

Impact of Artificial Intelligence in Beekeeping

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Resumen

La Inteligencia Artificial es la tecnología que se incorpora a sistemas, dispositivos o máquinas para imitar a la inteligencia humana y que puedan realizar tareas cotidianas. De igual manera tienen la capacidad de evolucionar a partir de la información que van recopilando. Con la inclusión de esta tecnología en muchas áreas de trabajo, las actividades primarias no se han quedado atrás. La apicultura, actividad que se deriva de estas, enfocada a la crianza de abejas, ha comenzado a probar la Inteligencia Artificial en sus procesos. Gracias a estas pruebas, se ha podido observar que muchos problemas que comúnmente enfrentan los apicultores, pueden resolverse de una manera eficaz. Desde colmenas inteligentes hasta softwares que pueden detectar enfermedades o plagas, son las innovaciones que han permitido que la tecnología tenga un lugar dentro de la industria apícola. Mejorando significativamente la obtención de los productos y el cuidado de las abejas.

Abstract

Artificial Intelligence is the technology that is incorporated into systems, devices or machines to mimic human intelligence and enable them to perform everyday tasks. They also have the ability to evolve based on the information they gather. With the inclusion of this technology in many areas of work, primary activities have not been left behind. Beekeeping, an activity derived from these, focused on the breeding of bees, has begun to test Artificial Intelligence in its processes. Thanks to these tests, it has been observed that many problems commonly faced by beekeepers can be solved in an effective way. From intelligent hives to software that can detect diseases or pests, these are the innovations that have allowed technology to have a place in the beekeeping industry. Significantly improving the production of products and the care of the bees.

Palabras clave. Inteligencia Artificial, Apicultura. Tecnología, Desarrollo, Aplicación.

Keywords. Artificial Intelligence, Beekeeping, Technology, Development, Application.

1. INTRODUCTION

Today we live in a world where technology has reached the most marginalized places on the planet, revolutionizing the way we live, produce and socialize. Everyday life has totally changed. In any part of the world, you can now have access to technology, people who a few years ago did not count on this. Now it is common to find smartphones, computers, SmartTV's, among others, in most places where there were none before. Similarly, there are many areas of work where the use of technology has expanded. It is no surprise that it is also used in agriculture.

Many years ago, it was unimaginable that any kind of device could be used in the field of agriculture, beekeeping, etc. With the passage of time, the methods used in these primary activities have been modernized. One of the things we have been hearing regularly nowadays is the term Artificial Intelligence (AI). This technology has been around for many years, but it is in the 21st century that it has really started to develop more. We see it clearly on websites with bot chats, where an Artificial Intelligence responds according to what

you ask it, or with Smartphones that most of them include an assistant that uses AI to help you with some functions of the cell phone.

The growth of this technology has been such that its use in the field is no exception. Mainly in beekeeping, where the worker has to be very attentive to their hives, because any negative situation that may arise due to carelessness or natural threat, would cause the loss of these, which translates into economic losses for the apiary.

With the help of Artificial Intelligence, the beekeeper can facilitate his work, even automating some processes or detecting threats in time.

In this article we will show some examples of how AI can be used in beekeeping, seeing how it helps the beekeeper to do his job.

2. ARTIFICIAL INTELLIGENCE AND BEEKEEPING

The term Artificial Intelligence was formally coined by the American John McCarthy, at the Dartmouth Conference in 1956. In simple terms, Artificial Intelligence, hereafter referred to as AI, refers to systems or machines that mimic human intelligence to perform tasks and have the ability to iteratively improve upon the information they gather (Oracle Mexico, 2018).

AI manifests itself in several ways. Among them we have: Conversational bots that use AI to understand customer problems faster and provide more efficient responses; Intelligent assistants use AI to analyze critical information from large free-text datasets to improve programming; Recommendation engines can provide automated recommendations for TV programs based on users' viewing habits (Oracle Mexico, 2018).

Artificial Intelligence is an advance within a technological and scientific point of view. It has proven to be an element that helps humans to perform tasks that involve greater difficulty or where the person is exposed to dangerous environments. It is clear to say that AI does not seek to completely replace the human being in the work, but it does seek to reduce as much as possible the times and ensure the automation of processes. For example, it has proven to be a method of helping humans to perform repetitive tasks with degrees of complexity, data analytics, among others. There is still a long way to go before AI goes global, but its expansion has already begun and in a few years, we will be able to see an environment where automation predominates thanks to Artificial Intelligence.

AI has a wide application in the world of work, allowing its use in many areas. In the healthcare sector, Artificial Intelligence has been used to allocate space in hospitals and to organize workers' shifts; In the financial sector, AI has also been used to make investments, detect payments or failures that human professionals then have to investigate; In the video game industry, it is common for the real player to interact with a virtual player, managed with Artificial Intelligence; In the area of transportation, both aviation and road; The industry is also no stranger to this evolution and has included AI through, among other things, robots that are programmed to work in environments with humans; The media are no exception, with the use of Artificial Intelligence can detect fake news or fake news through data analysis on the origin of this information; In data processing this

technology has benefited education, the creation of natural language interface, intelligent access to data, database managers and intelligent data analysis (ITCL Noticias, 2018).

There are many areas where Artificial Intelligence has been applied and this makes us see the impact it has had at a social level, where people interact more and more with autonomous devices; at a technological level, there are more and more devices that use AI, such as smartphones, laptops or computers, Internet of Things, virtual assistants, among others; And at the scientific level, progress has been made in the study of AI, in the improvement or refinement of this evolution, discoveries of great importance, such as neural networks, machine learning, artificial vision, among many others.

In addition to the above, there are different types of Artificial Intelligence. Each one has a different function, depending on the application assigned to it. Some of these types are:

Reactive machines: These are the most basic type of artificial intelligence, and refer to machines that act and react, but without using memories or experiences for the benefit of their operation (Molinetti, 2019).

Limited memory: Refers to machines that maintain memories and data that allow generating transient actions based on the information collected, but without generating learning based on experience (Molinetti, 2019).

Theory of mind: It is considered for machines that are able to understand that there are people and individuals with emotions and thoughts of their own. Meaning that they will have to adapt and adjust according to their environment (Molinetti, 2019).

Self-awareness AI: this is for machines that will have the ability to be self-aware, assuming that they exist and generating cognitive learning based on their own and other individuals' experience. Of the types of artificial intelligence, it is estimated that there is still a long way to go to develop AI of these characteristics (Molinetti, 2019).

Neural networks: Artificial neural networks are a model inspired by the functioning of the human brain. It consists of a set of nodes known as artificial neurons that are connected and transmit signals to each other. The main objective of this model is to learn by automatically modifying itself so that it can come to perform complex tasks that could not be performed by classical rule-based programming (Atria Innovation, 2019).

Computer vision: Computer vision is a scientific discipline that includes methods for acquiring, processing and analyzing images of the real world in order to produce information that can be processed by a machine (Contaval, 2016).

Considering the above, one of the work activities that has benefited from Artificial Intelligence, are primary activities or agriculture.

For example, data to apply AI in agriculture is usually taken by sensors, in drones or tractors, to then suggest to farmers the actions they should carry out throughout their agricultural year (Hablemos del Campo, 2018).

Therefore, beekeeping, which is derived from primary activities, is no stranger to the use of Artificial Intelligence. As the work depends on an animal (in this case bees), it is of utmost importance to take care of it and raise it as well as possible.

Beekeeping is the breeding and care of bees, through which products such as honey, royal jelly, propolis, wax and pollen are obtained (Secretaría de Agricultura y Desarrollo Rural, 2015).

The apiary is the place where all the hives are concentrated in which the bees live, these are divided into three types of hierarchies, first, there is the Queen Bee whose only function is to lay eggs, then the Female Workers responsible for collecting nectar and pollen, and finally, there are the Male Drones, who fertilize the queen bee, once they fulfill their function, they are thrown out of the colony (Secretaría de Agricultura y Desarrollo Rural, 2015).



Figure 1. SAGARPA (2015). Products derived from bees. [Figure]. Gobierno de México. <https://www.gob.mx/agricultura/es/articulos/que-es-la-apicultura>

Beekeeping is one of the most important agricultural activities in the world. The benefits obtained from it are of great human consumption, mainly honey. Besides, it helps nature, thanks to the pollination that takes place when bees go out to collect pollen. Economically speaking, it leaves very good income to the families that are dedicated to this, since the products are highly consumed and used by other people or by companies that use the derivatives to create other products.

Beekeepers are looking for other ways to improve their work environment using today's technology. This is where Artificial Intelligence comes in. Thanks to devices that have been created or prototypes that use AI, they have changed the way of working in those apiaries where it has been decided to use this technology.

In the research conducted, different uses of Artificial Intelligence in the beekeeping industry were found. Some of these applications will be shown below:

3. BEEHOME. THE ARTIFICIAL INTELLIGENCE AND AUTOMATED APIARY



Figure 2. Ecolcolmena Blog (2020). Beehome.

Ecolcolmena. <https://ecolcolmena.com/beehome-el-apiario-con-ia-inteligencia-artificial-y-automatizado/>

Beehome, the artificially intelligent and automated apiary that applies precision robotics, vision and artificial intelligence (Ecolcolmena, 2020).

This is the world's first automated hive, developed by Israeli startup Beewise. Called Beehome, it is an autonomous apiary. It can house up to 40 hives of bees, or 2 million bees, and the system takes care of their health in every aspect; it even performs hive management and honey harvesting (Ecolcolmena, 2020).



Figure 3. Ecolcolmena Blog (2020). Beehome, the apiary with AI (artificial intelligence) and automated. Ecolcolmena. <https://ecolcolmena.com/beehome-el-apiario-con-ia-inteligencia-artificial-y-automatizado/>

The idea of an autonomous hive came from a beekeeper by profession, who was appalled by the fact that beekeeping methods have not progressed for years. He was convinced that a computer system, artificial intelligence and robot could do a much better job (Ecolmena, 2020).

This is a great innovation for beekeeping, you can clearly see that when you combine the traditional with technology, new ways of working emerge.

It is interesting to see how computer vision is applied in this project. In this way the bees can be kept under surveillance without the need for the beekeeper to be present in the hives.

4. AN APP TO PREVENT COLONY COLLAPSE DISORDER (CCD)

The work developed by Jerry Bromenshenk and a group of fellow university bee experts is in the final stages of testing. It is an application that, through the use of a form of artificial intelligence, is able to analyze the sound of buzzing bees with the goal of concluding whether or not they are suffering from a series of diseases (Nieto & Poto Galán, 2018).

Bees are indispensable for both pollination and honey production. A change in their natural rhythms could affect the ecosystem and disrupt normal colony functioning (Nieto & Poto Galán, 2018).

To combat such incidents, this app has been invented to prevent certain types of afflictions such as Colony Collapse Disorder (CCD). This is a mysterious syndrome that has affected beekeepers in both North America and Europe and severely disrupts the bees' daily lives. CCD causes bees to disappear instantly and for no obvious reason from the hive, abandoning their queen, and breaking with the usual dynamics of a natural swarm, where a large group of worker bees follow the queen to form a new colony (Nieto & Poto Galán, 2018).

As an experienced beekeeper would know, the application's algorithm is able to listen to the buzzing of the bees and determine their health. In as little as thirty seconds, the beekeeper can analyze the sound emitted by his little ones by bringing the mobile device close to the hive. If the app detects health problems in the insects, it will notify the beekeeper instantly, thus facilitating the beekeeper's work (Nieto & Poto Galán, 2018).

They studied the sound recordings of the thousands of colonies in their worldwide network of beekeepers that were known to have experienced a problem. A whole database of sounds allowed the development of an artificial neural network, i.e., a form of machine learning used for the recognition of certain patterns, thus helping to build algorithms that could link sounds associated with certain hive problems (Nieto & Poto Galán, 2018).

Artificial intelligence is not only limited to robots. It can also be introduced through apps that integrate a learning algorithm. And with this, it can automatically recognize patterns and indicate to the user whether it is an element A or an element B. In the case of this application to combat CCD, a database is used where all the sounds collected are stored and when the algorithm is activated, it makes a comparison with all the buzzing sounds until it finds the one that is most similar, thus indicating to the beekeeper if his bees have a health problem.

5. DEVICE THAT USES ARTIFICIAL INTELLIGENCE TO MONITOR BEEHIVES

A student and a teacher of the Universidad Tecnológica Nacional-Facultad Regional Buenos Aires (UTNBA) developed a device that allows monitoring beehives remotely, preventing diseases and increasing their production. The device uses the Internet of Things (IoT) applied to beekeeping, which allows monitoring bee hives remotely (Universidad Tecnológica Nacional - Facultad Regional Buenos Aires, 2019).

The device is an intelligent device that uses artificial intelligence to calculate the weight of the hive, measure its temperature and humidity and record the sound of the bees to prevent possible diseases and maintain the health of the hives. "The objective is to facilitate the work of a beekeeper and that he can do it remotely from home, also saving on travel costs," said the author (Universidad Tecnológica Nacional - Facultad Regional Buenos Aires, 2019).

The device, which has a connectivity module to control it from a cell phone or a computer, has an ecological impact, since it foresees the death of bees due to famine, improves honey and food production worldwide and promotes and boosts beekeeping in Argentina. The device, which is in its final stage of development, would cost US\$400 and would allow the monitoring of up to 100 hives (Universidad Tecnológica Nacional - Facultad Regional Buenos Aires, 2019).

In this application it can be seen that both the use of a device and an app were combined. Commonly AI is used in this way, combining a hardware (HW) and a software (SW). Both complement each other, while the HW is in charge of collecting the information, the SW processes that data and applies the algorithm programmed for recognition. This device could be one of the promising ones for beekeeping, since it performs functions that are of high importance such as measuring temperature, humidity, weight, etc., important elements in a beehive, mainly the first two that must be rigorously maintained within a range, because otherwise there could be fatal consequences for the bees.

In this sense in our country through the Tecnológico Nacional de México, it allows young people like me to work on scientific and technological innovation projects where different types of technologies are applied to make a contribution to the private or public sector. In my case, I have been working on a project called "Image recognition system for quantification of dead Varroas mites in bee hives" which involves the use of Artificial Intelligence, focusing on computer vision, with bees. In short, the project consists of a software that will allow the user to count how many Varroa mites have died in a hive by means of a photo or image. Varroa is the main threat to bees, as it causes disease and, if not treated in time, death. This project will benefit beekeepers, as they will be able to save a lot of time when counting varroa. It will also optimize the care of the hives, thereby increasing the quality of the products obtained from them.

My project makes use of Artificial Intelligence, focusing on computer vision. In turn, within this discipline, there are different ways to apply it. In my specific case, an edge detection algorithm is used, which applies different filters to the image, and at the end it shows the number of objects present in the photo.

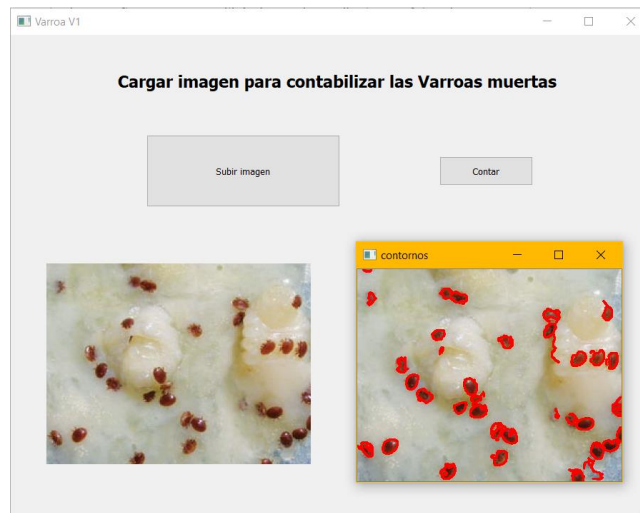


Figure 4. (2021). Own elaboration. Varroa detection using computer vision.

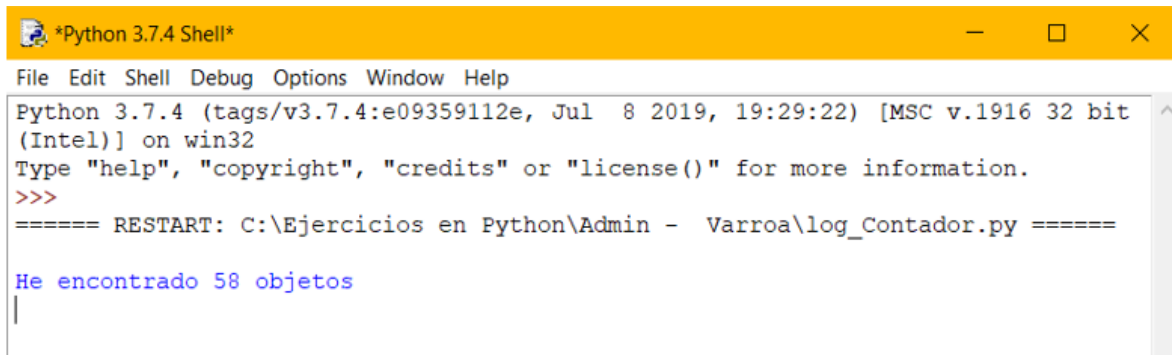


Figure 5. (2021). Own elaboration. Number of objects found in the image.

The use of AI in this kind of projects shows that we are becoming more and more dependent on this technology. This will open a new path in the development of devices or software, which are fully automated thanks to the introduction of Artificial Intelligence, combined with human interaction, will create an environment full of innovations that will facilitate any activity, from industrial work to a simple bee hive.

6. CONCLUSIONS

The current use of Artificial Intelligence in beekeeping has impacted the industry in many ways. It has served to combat pests and diseases contracted by bees, save time in the process of obtaining products, and even to monitor a hive remotely, without having to be present on site. All these processes have been tested by its creators and have obtained positive results, creating a new way of working with bees.

Both the project I am carrying out and the others that have been listed in this article can be a spearhead to motivate the beekeeping sector to invest in technology, improve the processes that in some way will impact in economic terms in obtaining beehive products and increase production with less personnel in the apiary.

In the case of my project that focuses on the detection and quantification of Varroas, it could be a starting point in the future to identify other types of pests, and even use microscope images where viruses or bacteria can be visualized in order to count them.

Beekeeping's foray into Artificial Intelligence is a clear example of what technology has been able to do today. The use of AI in beekeeping is just the beginning of an era where process automation will be the most characteristic of this technology.

There are many elements that intervene for a good production in beekeeping, mainly aspects that have to do with the nature of the place where this activity is carried out, as is the case of diseases or pests that can attack the hive, putting it in danger. Thanks to the examples we have seen of how to use AI, all these problems can be reduced to a minimum, facilitating the beekeeper's work.

Technology is advancing day by day. New devices are emerging and incorporating Artificial Intelligence, making them smarter. In the case of beekeeping, it can be seen that the application of AI will turn this activity around in terms of methodologies. It will change the way of working, new standards will be applied to the beekeeping industry, it will be a new era for beekeeping, where technology will predominate. And with this, new data will be obtained for science, deepening the study of bees, where there are still many unknowns to be solved and AI could be the key to the discovery of new aspects of this living being that were not known before.

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