EDU468726

we4bee – Earthquake Research with Bees

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Learning Objectives

- Honeybees are superorganisms with an annual economic value of 265 billion euros
- Bees respond highly sensitively to environmental parameters
- we4bee unites education and research
- Network of high-tech beehives collects valuable data
- Data anomalies detected parallel behavioral patterns

Description

we4bee is a non-profit project for environmental education and environmental research initiated by the renowned bee researcher Prof. Dr. Jürgen Tautz. The team´s vision is to predict natural disasters like earthquakes by using honeybees as biosensors. In order to do so, we4bee started building a worldwide network of beehives equipped with high-tech sensors. So far, 100 we4bee systems have been issued mainly to schools and teaching institutions. Schoolchildren become enthusiastic researchers who, in addition to the parameters they collect (temperature, air pressure, humidity, weight, fine dust, wind, rain, camera recordings) make a valuable contribution to the analysis of the data based on their observations. With the help of the provided apps and supplementary teaching materials, environmental education can be experienced. The combination with state-of-the-art machine learning and big data methods not only enables we4bee to better understand the behavior and needs of the honeybees as sympathetic representatives for the insects, but also allows to predict the bees´ behavior and possibly even the prognosis of environmental events like severe storms or erathquakes.

Speaker(s)

Prof. Dr. Jürgen Tautz is a world-renowned bee expert, successful author and initiator of HOBOS (HOney Bee Online Studies), the first internet-based teaching and learning platform that provided access to video streams and measurement data from bee colonies, followed by we4bee in 2018. He dedicated his life to bee research after taking over a professorship at the biology department at the University of Wuerzburg in 1990. Tautz studied biology, geography and physics. Having won numerous prizes in scientific communication during his career, Tautz has written several

bestselling books about bees and bee behavior – one of which, "The Buzz about Bees", has been translated into 20 languages.

Hans Neumayr is a passionate engineer with a high bee affinity who started working for we4bee in January 2019. He has been a beekeeper for more than 50 years. During his professional career, he worked as Lab Manager and editor for Franzis Verlag (an electronic specialist publisher) and as Field Application Engineer for Siemens and Infineon (a semiconductor company). He has been following the Eagle development since the release of version 1.0.

Padraig Davidson is an informatics PhD students at the Data Science Chair of Prof. Dr. Andreas Hotho at the University of Wuerzburg, Germany. He coordinates the data retrieval from we4bee hives and uses machine learning techniques to identify behavioral patterns and develop prediction algorithms.

Richard Hammerl, Fusion 360 Community Manager Electronics at Autodesk supported the project in technical questions on EAGLE and Fusion 360 Electronics.

Honeybees are superorganisms with enormous economic value

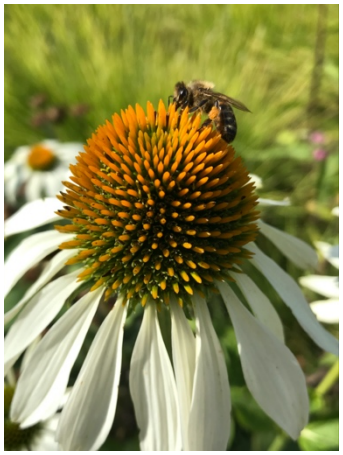
Bees pollinate 80% of all useful and wild plants and thus have an annual worldwide economic benefit of 265 billion euros. This makes bees the third most important livestock after cattle and pigs. Monocultures and the associated use of pesticides threaten the honey bee and have already led to the disappearance of this animal in parts of China. Since then, migrant workers there have had to laboriously pollinate fruit trees by hand. In order to counteract this alarming development and ensure the preservation of the honey bee, we must better understand its behavior and needs.

Alarming insect decline

Insect biomass is rapidly declining. Studies show a 76% drop from 1990 to 2015. This is dramatic as 80% of wild plants and crops rely on insect pollination and 70% of all crops show yield increase upon insect pollination compared to self- or wind pollination. Besides, the increasing lack of biodiversity due to the species extinction not only threatens our ecosystem, but also impacts food chains.

Honeybees are highly symapthetic insects

While worms and bugs are having a hard time finding supporters for their cause, honeybees have been fascinationg human beings for thousands of years. The history of early beekeeping and respective studies dates back to 2,500 B.C. when honeybees were being observed in Egypt. The honeybee has remained popular with children and adults alike ever since.



Honeybee on Echinacea

Bees are groups of synergetically interacting organisms of the same species, so-called superorganisms. Even though bees have been studied for thousands of years, there is little knowledge on how honeybees manage to be so efficient and successful with a plethora of findings remaining to be uncovered by science. we4bee took out to shed light on some of these mysteries.

Bees respond highly sensitively to environmental parameters

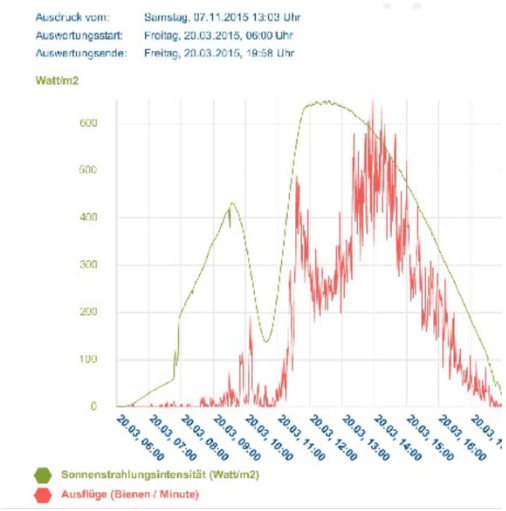
Bees are highly sensitive animals that react to a change in environmental parameters. During the solar Eclipse in March 2015, honeybee flight patterns have been observed to parallel with the fast changing sunlight levels. Besides, honeybees have been shown to react to solar winds which disable their solar compass leading to disoriented bees that no longer find their way home. Furthermore, bees have been observed to return to their hive long before severe weather occurs. Nevertheless, the scientific explanation for this behavior remains to be elucidated.

Animals as highly sensitive biosensors

Many different animals have been shown to behave differently prior to natural disasters. Several days before e.g. tsunamis or earthquakes hit, they change their commonly observed behavior. In 1975, snakes left their nesrts in Haicheng, China, in mid-winter. Irritated and scared inhabitants left their homes before an earthquake (7.3 magnitude) hit the evacuated city a couple of days later. Noone was injured. Unfortuantely, people in Sri Lanka were unable to interpret the behavior of elephants that went into the mountains prior to one of the deadliest tsunamis in recorded history that killed more than 227,800 people in 14 countries in 2004. Not only elephants, but also flamingos had shown awkward behavior days before the 100 feet high waves hit the shores.

Honeybees behave differently prior to natural disasters

Beekeepers from around the world keep contacting Prof. Dr. Jürgen Tautz asking for advice. They claim to have observed a change in their honeybees´ behavior prior to earthquakes or severe weather conditions and ask for scientific proof for their observations.



Solar eclipse in March, 2015 –
flight activity of bees (red) compares to changing sunlight levels (green)

we4bee took out to proof these observations scientifically in order to identify behavioral patterns allowing to predict natural disasters. We are confident that these predictions can help save lives as honeybees are highly sensitive biosensors that outperform any sensor system available to date.

we4bee unites education and research

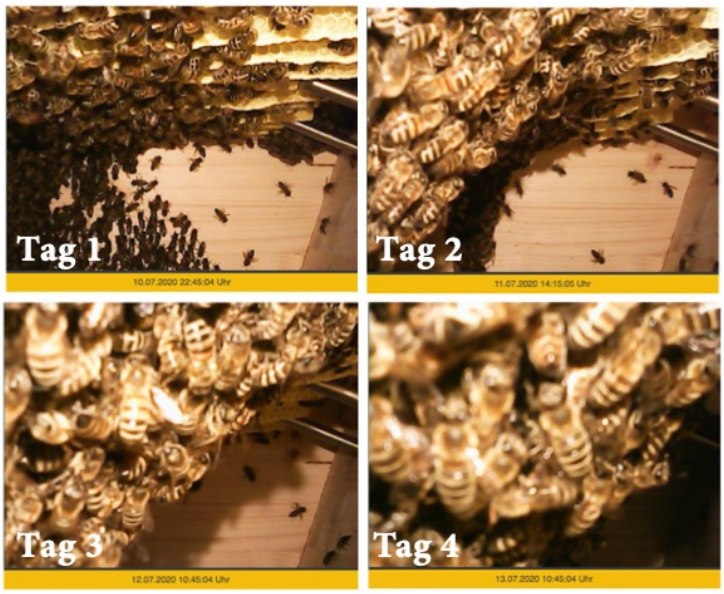
we4bee started its project “Big Bio Data” with the goal of setting up a worldwide network of beehives equipped with different sensors monitoring the honeybees´ behavior. Lessons learned from the predecessor project HOBOS (HOney Bee Online Studies) as well as knowledge acquired in different scientific studies were the basis for the we4bee setup. Apart from the scientific approach, we4bee enables children and adults to study bees and learn about their importance for our environment and humans alike.

298 applications from 17 countries

Within a 6-week-period, we4bee received 298 applications from 17 countries from schools, institutions, museums and urban beekeepers who wanted to receive one of the first 100 high-tech hives sponsored by the Audi environmental foundation. Upon a tough selection process, 100 participants from 7 countries, mainly schools from Germany, were chosen and supplied with a we4bee system.

Apps supply users with data sets

A web application together with an Android and iOS app supplies users and anyone interested in the data collected inside and ouside each of the we4bee hives. Users are able to comment the data by describing their observations as well as beekeeping activities like varroa treatment or feeding.



we4bee app screenshots:
Inside camera capturing bees occupying
a we4bee system within four days

we4bee unites education and research by involving students and beekeepers in data alignment and analyses (e.g. within student´s research projects).

Network of high-tech beehives collects valuable data

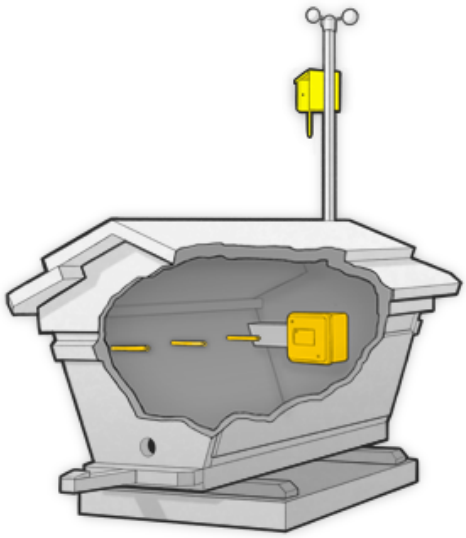
The experienced engineer and dedicated beekeeper Hans Neumayr took on the challenging task of developing a low-maintenance, cpmpact and affordable we4bee high-tech beehive allowing data to be collected locally and being transferred to the University of Wuerzburg using LAN or WiFi.

16 sensors collect valuable data sets

The we4bee hive is equipped with 16 different sensors collecting data on temperature, humidity, air pressure and quality, light, wind, rain and noise apart from cameras capturing the flight hole as well as the inside of the hive.

Eagle and Fusion 360 were used

The different boards were developed using Eagle by Autodesk and the jackets used to protect the environmental sensors were designed using Fusion 360.



Temperature sensor positions (yellow) within the we4bee system

Additional sensors will be added to the modular we4bee system to evaluate even more interesting parameters.

Data anomalies detected parallel behavioral patterns

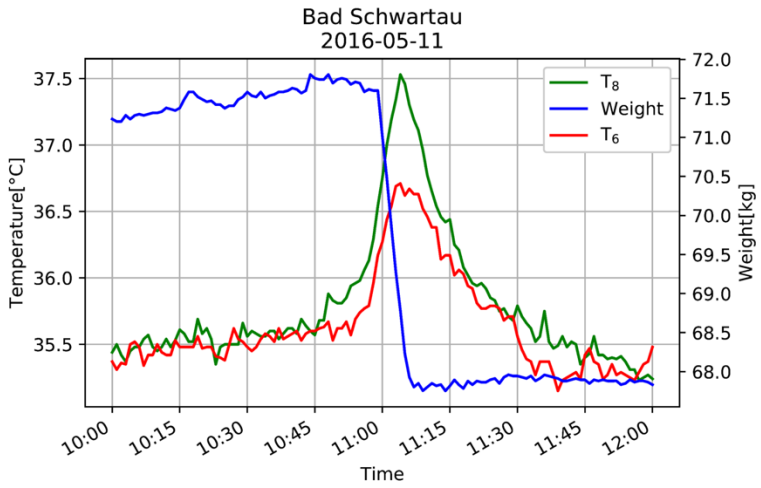
With a measurement frequency of 1Hz, each we4bee system delivers about 40,000 sensor values per hour and 136 images per day. The collected data is being analyzed via machine learning to detect unusual events in the bee colonies observed. These algorithms allow preditions about the colony status as well as advise the beekeepers on any kind of necessary intervention.

Neural networks can detect anomalies

Recurrent autoencoders were used to identify anomalies within the colonies: The encoder compresses the input data into the latent space before the decoder decompresses the data. It can do so for normal behavior, but fails to do so in case of anomalies. Hence, this method can be used to detect any kind of anomaly like behavioral anomlaies or external interfereance as well as sensor anomalies.

Swarming is detected as an anomaly

When part of the bee colony leaves the hive for good, the event observed is called swarming. we4bee´s initial research paper conducted by Prof. Dr. Andreas Hotho, the scientific project manager at we4bee and head of the data science chair at the University of Wuerzburg and his PhD student, Padraig Davidson, demonstrated that any swarming event could be detected using deep recurrent autoencoders.



Several sensors detecting a swarming event
(blue: scales, red and green: inside temperature)

For details, please read the scientific publication "Anomaly detection in beehives using deep recurrent autoencoders" by Padraig Davidson et. al, March 2020.

In case you are interested in supporting we4bee in any way, we are looking forward to hear from you via E-Mail (info@we4bee.org). Let´s make a difference!