Microsoft

AI for Earth Grantee Profile

Harrison Atelier
Pollinators Pavilion

Summary

Unlike the familiar honeybees which live together in hives, most bee species are solitary and therefore difficult to study. These solitary bees also play a far greater role in pollination than is commonly known, and understanding their lives is important to managing biodiversity and conservation efforts. For that purpose, Dr. Ariane Harrison and her team at Harrison Atelier created the Pollinators Pavilion, a prototype field station and educational tool that provides an artificial habitat and monitoring station for 2,000 solitary bees. Using automated cameras and machine learning analysis, the Pavilion will help researchers better study the bees, while also providing a means for the public to learn more about these important pollinators as well.

Using architecture and machine learning to study solitary bees

More than 75 percent of the world's food crops depend, to some extent, on pollination. But there has been a dramatic decline in the population of invertebrate pollinators in recent years, with over 40 percent of native bees in North America facing extinction, due in part to agricultural intensification removing pollinator foraging and natural nesting habitats. Despite the critical role pollinators play in maintaining the integrity and biodiversity of whole ecological communities, there is surprisingly little information on basic aspects of these bees. There are over 20,000 known bee species globally, with over 4,000 in the United States alone. Of these 4,000, about 10 percent are still undocumented. With insufficient data on these bees, helping with conservation and biodiversity is difficult.

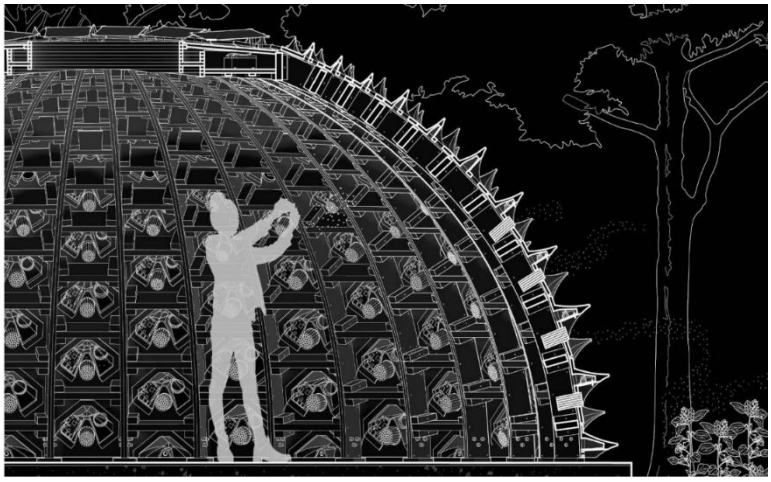
The Pollinators Pavilion
[Image courtesy Harrison Atelier]

Although the hive-dwelling honeybees are the most familiar to the general public, 90 percent of the planet's bee species are solitary bees, which instead live alone in found cavities—a tree trunk, a hollow stem, or dead wood. Solitary bees are finding it harder to find places to nest as changes in agricultural practices have damaged their ecosystem. The varied and individual nesting habits of these solitary bee species make them difficult to study; up to now, they have to be collected in nets or trapped, which fails to document their habitats. However, architect Ariane Lourie Harrison and her design team at Harrison Atelier have devised a project to bring bees, researchers, and the public together: the Pollinators Pavilion.

Bringing bees, scientists, and the public together

As an educator and coordinator of the Master of Science programs in Architecture and Urban Design at Pratt Institute, Dr. Harrison's research centers on finding a larger role for architecture in environmental activism by questioning how humans can better cohabit with other species. This questioning led her to envision the Pollinators Pavilion, which provides an artificial habitat for solitary bees that is analogous to the natural crevices they would normally use for nesting. This safe place allows scientists to study them and teach the public about them in the process.

The Pavilion serves many functions—it's an architectural object, visitor's center, and field station. The key challenge it meets is reducing the time and cost to study these elusive and dispersed pollinators. It also seeks to bring visibility to the threat of decline to these species and raise awareness of the solitary bees as a significant contributor to sustainable agriculture practices. Harrison explains the goal is to "contribute to scientific literature on solitary bees by monitoring the nesting habits of this important group of pollinators at close range by using no kill methods, anticipating their potential role in agricultural pollination."



Pollinators Pavilion schematic
[Image courtesy Harrison Atelier]

Capturing bees in their natural habitat

The Pollinators Pavilion sits in New York's Hudson Valley at Old Mud Creek Farm and promotes biodiversity conservation of native pollinators. "Managed farms offer a valuable context to introduce analogous habitats for solitary bees which, once better understood, can become a robust and native agricultural infrastructure," says Harrison. The spiky structure itself, reminiscent of a bee's eye and a magnified grain of pollen, is made of wood and over 300 cast concrete panels each designed to house 30 to 50 bee nesting tubes protected from the rain by a pointed canopy. Nesting tubes are six inches long with diameters from 3–9 mm and are made of cardboard, bamboo, glass, wood, and other substrates. Typically, a six-inch nesting tube can accommodate three to six egg cells. The bees use leaves, mud, and other elements to seal the entrance of

Nesting tubes and monitoring platform
[Image courtesy Harrison Atelier]

nesting tubes so it's easy to see if the tubes are inhabited. Their habitation patterns will also be documented in images by the cameras trained over each collection of nesting tubes.

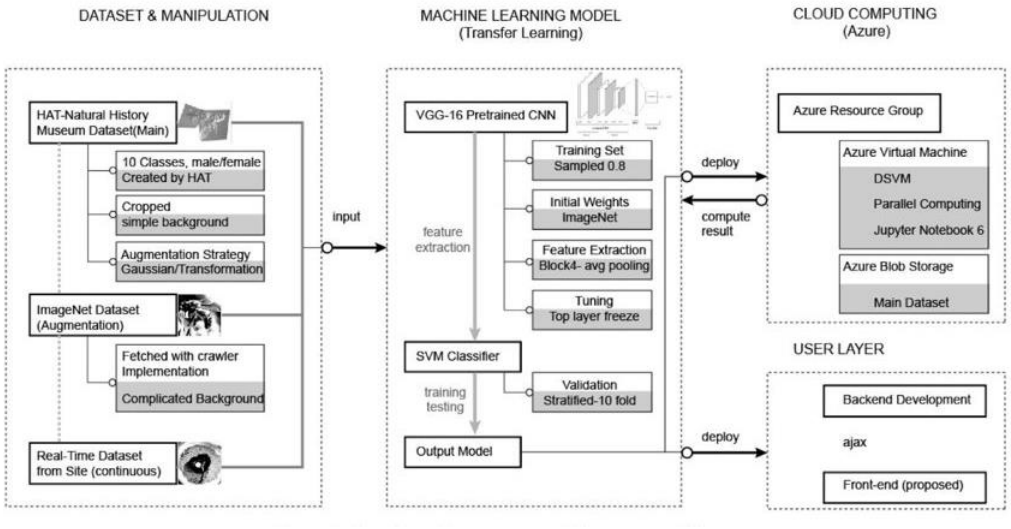
Pollinators Pavilion, Governors Island, NYC
[Image courtesy Harrison Atelier]

With its visible and striking façade, the Pollinators Pavilion shows how architecture can become "a literal scaffold for environmental monitoring technologies. We envisage the exteriors of building as significant data-gathering surfaces as well as habitats," says Harrison. The Ductal concrete panels serve as rain canopies for nesting tubes, while housing a solar powered monitoring platform. Cameras, sensors, and microprocessors are inserted into each panel facing the nesting tubes. When triggered by insect movement, motion sensors prompt an embedded camera to photograph the insect. The design of the panels themselves allow for a large number of images in which the subject species is at a consistent scale. Harrison explains, "This consistency of image background and scale is extremely important in effectively producing an image database for training the machine learning system, which automates insect identification without trapping and killing specimens." Traditionally, insect identification is done by killing and pining them on a similar background. However, Harrison argues that "for machine learning, it probably doesn't matter that much if the background is always same, if the insect is always at the same scale. The distance from the nesting tube opening to the camera is about six or eight inches so there is going to be a certain kind of consistency of scale of backdrop and we're hoping that that really helps us in cutting out some of the ambiguity introduced by varied backgrounds." By having consistent distance between the camera and the nesting substrate, Harrison points out that the architecture itself "maintains the space between the camera, processor, and the nest."

Advancing the models with Microsoft Azure

The Pollinators Pavilion started with over 600 images of solitary bees from the collections of Dr. Jerome Rozen from the American Museum of Natural History to develop the initial machine learning system. Adding to this collection with the Pavilion images, the model has evolved and learned with 89 percent accuracy. A grant from Microsoft AI for Earth and access to Microsoft Azure resources offer the team the opportunity to significantly improve their workflow and analysis. Harrison explains, "The Pollinators Pavilion project allies the strengths of architecture as a framing and scaling device with the computational power of Microsoft Azure and advanced machine learning systems to develop databases for this critical class of pollinators." Harrison further explains that the AI for Earth network has brought the team into many new networks, from the Penn State University Biodiversity symposium organized by Dr. Christina Grozinger at the Huck Center of Life Sciences to discussions with Dr. Andrew Straw at the Institute of Biology I & Bernstein Center Freiburg at the University of Freiburg.

Yuxiang Chen, the project designer for the machine learning, says, “The team used two different training models, a VGG16 and SVM combination architecture, in order to prevent the overfitting and underfitting issue in the training and trying to find the better solution in the middle point which will lead to better parameter settings.” Chen continues, “Using Azure and being able to pull data out of the Azure data blob at any time is very helpful. Using the DSVM and the blob storage saves a lot of time and it helps us to work very easily as a team. It’s very easy to track everyone’s progress.”



Machine learning project system architecture overview [Image courtesy Harrison Atelier]

The open-source models are available on Github. Real-time video feed can also be seen at www.pollinatorspavilion.com.

Following the success of the first Pollinators Pavilion, a second “slice” of the Pollinators Pavilion has been built in partnership with The Bee Sanctuary on Governors Island in New York City as part of the climate hub; this has formed the base of field studies and climate workshops with Guerilla Science’s initiatives to promote climate literacy. A hempcrete version of the Pollinators Pavilion is being designed for Governors Island and for the Churchtown Dairy in Hudson, New York, part of the Stone House Farm regenerative farming initiative. This Pavilion, like its predecessors, will function as a multipurpose structure for beauty, research, and education. The results of the Pollinators Pavilion project overall will be shared broadly and to a diverse public including New York State organic agricultural institutions, scientific and research institutions, and K–12 public schools in and around Hudson, New York.

Educational materials for students during Guerilla Science Workshop on Governors Island [Image courtesy Harrison Atelier]

About Harrison Atelier

Harrison Atelier is a Brooklyn-based architecture firm founded by Dr. Seth Harrison and Dr. Ariane Lourie Harrison. Its central research question, "how can we build for more than one species?" challenges the conventions of a human-centric architecture and proposes cohabitation by multiple species while also seeking a larger role for architecture in environmental activism. The design team for the Pollinators Pavilion, led by Dr. Ariane Harrison, includes Dr. Seth Harrison, Yuxiang Chen, Zongguan Wang, Nai Hua Chen and Eileen Xu, all members of Harrison Atelier; the AI team includes Zhengyang Chen of the Georgia Institute of Technology and Hanwen Zheng of the University of Munich.

About Ariane Harrison

The principal investigator for the Pollinators Pavilion, Dr. Ariane Lourie Harrison is a registered architect in New York State and the co-founder of Harrison Atelier. She is the Coordinator of the Master of Science programs in Architecture and Urban Design at Pratt Institute GAUD, working on directed research with over 25 advanced degree students each year. She was a critic at the Yale School of Architecture from 2006 to 2017. She received her AB from Princeton (summa), her M.Arch from Columbia GSAPP (excellence in design), and her Ph.D from New York University.

About Yuxiang Chen

The project manager of Harrison Atelier, Yuxiang Chen leads the AI and design team for the Pollinators Pavilion. He is a faculty member at Pratt GAUD. He is devoted to the research on robotic programming and digital fabrication for sustainable architecture, being in a Tongji Digital Future team in 2016 and Pratt Consortium research center in 2018. He received his Bachelor of Architecture from Tongji University, and his Master of Science degree (with Pratt Circle Awarded) from Pratt Institute GAUD.

Resources

Websites

www.pollinatorspavilion.com
www.harrisonatelier.com
Pratt Institute | Research Open House | Research Open House 2020 | School of Architecture | The Pollinators Pavilion
https://www.aiany.org/architecture/featured-projects/view/pollinators-pavilion/

Documentation

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