Bumblebee Re-Identification Dataset

Frederic Tausch[1,2] frederic.tausch@apic.ai
Simon Stock[2] simon.stock@kit.edu
Julian Fricke[3] julianfricke@eurofins.com
Olaf Klein[3] olafklein@eurofins.com

[1]apic.ai, Karlsruhe, Germany
[2]Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany
[3]Eurofins Agroscience Services Ecotox, Niefern-Oeschelbronn, Germany

1. Purpose

Over the past decade, entomologists have observed a worldwide decline in the population of pollinating insects [16, 13]. In Germany, the insect biomass dropped by up to 76.7 % in some areas, including wild bees from 1989 until 2016 [13]. Even though there is a number of hypotheses about of potential underlying causes for this decline, there are concerns that insecticides are at least partially responsible [8, 17, 12]. The design of insecticides requires accurate risk assessment procedures to avoid damage to beneficial insects and like pollinators such as the buff-tailed bumblebee (*Bombus terrestris*). In order to provide legal authorities with an accurate risk assessment of plant protection products on bees (*Apis mellifera, Bombus terrestris and solitary bees*) the OECD [15], EFSA [5], EPA [6] and other legal entities around the world published protocols, guidance documents and guidelines for such assessment. However, recent studies urge the importance of expanding them to include assessments of effects which are not lethal yet harmful. These sub-lethal effect include the change in behavioral performance, such as ability of foragers to return to the colony [19]. Current guideline drafts by the EFSA [4] include homing flight studies to test insect behavioral performance. They inspect whether and which individuals return, therefore insect re-ID (re-identification) is crucial [18]. Current bumblebee re-ID techniques are limited to placing markers on individual subjects, which can be analog [11] or digital (RFID) [21]. These steps are very time consuming, intrusive, and are prone to mechanical failure. To find a solution to demedy these shortcomings, a visual approach is proposed. Recently deep learning systems emerged that can learn, through their exposure to many examples, the particular features that allow the discrimination of individuals. Especially the success of re-ID of fruit flies deems the re-ID of bumblebees on images feasible [20]. In order to build such a re-ID system, a dataset is needed. Therefore we propose the following bumblebee re-ID dataset.

Figure 1. Two monitoring systems are attached to individual bumblebee hives. Bumblebees are filmed at the hive entrance.

Bumble bees were chosen, due to there relative small colony size [1] and their exceedingly rare size variation [9] compared to other eusocial insects, for visual re-ID.

Feature of worker	mean (mm)	min (mm)	max (mm)	SE	N	source
Wing length	7.9	5.4	10.7	0.12	100	[10]
Height of corbicular hairs	0.65	0.65	1.9	0.03	100	[10]
Thorax width	4.7	2.3	6.7	n/a	6,371	[9]

2. Methods

Even though the discrimination of individual animals by experts has been used in the past to create animal re-ID datasets, to the best of our knowledge, there are no such experts for bumblebees. Therefore approaches for data collection are evaluated that utilize environments with known ground truth and therefore reducing error or human bias.

2.1. Experimental setup

In order to create a dataset of bumblebee images for re-ID, the following experiment was conducted with two research hives. Each with a population of around 80 workers and 20 drones. Theses research hives have been connected to apic.ai's visual monitoring system via tubes (figure 1), which has formerly been used to track honey bees [7] and differentiate genera etc [14]. Eurofins Agroscience Services Ecotox, a globally active contract laboratory, has already used this technology [12] and assisted with the creation of the dataset. To create an environment with known ground truth, human intervention forced the bumblebees to leave their hive through the tube system. Since every bumblebee can only leave once, each individual bumblebee will have their unique id and not be observed twice.

2.2. Image acquisition

The Sony IMX219 color chip (widely used raspberry pi camera) was used without an infrared filter to capture the images. The video material was recorded at 40 frames per second with a resolution of 640 x 480 pixels. Infrared lights with a centroid wavelength of 850 nm were used to create consistent illumination on the images. The spectrum is invisible to bumblebees [3]. Furthermore the camera is aligned parallel to the observed surface at a fixed distance. Therefore the observed number of pixels reflects the size of the bumblebees. Due to the nature or ecotoxicological studies (e.g., homing [18], hive migration and foraging studies) it is possible to create these semi-controlled environments at the entrance of the hive and therefore apply algorithms based on this re-ID data set to such studies.

2.3. Data processing

For a more convenient assessment, basic background subtraction was used in order to find sequences that contain bumblebees [2]. In the next step, the images were manually annotated. Bounding boxes with unique, temporally consistent IDs were placed on each individual. These unique IDs will be used to create a dataset of same sized cropped bumblebee images related to each ID.

3. Results

The process of annoting and systematically publishing of the dataset as a potential benchmark is still in progress. Until the data quality is reviewed, please refer to data@apic.ai for early access.

The published dataset will consist the images itself (figure 2) and a lookup table that maps an ID of a bumble bee to a list of images. Out of the two hives observed, the images from one will be dedicated for training, while those of the others will be used for testing.

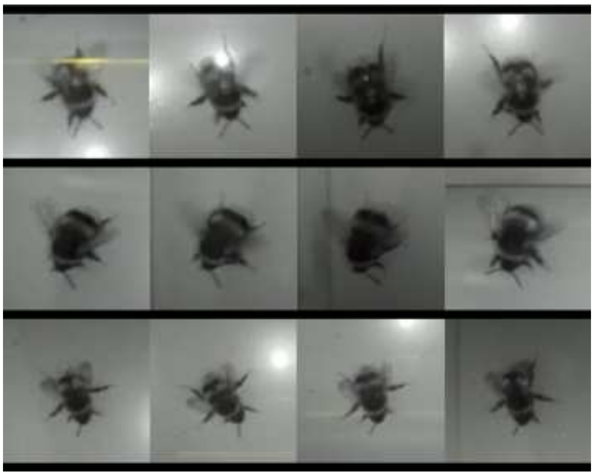

Figure 2. Samples from three different bumblebees.

4. Conclusion and Outlook

In this paper, we shared our approach to create a re-ID bumblebee dataset. We also emphasized the importance of insect re-ID in entomology and risk assessment of plant protection products. A solution which enables accurate and cost-effective re-ID of bumblebees can provide a basis for the assessment of homing flights as an accepted behavioural end point in ecotoxicological studies. The technology could serve as a tool for the measurement of sublethal effects, which is not restricted by the availability of expert knowledge, observation windows and measurement error. This would be a good argument for the inclusion in future guidance documents and hence, contribute to the enhancement of risk assessment protocols for plant protection products. We welcome the computer vision community to participate in this approach to improving pollinator safety.

References

[1] A. Bourke. Colony size, social complexity and reproductive conflict in social insects. *Journal of Evolutionary Biology*, 12(2):245–257, Mar. 1999.

[2] G. Bradski. The OpenCV Library. *Dr. Dobb's Journal of Software Tools*, 2000.

[3] L. Chittka and N. M. Waser. Why red flowers are not invisible to bees. *Israel Journal of Plant Sciences*, 45(2-3):169–183, 1997.

[4] EFSA. Draft guidance document on the risk assessment of plant protection products on bees (apis mellifera, bombus spp. and solitary bees).

[5] EFSA. Guidance on the risk assessment of plant protection products on bees (apis mellifera, bombus spp. and solitary bees). 11(7):3295.

[6] U. S. EPA. Guidance for assessing pesticide risks to bees. 2014.

[7] M. D. Frederic Tausch, Katharina Schmidt. Current achievements and future developments of a novel ai based visual monitoring of beehives in ecotoxicology and for the monitoring of landscape structures, 2019. International Commission for Plant Pollinator Relationships.

[8] H. C. J. Godfray, T. Blacquière, L. M. Field, R. S. Hails, G. Petrokofsky, S. G. Potts, N. E. Raine, A. J. Vanbergen, and A. R. McLean. A restatement of the natural science evidence base concerning neonicotinoid insecticides and insect pollinators. *Proceedings of the Royal Society B: Biological Sciences*, 281(1786):20140558, July 2014.

[9] D. Goulson. *Bumblebees: their behaviour and ecology*. Oxford University Press, USA, 2003.

[10] D. Goulson, J. Peat, J. C. Stout, J. Tucker, B. Darvill, L. C. Derwent, and W. O. Hughes. Can alloethism in workers of the bumblebee, bombus terrestris, be explained in terms of foraging efficiency? *Animal Behaviour*, 64(1):123–130, July 2002.

[11] D. Goulson and J. C. Stout. Homing ability of the bumblebee bombus terrestris (hymenoptera: Apidae). *Apidologie*, 32(1):105–111, Jan. 2001.

[12] F. T. Gundula Gonsior. Impact of imidacloprid on honey bee ac- tivity during feeding in an oomen study, 2019. International Commission for Plant Pollinator Relationships.

[13] C. A. Hallmann, M. Sorg, E. Jongejans, H. Siepel, N. Hofland, H. Schwan, W. Stenmans, A. Müller, H. Sumser, T. Hörren, et al. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. *PloS one*, 12(10):e0185809, 2017.

[14] J. Marstaller, F. Tausch, and S. Stock. Deepbees-building and scaling convolutional neuronal nets for fast and large-scale visual monitoring of bee hives. In *Proceedings of the IEEE International Conference on Computer Vision Workshops*, pages 0–0, 2019.

[15] OECD. Guidance document on the honey bee (apis mellifera l.) brood test under semi-field conditions, 2007.

[16] S. G. Potts, J. C. Biesmeijer, C. Kremen, P. Neumann, O. Schweiger, and W. E. Kunin. Global pollinator declines: trends, impacts and drivers. *Trends in Ecology & Evolution*, 25(6):345 – 353, 2010.

[17] M. Rundlöf, G. K. S. Andersson, R. Bommarco, I. Fries, V. Hederström, L. Herbertsson, O. Jonsson, B. K. Klatt, T. R. Pedersen, J. Yourstone, and H. G. Smith. Seed coating with a neonicotinoid insecticide negatively affects wild bees. *Nature*, 521(7550):77–80, Apr. 2015.

[18] R. Scheiner, C. I. Abramson, R. Brodschneider, K. Crailsheim, W. M. Farina, S. Fuchs, B. Gruenewald, S. Hahshold, M. Karrer, G. Koeniger, et al. Standard methods for behavioural studies of apis mellifera. *Journal of Apicultural Research*, 52(4):1–58, 2013.

[19] C. W. Schneider, J. Tautz, B. Grünewald, and S. Fuchs. RFID tracking of sublethal effects of two neonicotinoid insecticides on the foraging behavior of apis mellifera. *PLoS ONE*, 7(1):e30023, Jan. 2012.

[20] S. Schneider, G. W. Taylor, S. Linquist, and S. C. Kremer. Similarity learning networks for animal individual re-identification – beyond the capabilities of a human observer, 2019.

[21] D. A. Stanley, A. L. Russell, S. J. Morrison, C. Rogers, and N. E. Raine. Investigating the impacts of field-realistic exposure to a neonicotinoid pesticide on bumblebee foraging, homing ability and colony growth. *Journal of Applied Ecology*, 53(5):1440–1449, May 2016.