Biomimetics Strategies to Overcoming Noise

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Abstract Noise is considered an artefact, in the practical use it is overcome by cool down the system in general at 77 K. We consider three biological examples which overcome noise by filtering the ratio between the signals and noise by using a distribution system. Noise is considered here in statistical terms poison, where the incident photon or otherwise in a detector and the detector has not influence and cannot increase.

Keywords Thermal noise · Poison · Signal/noise ratio optimization · Infrared · Terahertz and magnetic detectors

1 Introduction

Noise, as defined by Frieden [1], assumes that x_m is an event (for example a photon) where $P(y_m|x_n) = P(y_m)$, and P is the probability, y_m is the event passing through a filter or communication filters, by the law of largest numbers (i.e. the sample size gets closer to the average size of the whole sample).

Dereniak et al. [2] described noise using the analogy of a set of automobiles exiting a highway, and to be able to be detected, the automobiles need to exit at

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same speed and distance since the photons event are random, the only option of detecting them is by slowing them down by cooling systems (77 K).

While noise as found in near infrared is described by Holst [3], many factors affect the transmittance; factors like airborne particle affect the transmittance of any signal, this is much less in far infrared (Terahertz). For this reason, many applications like medical ones consider far infrared scanning systems. Other types of noise, found biological systems include magnetic field noise, which is produced by thermal motion of electrons (Johnson Current Noise) [4].

Nature gives us several examples of how noise overcome [5]. Biological systems evolve in the direction of minimizing cost and saving resources [6]. We are considering three natural examples that may solve the problem of noise in near infrared systems: Phyton, Middle Infrared: *Melanophila acuminata* Beetle and Magnetic Fields of *Magnetospillium magnetotactum*.

2 Methods

2.1 Snakes

Pytone were obtained with help Pittsburgh Herpetology Society and through privates' breeders. The snakes where kept in room temperature, under strict ethical conditions, and fed once every week [7–9].

2.2 Histology

Frozen sections of Pythonomie and Boniae sensor were cut 5.00 μm mounted on slides and stained with Azure methylene blue eosin dissolved in phosphate buffer solution which gives a nuclear purple colour [10–13].

2.3 Melanophila Acuminata

Melanophila acuminata were provided by Richard Westcott and Nathan Schiff. They had been collected from two locations: the Sandy River delta in Multnomah Co., Oregon and Olallie Lake in Jefferson Co., Oregon, in the Cascade Range at 1615 m elevation. The beetles were kept at 25 °C in a humidified environment and were fed raisins, peanuts and water.

2.4 Histology

Frozen sections of beetle sensory pit organs were cut at 5–10 µm thickness, mounted and stained with fuchsin Schiff, naphtol yellow and Sudan black [14] for differential staining of lipids [15–18], proteins [19] and polysaccharides.

Magnetospirillum gryphiswaldense was grown micro aerobically in flask standard medium [20] for 24 h at 25 °C as described earlier [21]. Cells were harvested by centrifugation (10,500 × g, 20 min, 4 °C) and washed twice with ice cold wash buffer (20 mM Hepes pH 7.4, 5 mM EDTA). Cell pellets were stored at −80 °C until use. Magnetosome isolation and purification with minor modifications was performed according to the protocol of Uebe et al. [22].

2.5 Scanning Electron Microscopy (SEM)

The SEM micrographs were taken with an electron microscope Phillips XL 30 FEG SEM. The electron microscopy samples were treated with ethanol to remove lipid in the cuticular region.

2.6 Zinc Phosphide

Single needles of zinc phosphide (Zn_3P_2) were grown by physical vapour transport [23] in a two zone furnace. Powder Zn_3P_2 (Sigma Aldrich) was used as the source material for needle growth. The material was [24] sealed under vacuum (<1 Pa) in quartz ampoules in which the growth took place, and were carbon coated by cracking of methane at 1000 °C in order to avoid chemical reaction between the Zn_3P_2 and the silica and prevent oxidation [25].

3 Results

Phyton has been described earlier in a morphological study by Weyand et al. [26]. The snake does not have a specific specialize sensor [9, 27–33], but Fig. 1 shows the system is just open ended nerves.

In the case of *M. acuminata* specialized sensor are present [34]. Figure 2 shows the sensor and Fig. 3 shows the sensor after special staining.

In the case of *magnetosomes* many examples can be considered; Fig. 4 shows the magnetosomes in *Magnetospirillum magnetotacticum* with flagellae used in orientation from a higher gradient to a lower oxygen concentration within magnetic fields [35].

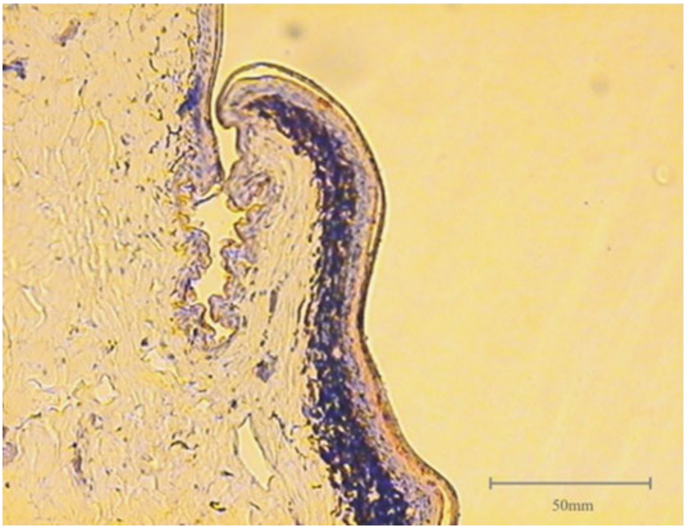


Fig. 1 Shows the open ended dendrites (where nerve activity occurs) which act as the sensor in python (via azure Methylene blue Eosin) [26]

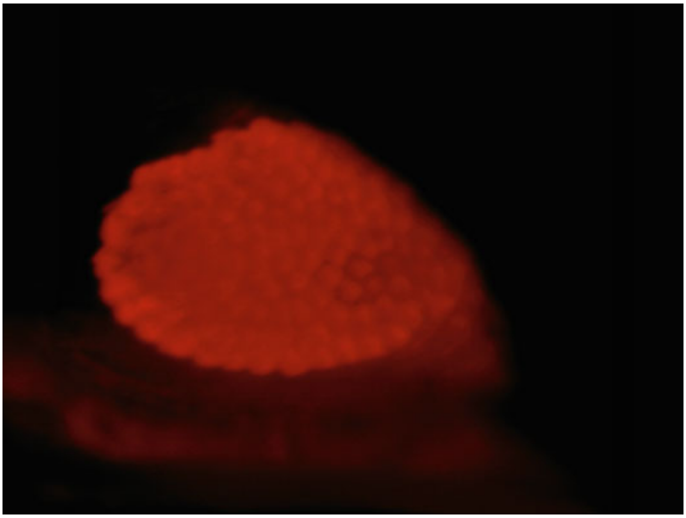


Fig. 2 Shows the sensor system of *M acuminata* under fluorescent light, consisting of 150–200 sensors

4 Discussion

Each of the biological examples have designed sensor systems that are adapted to reduction of noise, in some case more specialize than other just using what is available to achieved a functionality. In the case of Pythons, the IR detection

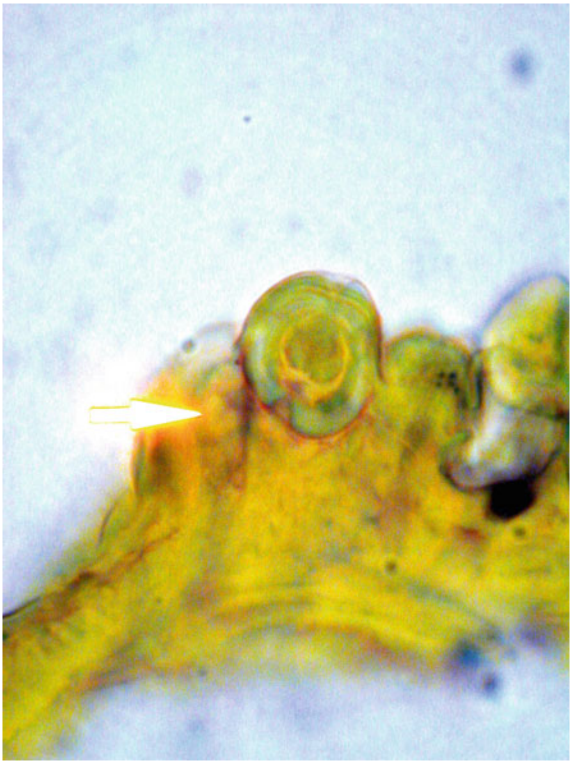


Fig. 3 Shows the sensor system of *M acuminata* after special staining. Staining denotes different components of the sensor, yellow is protein, and green is a mix of lipids with protein and red polysaccharide

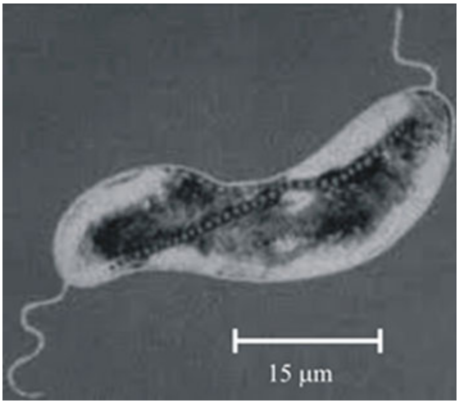
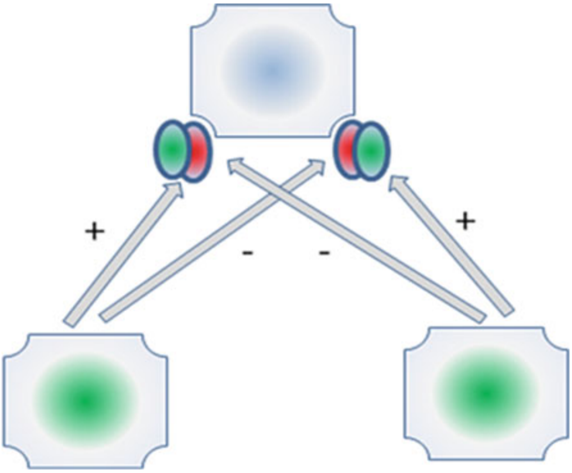


Fig. 4 Shows the magnetosomes in *Magnetospirillum gryphiswaldense* used to orient itself in magnetic field

mechanism is not made of photoreceptors—while photoreceptors detect light via photochemical reactions, the protein in the pits of snakes is a heat-sensitive ion channel (actually a temperature sensitive ion channel). It senses near-infrared signals through a mechanism involving warming of the pit organ, rather than chemical

Fig. 5 Shows a binary inhibitor model with excitatory synapses



reaction to light [36]. *M. acuminata* has specialize sensors and the mechanism is photoreceptor-based [37], whereas in the case *magnetosomes* the system is based on magnetic field gradient [38].

The two options are possible to study Biomimetics strategies to overcoming noise: The first option utilizes the insertion of clamps for measuring signals originated from the activated sensor, and it is found in the biological process [7, 39]. The second option is to simulate the sensor using hybrid neural net structure, which involves two processing levels. The first level is for Signal/Noise ratio optimization done by so called DLS spectra and the second a biologically inspired visual signal processing unit (basic module) which models optical and acoustical pattern recognition in ear and eye; by a three-neuron-structure with INEX-synapses (Binary inhibitor model) as shown in Fig. 5. This basic module structure—which solves also the XOR-problem—is a high sensitive edge detector enabling the accentuation of even minimal contrasts in visual scenes [40–45].

This model works well with any level of signal input and when *M. acuminata* sensor is simulated it is shown to take an average of the signal, filter the noise since the sensor is continuously taken samples filtering the signal, which is possible to obtain information, a system to simulated based on specific process for example using Zinc phosphide [24, 46, 47] micro-wires [25, 48, 49], such system can be possible Fig. 6 show a single microwire and Fig. 7 shows the setup microchip setup (Fig. 8 shows the reader), with the signal reader and the same concept can be applied to *magentosomes* as show elsewhere [50, 51].

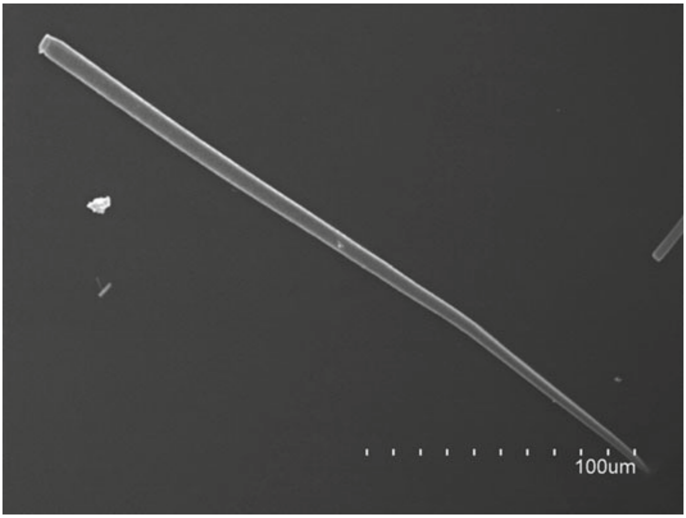


Fig. 6 Show a single Microwire as the building block to build the microchip, the diameter is 50 microns with a length of 100 micros

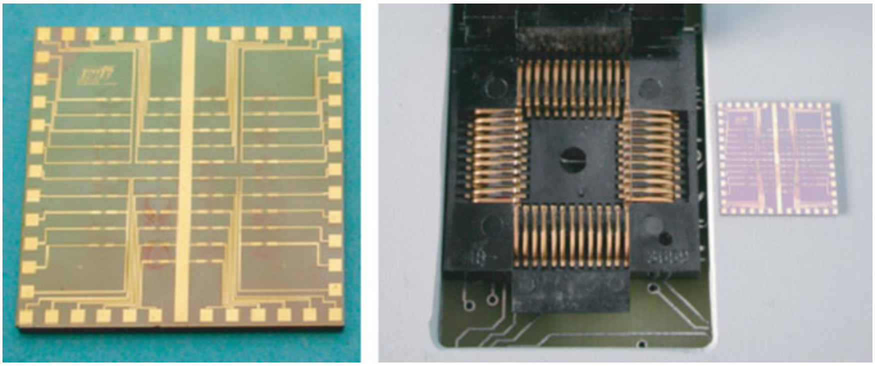
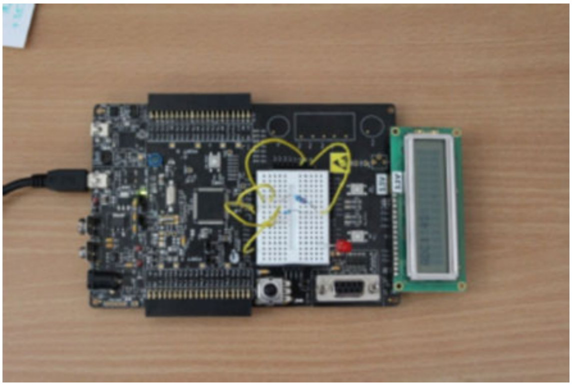


Fig. 7 Show the microchip and the space to set the microwires

Fig. 8 Inlet sensor readout and data processing



5 Conclusion

Distinct biological systems use the same principals to overcome noise by multiple distributed systems [52, 53], whether it is due thermal or photons, by having multiple sensors as a solution; this arrangement can average the ratio between the signal and noise. Noise as mention when the sample is sizes of the whole signal ratio crated the noise by continually picking the sample refined the signal in each case to achieve an objective, snake for pray, *M. acumainata* can detect fires from 150 km, using the burn wood, which is actually soft to deposited eggs, then larvae have protection and food. Bacteria case is anaerobic, moving from higher concentrations of oxygen versus lower concentration since the iron oxidises and sulphide iron oxide is found in this regions. The biological systems show a solution for far infrared, terahertz and magnetic detectors.

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