The Sound Beehive Experiment

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Abstract

The Sound Beehive is part of a series of ecological instrumented beehives leading towards a fully biocompatible intelligent beehive [Maes, 2013]. These beehives allow me to study the tight interaction between city honeybees and urban ecosystems, using artistic research practices and in collaboration with scientists.
The Sound Beehive Experiment monitors the development of a bee colony on the basis of the sounds it generates. For this purpose, we developed a beehive that is equipped with sensors, microphones and cameras. The Sound Beehive is installed in the Urban Bee Laboratory on a rooftop in the Brussels city centre. Data is streamed to central repositories and analysed using statistical techniques and graphic visualizations.

1. An Ethological Approach

Honeybees are bio-indicators. They provide a constant stream of information on the environment in which they forage, via their daily activity, and via the pollen and nectar they harvest. Environmental problems such as the use of pesticides can be detected by monitoring the colonies with audio and video tools and by scanning their daily activity over several years (Michels, 2011).
In nearly all industrialised nations, bee colonies are now threatened. The compromised state of the foraging areas for bees is worrisome. By using bees as bio-indicators and by translating the information into artworks, I make citizens aware of the increasingly negative effects of our lifestyle and methods of industrial production. I am a media artist collaborating with computer scientists and engineers to develop art-science projects. Interested in showing the hidden structures in nature, I am using innovative technological methods to probe the living world.
To study the bees in their natural environment, following the footsteps of von Frisch and other ethologists (von Frisch, 1953), we have built a customized 'sound device'. Microphones inside the beehive enable us to continuously monitor the colony's buzz. Together with outside and inside video monitoring it forms a non-intrusive scanning device for controlling the colony's health and development. We also installed a network of temperature and humidity sensors spread throughout the beehive. The annotated video and audio data are uploaded to our open source video database http://pandora.okno.be. All time-stamped sensor data from the lab's weather station, as well as the temperature and humidity data measured inside the beehive, are made public on http://opensensordata.net.

2. Instrumentation

Our custom-built audio, video and sensor device is integrated in a Warré beehive (Fig.1). It is a sustainable beehive in which the colony develops at its own pace. We started to customize our Warré beehive by putting electret microphones in the top cover and by attaching contact microphones in the frames of the brood box. All microphones are connected to pre-amps stored in the rooftop. They are powered by a battery that is located a few meters away from the hive to avoid the creation of electro-magnetic fields.
For recording the video images, we use Raspberry Pi computers. The Raspberry can be easily integrated in complex installations and is equipped with a series of USB and Ethernet connections to function in a network of devices. We integrated two small high-resolution cameras in our setup; one camera to record the activity on the landing platform and a second infrared camera to registrate the activity inside the brooding box.
The analysis of the images gives us information on the relation of the bees to the environment. A beecounter is integrated in order to determine the in/out flux and detect homing problems related to pesticide contamination. The images also give us information

about the pollen supply and the development of the colony related to the activity level of forager bees, fanning bees, dead bees and lazy bees on the landing platform.

3. Bee Activity Related to the Environment

A bee colony is very responsive to the biotopes of which it is a part. The production of honey is dependent on the flowers we grow, the plants we like, and the garbage or pollution we produce. The colony is also very sensitive to environmental variables such as outside temperature, rainfall and humidity, the wind and hours of sunshine. We therefore compare the behaviour of the bees and the development of the colony with the data from the weather station. In our rooftop field lab, we have installed a Libellium agriculture kit, including several environmental sensing devices. E.g., the hours of solar activity, as well as the soil composition, determine the nectar flow of the flowers and their visits by the bees. Nectar secretion increases as pollinators visit the flower.
We set up a database of the pollen contained in the honey of our urban bee colonies and we started to determine the pollen source. By studying the pollen in a sample of honey, it is possible to collect evidence of the geographical location and genus of the plants that the honeybees visited. As such, we start to trace green corridors through the city.

4. Data processing

In January 2015 we started analysing the recorded files. We scanned the soundfiles in terms of their brightness, loudness and noise level. For the analysis of the video files, we made use of motion detection via the frame difference method. The analysis of the sound files is a complex matter. We therefore use techniques of Artificial Intelligence in collaboration with the Brussels Free University. We have recorded large amounts of data in order to investigate whether we can detect patterns. All together these data give us plenty of parameters to combine and to play with, to create models and to compare different moments in time and thus to study the behaviour of the colony relative to timeline/season and environmental parameters.
A video shows a graphical rendering of AI analysis of colony behaviour combining real audio data with measurements of the microclimate inside the hive: temperature, CO2 and humidity (Fig.2).
Another video shows 365 days of activity inside a real observation beehive, played back at high speed. The images were recorded with an infrared camera inside the hive and processed using pattern recognition, AI and computer graphics algorithms. These images offer the stunning visual experience of a bee colony in action (Fig.3).
To create an immersive sound installation we analysed the sound files recorded in the hive. *The Scaffolded Sound Beehive* (Fig.1) is a wooden sculpture, constructed using open source digital fabrication and mounted on scaffolds of 2,5 meters high. Visitors can enter in this upscaled model of the Warré beehive and experience an auditory artistic interpretation of hive activity. We processed the recordings (made in the real beehive) using sophisticated pattern recognition algorithms and artificial intelligence analysis software, and edited the sound files by adding swirling electronic sound clusters to sonify the ebb and flow of swarm activity in the hive.

Conclusions

The Sound Beehive immersive installation was introduced during the first Renewable Futures Conference (Rixc.org) in Riga, May 2014, and has been shown at the Institute of Evolutionary Biology (IBE) in Barcelona (May-June 2015), and at the AI and the Arts, exhibition for the international conference of Artificial Intelligence in Buenos Aires, Argentina (July 2015). The enormously positive response of viewers shows clearly that the presentation of scientifically inspired art can have a strong impact and raises awareness of important societal issues, and also that art-inspired science can have a fruitful positive effect to push science in new directions.

References

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von Frisch K. (1953) The Dancing Bees: An Account of the Life and Senses of the Honey Bee, Harvest Books New York.

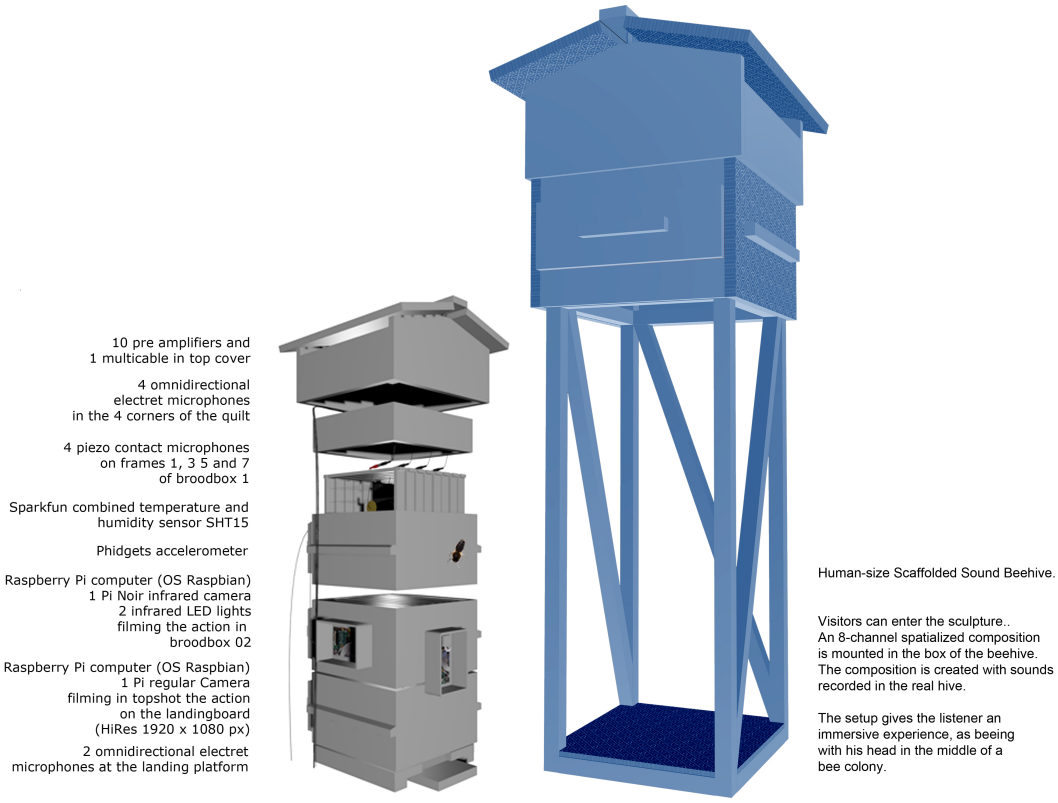

Figure 1. Left: Diagram of the instrumented Sound Beehive, Right: the Scaffolded Sound Beehive Sculpture

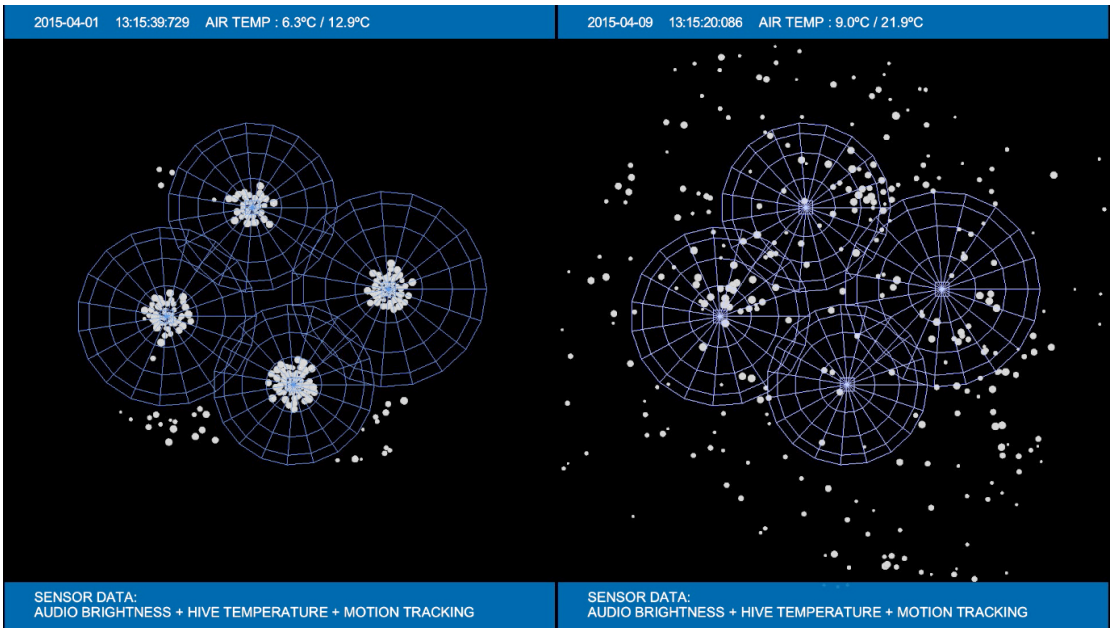

Figure 2. Novel visualisation of results of Deep Learning. The spheres represent learned categories. The white dots are hypothetical bees spatialized for how well they fit with the categories. *Analysis of the data collected in the beehive, comparison between 2 days. (audio brightness, the temperature inside the beehive and the motion tracking on the landing platform.)*

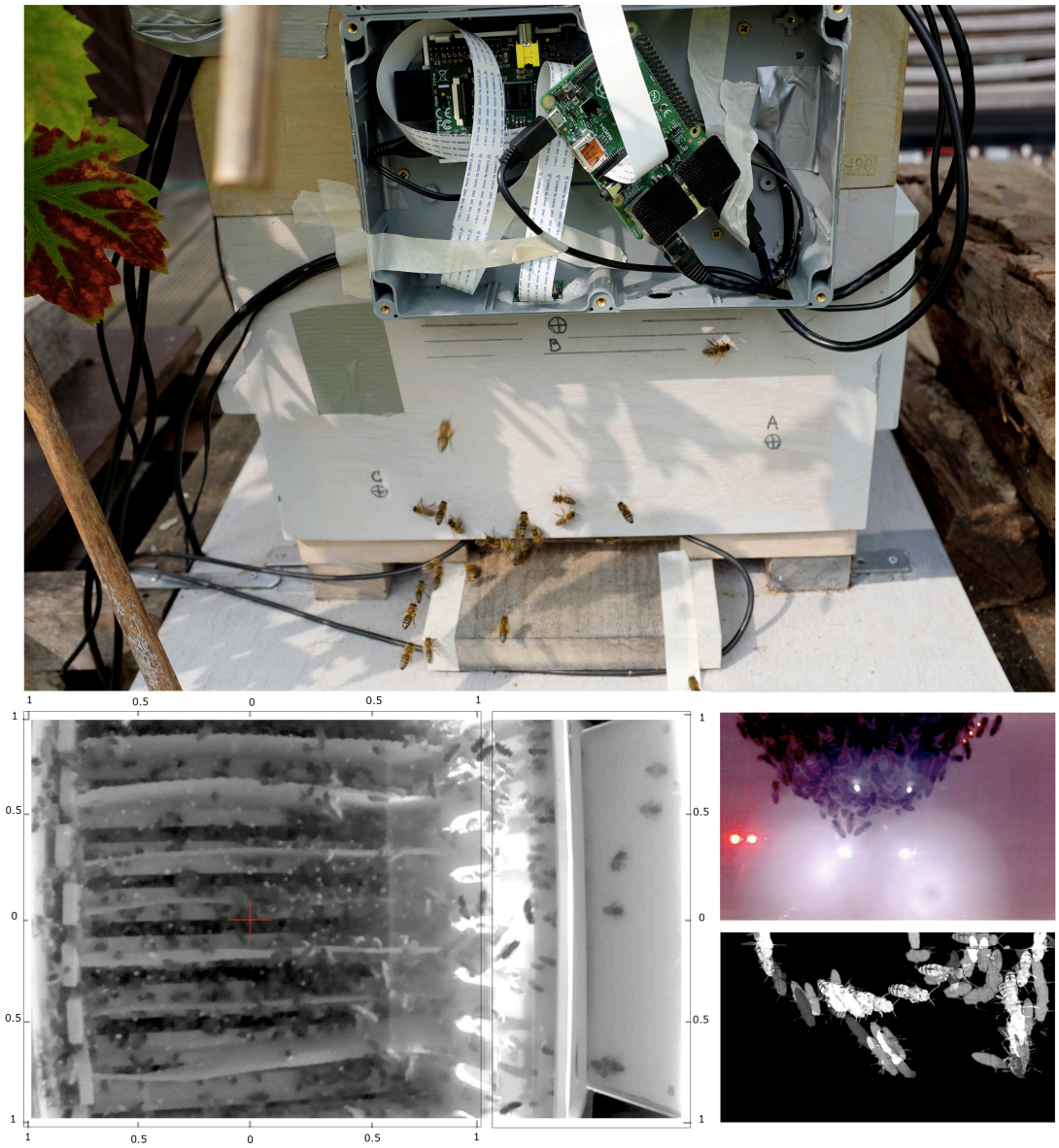

Figure 3. Top: streaming activity on the landing platform. Field recordings. Cameras connected to Raspberry Pi computers film, process and stream the visual data recorded in the hive.
Bottom left: Piezo sensors are inserted into the hive, between the comb frames and in front of the entrance on the landing platform. Bottom right: video-analysis of the activity inside the beehive.

bio - AnneMarie Maes

AnneMarie Maes works on the interwoven threads of multi-media installations, ecological issues, and social and anthropological projects. Her current work focuses on the ongoing Bee Monitoring project which sets up laboratories for bee colonies and urban gardening. She is a founding member of the organizations So-oN and OKNO and holds masters in fine art and cultural studies.

bio - The Brussels Urban Bee Lab — BUBL

BUBL is an independent international collective of artists, scientists, beekeepers, technicians and creative people. It uses artistic, scientific and technological research to tackle challenges

related to sustainability and the monitoring and survival of city honeybees. An extensive rooftop garden in the centre of Brussels hosts the headquarters of the BUBL laboratory. It houses several experimental beehives and instrumentation equipment. From this laboratory, data are continually being broadcast via streaming technology. The installations developed by BUBL explore highly experimental technologies, such as microbial fuel cells, digital and organic fabrication using OpenStructures, bio-mimicry, spatialised sonification, web-based continuous data streaming, data mining based on Artificial Intelligence, organic electronics, solar energy for powering low-energy computing, etc. Our lab collaborates with several universities and a network of artistic research centres throughout Europe.