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

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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)

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