SMARTSPECTOR®

artificial perception engineering

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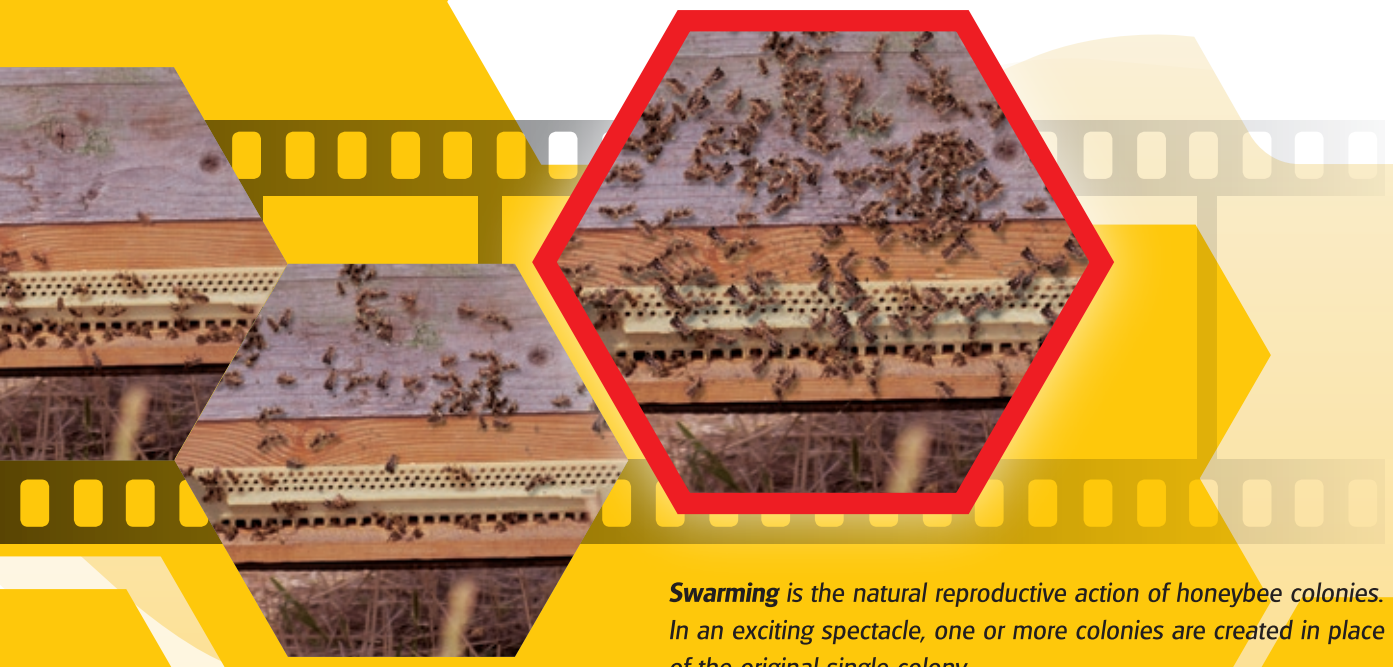
Did you know?

Honeybees ...

- see with their compound eyes with a resolution of some thousand pixels
- are blind to red but can see ultraviolet beyond our range of colour perception
- perceive polarisation of light to negotiate the direction of the sun
- have a sophisticated magnetoreception system and are therefore able to navigate by perceiving the terrestrial magnetic field
- have a well-developed sense of time, the so-called circadian rhythm
- cooperate to find food and use the waggle dance to communicate with each other



Swarming *is the natural reproductive action of honeybee colonies. In an exciting spectacle, one or more colonies are created in place of the original single colony.*

The prelude to swarming, which usually takes several hours, is characterised by extraordinary flying activities and a characteristic humming sound.

Finally, the new colony leaves the hive with mainly young and inexperienced bees behind and heads for a new nesting point for its queen – a trip that may take several days. Swarming always weakens the remaining hive so that it is unproductive for the entire season.

Swarm management *is an important aspect in beekeeping and long-term measures to prevent bees from swarming characterise the experienced beekeeper. Nevertheless, swarming cannot be avoided totally and not every swarm is recognised. Every year, swarming causes considerable economic damage to the beekeeper.*

SMARTSPECTOR GmbH - Company Profile

Smartspector artificial engineering GmbH was founded in March 2006 by a video and sensor solutions engineering team with an Austrian supplier in the province of electronic toll collection. What the team had in mind was to regain decision-making authority and to advance the pre-existing key competence beyond the business area of their previous employer. Since October 2007, Dieter Schmidradler has been the sole proprietor of the company.

Smartspector sees itself as a turning platform and a driving force for new sensor technologies to be applied in various industries. Through close relationship with industry and strategic partners in research as well as co-operation with excellent third-party service providers, Smartspector has ideally identified its market position.

Today, Smartspector looks back upon an overly dynamic startup-phase with intensive networking and R&D activities. As a founder member of the Austrian traffic telematics network ANTTS, Smartspector has consolidated its position in the field of roadside sensor systems.

Smartspector gained profound insight into actual user needs and commercially available technology in the first place. Second, Smartspector defined several in-house products with significant excess value. Creating Pumilio™ LPR, the most compact all-in-one licence plate recognition system in the world, Smartspector realises a core technology to provide highly performant products of unequalled effectiveness.

All current Smartspector sensor systems are based upon the same software architecture, the *Smartspector Vision Engine*, and implement a powerful virtual device model. The platform has been designed from scratch to meet the vital requirements for roadside sensor systems:

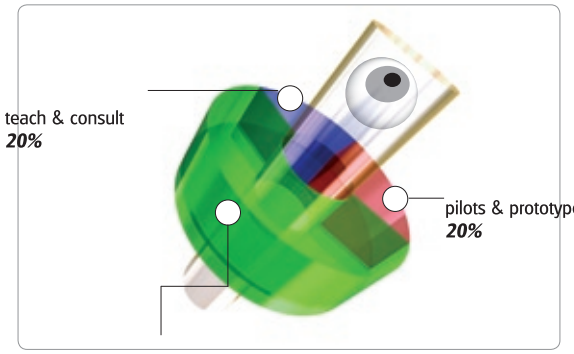
- *continuous security measures with regard to data authenticity and device administration*
- *comprehensive remote administration capabilities*
- *standardised communication with consistent configuration and data fusion from multiple sensor devices*

As to machine-vision, Smartspector devised remarkable innovations in the field of roadside sensor systems:

- *Novel LPR engine, Smartspector Normative Symbol Description, features a precise formal character description rather than generic font training. The new approach is meant to identify liminal differences between similar symbols; compared to a previously applied third party string reader, the algorithm showed also a significant boost in overall throughput*
- *Highly performant segmentation strategies enable licence plate localisation at full frame rate. This guarantees best possible dynamic shutter control to give brilliant images as a solid basis for licence plate recognition.*
- *Novel motion-analysis and visualisation strategies open a new field of applications and enhance efficiency in the documentation of moving vehicles.*

Strategic Partnerships and Synergies

Smartspector artificial perception engineering GmbH is clearly focused on advancing technology; to diversify and improve technical standards, Smartspecor provides core technology mostly unvaried for different partners and customers. In 2009, Smartspector Aurora has been established as our congenial partner for entering new markets and for supporting our products. Moreover, Smartspector is also open for worldwide strategic partnerships. Thus we at Smartspector invite everyone interested to become a strategic partner for concerted business.

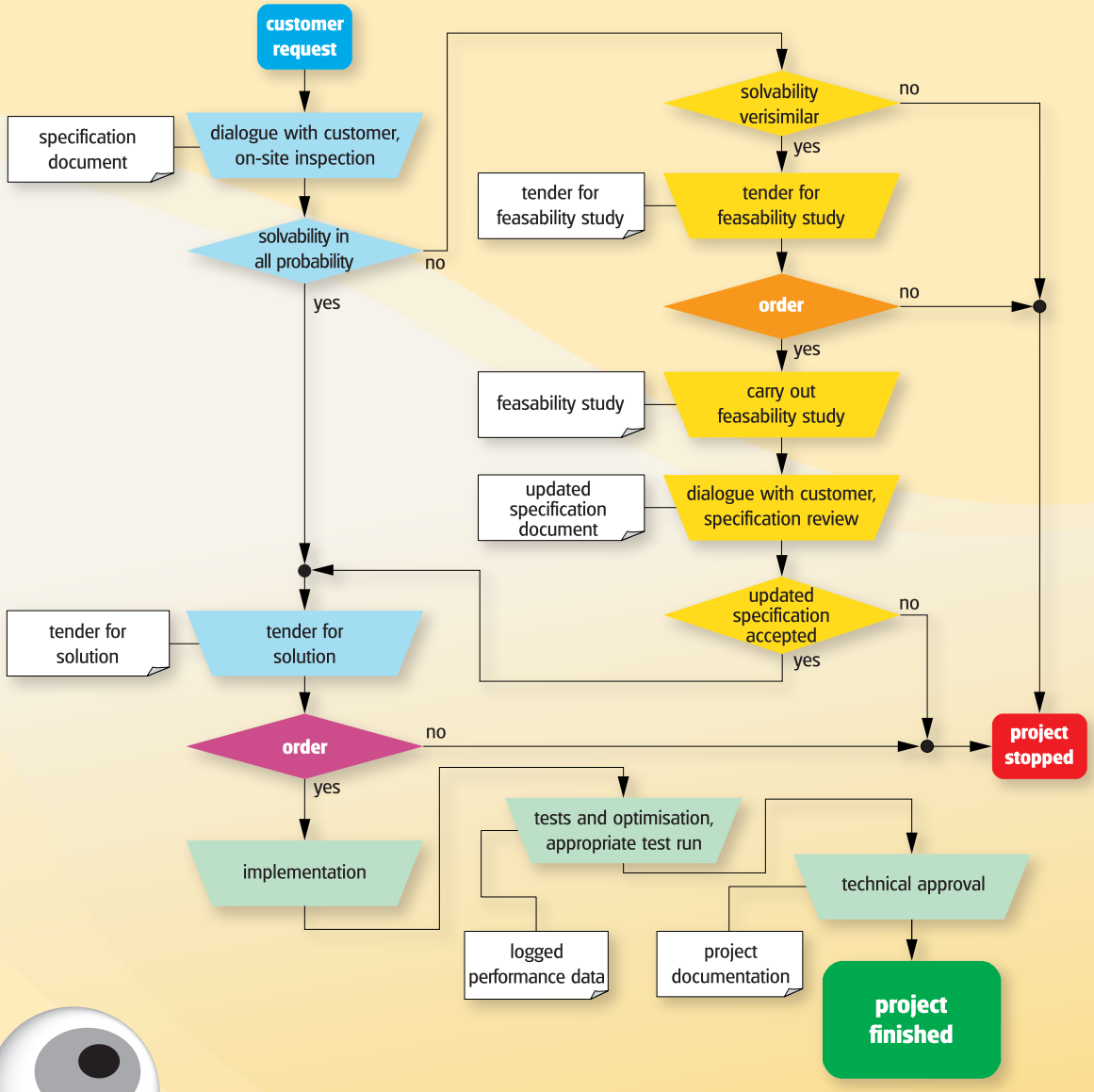


Quality Management and Innovation

Whenever we design new customer applications, only released devices or pre-existing infrastructure from third parties are permitted, i.e. quality and availability of the devices are well known by a continuous evaluation of our suppliers.

Generating optimum solution, however, requires close co-operation with selected companies engineering novel sensors and platforms. Due to our constant efforts to gain experience with new instruments, a field-tested device is materialised - prior to product release, by means of well-defined feedback loops to our suppliers and engineering partners.

To keep the risk of tricky problems low, such projects are always mapped to a multi-stage process. This is usually carried out in such a way that a feasibility study precedes the implementation stage per se.
The output of such a feasibility study usually renders a reviewed and refined specification document.



Ambient-Tolerant Artificial Perception

Our aim to design robust algorithms for outdoor applications for a huge variety of ambiances originates from recurrent activities in the field of traffic telematics.

Unlike typical inspection tasks e.g. in the field of industrial production, natural scenes are characterised by numerous cyclic and stochastic variations:

- ***daylight***
- ***switched and dimmed artificial light sources***
- ***bad weather, e.g. fog, rain, snow***
- ***nonstatic objects in the background scene, e.g. windswept leaves***

Hundreds of installed sensors in nationwide tolling systems are a splendid example of ambient-tolerant artificial perception systems in commercial operation. Proven high-performance for vehicle classification and vehicle identification over 24 hours a day and over 365 days a year are a solid certificate for well-engineered sensor applications. Only a detailed consideration of all functional units and their inherent fuzziness allows a reliable fusion of sensor data. With the matching-performance of this data from multiple sources (e.g. laser, video, and communication), the final performance of total roadside installations is defined and delimited.

Smartspector has gained key competence in designing, implementing and optimising such roadside applications over years; by closely co-operating with customers and operational staff we have an excellent understanding of actual user needs and also profound expertise in developing robust and well maintainable sensor systems for a wide range of applications.

Our business is setting up highly useful artificial perception systems, collecting data when bees have already retreated into their hives. These systems rely on state-of-the-art sensor devices and Smartspector algorithms in order to observe and identify processes in natural scenes.

In contrast to precisely application-specific optimised machine vision systems mainly for the field of industrial production, artificial perception is, in our understanding, taking pre-existing overall conditions into consideration, setting up suitable sensor principles and implementing preferably generic algorithms to identify activities in natural scenes. Typical application requirements are to

- ***recognise anomalies***
- ***perceive statistical data with well-defined performance over any timescale***
- ***acquire data in an event-driven manner: provide only relevant images, video streams and related data***

The methodology takes typical environmental conditions such as sunlight or time-dependent artificial light and bad weather into account. By having a pre-implemented generic model, the efficient adaptation towards special conditions in a concrete application becomes possible. Typical measures are minor optimisations in the algorithms and adjusting parameters to define the discrimination of a permanent, yet not totally static background, and transient foreground objects in their rather site-specific trajectories, shape and size.

Any technical perception system has its limitations with regard to the visibility and descriptiveness of several unexpected incidents. In other words, compared to natural beings machines still appear quite unintelligent in cases of unfamiliar situations; keeping in mind that bees have existed on this beautiful planet for about 100 million years in an ongoing symbiosis with biota, some seemingly dramatic insufficiency of technical means for „artificial perception“ may be reconceived with leniency.

Tailoring Smartspector perception systems for complex environments is usually done by carefully carrying out preliminary investigations. This preparatory step minimises the probability of relying on unrealistic performance expectations in a planning phase, of a lack of usefulness in regular operation and finally of getting overall expenses out of hand.

Improve Logistics Supply Chain: Identification of Rail Cargo

(Application Sample 1)

➔ Rail cargo shall be identified visually by detecting the presence of waggon trains and by reading identification numbers on containers, waggons and swap bodies.

Design specification:

Inspect site, determine vital requirements and an advantageous sensor configuration:

- a multitude of symbols and characters can be found on waggons, but only a few character strings are relevant for identification
- many different fonts, font sizes, alignments and colours have to be handled by the perception system
- direct sunlight appears once a day and cannot be avoided with reasonable effort
- actual passage speeds of trains and dimensions of the fonts define required camera resolution and frame rates
- reading symbols 24h a day requires active illumination, which has to be optimised to provide homogeneous exposure of all relevant parts of the object
- all light sources must be infrared and eye-safe to prevent any disturbance and harm to people on the marshalling yard

Temporary test site Rail Cargo Austria, cargo terminal north-west, Vienna, Austria

Background estimation 24 hours a day: Only those images shall be stored and evaluated which actually show a passing train. Interferences due to sunlight are unavoidable, which is not a specific problem for this site but rather typical for optical outdoor applications.

Locate and automatically read relevant IDs: A multitude of different fonts, a wide range of contrasts and surface structures require tricky optimisation steps to find a well-working setup in reading IDs.

Evaluation results: Without supplemental matching data from a central system and with reasonable effort for tuning the algorithms, average performance values around 60% for waggon and container ID turned out to be typical for day and night operation.

Keep Compliance High: Roadside Enforcement Systems

(Application Sample 2)

Busy all day long, during all seasons: Roadside equipment e.g. for the nationwide bus and truck tolling systems in Austria and Switzerland to soundly identify liability (permissible maximum weight more than 3.5t) and class of passing vehicles, to read license plates and to keep images as means of evidence.

While a patented arrangement of outdoor laser scanners detects, tracks and classifies passing vehicles, triggered cameras with related infrared flashes acquire images from the scene and provide these images with optimised contrast for automatic LPR (Licence Plate Recognition).

Truck tolling test site on highway A22, Vienna, Austria

Improve Road Safety: Smart Camera-based Wrong-Way Driver Detection

(Application Sample 3)

Proven wrong-way driver detection for highways: A compact smart-camera system provides real-time alerts for central alarm management and immediate local signalling with multiple traffic lights and active displays.

Seen at highway A9, Gratkorn Süd, Austria

Optimise Showrooms:
Identify Eye-Catchers and Subliminal Customer Behaviour

(Application Sample 4)

Reliable determination of consumer behaviour more detailed than on the level of pure volume of sales usually is an expensive and time-consuming task. A visual process which automatically records the customers' whereabouts in the shop can be an impartial and convenient way of identifying eye-catchers and typical behaviour in a showroom.

Interio, Ringstraßen Galerien, Vienna, Austria

Really got passion, time and money to manually analyse thousands of those images again and again? Say no, instead let ambient-tolerant algorithms do the boring job for you:

Migrate Swarm of Honeybees: Keep Queen in the Beekeepers Realm.

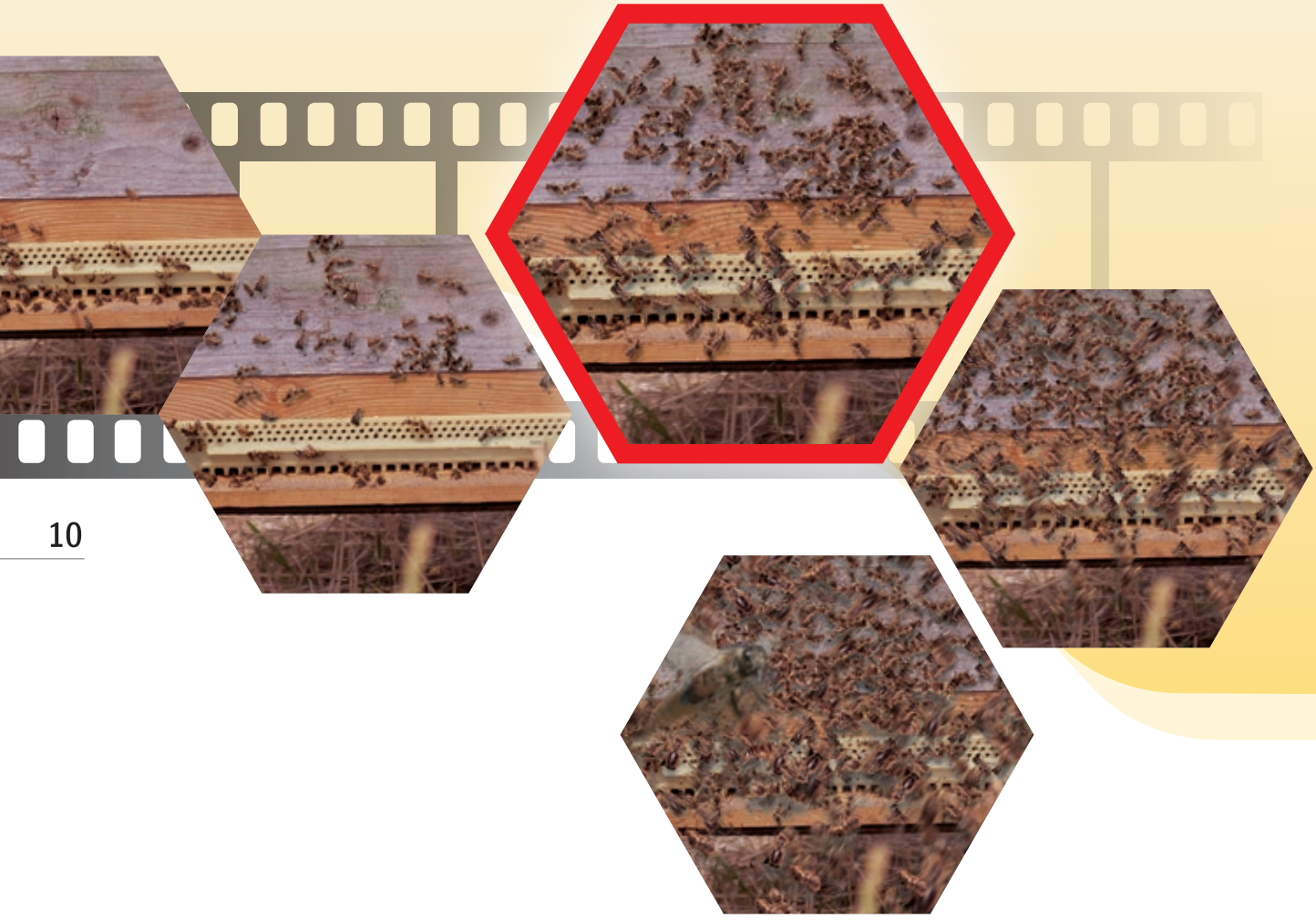
(Application Sample 5 from a draft discussion in the *Smartspector Future Lounge*[1])

An ambient-tolerant perception system shall detect pre-swarming activities and forward an alarm message to the beekeeper.

Contrasting with previous sample applications, such algorithms do not rely on the tracking of individual beings; rather, the global behaviour around the hive has to be investigated.

Supplemental non-optical sensor-data significantly improves the hit rate and minimises the probability of false alarms. In particular additional consideration of ambient temperature qualifies seemingly abnormal behaviour, because bees tend to quit the hive temporarily at high temperatures.

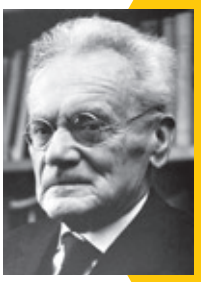
With inspection over an extended time period and visual input from several hives close to one another, medium-term adaptive algorithms calibrate automatically to keep the installation and setup-procedure easy.



1 *i.e. casual meetings with friends and partners from different lines of research and business with the purpose to exchange views and opinions beyond everybody's day-to-day business*

Did you know?

Karl Ritter von Frisch ...



studied the senses of bees

- The bee's sense of colour and shape (1914-1915)
- The bee's sense of smell and its significance during blooming (1919)
- The bee's sense of taste (1934)

identified their mechanisms of communication

- Bee's ‚language' - an examination of animal psychology (1923)
- The bee's dances (1946)
- The dance language and orientation of bees (1967)

showed their sensitivity to ultraviolet and polarised light

- The polarisation of skylight as a means of orientation during the bee's dances (1949)
- The sun as a compass in the life of bees (1950)

Karl Ritter von Frisch was the first to systematically investigate the sensory perceptions of honeybees and the way these insects communicate among themselves. His theory was disputed by other scientists and greeted with scepticism at the time, but after decades it was definitively proved to be an accurate theoretical analysis.

Along with Konrad Lorenz and Nikolaas Tinbergen, Karl Ritter von Frisch was finally, in 1973, awarded the Nobel Prize in physiology and medicine for his achievements in comparative behavioural physiology and pioneering work in communication between insects.

Like numerous other exceptional personalities, he was not only enthusiastic in his research activities but he also found his vocation in providing non-experts with an understanding of his field of research and coherences in nature.

Round dance

Tail-wagging dance

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