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Integration of Beekeeping with the Concept of Smart Manufacturing

Abstract: Smart manufacturing encompasses various industries, including honey production on beekeeping farms. Modern technologies enable the resolution of complex and critical tasks in this field. This scientific article presents a method for integrating smart manufacturing into beekeeping. It describes the concept of digital control over processes inside hives, automation of hive management processes, monitoring, and problem forecasting. This, in turn, simplifies traditional beekeeping methods and improves both the vitality of bees and the productivity of honey production. Beekeepers of various levels, from amateurs to professionals managing large apiaries, are in great need of technologies that can enhance their efficiency. However, modern mass markets for beekeeping equipment, unfortunately, lack affordable solutions. Therefore, this problem remains relevant and requires attention in this field.

Keywords: Digitalisation, Automation, Smart manufacturing

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Introduction

Honey production is a complex and meticulous process that requires a high level of knowledge in this field and involves solving numerous complex tasks, such as: monitoring the condition of the bee colony includes necessary regular (weekly) inspections, fighting varroa mite infestations, predicting swarming, tracking queen presence, controlling colony growth/efficiency, and preventing starvation. The appliance of automated control procedures and targeted interventions against critical beehive conditions is the beekeeper's main concern and is carried out through periodic control checks of the entire apiary [1]. Human labor becomes more efficient with the use of smart manufacturing in beekeeping. Physical labor is reduced, and with an increase in the number of beehives, human labor does not increase. Additionally, the time for visual inspection and diagnostics of hives on-site is shortened.

Materials and methods

The methodology involves selecting a combination of hardware and software and establishing a connection between automated tasks and the operator.

Figure 1. Data analytics SaaS app for beekeepers

For data analysis in beekeeping, we use a SaaS (Figure 1) application that includes AI detections of frame photos, bee counts, queen and queen cups, varroa mites, frame cells, management of apiaries, hives, frames, and photos, an AI advisor, a mobile app, manual inspections, an inspection timeline, and re-training on user data. Therefore, to accurately analyze the impact of the environment on the state of the bee colony, it is necessary to use sensor devices with sufficient accuracy [2].

IoT sensors for beehives are integrated with hardware for transmitting infrequent telemetry data and are used to measure internal hive temperature. The temperature is a very important parameter for bee colonies, as its detection can be used to identify different conditions in the hive, such as brood development, the pre-swarming condition, and, in general, the health status of the hive [3]. IoT sensors, also are used to measure humidity, atmospheric pressure, hive weight, CO_2 levels inside the hive, PM2 pollution outside the hive, wind speed, and audio. Numerous algorithms can be used for feature extraction and analysis of bees' acoustic [4]. Putting a sensor inside a beehive to gather data from a colony is an advantage over being outside [5].

The web application enables plotting time series data in Grafana, performing analytics through graphs for identifying correlations and anomalies, and generating notifications.

Monitoring the entrance of a beehive is comprehensively performed using the Vision application and an IoT device (Figure 2). It includes video streaming and playback (Figure 3), counting incoming/outgoing bees, varroa mite detection, detecting seizures caused by pesticide exposure, monitoring pollen foraging activity, ant infestations, queen mating flights, theft alerts, and hornet attack notifications.

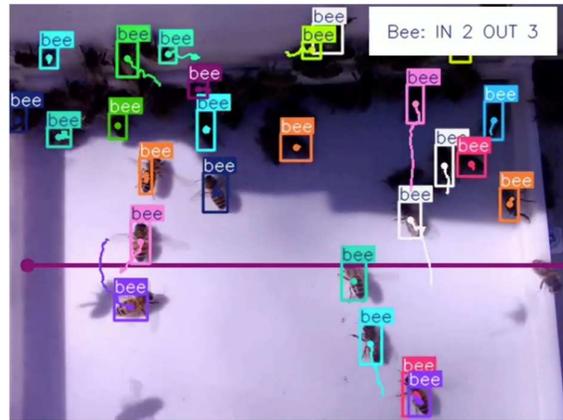Figure 2. Hive entrance video monitoring / IoT device

Figure 3. Video streaming & playback

In addition, smart beehives can include a frame extraction mechanism (Figure 4), 2 cameras to take photos of the frame for uploading to a web app, frame extraction for honey harvesting, frame movement across hives, and initially, a robot for a single colony. It moves on rails and also contains sensors for temperature, humidity, weight, and audio monitoring, as well as ventilation, automatic feeding, and anti-varroa mite treatment. The varroa mite disease is one of the most common causes of bee mortality [1].
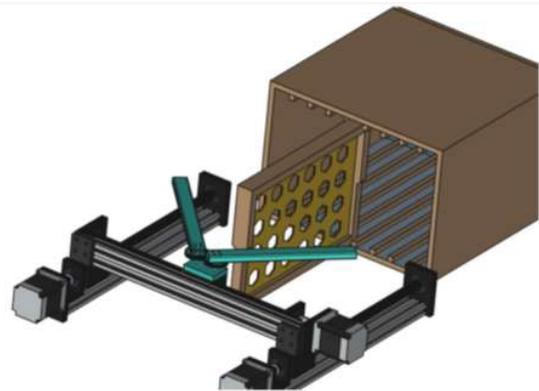

Figure 4. Frame extraction mechanism

Conclusion

In the course of the study, a methodology was developed for the implementation and use of smart manufacturing technologies in beekeeping. The technology, consisting of data collection devices, software, and data transmission peripherals, has proven its suitability and efficiency in use. This enables the simplification of tasks in beekeeping while improving the quality and productivity of honey production.

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