner, A. (2024). Automated airborne monitoring of livestock using autonomous uninhabited aerial vehicles with vision-based remote sensing. In: The 11th European Conference on Precision Livestock Farming, 09-12 September 2024, Bologna, Italy.
- [26] Kuru, K., Ansell, D. Jones, D. Watkinson, B., Pinder, J. M., Hill, J. A., Muzzall, E., Tinker-Mill, Cl., Stevens, K., and Gardner, A. (2024). IoTFaUAV: Intelligent remote monitoring of livestock in large farms using autonomous unmanned aerial vehicles with vision-based sensors. *Biosystems Engineering*.
- [27] Kuru, K. *et al.* (2024) Deployment of autonomous IoT drones for precision farming in an automated manner. In: *Use of technologies in Agriculture*, 25 April 2024, Myerscough College, Preston, UK.
- [28] Kuru, K. *et al.* (2023). Airborne Vision-Based Remote Sensing Imagery Datasets From Large Farms Using Autonomous Drones For Monitoring Livestock. *IEEE DataPort*.