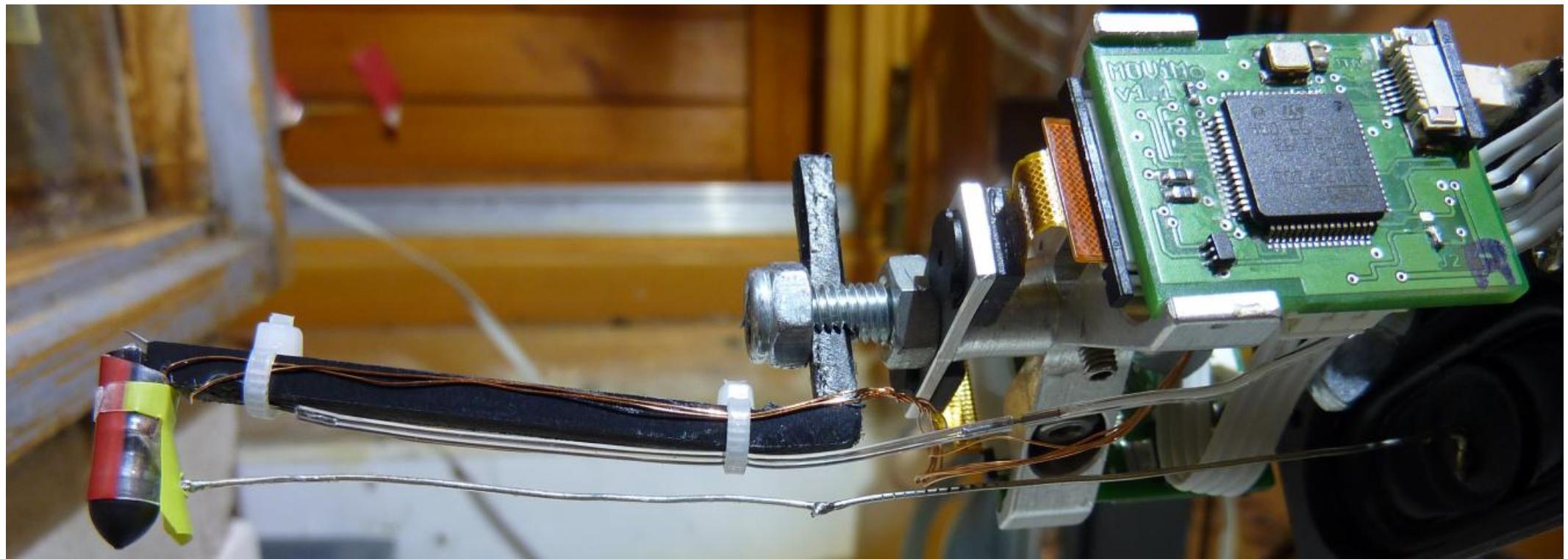


RoboBee: eine Roboterbiene zur Erforschung des Bienentanzes

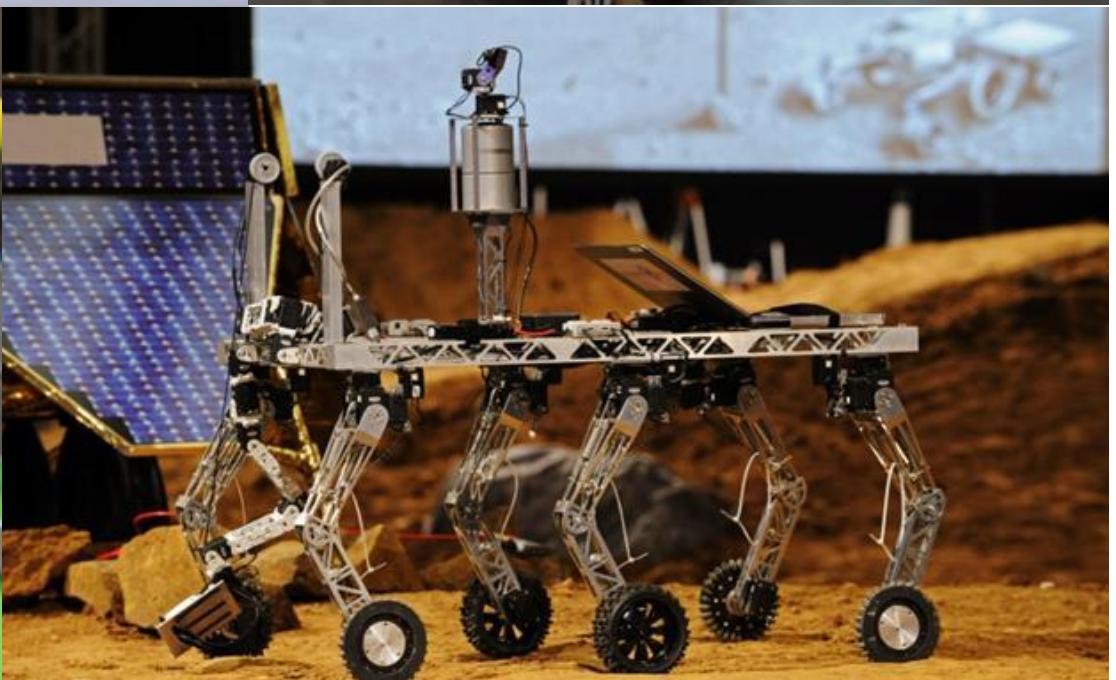
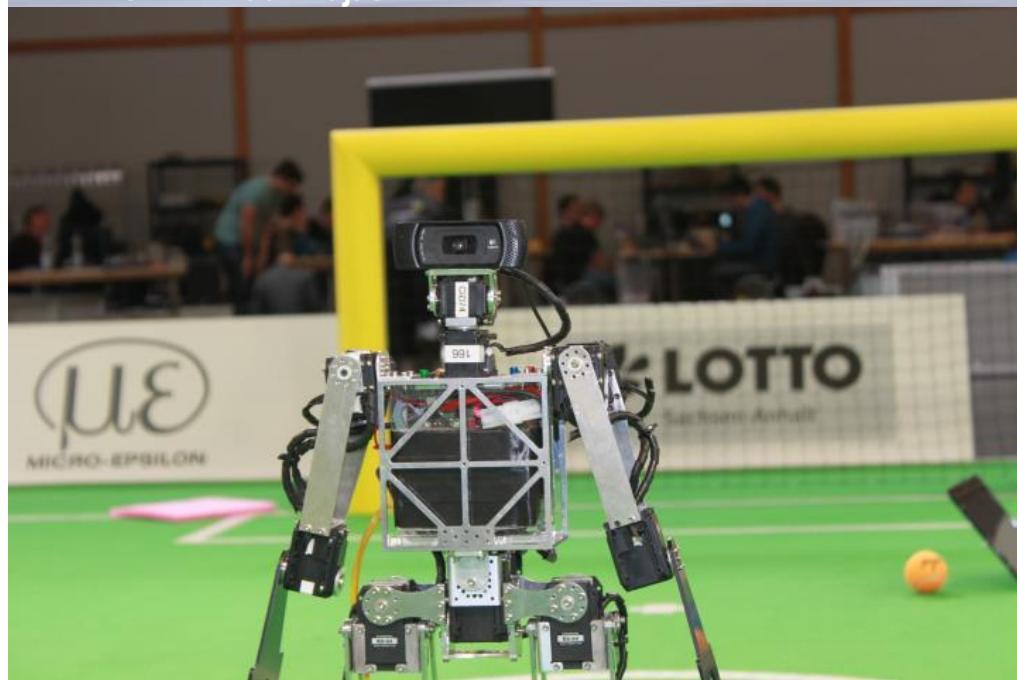


Tim Landgraf
FU Berlin

Intelligent Systems and Robotics Group



Prof. Dr. Raúl Rojas

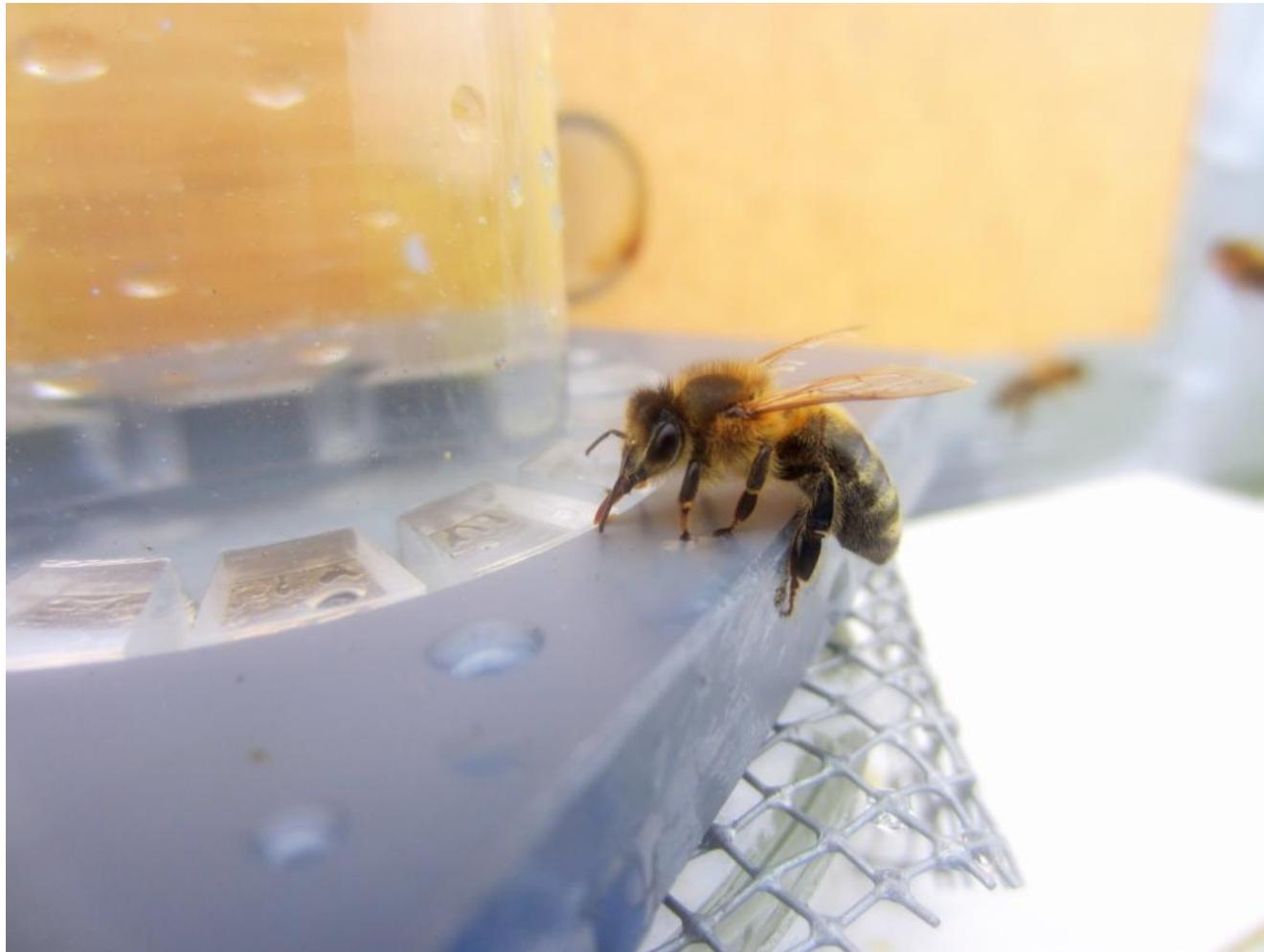


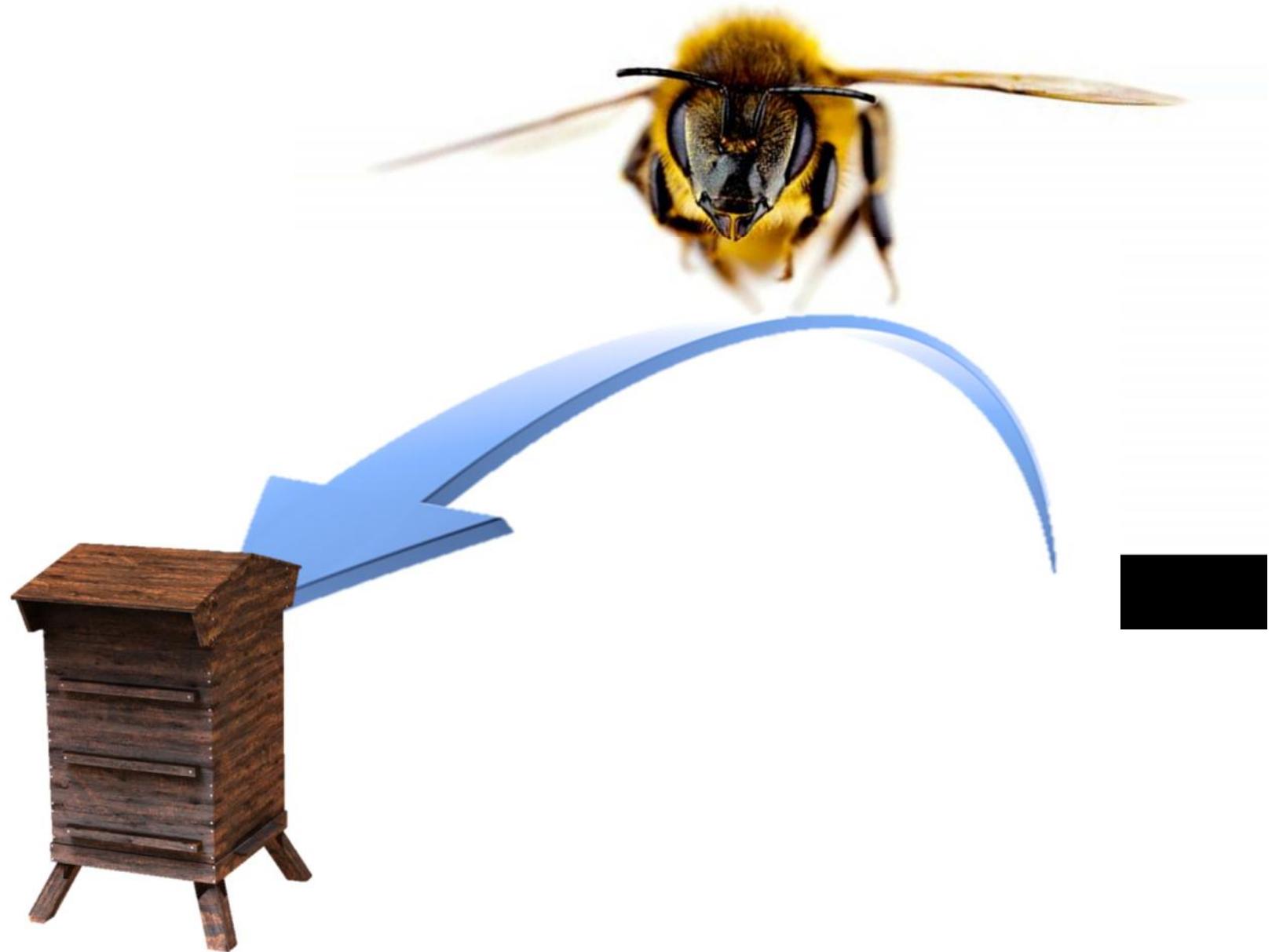


BIOROBOTICS LAB

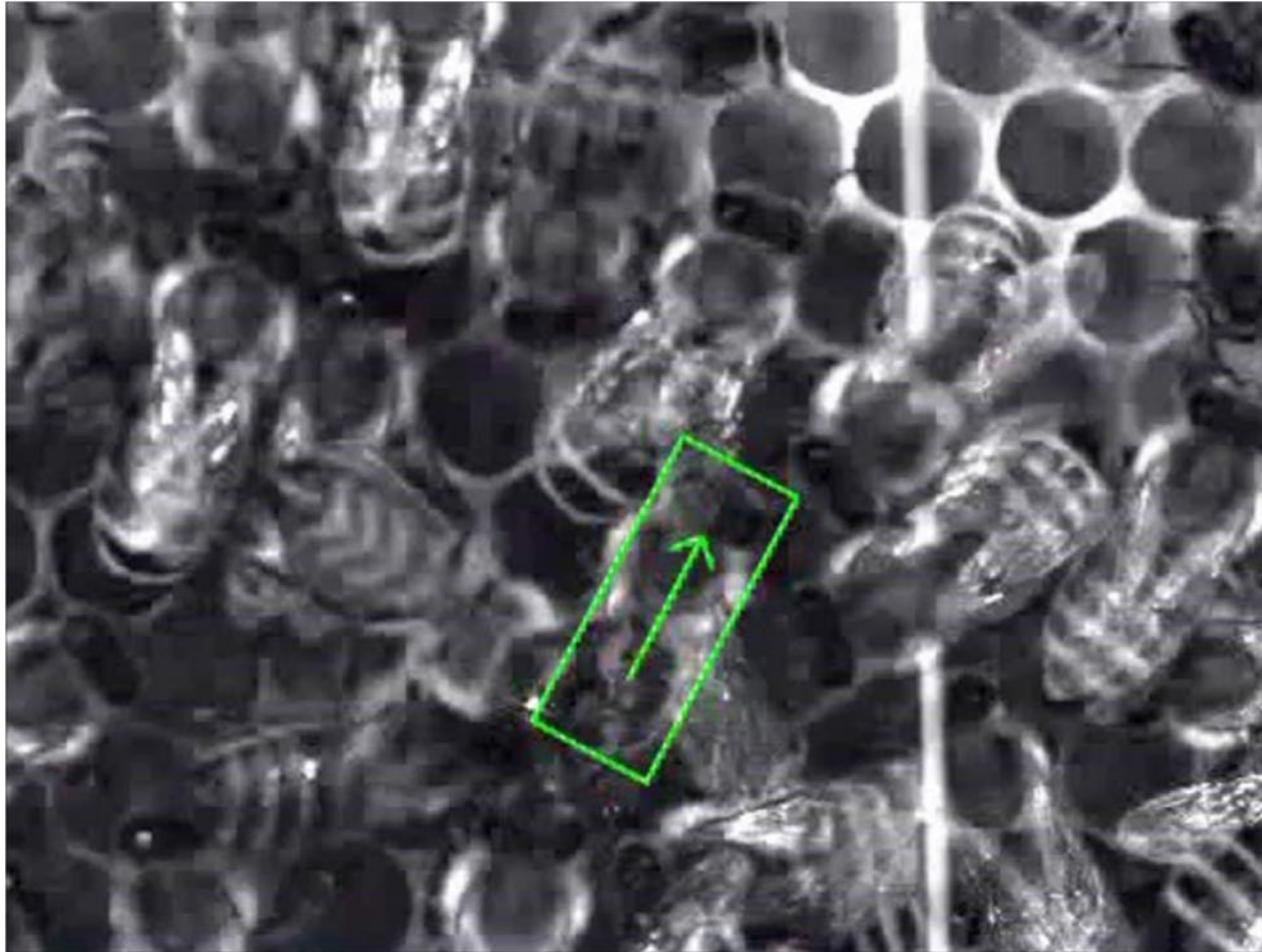


... eine Sammlerin im Feld

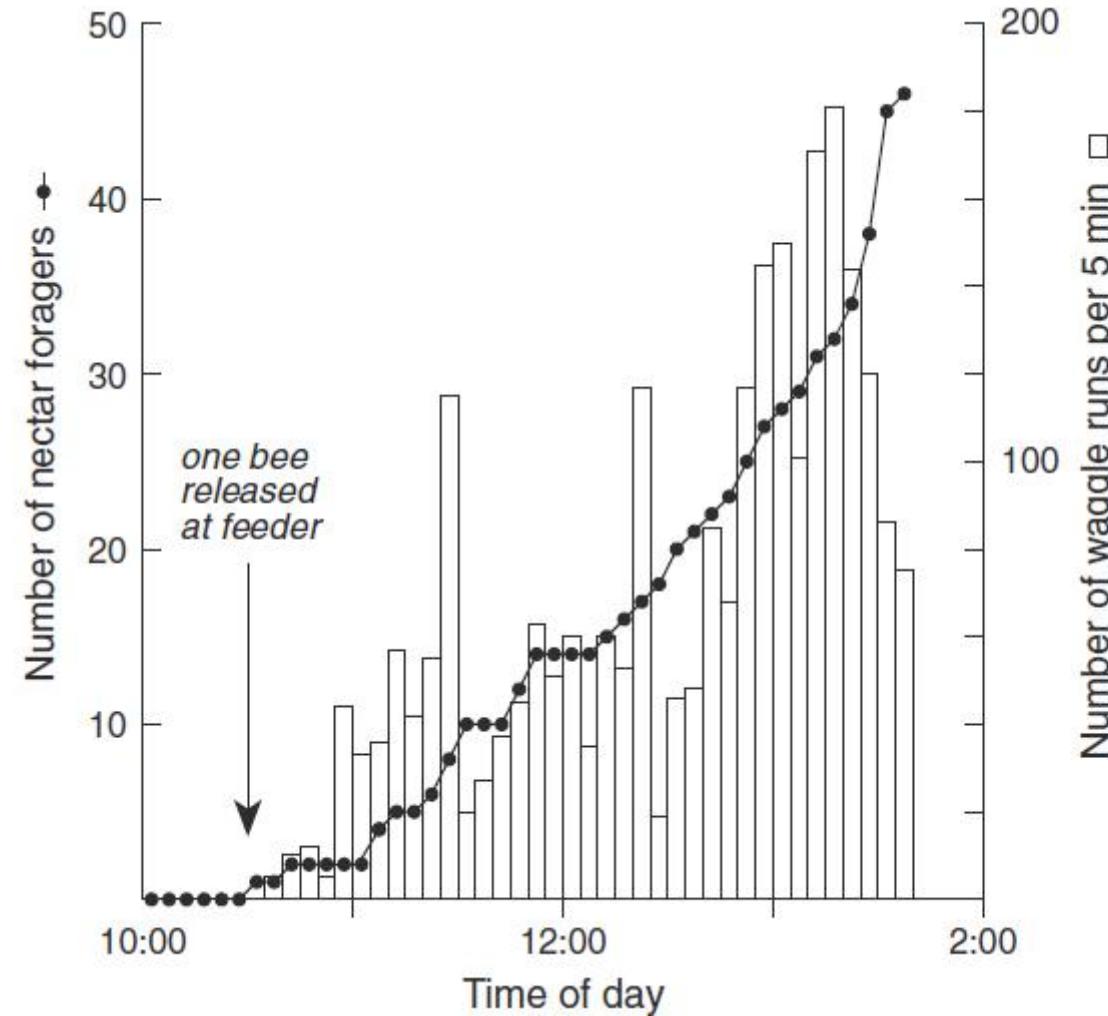




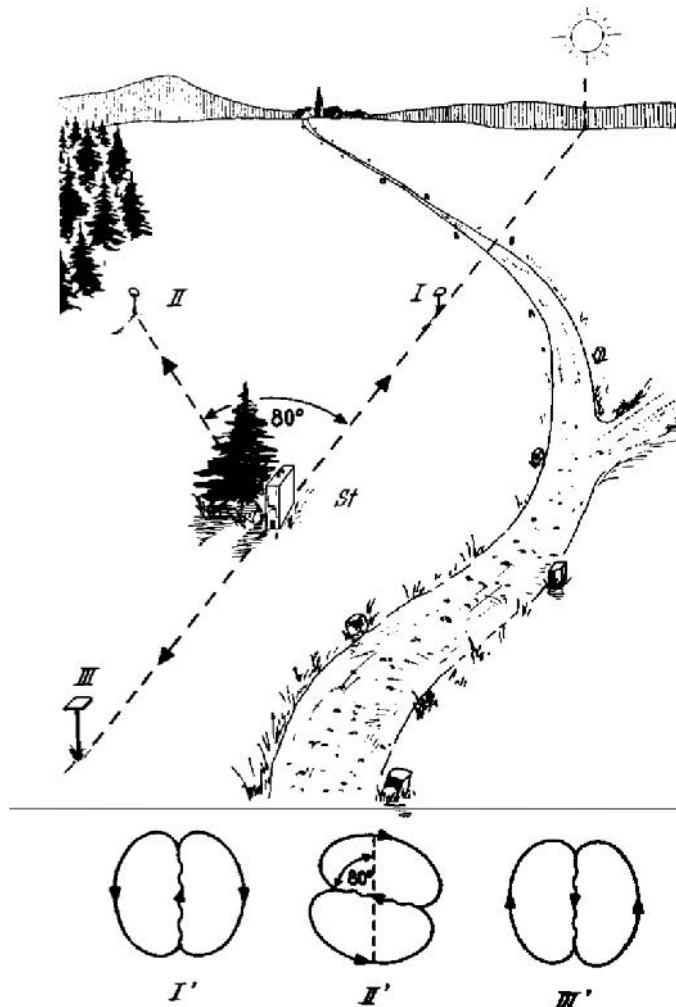
... auf der Wabe



... Ankünfte an Futterstelle



Informationsgehalt des Tanzes



im Feld

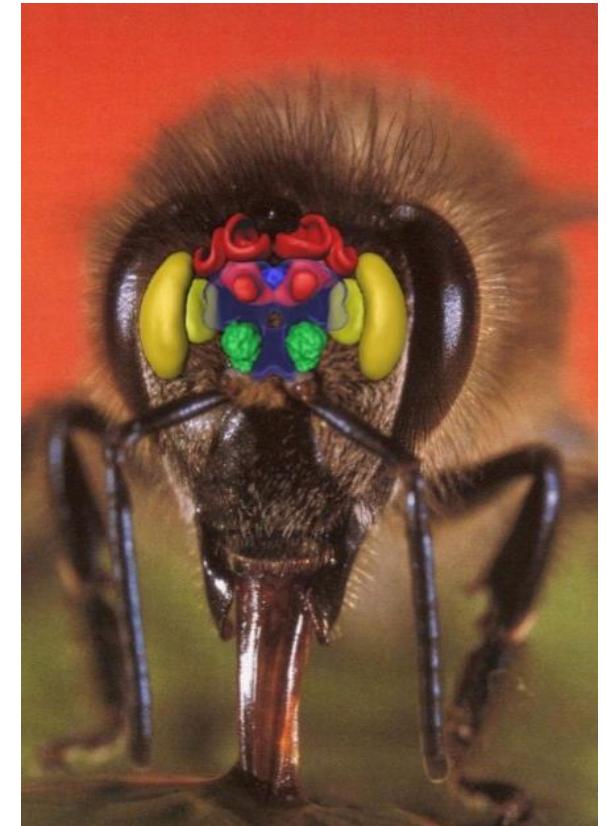


Karl von Frisch

auf der Wabe

Bemerkenswerter Prozess!

- $F = \text{Features}(\text{Site})$
- $D = \text{Dance}(F)$
- $P = \text{Perceive}(D)$
- $M = \text{MappingToField}(P)$
- $Y = \text{Flight}(M)$

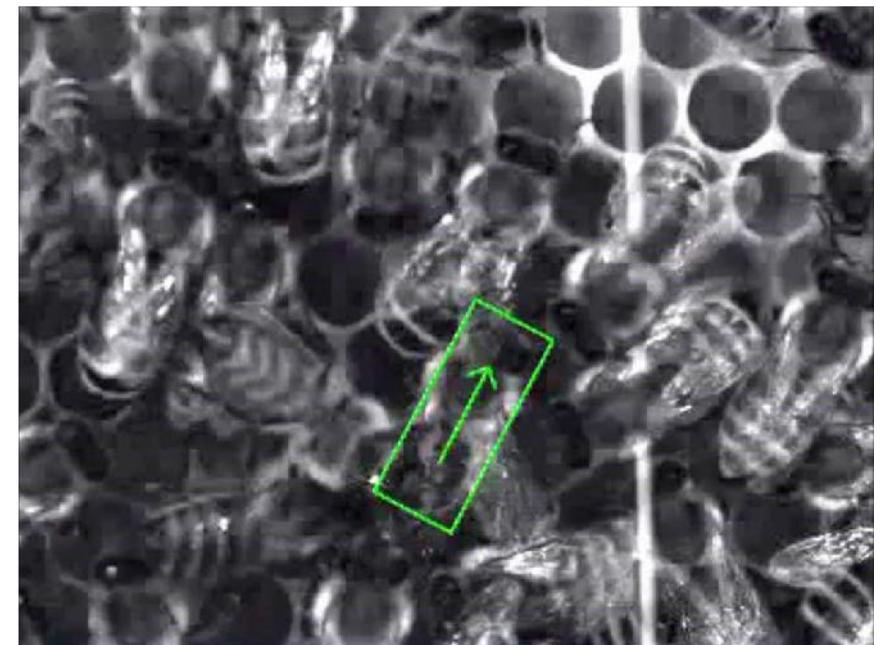


Source: Neurobiology Group FU Berlin

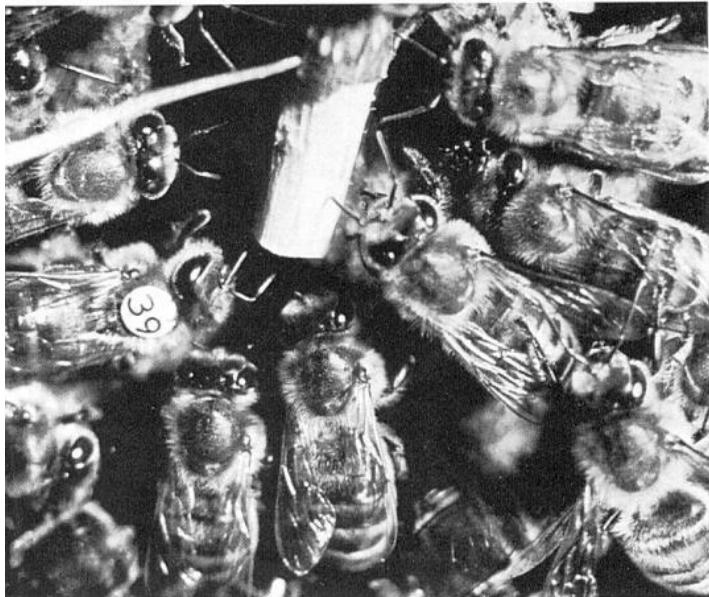
= Flight(MappingToField(Perceive(Dance(Features(Site)))))

Stimuli emitted by Dancers

- Body movements
- Wing buzzes
 - Particle oscillations
 - Laminar air flows
 - Dynamic electrostatic fields
 - Comb vibrations
- The “waggle scent”
- Heat
- Food and odor samples



Historic Robotic Bees



Harald Esch, 1950s



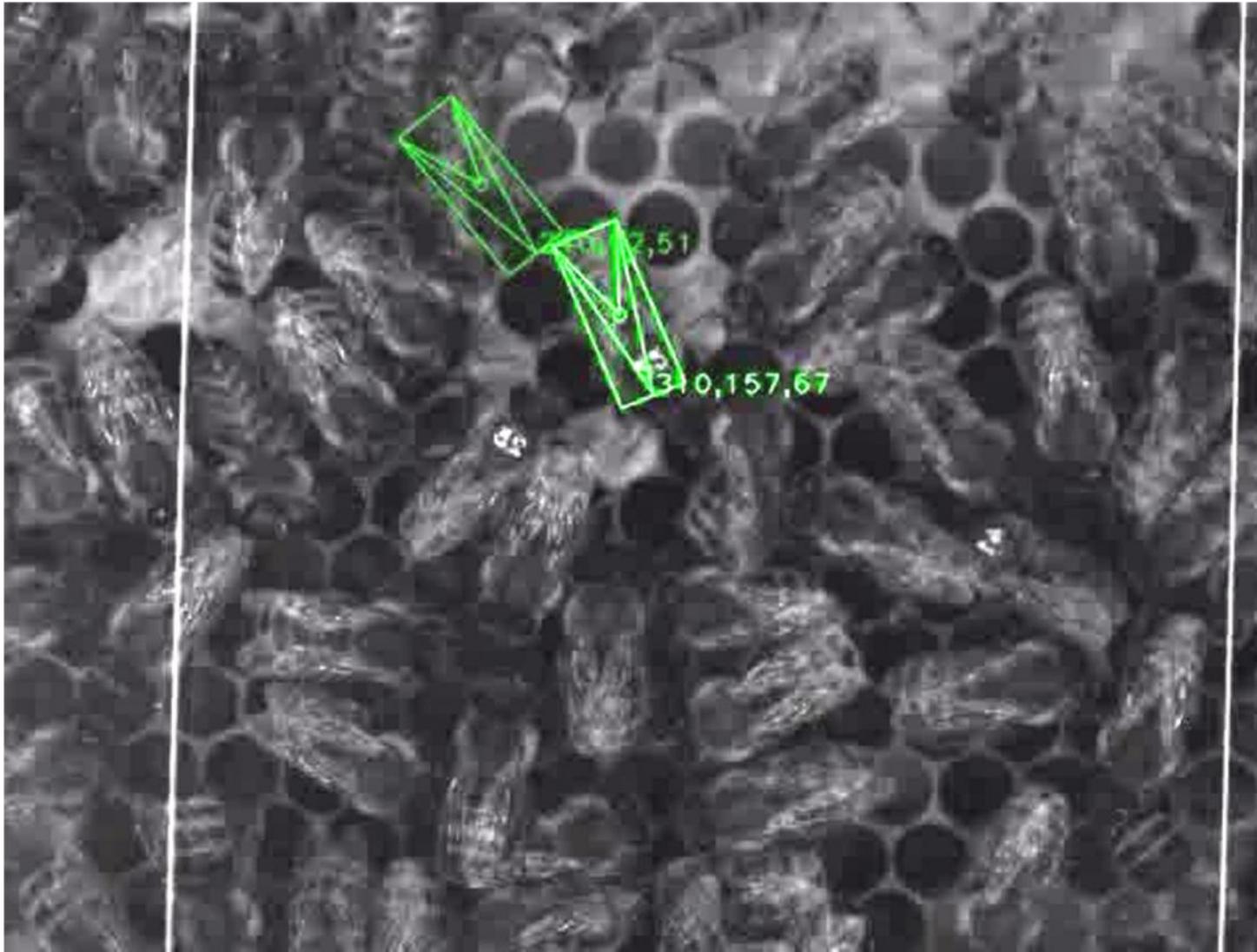
Axel Michelsen, 1990s

NO FOLLOWING BEHAVIOR REPORTED

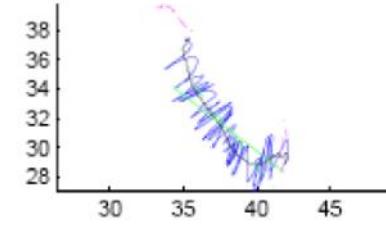
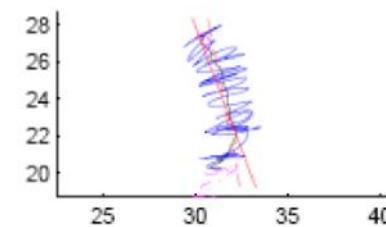
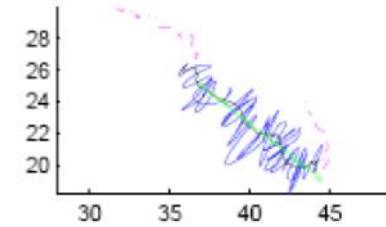
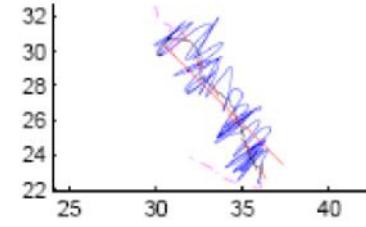
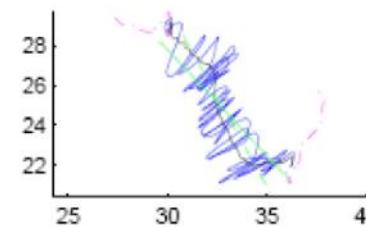
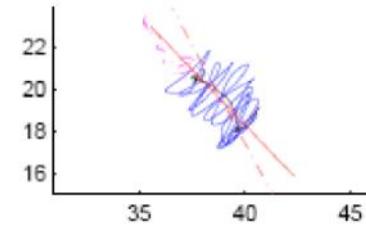
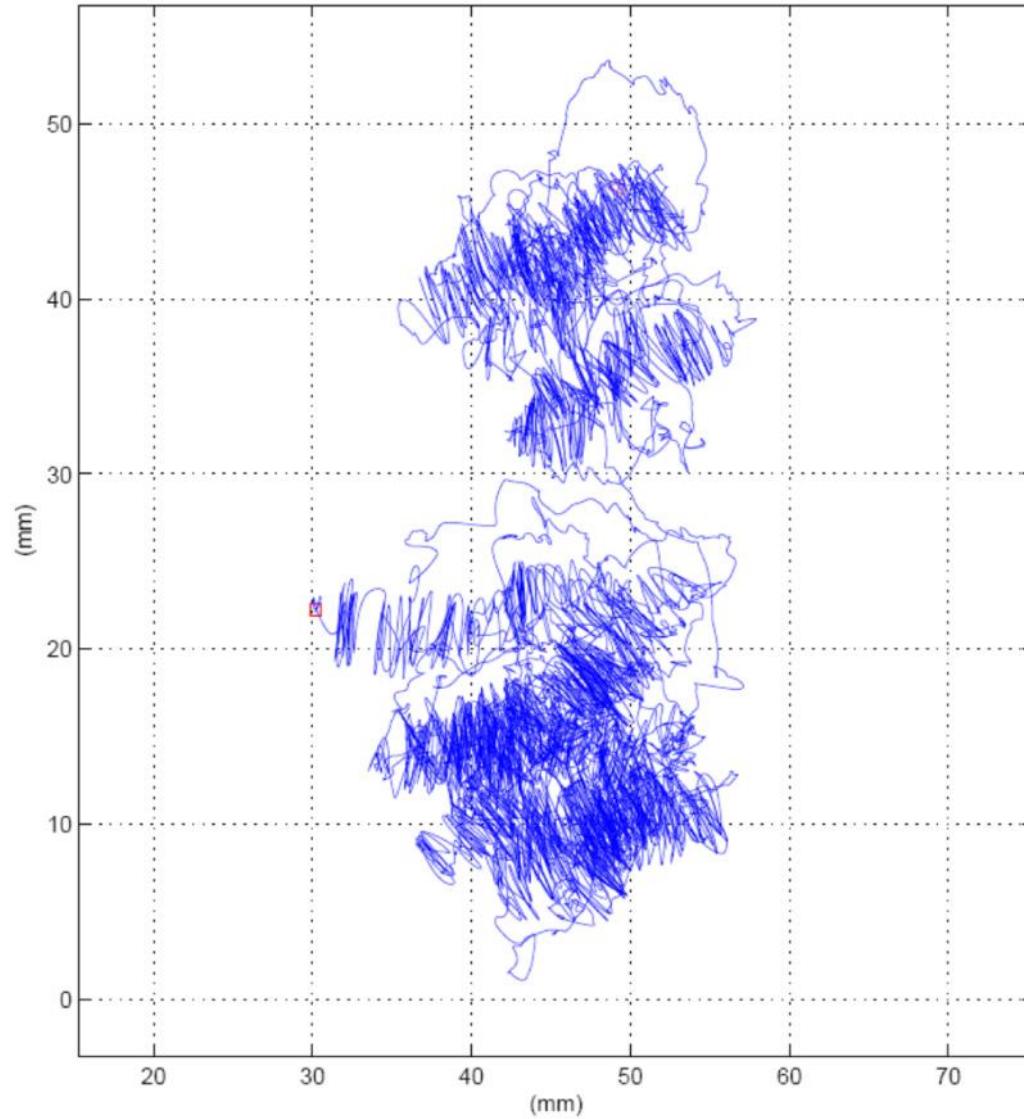
RoboBee



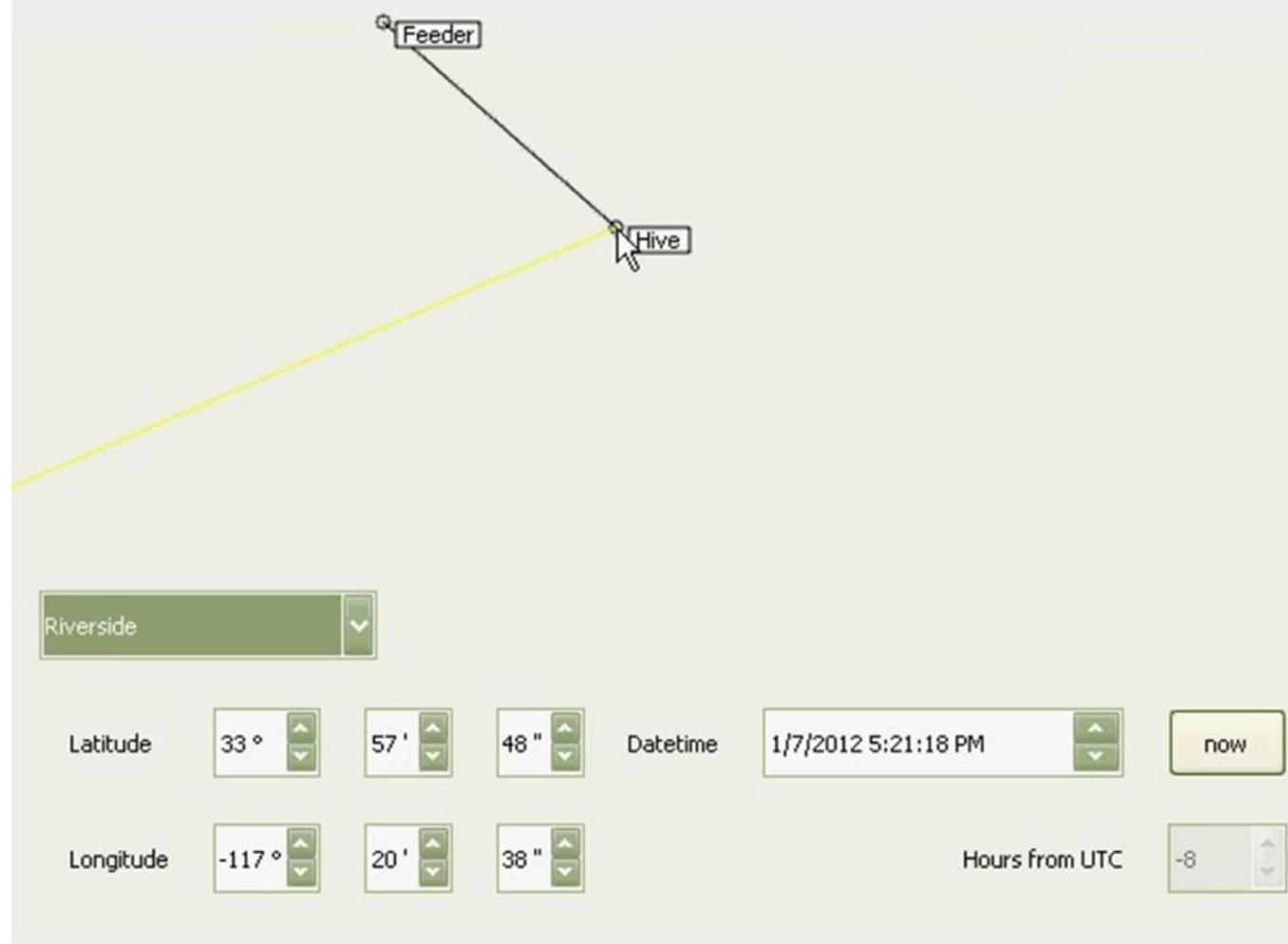
Dance Tracking



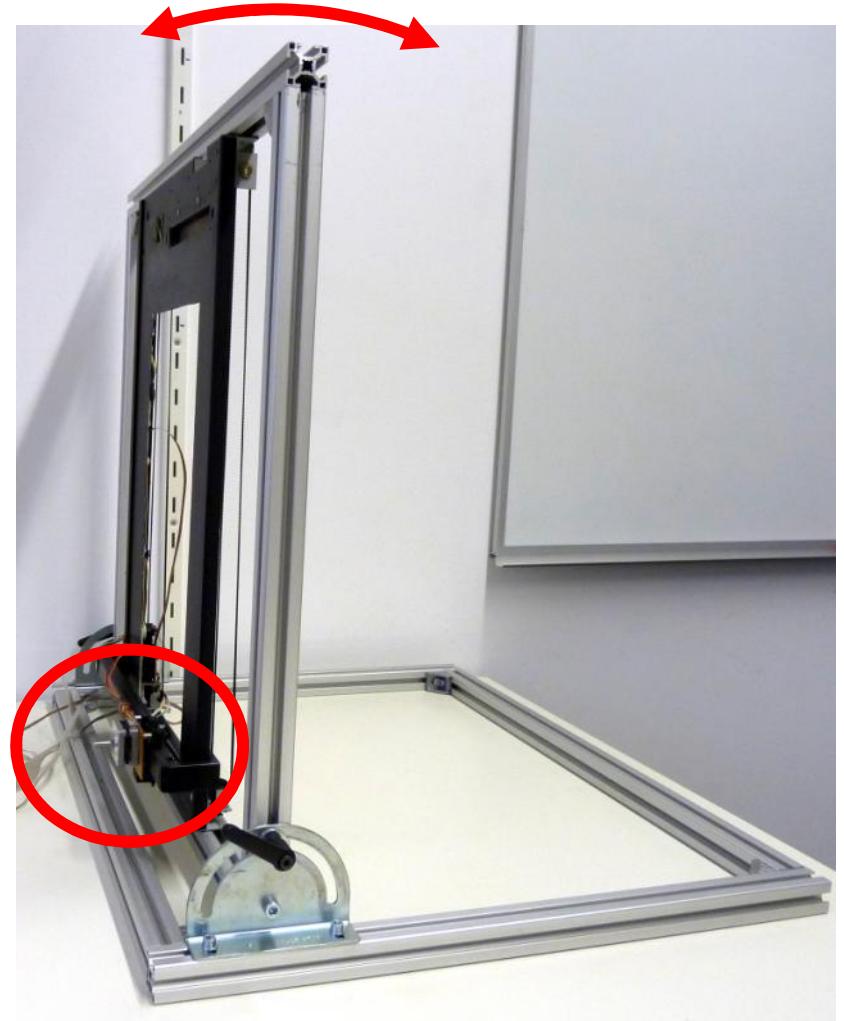
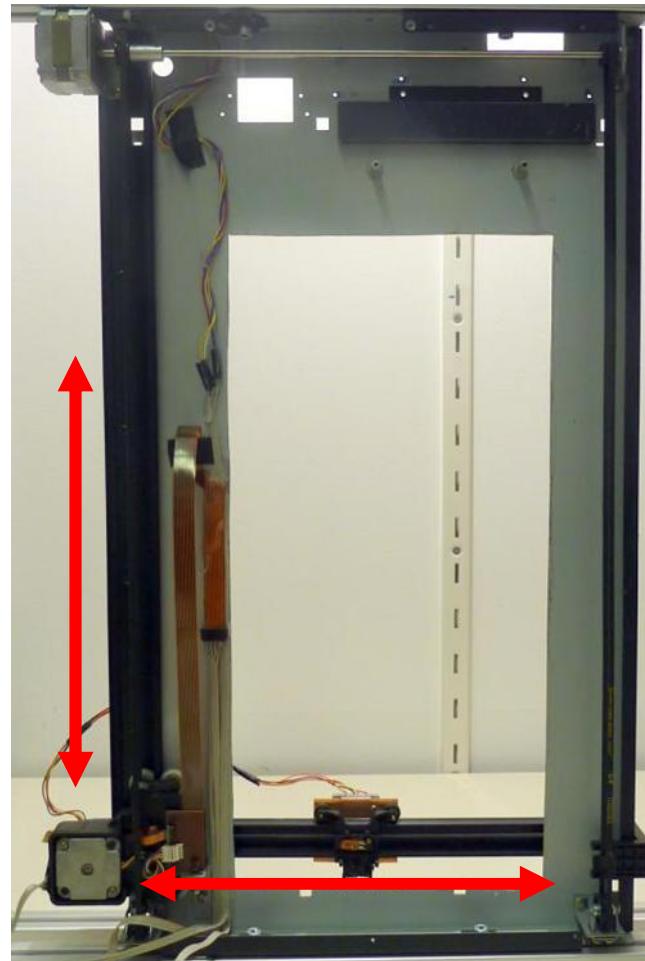
Trajectory Analysis



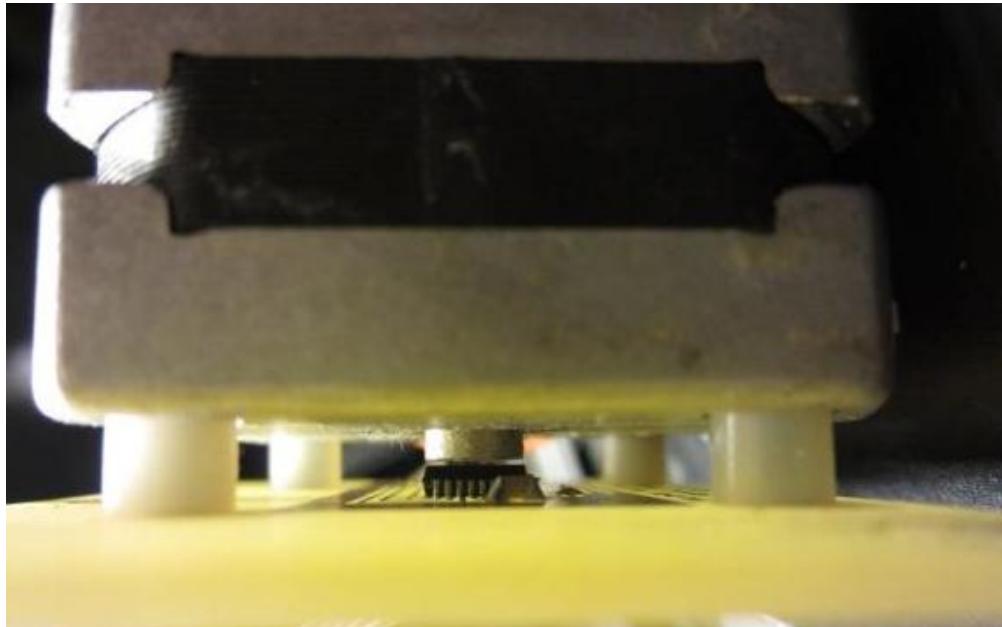
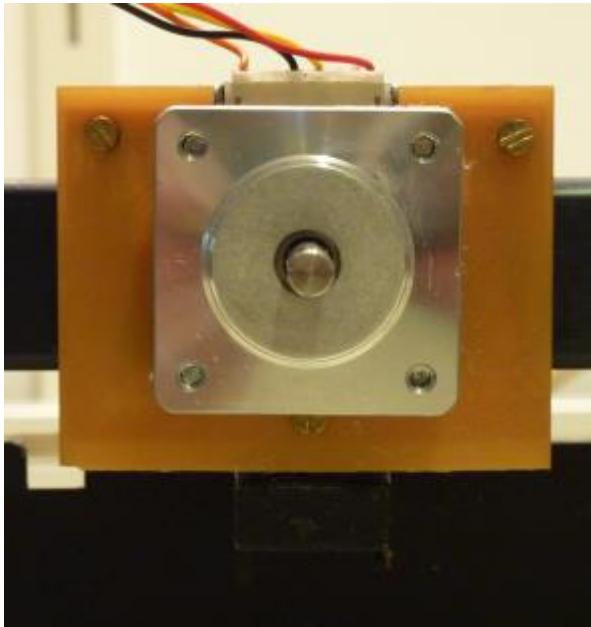
Model of the Dance



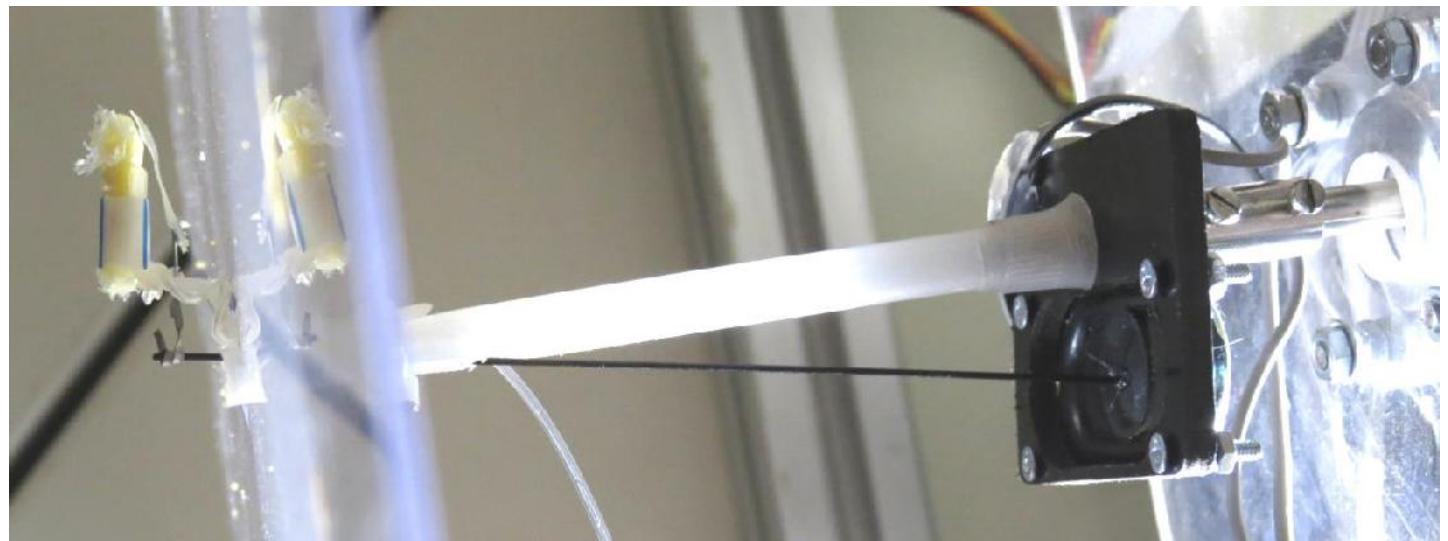
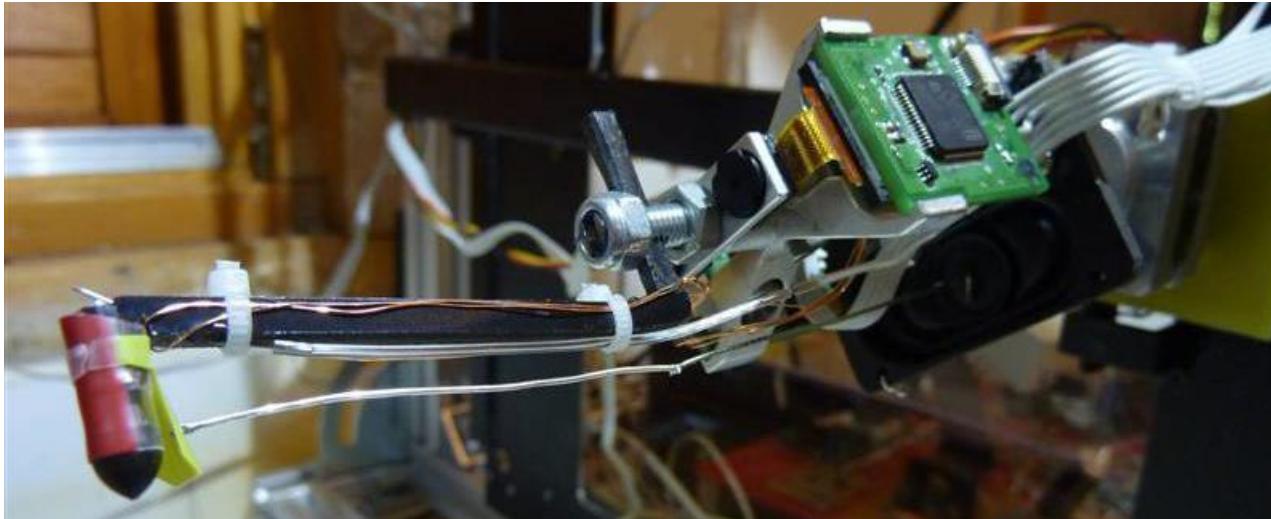
RoboBee Hardware: Plotter and Frame



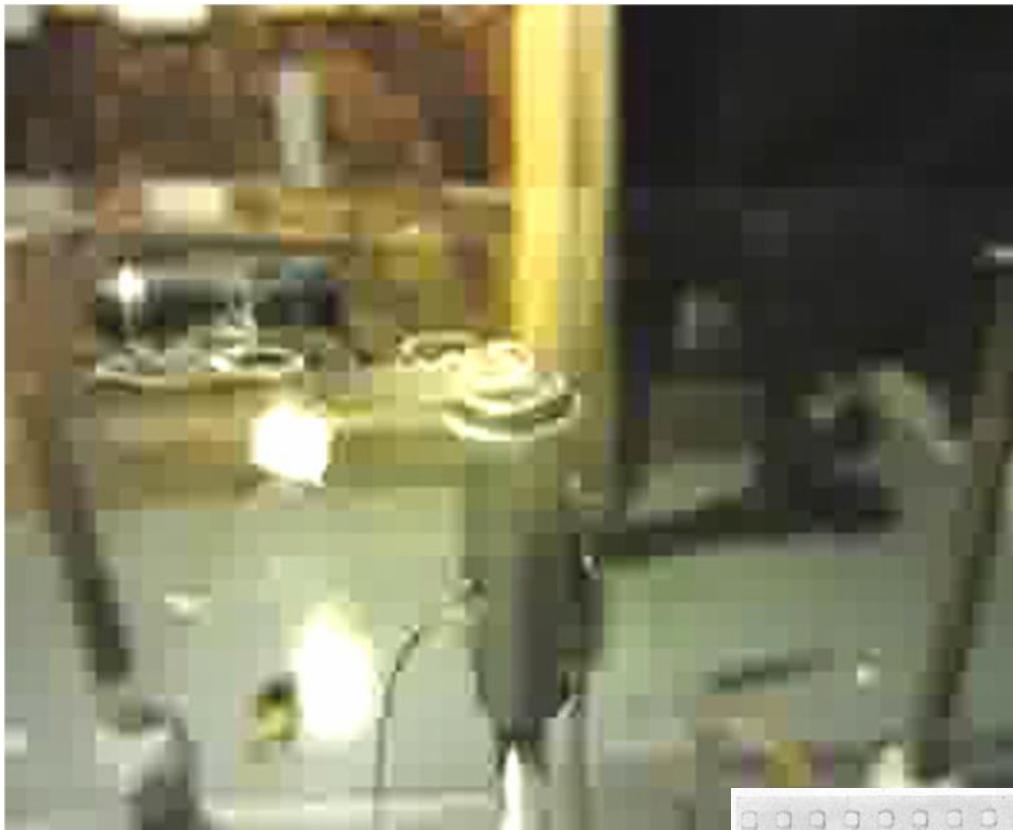
RoboBee Hardware: Orientation Motor and Rotary Encoder



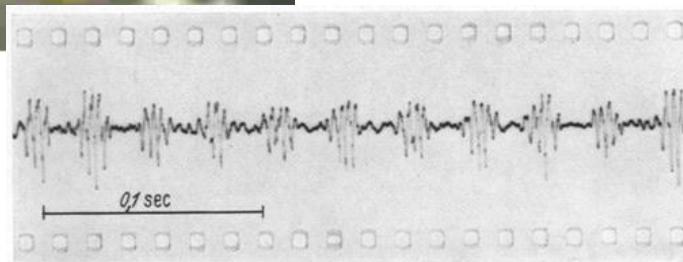
RoboBee Hardware: Arm, Body, Wing Driver and Cameras



Vibratory Cues: Wings

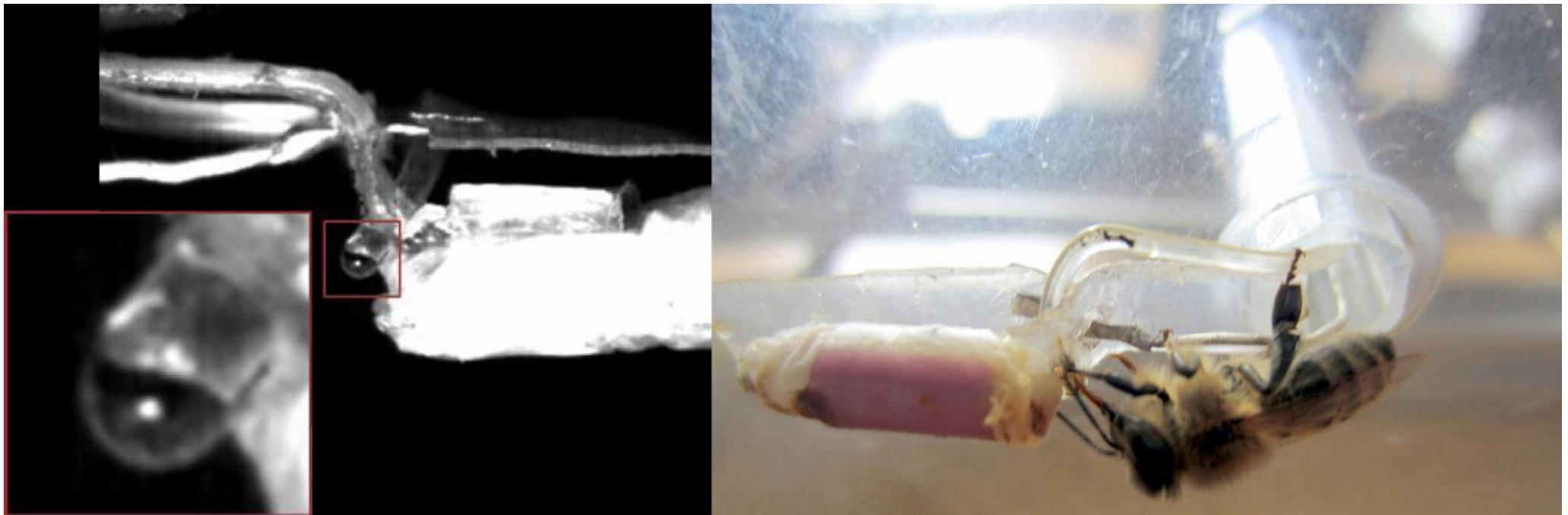


Recorded at 250 Hz
Playback at 25 Hz



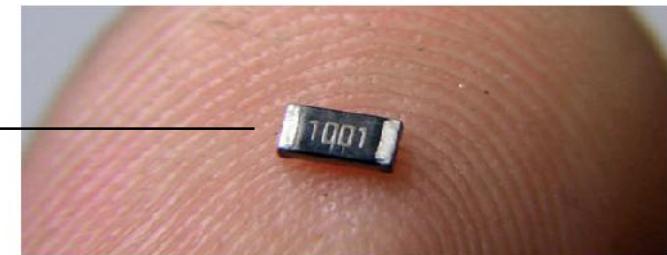
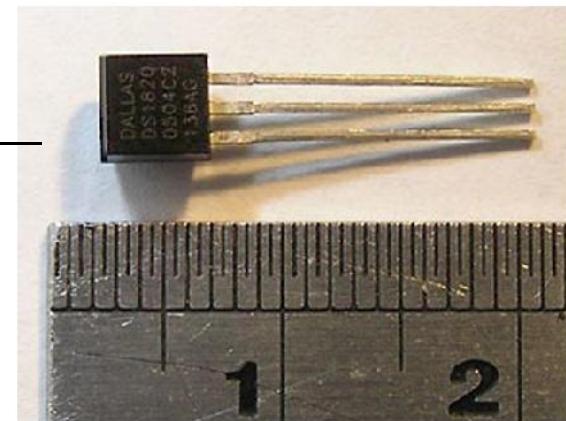
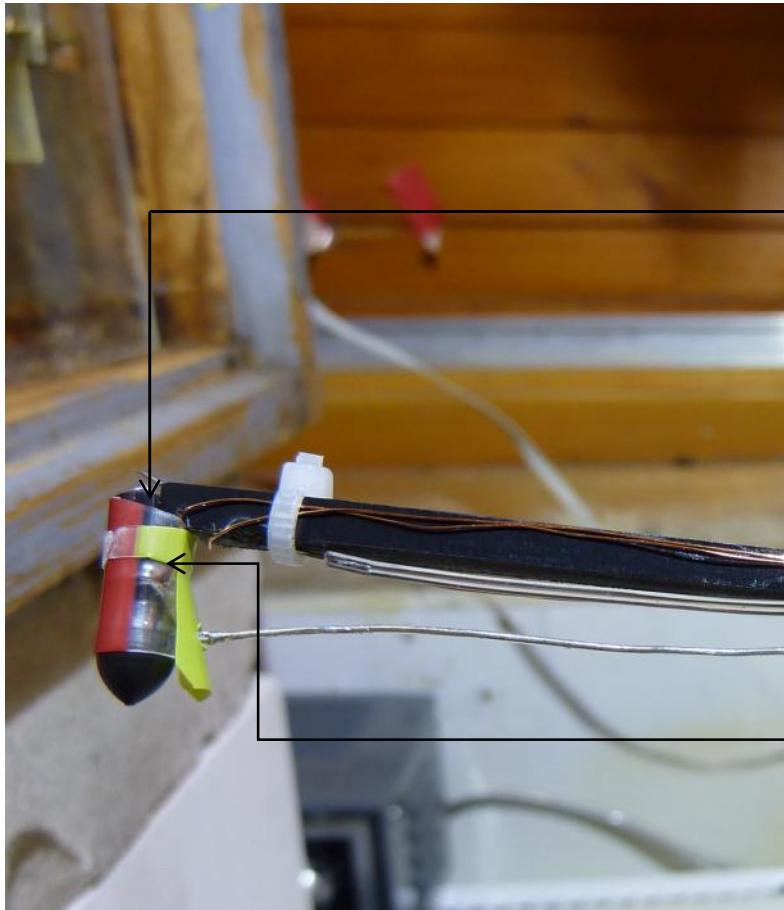
Recorded at 1000 Hz
Playback at 25 Hz

Gustatory Cues: Trophallaxis



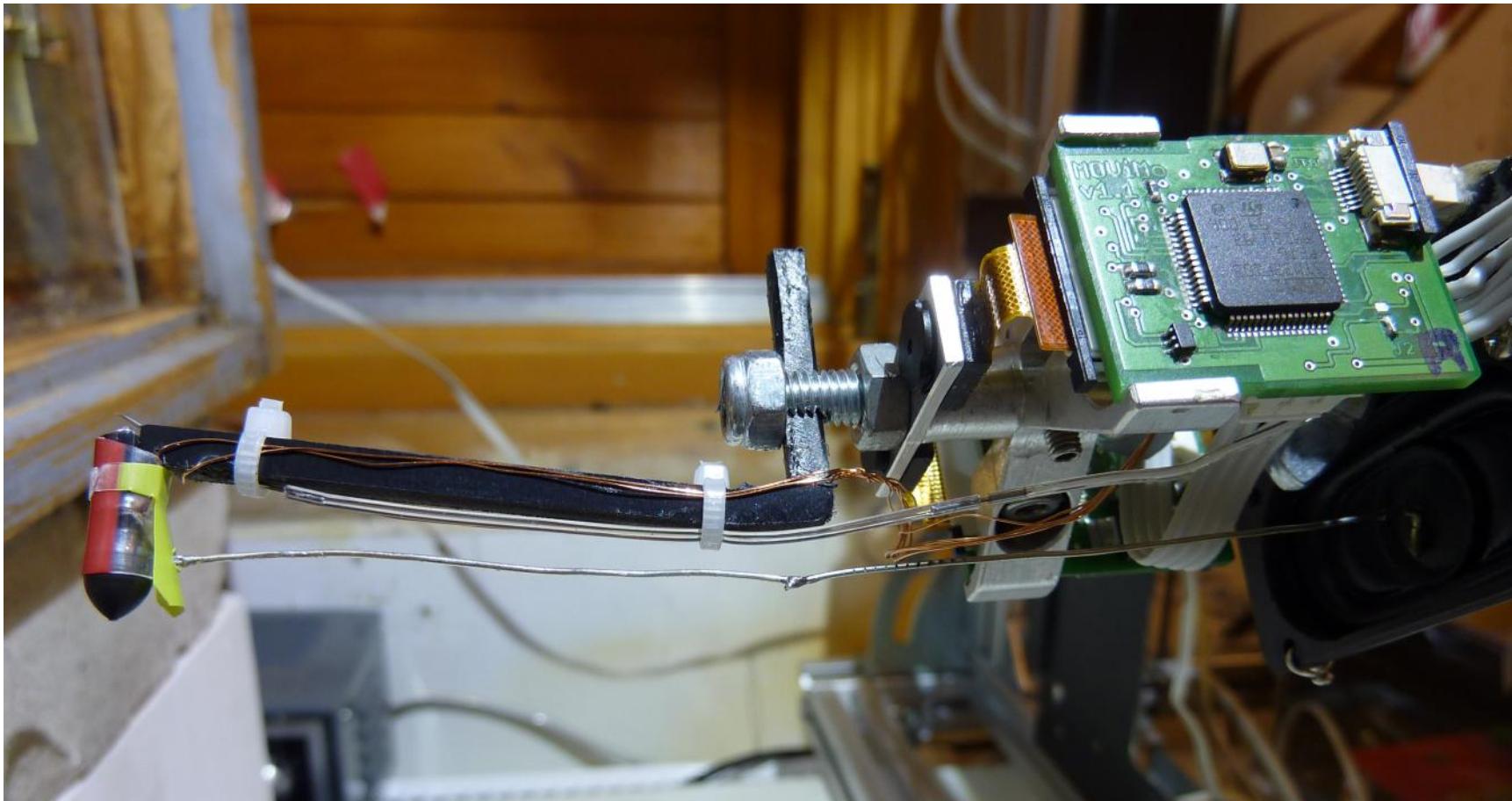
10.10.2015

Thermal Cues: RoboHeating

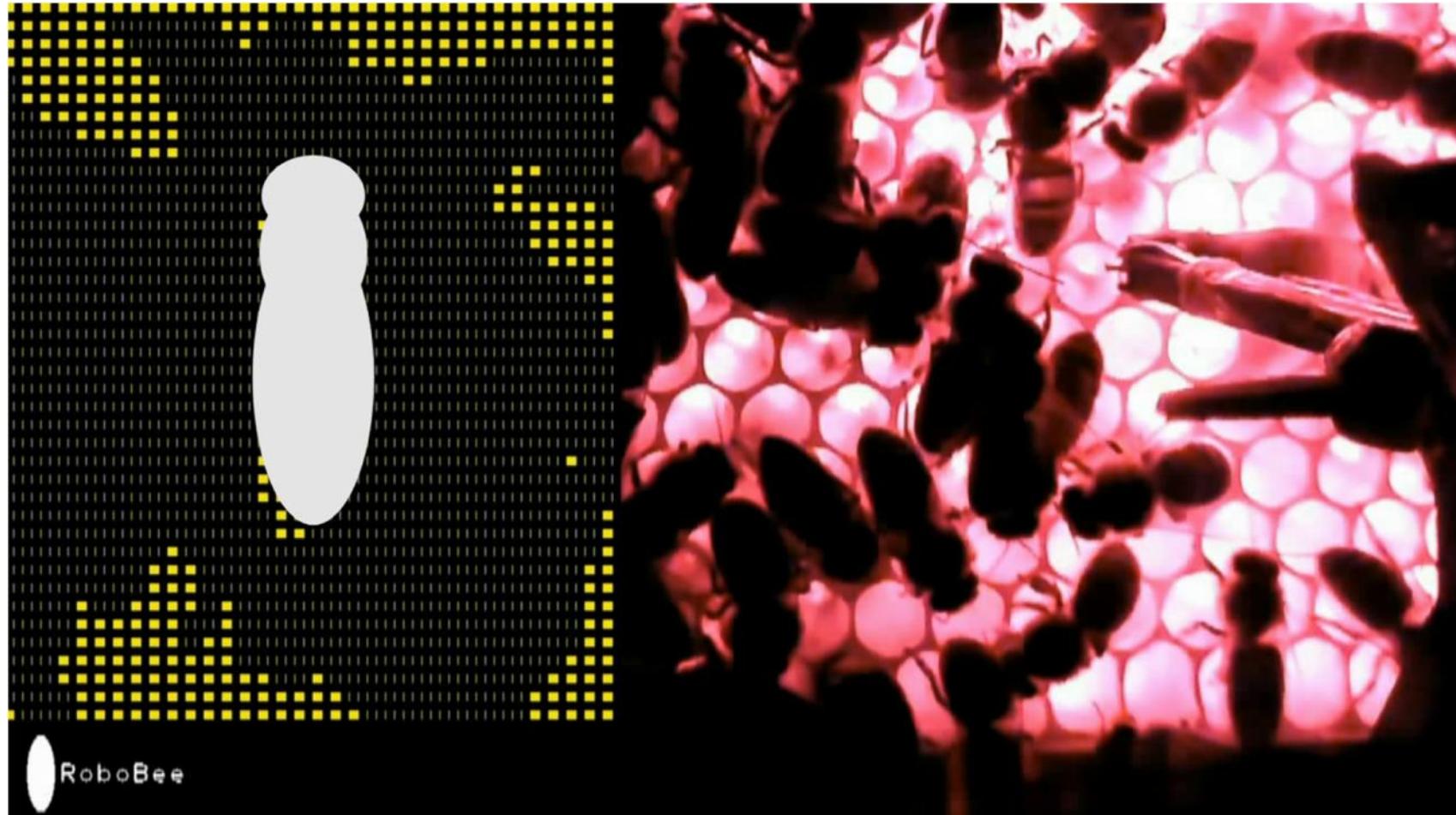


heating: resistor

Behavioral Cues: RoboBee Cameras



RoboBee's Vision system



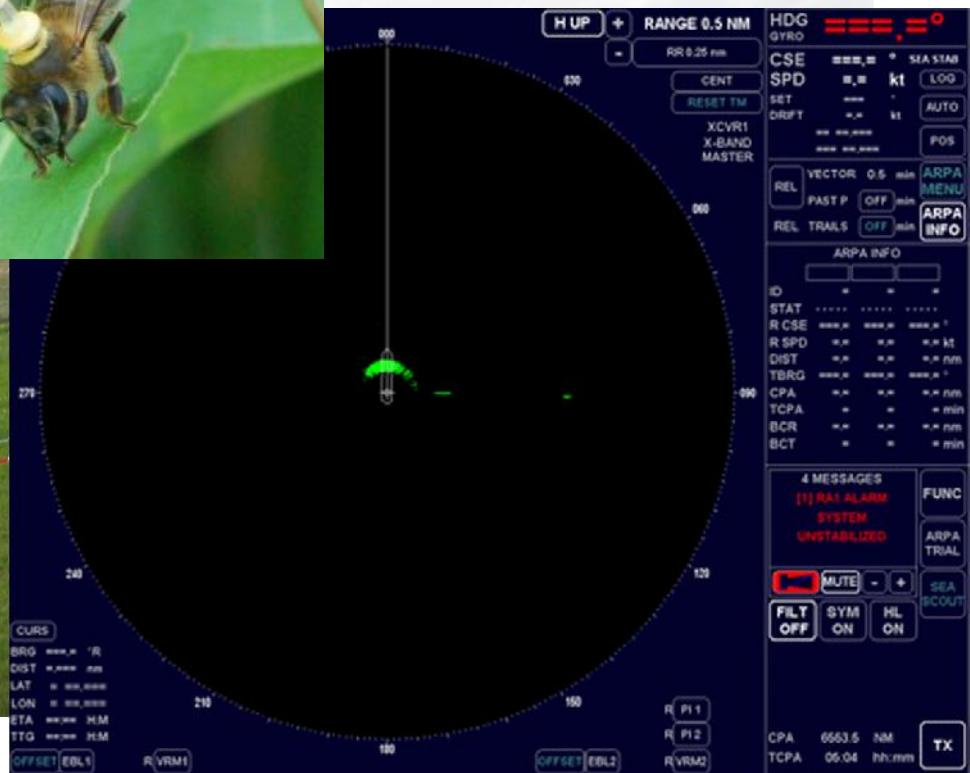
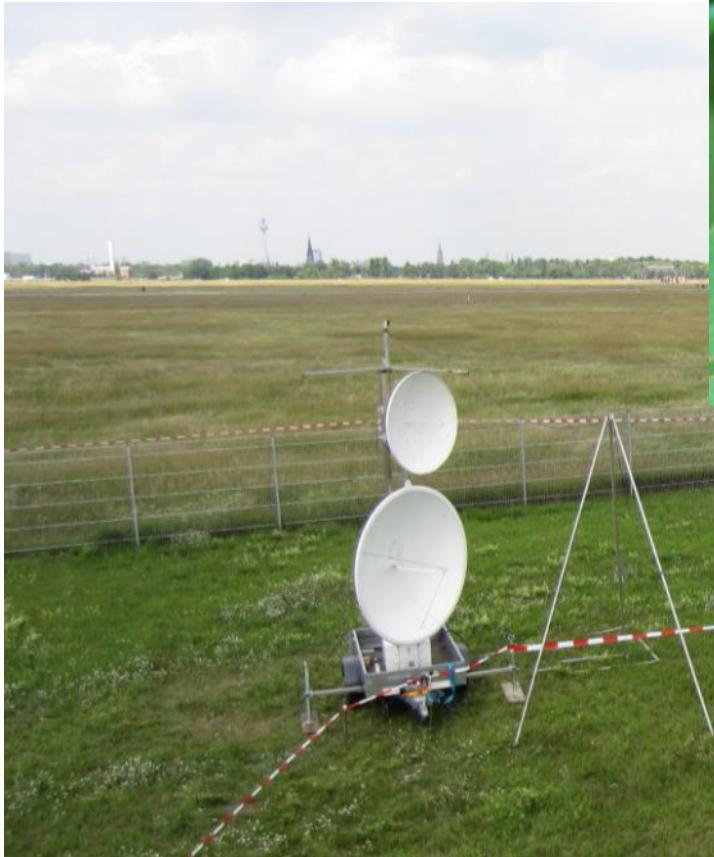
RoboBee Hardware: Hive Setup





[w]

Harmonic Radar

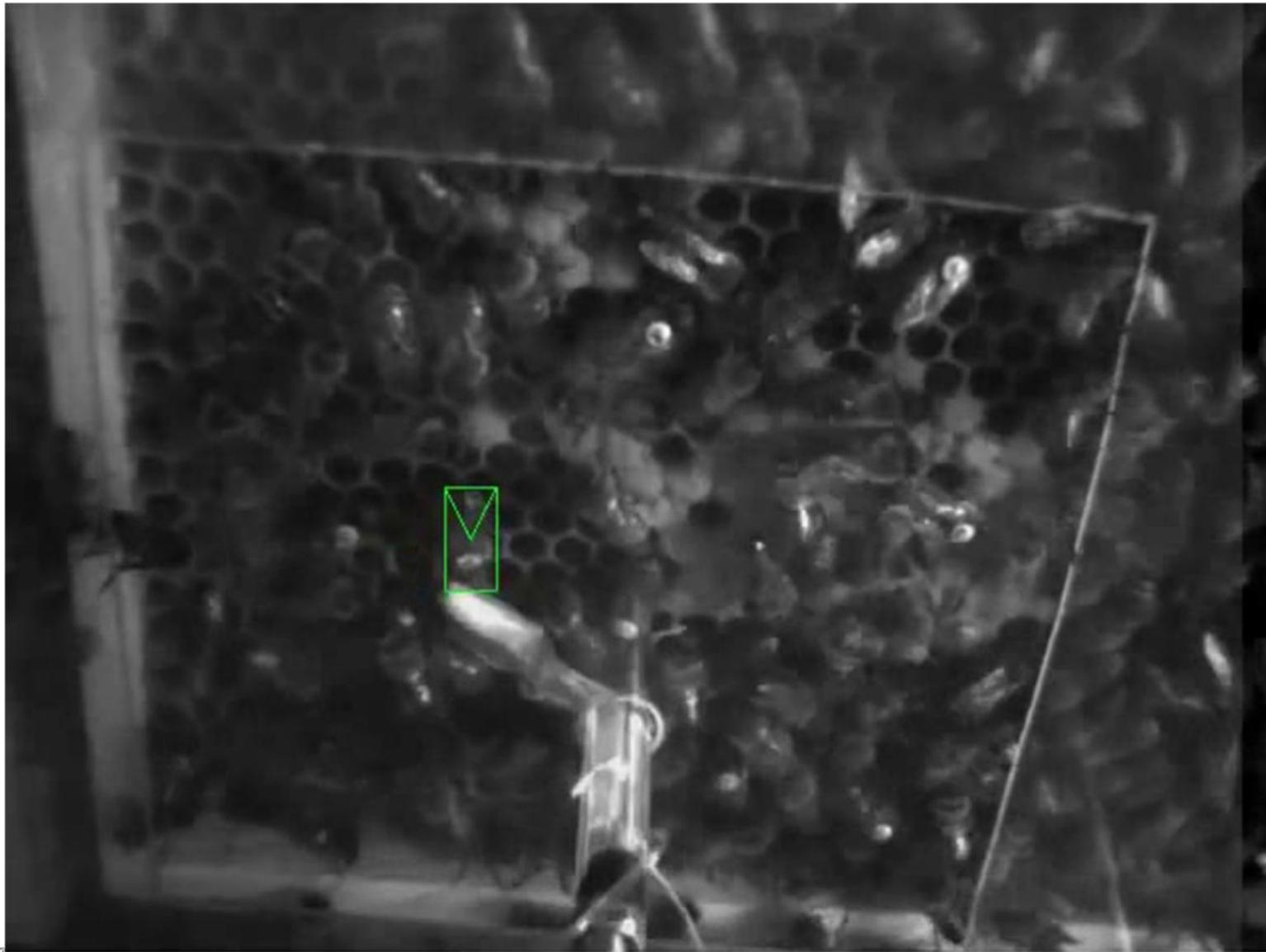


Prof. Dr. Dr. h.c. Randolph Menzel

Recruitment Experiment



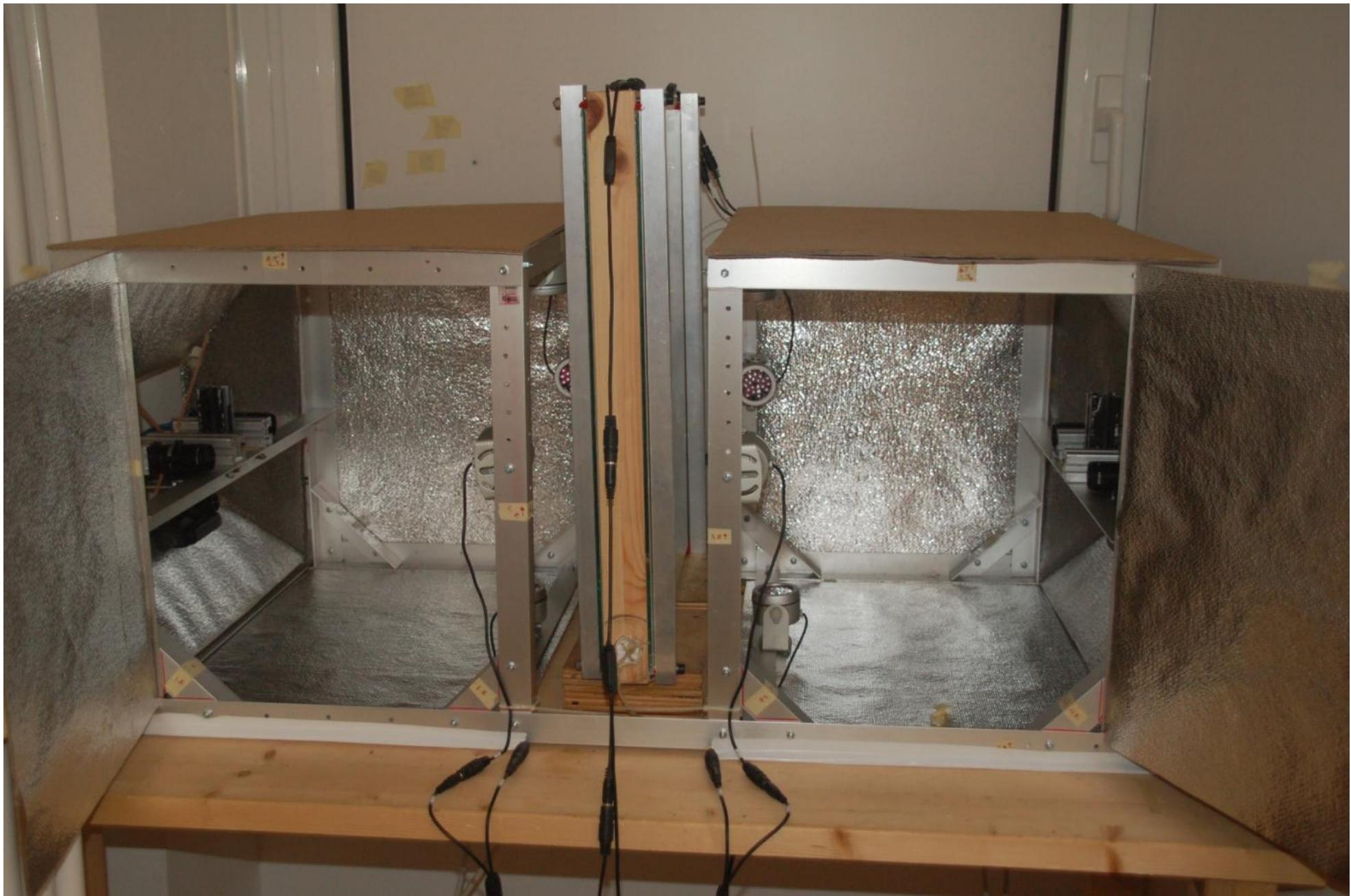
RoboBee: bees follow robotic dances



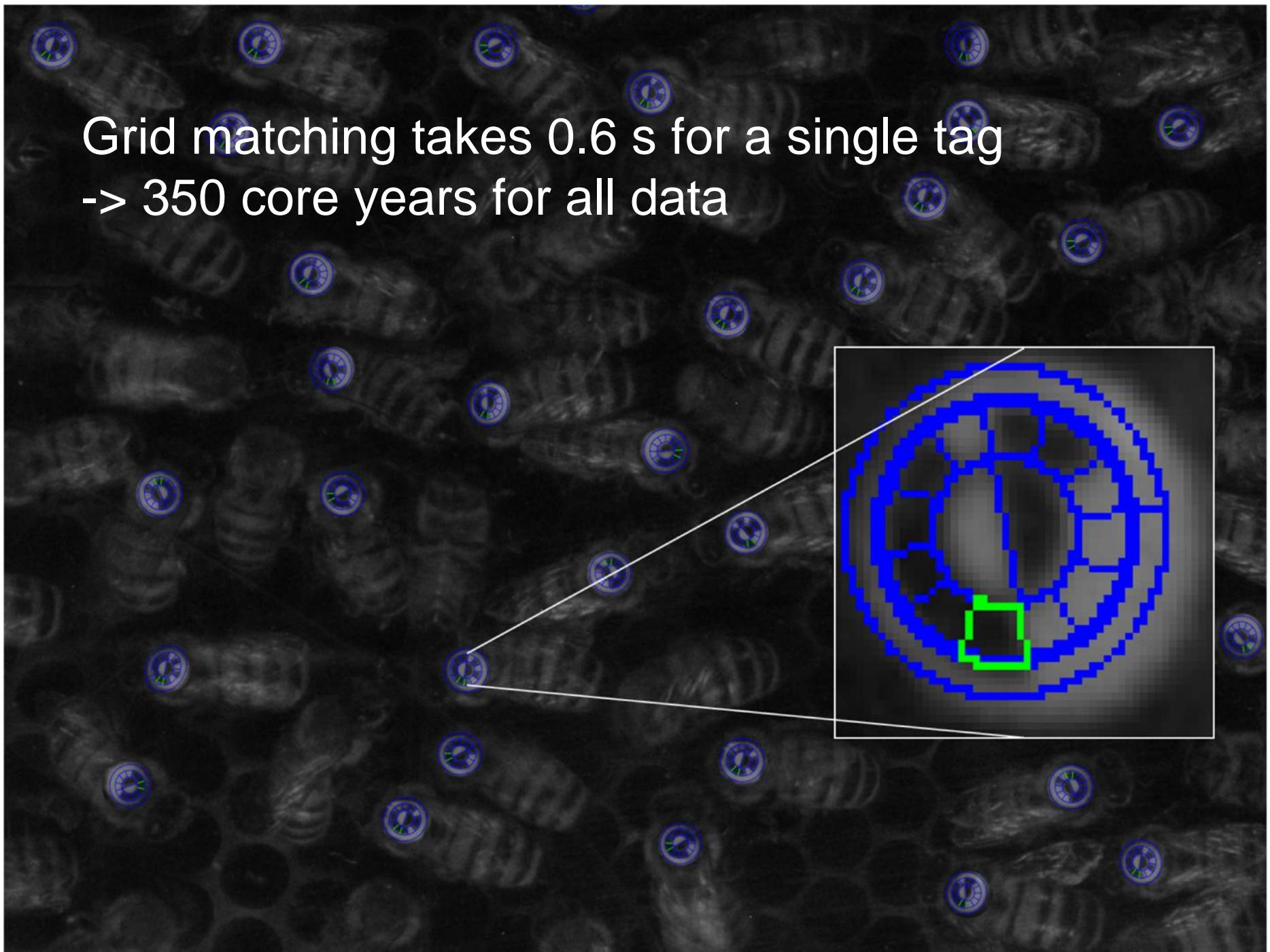
BeesBook



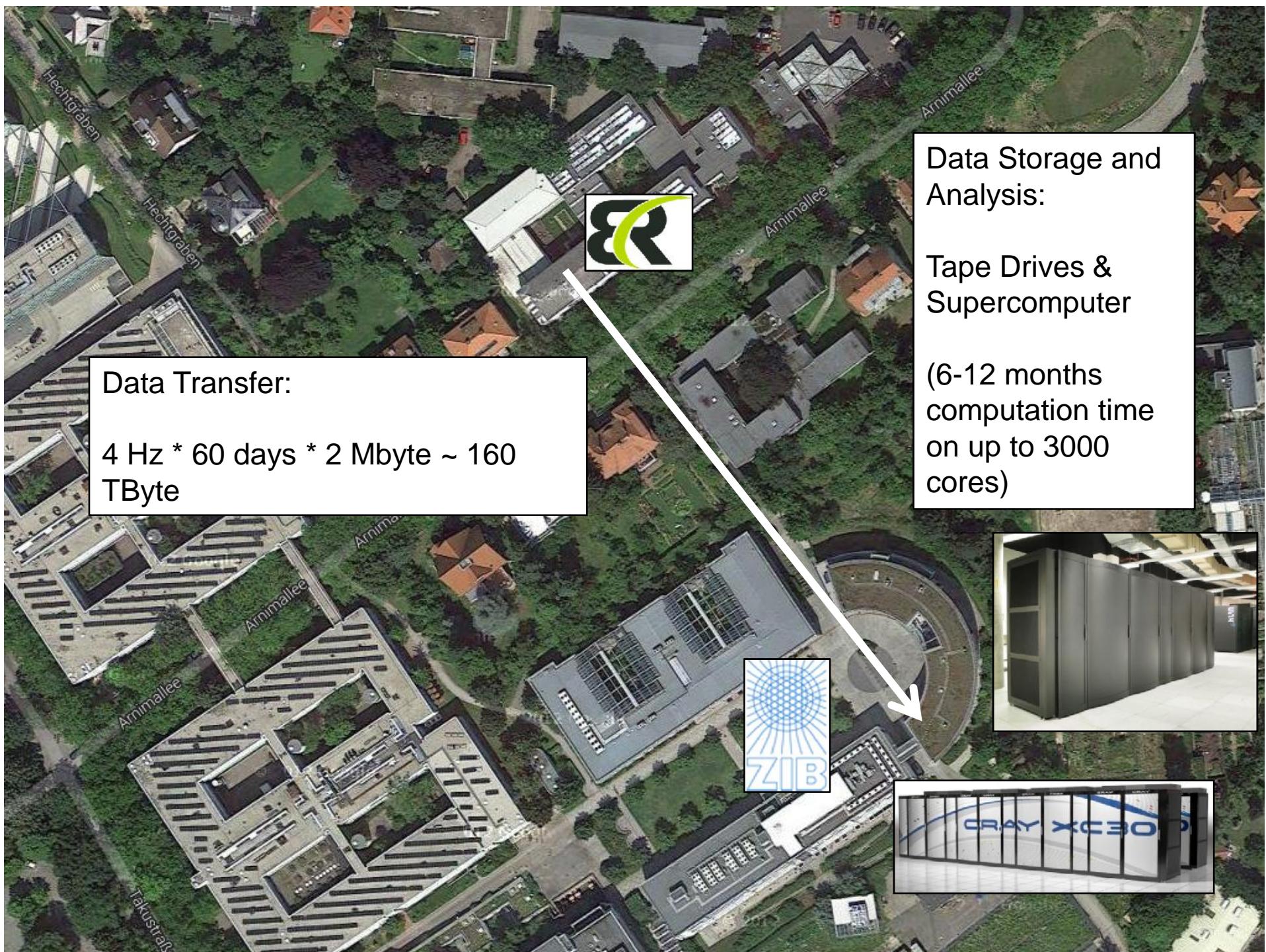


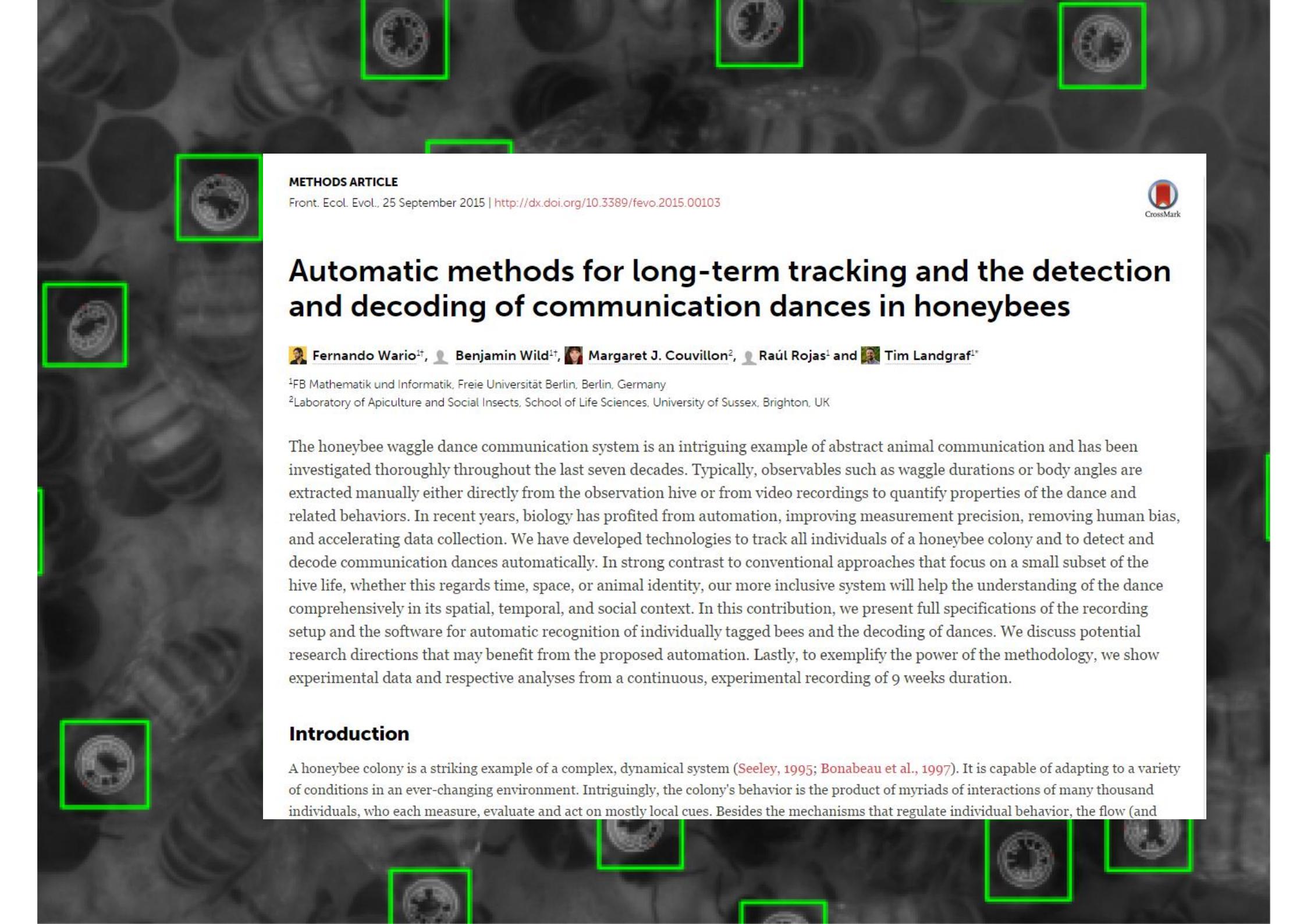






Grid matching takes 0.6 s for a single tag
-> 350 core years for all data





METHODS ARTICLE

Front. Ecol. Evol., 25 September 2015 | <http://dx.doi.org/10.3389/fevo.2015.00103>



Automatic methods for long-term tracking and the detection and decoding of communication dances in honeybees

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²Laboratory of Apiculture and Social Insects, School of Life Sciences, University of Sussex, Brighton, UK

The honeybee waggle dance communication system is an intriguing example of abstract animal communication and has been investigated thoroughly throughout the last seven decades. Typically, observables such as waggle durations or body angles are extracted manually either directly from the observation hive or from video recordings to quantify properties of the dance and related behaviors. In recent years, biology has profited from automation, improving measurement precision, removing human bias, and accelerating data collection. We have developed technologies to track all individuals of a honeybee colony and to detect and decode communication dances automatically. In strong contrast to conventional approaches that focus on a small subset of the hive life, whether this regards time, space, or animal identity, our more inclusive system will help the understanding of the dance comprehensively in its spatial, temporal, and social context. In this contribution, we present full specifications of the recording setup and the software for automatic recognition of individually tagged bees and the decoding of dances. We discuss potential research directions that may benefit from the proposed automation. Lastly, to exemplify the power of the methodology, we show experimental data and respective analyses from a continuous, experimental recording of 9 weeks duration.

Introduction

A honeybee colony is a striking example of a complex, dynamical system (Seeley, 1995; Bonabeau et al., 1997). It is capable of adapting to a variety of conditions in an ever-changing environment. Intriguingly, the colony's behavior is the product of myriads of interactions of many thousand individuals, who each measure, evaluate and act on mostly local cues. Besides the mechanisms that regulate individual behavior, the flow (and

Dankeschön!

Für weitere Informationen:

biorobotics.mi.fu-berlin.de

