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THE USE OF SMART APICULTURE MANAGEMENT SYSTEM: REVIEW PAPER

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AUTHOR'S CONTRIBUTION

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ABSTRACT

Bee colony ought to be often monitored via beekeepers to limit pest and predator issues and increase bee colony productivity. Mostly bee colony has monitoring focused on periodic inspections by beekeepers, which should be impractical and cost expensive. The objective of this review was to highlight quite several smart apiculture management structures in the beekeeping practice. Precision beekeeping or remote hive monitors will allow you to monitor the status of your honey bee colonies and apiaries from any internet-enabled system such as a smart phone, tablet. Currently, there is different intelligent beekeeping supervision systems had been on hand in the world. Some of the units are a wireless node and cloud database server, local data server, supervisory control, and data acquisition system, GIS for bee management, photography, and infrared imaging of apiary and relative humidity sensor. These technologies are used for measuring parameters like everyday exercise of honeybee colony, flaying target detection, remote hive health monitoring, bee traffic monitoring using monitoring bee flight and temperature of the hive. Generally, the use of precision apiculture allows us to show the beehives for many feasible reasons, such as research, records about the daily management of bees by way of beekeepers, and to gain knowledge of how to minimize the time assigned to duties without reducing production. As a result, to practice this technology supplying focus for expertise and beekeepers and additionally, governmental and non-governmental companies ought to be advertising the use of precision apiculture technologies.

Keywords: Smart; beekeeping; management; hive; monitoring; precision apiculture.

ABBREVIATIONS

ASCII	*:American preferred code for statistics interchange*
ADC	*:Attack harm carry*
EMC	*:Electronic drugs compendium*
GSM	
MOV	*:Movie file format*
RS	*:232 endorsed widespread for 232*
SHT15	*:Temperature and humidity sensors*
SPARC	*:Scalable processor ARChitecture*
SCK	*:Serial clock*

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UART :Universal asynchronous receive transmitter
USB :Universal serial bus

1. INTRODUCTION

Start of beekeeping dates to the dawn of civilization where beehive colonies are used as a source of honey, wax, and propolis. Nowadays, these natural products are importantly suitable for nutrition, medicine, and industry. Honeybees are the most vital pollinator bugs for a wide range of cultivated crops. The European Union parliament referred to in decision T6-0579/2008, which 79% of the world's foods allowance is structured on honey bees and also about 85% of honey yield variations between the colonies are due to environmental conditions and 15% is due to genotype distinction [1,2,3].

Today, the honeybee population is affected due to modern-day civilization, such as pollution, climate changes, invading pests, etc. With the ever-growing human population and meals production, it is indispensable to preserve beehive colonies and enable them to maximize their pollination activity as properly as honey productivity. Thus, beehives need to be monitored by way of beekeepers to take preventive actions to assist bee colony to overcome arisen problems. Most commonly, beehive monitoring focused on periodic guide inspections by using beekeepers, which could be impractical and time and fee expensive. Precision apiculture, a subsection of precision agriculture, relies on a set of instrumentation used to monitor the health and productivity of beehive colonies. Precision beekeeping (PB) or distant hive monitors will enable you to display the reputation of your honey bee colonies and apiaries from any internet-enabled device such as a smart phone, tablet; consequently enabling speedy response through the beekeeper in case of necessity. Precision beekeeping is aiming to decrease useful resource consumption and maximize the sustainable products and services of honeybees [4,5,6,7].

Precision beekeeping device like wireless sensors, placed inside beehives, permits beekeepers clear insight into bee colony health, without the desire for the constant disturbance brought by manual inspection. Various types of parameters can be monitored inside the beehive, such as temperature, relative humidity, CO_2 level, the weight of beehive, audio and video recordings of colony endeavor and many others. Wireless communications between sensors enable the formation of verbal exchange networks, so all beehives can be monitored at once and effects can be analyzed and in contrast [8]. This review aimed to spotlight a variety of smart apiculture supervision services in the beekeeping practice.

2. TYPE OF COMMERCIAL BEEHIVE MONITORING SENSORS

2.1 Wireless Node and Cloud Database Server

The wireless node replaces the information acquisition and processing designed to show the thermoregulatory capacity of the honeybee colonies in hives with open-screened bottom boards [9]. Three LM35 temperature sensors were in different areas of each beehive together with two SHT15 sensors, which can measure the hive’s temperature and humidity. An SHT15 used to be positioned on the top aspect of the beehive by using the gap leading to the air chamber placed below the lid.

Wasp mote Plug & Sense Sensor nodes integrate more than 70 sensors, adapting to any wireless sensor scenario appropriate for outdoor operation, and sensor probes are easy to add or change Wasp mote Plug & Sense is important for honeybee project because the set up is power impartial with solar panels that allow the nodes to work autonomously for years, thanks to Wasp mote's extraordinarily low energy consumption. The sensor node needed to fit interior the beehive, without impeding the activity of the beekeeper and to avoid any interference with the bees. Wasp mote nodes installed in the beehives measure CO, CO_2, O_2, temperature, humidity, chemical effluent (NO_2, H_2, NH_3, Toluene, Isobutene) and airborne dust, all essential indications of the health of the bee colony within. The purpose of monitoring is to send vital real-time records without delay to the beekeeper; some other is to gather facts for analysis and to construct a database that enables partners in biology to study pests and diseases [10].

Cloud Database Server is a replica of the neighborhood database of each beehive that is carried out in the cloud database server. This server ensures an extra level of security, providing each a backup and get right of entry to the facts of the beehives and sending the accumulated records to the cloud. As a result, this server the beekeeper can get the right entry to all information about the beehives from somewhere through the web and can additionally receive alarms or different moves required using the beehives with an automatic analysis of these data. The battery level and data related to whether or not there are mistakes in the statistics acquisition from the node are also stored in this database [11].

Fig. 1. Diagram of sending records to the Cloud using (global system for cellular communication) GSM-Remote Monitoring Beehives

2.2 The Local Data Server, Supervisory Control and Data Acquisition System

Two applications are executed on the local computer positioned in each apiary. Supervisory control and data acquisition system (SCADA), which synchronizes, requests and processes the data of the node in every beehive and (Michael structured query language) MySQL, the world's most famous open-source database [12]. MySQL is additionally executed in the cloud data server, and a replica of the local database of each hive is carried out. This server guarantees an extra level of security in the event of a communications failure given that it stores and sends the data acquired in each beehive to the cloud. The local computer is an embedded industrial computer, which shows advanced protection against environmental conditions, as it should be placed beside the beehives. The computer communicates directly with the coordinator node of the wireless network using a USB interface. We used Libelium's "XBee USB-Serial gateway" module as the coordinator of the community and gateway [13].

2.3 Weighing Scale

The weighing scale consists of a metallic 50 cm × 40 cm frame with a 150 kg load cell-associated. This weight is more than enough, as the weight of a beehive can be up to 80 kg. The load cell is linked to a BR80 display by way of different values. The resolution can be set up from 1 kg to 5 g. The BR80 show has a DB9 connector that periodically sends the weight values via a series RS-232 interface frame consists of seven bytes. The first character sent is "=", which is used to synchronize with the receiver (Wasp mote) and to be aware that the six digits concerning the price of the weight will be then sent. The first digit is most significant, and as specific with the aid of general RS-232, all of the characters are codified in ASCII code. The transmission speed can be configured from 1200 to 9600 bauds. The lowest velocity has been selected in our case to permit the Wasp mote to receive the measurements from the three SHT15 sensors without overflow taking place in the reception buffer of its UART. Placing a honeybee hive on a scale to weigh it disturbs the hive very little and if the hive is kept on the scale, then weighing it does not disturb the bees at all. Hive weight records can link satellite observation to plant-bee interactions and ecosystem local weather change. Daily hive weight adjustments point out nectar drift and pollen series activities. Daily hive weight adjustments point pollen sources phonology (starting and ending days of pollen and nectar flow), population trends. Beehives translocations can be made primarily based on the files of scale hive. Occasional weighing (weekly or even daily) is typically performed to determine when to harvest honey or to estimate hive food reserves [14,15,16]. Continuous weighing with a sufficiently particular scale can furnish that information as well as data on shorter-term changes in the hive. Weight records are convenient to define and analyze: A colony has a single weight value at a given point in time and scales are widely available and easily installed. Most load cells manage for temperature variability, at least over a given range of values, but some weather factors, such as precipitation and wind, can affect the data.

2.4 Photography and Infrared Imaging of Apiary

There are three SHT15 temperatures and relative-humidity sensors had been hooked up in every beehive in special locations:

- Middle of the brood region
- An area with honey/pollen reserves in the periphery of the same brood comb, and
- Honeycombs separated from the brood combs.

All of the sensors have been placed 12 cm top of the comb. A node with simply one SHT15, covered from environmental conditions, was installed to measure the temperature and humidity backyard the hives. Each beehive was once installed on a scale connected to the wireless node to weigh it in real-time. The wireless node and the show of the weighing device were protected internal an IP65 field by using every beehive. Three sensors were set up due to the fact in accordance to research carried out they show vast variations with the thermal law that the bees carry out in different zones of the hive [9]. Thus, in the central brood area of the colony, the temperatures are steady between 34–35°C, which is the best temperature for the development of the bee larvae.

The application infrared imaging is used to monitoring the bee colony temperature [17,18,19]. The infrared imaging can give data about the heat distribution of a single colony or a group of colonies. The thermal imaging approach was once used via Eskov and Toboev to monitor thermal method in the inter-comb bee clusters and the temperature of different body components in the course of the wintering period. The temperature of different body parts was found to depend on the localization of bees in the nest and the external temperature. The dependence of the thermoregulatory activity of bees on the exterior temperature fluctuations lowered at some stage in wintering. The trends of distribution of thermal fields in clusters of wintering bees are printed [17]. Also, long-wave infrared imaging used to be used for non-invasive assessment of the interior populace of honey bee colonies. The radio metrically calibrated camera sign is associated to the wide variety of frames that are populated by way of bees internal each hive. This allows speedy measurement of the population without opening the hive, which disturbs the bees and can endanger the queen. The fantastic effects had been got just before sunrise when there is the most thermal distinction between the hive and the background. This system can be essential for beehive monitoring or for applications requiring frequent hive assessment, such as the use of bees for detecting chemical substances or explosives [19].

2.5 Relative Humidity Sensor

To measure the humidity inside the beehives three SHT15 sensors had been used [20]. They have been chosen due to their amazing reliability and steadiness and their low energy consumption. These sensors permit the measurement of temperature via a band-gap sensor and of the relative humidity through a capacitive sensor. The SHT15 sensor consists of a 14-bit analog/digital converter (ADC) and a serial interface circuit. The ADC converts the sign generated by means of both sensors into a digital sign and transfers the effects of the conversion through the serial interface. In this way, a better-quality signal, rapid response, and higher immunity to external disturbances (EMC) are obtained. Within the SHT1x family, the SHT15 is the sensor with higher accuracy, presenting an error of ±0.3°C for temperature and ±2% for relative humidity.

With Plug & Sense! The version of Wasp mote with the aid of Libelium, we would have required to use the 808H5V5 humidity sensor and the MCP9700A temperature sensor. These sensors are analog, so they would have needed to be linked to the analog channels of the ATmega1281. To obtain the highest feasible decision in the ADC of the microcontroller, Wasp mote Plug & Sense! Must include a signal amplification board. Regardless, since the ADC of the ATmega1281 is a 10-bit converter, a worse resolution would be obtained; because SHT15 sensors include an internal 14-bit ADC and because they are beside the dimension sensor, a higher signal-noise ratio is obtained. On the other hand, the cost of the node is reduced, as Wasp mote Plug & Sense! It is more expensive.

The reading and request for facts is executed through a serial interface primarily based on I²C known as Sensibus. This interface uses two signals: SCK and DATA. SCK is used to synchronize the communication between the microcontroller and the SHT15 sensor. The DATA pin is used to transfer data to or from the sensor. The SHT15 generates the measurement data with the falling edge of SCK. Thus, the microcontroller needs to study the data bits in the rising edge of SCK. The implementation of the verbal exchange protocol has been carried out via software program the use of two I/O pins of the microcontroller [21].

2.6 Wireless Solution for Bee Colony Temperature Measurements

Temperature measurements of bee colonies have a stretched history. Currently, bee colony temperature measurements seem to be the humblest and less expensive way to screen bee colonies. The little charges of data collection, processing and information handover of temperature size structures facilitate the request of temperature measurements in beekeeping. Monitoring of the bee colony temperature can be carried out the usage of a variety of strategies and tools:

1. Manual temperature measurements, measurements by using different loggers and iButtons
2. Wired sensor networks
3. Wireless sensor networks
4. Infrared imaging

Temperature information can assist to discover such colony states as death, swarming, brood rearing and brood much less state [22].

With the rapid improvement of IT and ICT, it has become possible to increase whole sensor networks for temperature measurements. One wire sensor networks are popular when it is possible to keep all measurements in the PC database for similar information analysis. The beehive observation system consisted of the manage subsystem, measuring (temperature and relative humidity) subsystem and video recording subsystem [23]. The writer of this paper additionally did realistic experiments acquiring the beehive temperature measurements in the closed environment created in the wintering building. Up to 30 beehives had been placed in the building. Each hive used to be geared up with a small digital temperature sensor. All sensors were sequentially linked with the Temp08 interface device, whilst it was connected with the give up data the use of the COM port. All data from the sensors have been transmitted to the computer database. Based on the temperature information it is viable to conclude if the bee colony is in a passive/inactive state, if the brood-rearing technique has started and if the bee colony is still alive. This record is very useful for the beekeeper, due to the fact it is needed to monitor the brood-rearing process, and if this method has commenced too early it is needed to slow down this process. Premature begin of bee breeding in wintry weather can purpose excessive energy consumption of the bee colony that, in turn, can lead to the possible loss of life of that colony. That is the most important threat component at some stage in the wintering in the extraordinary construction [24].

Nowadays, wireless sensors and wireless solutions for different object monitoring tasks and data acquisition have become more popular. But unfortunately, in beekeeping, the writers of the paper observed only one example of a wireless system prototype for bee colony remark [25]. The main components of a wireless networking tool are listed below.

Beehive circuit: It is flexible, fantastic slim, with a built-in Li-Po charger. External photo voltaic panels are used to supply electricity for the circuit, Sensors: Temperature and humidity sensors, Zigbee circuit for wireless communication, Embedded computer, Software, Database: The system makes use of MYSQL. But wireless solutions and software of wireless sensors will be growing and its utilization in beekeeping will make better soon.

2.7 Remote Monitoring of Bee Colony Temperature Changes

When it became easy to implement bee colony temperature measurements, the development of computer-based structures started out to ease the get entry to the measured data and to enable beekeepers to reveal their bee colonies in real-time. WEB structures started to be applied for the visualization of measurements. The predominant thought is that a beekeeper from any place, where there is the Internet coverage ought to join to the web server and checks the temperature in the hives. As beekeepers normally are no longer very experienced in using PC applications, the WEB interface should be as simple as possible, without any possibility to make any wrong actions. The net device has developed the usage of ASP Net technology and divided into a number of modules. The first module's real data about the bee colony temperature is the final measurement for all sensors. The 2nd module option is the detailed evaluation of the bee colony temperature with an alternative to graphically show average, minimal or maximal temperatures for the hive and the 3rd module an option for administration and modifying information in the configuration file [26].

3. APPLICATION OF BEE HIVE-NETWORKING MONITOR ARCHITECTURE

Several technologies can be utilized for monitoring the bee colony and application of the data-gathering phase [27]. The data collection process in PB can be categorized into three organizations [28]. 1. Apiary-level parameters (meteorological parameters and video observation); 2. Colony-level elements (temperature, humidity, fuel content, sound, video, the vibration of hive and weight) 3. Individual bee-related considerations (the range of incoming/ outgoing bees, the range of bees in the hive entrance area).

Beehive-monitoring systems must meet countless large requirements:

- They must use a minimally invasive method
- They must be operational in remote areas for long periods, and
- They must allow real-time monitoring.

3.1 Measuring Daily Activity of Honeybee Colony

Incoming bee's comings: The range of incoming bees extended regularly until 10:20 h after which it dropped until 10:40 h (140 bees). At that time, all activity was once suspended for a number of minutes. The returns then endured till round 11:20 h (1 500 bees), the time when the swarm left the colony. During swarming, the variety of incoming bees was once much decreased (400 bees), but just in a while (11:35 h) a big proportion of bees returned: 6500 bees within a 20-min period. As used to be the case for the outgoing bees, the quantity of incoming bees remained quite constant until 17:00 h, and then declined till 22:35 h.

Outgoing bees: The worker bees started to go away the hive early at 6:45 h (10 bees) when the ambient temperature was once 8°C; their wide variety accelerated from 8:30 h (50 bees) to 10:20 h (1 0 bees). The variety of outgoing bees then decreased drastically (130 bees) before it rose again at 10:45 h. There was significant increase from 11:20 (1 300 bees) which reached a height of 6 600 bugs at 11:35 h. Therefore, 19 150 bees left the hive to form a swarm within only 15 min. The number of outgoing bees then remained constant until 16:45 (1 100 bees).

The daily activity of the colony: This counting device appears to be well suited applicable for monitoring and registering honey bee activity at the hive entrance, in special climate conditions, and even in the case of swarming. It can be used coupled with other processes learn about the foraging behavior of the colony, and they have an impact on exterior factors such as the spraying of pesticides on colony life. The variety of incoming and outgoing bees of a hive is solely one of the parameters of colony activity; however, it can't be directly equated with foraging undertaking (nectar and pollen gathering) though they are strongly related. The use of a counting device does now not stop behavioral studies from being carried out each for the colony degree and for the flowers visited by way of bees. The gathering of several quantitative should not be viewed as an alternative for the essential observations regarding different parameters of colony behavior. All these methods are complementary [29,30].

3.2 Flaying Target Detection

The segmentation approach is an extension of standard motion detection techniques with adaptive background modeling. The major improvement is the use of the depth data to drive the adaptation of the background intensity model. The stereo digital camera provides a pair of gray scale images (left and right) and a corresponding disparity map. Below, It; u; v refers to the intensity of the pixel at time t and position (u; v), while Dt; u; v refers to the distance from the camera at time t and role (u; v). The objective here is to compute two binarized masks based on I and D: a determined depth target masks DDTM and an undetermined depth target mask UDTM [32].

Table 1. Measurable bee colony parameters

Parameter	Method
Weight and temperature	Mechanical balance and in-hive mercury thermometers
Weight	Mechanical balance & Electronic balance
Temperature	Electric thermocouples
Temperature, O_2, and CO_2	E-thermocouples, metabolic chamber, extracted air passed through external detectors
Temperature	Extracted air passed over the thermometer
Temperature, CO2,#of fanning bees	In-hive mercury thermometers, extracted air passed through external detectors
Temperature, O2, # of fanning bees	Metabolic chamber with extracted air passed through external detectors
Temperature, O2, and CO2	Extracted air passed through detectors
Temperature, O2 and CO2, RH	In-hive temperature sensors; extracted air passed through gas detectors
Vibration	In-hive sensors
Acoustics, temperature, RH	In-hive sensors
Forager traffic	Hive entrance sensors
Forager traffic	RFID tags and entrance sensors5
Colony thermal image	2D outward IR camera
Atmospheric pressure	In-hive sensors/out-hive
PM 10	In-hive sensors/out-hive
The number of mites	2D outward camera

Source: [31]

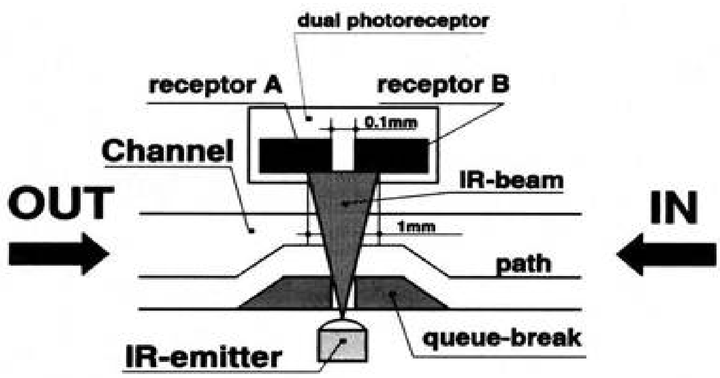

Fig. 2. Each day honey bee undertaking measuring devices

Table 2. Possibilities of bee diseases manipulate automatization

Disease			**Symptom**	**Treatment**	**Appropriate sensor**	**Appropriate actuators**
Contagious disease	Viral	Acute bee paralysis	Black shiny bees without bristles	24Hr starvation & controlled antimycotic feeding	Visual camera and image processing	Controlled feeder
		Sac brood	An uneven brood pattern with discoloured, sunken brood cells	24 Hr starvation & controlled antimycotic feeding, re-queening if >5% of brood is infected	Visual camera and image processing	Controlled feeder
	Bacterial	American Foulbrood	Irregular & patchy brood pattern, sunken cappings, sulphurous smell	The colony should be killed, Alternatively, gamma radiation or antibiotic treatment	Visual camera and image processing, artificial nose	Controlled feeder
		European foulbrood	patchy brood pattern, ammonia-like smell	infected frames incineration controlled antimycotic feeding	Visual camera and image processing, artificial nose	Controlled feeder
	Fungal	Chalk brood	Presence of the hard, shrunken chalk-like white to grey mummies in/ around brood & entrance	Brood reduction, queen and comb replacement, controlled feeding with vitamin C and nystatin	Visual camera and image processing	Controlled feeder, robot manipulator
		Stone brood	A whitish-yellow collar-like ring near the head end of the infected larva, after	Mandatory incineration of colony and comb	Visual camera and image processing	Robot manipulator and incinerator

Disease			Symptom	Treatment	Appropriate sensor	Appropriate actuators
			death, the infected larva becomes hardened and quite difficult to crush			
	parasitic disease	Nosema	Brown diarrhea on combs and the outside of the hive, bloated abdomens, crawling bees	Indoor conditions control, comb disinfection, requeening, combs replacement and brood reduction	Visual camera and image processing	Robot manipulator indoor conditions controller
		Varroa	Constant colony decrease, patchy brood pattern, colony collapse	Biological regarding drone brood, physical - 10-15 minutes 46-48°C treatment, chemical	Visual camera and image processing the other observed Colony state signals	Robot manipulator, Thermic chamber, Controlled atomizer
		Acarine	Reduced bee lifespan, decreased overwintering capability	Chemotherapeutic measures	Combination of colony state signals	controlled atomizer
Non-contagious disease	Chilled brood		Similar to European foulbrood	indoor conditions control	Visual camera and image processing	Indoor conditions controller
	Dysentery		Dark-brown diarrhea on combs & the outside of the hive, bloated abdomens, crawling bees	Replacement of frames containing indigestible matter with frames containing sugar water or high fructose corn syrup	Visual camera and image processing	Controlled feeder, robot manipulator
	Chemical poisoning		Dead bees all around inside/ outside beehive, on pasture even on flowers	Colony reduction, indoor conditions control, controlled feeding with sugar water, Controlled pesticide application during the blooming period	Visual camera, image processing, combination of colony state signals	indoor conditions controller, controlled feeder, robot manipulator

Source: [31]

3.3 Remote Hive Health Monitoring

Commercial beekeepers usually manage quite a few thousand hives. The labor cost of hive maintenance can be reduced by automation, or if hive abandonment can be detected early, before the complete loss of the colony, this may additionally have a large financial affect on the industry. With the availability of industrial remote hive monitoring solutions such as Arnia® and Hive Mind®, commercial and scientific apiaries can be readily equipped with all the sensors required to generate predictive models such as those described here. Input from the meteorological sensors ought to generate predictions for the activity level in real-time.

A “calibration mode” would enable the model to train itself the use of incoming data, allowing for the automatic estimation of the parameters such as the scaling factor for each hive. Hive activity monitoring can function the same analytical procedure described above, except performed dynamically using live, incoming data. Confidence in this system could save labor by decreasing the need for systematic and periodic checking of all hives in a huge commercial apiary. Rather, targeted hive inspections should be in response to specific indicators indicating an excessive likelihood of deviation from anticipated hive activity.

The addition of different sensors may also reveal predictor variables that were now not considered here, in particular, variables related to the indoors of the hive. Brood temperature and sound measurements have been successfully used in the context of non-stop hive monitoring experiments [33,34]. It used to be shown that earlier than swarming, there used to be a significant make bigger in sound amplitude within the hive at positive attribute frequencies and that hive temperature was raised via three °C in the duration without delay before swarming [34]. Hive sound and temperature sensors, gas sensors and other continuous monitoring tools should be deployed, along with bee activity monitors. The contribution of these variables to model predictive strength may want to then be investigated.

3.4 Bee Traffic Monitoring by Tracking Bee Flight

A beehive traffic tracking of bee flight monitoring consisted of four major elements these are a camera, a white background, hive with bee traffic and photo processing bee counting software. A camera documents the bee traffic which is more advantageous thanks to a white history and an algorithm that computes the things to do of the hive (arrivals and departures). The camera is positioned above a Dadant beehive entrance, being sure that the entire entrance width is covered with the aid of the camera. The 12 megapixels camera sensor is equipped with a wide-angle lens (28 mm, f/1.8). It acquires 1080p videos at 60 frames per second (fps). Videos are saved in the MOV structure and resized for different experiment evaluations: 1080p, 720p, 540p and 360p at 60 fps or 30 fps. Finally, bees fly shut to the white background.

4. CONCLUSION

Remote monitoring structures meet the requirements to turn into a substantial tool for the monitoring of bee colonies. The use of precision apiculture allows us to monitor the beehives for many possible reasons, such as research, information about the day by day management of bees with the aid of beekeepers and learning how to limit the sources and time assigned to duties without reducing production. Several colony-level related parameters currently can be always measured temperature by temperature sensors or infrared imaging, air humidity, gas content, sound, the vibration of the hive, counting of outgoing and incoming bees, video statement and weighing. Based on this review the following recommendation has been assumed;

- Providing focus for both expertise and beekeepers about two precision apiculture.
- Governmental and non-governmental businesses must be advertising the use of precision apiculture technologies.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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