Varia zoosystematica profundorum

Experimental studies in deep sea communication

Generative Art/Computational Art Class

(Prof. Alberto de Campo), UdK Berlin

Recent biological research shows that fish communicate much more by sounds than was previously assumed - for example, the catfish hunts by driving its prey into specific areas by making loud sounds. ["Stumm wie ein fisch?" Wohl kaum!]

Marine mammals such as whales and probably dolphins are known to communicate acoustically over large distances; by comparison, very little is known about communication in the deep sea. From ca. 700m below the surface, the sea is completely dark, the only light sources are animals generating light by bioluminescence. As sound carries very well in water, it is plausible to assume that much deep sea communication is acoustic. Some species like the fawn cusk-eel (Lepophidium profundorum) are known to develop special muscles for making sounds during mating season, and some fish are known to make sounds by grinding their teeth; more unknown means of sound production are to be expected.

To address these open questions, the Generative Art/Computational Art class at UdK (Prof. Dr. de Campo), has developed models for Deep Sea communication, inspired by the work of Louis Bec and Vilem Flusser: A number of agents simulate aspects of the communicative behavior of different deep sea creatures. They transmit symbols ("letters") to each other which each individual assembles into longer chains ("words"); when an agent / creature has collected a word it deems meaningful, it expresses that word by emitting sound, light, or motion patterns. Some creatures generate rhythmic pulse sequences, some almost melodic phrases. Others let hues of colors flash over their skins, while others again float up and down in space in response to the conversation between them.

Despite the remoteness of this habitat, these observable communication forms may well be inadvertently influenced by human intervention: Songbirds are known to adopt the varying sound patterns generated by new car alarms into their songs; Wolfgang Mueller's work "Hausmusik" posits that the starlings now living near Kurt Schwitters' summer house in Norway sing variants of Ursonate segments learned by their ancestors who have listened to Schwitters practicing the Ursonate (and possibly being influenced by them as well). Submarines have been present in the deep sea since World War I, communicating by radio/encrypted morse; as sea animals may well have electromagnetic senses, and deep sea magnetic ore might well decode electromagnetic transmissions into mechanical vibrations, it seems quite likely that deep sea animals have been sensing and hearing messages as morse code rhythms for more than 100 years. As these patterns are also very robust against interference, and thus a potential advantage in natural selection, the deep sea creatures may very well have adopted such rhythmic encoding in sound and electromagnetic waves for their own communication purposes...

Simulating aspects of animal behavior allows studying phenomena that are difficult to observe in the wild; beyond that, given the freedom of such works in artistic contexts, one may also find that the strangeness of the unknown reflects the human world and its subjective experience in unexpected ways.

The current show at UdK Berlin is a preview for the full installation, which will by shown at Grosser Wasserspeicher Prenzlauer Berg, Berlin, from Sept 17 - 26 2010, thanks to an invitation by singuhr hoergalerie.

The individual creatures:

Paulantinautius divinatio - Bernhard Bauch

Anarchiteuthis benjolinensis semiprofundus - Alberto de Campo

Flexoteuthis - Dominik Hildebrand

Monatom - Akitoshi Honda

Vuvuzeloida diaboli silvestris bandaniensis - Ingrid Ladurner

Sweetysourus - Karin Lustenberger

Laufwerk - Naomi Mulla

Kaanikto Kanakta - Christian Zollner

In early stages of observation:

Humilis coconis - Tobias Purfuerst

Meteor Deep - Constantin Engelmann

Still under study - only sounds or images, no classification yet:

Mystery2 - Sarah Rechberger

Mystery3 - Johanna Tauber, Naomi Mulla

for continuously updated results, see:

http://entropie.digital.udk-berlin.de/wiki/DeepSea

A preview of this installation was shown at the UdK Berlin Rundgang 2010. The first full presentation will be shown at Grosser Wasserspeicher Prenzlauer Berg, Berlin, from Sept 17 - 26 2010, thanks to an invitation by Carsten Seiffarth and singuhr hoergalerie.

see also:

Acta infernalia 2010/7, pp 42-66.

Fine, M.L., Lin, H., Nguyen, B.B., Rountree, R.A., Cameron, T.M., and Parmentier, E. 2007. Functional morphology of the sonic apparatus of the fawn cusk-eel Lepophidium profundorum. Journal of Morphology. 268:953-966.

Flusser, V., and Bec, L. Vampyroteuthis infernalis. 1993, Göttingen.

Varia zoosystematica profundorum, vol XVII nr 3, pp 21-45.

This is a project developed jointly by the Generative Art / Computational Art class

at Universität der Künste Berlin:

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Naomi Mulla	Sarah Rechberger	Johanna Tauber
Andre Wakko	Christian Zollner	
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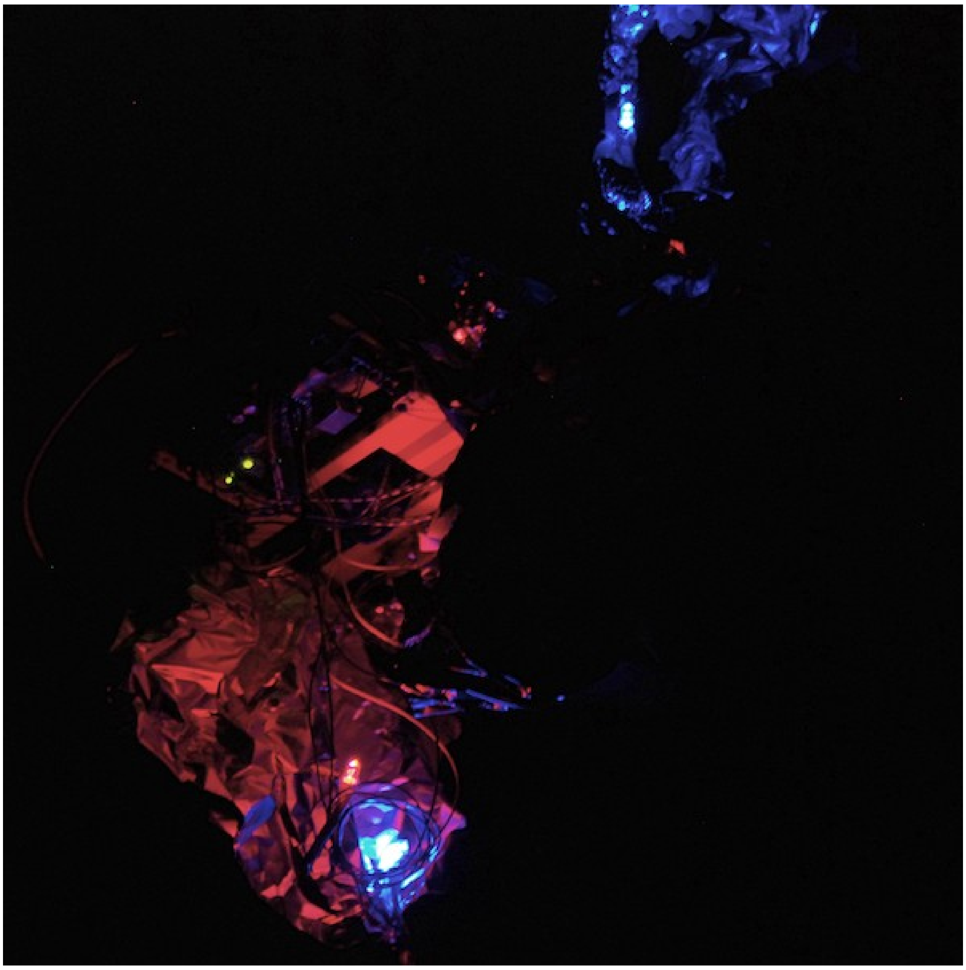
Tobias Purfürst	Johann Scholz	

The following models are the first three creatures in alphabetical order. More models of the individual creatures can be found at http://entropie.digital.udk-berlin.de/wiki/DeepSea.

Paulantinautius

(Paulantinautius divinatio)



Paulantinautius divinatio are deep sea octopuses belonging to the family of Bathypolypus arcticus. They normally live in depths from 1900m and below. Their most famous specimen was just brought back to its original environment after playing the widely publicised role of Paul the "WM-Krake".

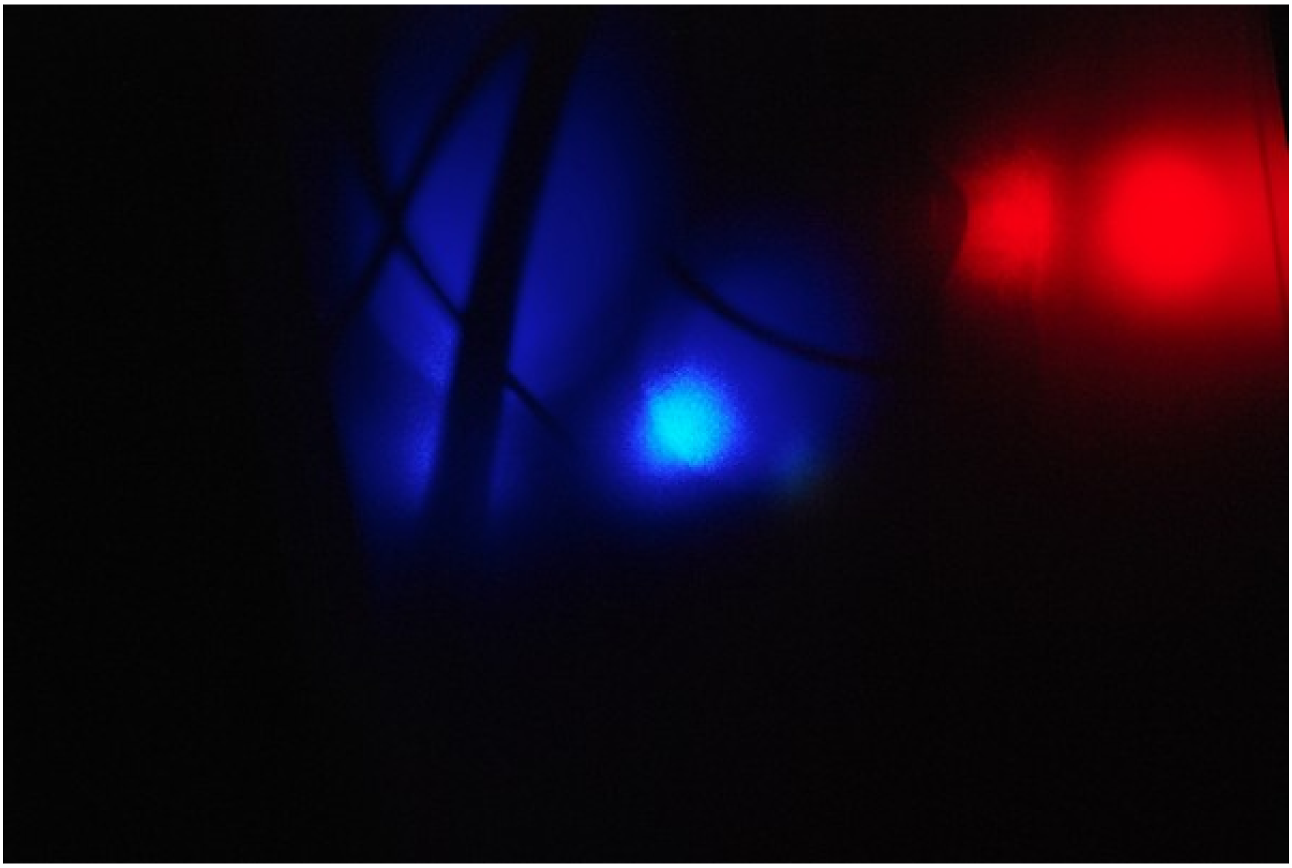
Research has determined that they use wavelength between 650 to 750nm and 420 to 494nm (humans would see this as blue and red colors) to perceive their surroundings and to navigate safely in the deep sea. They use audio frequencies between 3234Hz and 8038Hz to communicate with each other and discuss their last predictions. With a very special swim bladder, quite unlike those of any related speics, they are able to move vertically. A body part resembling a water propeller lets them move horizontally.

Unlike normal octopuses (having three hearts) the Paulantinautius has four hearts. This may play an as yet unexplained role in the popular myth that these creatures have tendencies toward soothsaying the future.

Model created by Bernhard Bauch

Anarchiteuthis

(Anarchiteuthis benjolinensis semiprofundus)

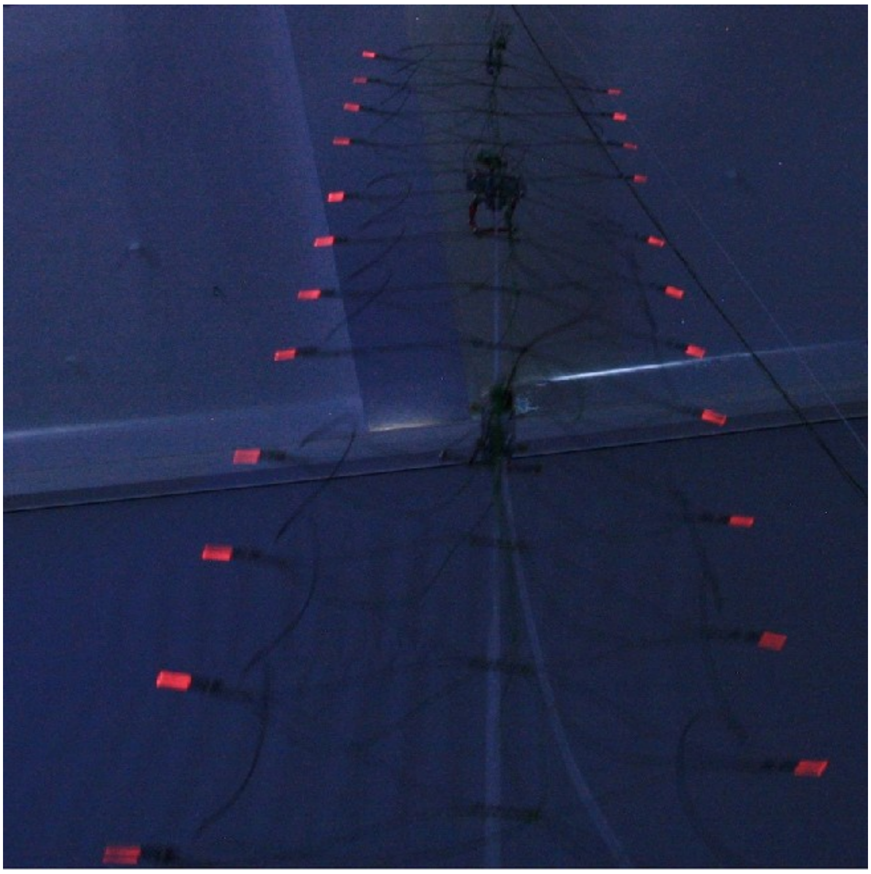


Anarchiteuthis benjolinensis semiprofundus is a deep sea octopus belonging to the Subclass Octopoda. They are known to communicate by electromagnetic means - details are discussed controversially between different research groups. They produce moving bioluminscent hues on their skin, which are considered likely to be a form of communication; details on what they communicate are unclear. Anarchiteuthis is a very recent discovery, and the model shown here mainly focuses on its acoustic expression; less on its visual communication by flashing colored hues on its translucent skin. They live in the Hadal zone, the deepest crevices in the ocean bed.

Model created by Alberto de Campo.

Sound production and light control employ the Benjolin instrument designed by Rob Hoordijk.

Flexoteuthis
(Flexoteuthis elongabilis)



Flexotheuthis is an extremely rare species which lives exclusively in very deep marine crevices, below at least 2500 meters. They are extremely sensitive to changes in the electromagnetic field. Current research results seem to suggest that this sensitivity aids them in fleeing and seeking safe shelter when submarine earthquakes occur. Flexoteuthis is one of the very rare species which possess a bioluminiscent nervous system; interestingly, the nodes (two for each body segment) also create wide-spectrum sonic pulses, which can be heard over considerable distances. Current hypotheses mostly agree that these sounds serve communication purposes with fellow members of their species. Some researchers favor the interpretation that their "song" mainly is a form of self-entertainment, and expresses their subjective well-being and contentment; their nervous system appears complex enough to justify the existence of such higher order mental states.

The model shown here is a baby flexoteuthis of ca. 3m body length when extended; until today only sub-adults have been found. It is generally expected that adult specimens will continue growing as long as they live, and will easily reach body lengths of 10-15 meters and more.

Model created by Dominik Hildebrand

Laufwerk

(Testudo marino-digitalis monopedes)

Laufwerke are marine testudides, and as such, members of the order stomatopoda. They live in the benthic zone of the deep sea and reach a standard length of 19 cm and 31cm with their mouth open. Due to their extravagant mouth-apparatus, Laufwerke are the only species known that appear to grow by half of their normal body-length during food intake (ingestion).

Anatomy and behaviour

Lacking a stomach, brain and almost everything except for the mouth, the predominant task in life of a laufwerk is eating. Due to the absent stomach, and the resulting inability to store food, Laufwerk requires a constant supply of food. This has introduced evolutionary pressure to integrate many other vital attributes into the ingestion mechanism. The most stunning result has been the very recent discovery of a so called "dessert stomach" (gaster dulcis), which serves to digest food with a sugar content over 30 percent, or generally food where the sum of sugar and fat contents exceeds 100%.

Like in most of living beings, the hard structure of Laufwerk's mouth is composed of upper and lower jaw, with an interesting difference: Instead of a joint between the two parts, the upper jaw is embedded in the lower jaw and slides in and out of it like a drawer (prognathia inferior variabilis).

Locomotion and digestion

The particular functioning of the mouth, which has not been observed in any other animal so far, is the basis of the musculoskeletal system of laufwerke. For locomotion, they have developed a foot connected to the upper jaw by a joint, called the predentary bone. While moving out the upper jaw, the bone gets driven into the ground, until further movement of the upper jaw is inhibited. The kinetic energy transfers to the lower jaw, which results in a forward motion of laufwerk. During the inward-motion of the upper jaw, the predentary bone is loosely dragged behind. Simultaneously with locomotion food intake takes place. Like species of the phylum of brachiopoda, laufwerke do not egest. They digest without remains. They neither belong to the classification of the Urmünder (Protostomia, mouth first) nor to the Neumünder (Deuterostomia, after first). Laufwerke belong to the Nurmünder (Monostomia, mouth only).

Mechanical intelligence

The apparent lack of a central nervous system (a brain) has also created an interesting evolutionary solution: mechanical intelligence. Laufwerke move passively with neither notion nor volition. The only change in direction appears when confronted with an obstacle. In case of collision a disk-bone on the lower jaw is activated and performs a gyroscopic motion, which results in a scanning process of the environment.

Model created by Naomi Mulla.

Methodological Notes

Scientific research has long been defined by the balance between observation of phenomena of interest, theoretical predictions (abstractions derived from observation), and experimental proof of these predictions; with the advent of computing, model-making ("simulation") has become a strong third base for scientific exploration. In several interviews, V. Flusser defines "reality" as a vanishing point which human experience research can asymptotically approximate; in this sense, simulation is creating alternative realities which can be equally valid for their respective context.

In biology in particular, this view leads to interesting perspectives: Large groups of people find experiments with living beings ethically problematic, as they are sentient beings (the role of perceived evolutionary proximity is interesting here). The gradualist view of modern Darwinism finds that cutting a clear distinction between whatever cognitive or other skills define "human specialness" and the general animal kingdom is constantly shifting: every time a new criterion is erected, a species turns up that demonstrates the same skill.

After genomes for many species have been completely read, the idea that all relevant information for a living being is encoded in genomes has turned out to be simplistic; this is not a problem of genetic text interpretation. A lot of the data seem irrelevant (maybe this is genetic code shrouding?), many phenomena happen in symbiosis with other life forms such as pervasively present bacteria, and where higher order behavior “comes from” is even more unclear (e.g., the idea that one could find a "homosexuality gene" is very naive).

Since Popper, scientific theories are not absolute truths, but temporarily considered the best of our knowledge, and only correct until falsified. For possible epistemic strategies, Considering how many formerly absolute truths have been toppled already, this calls for more epistemic humility. One new heuristics based on these insights is to assume less and hypothesize more, ideally in falsifiable ways - Speaking with Robert Musil, one can develop a sense of the possible, a “Möglichkeitssinn”.

This is the background for the approach of the present work, which could be called exploratory or simulative zoosystematics. Of course the pioneer work by Vilem Flusser and Louis Bec haven been major sources of inspiration here; however, rather than modeling individual specimens in rich detail, we have concentrated on modeling their shared behavior, mainly commonalities in communicative behavior across species.

The Communication Model

We posit that the basic pattern of communicative behavior shared across species in the environment we model works as follows:

- An individual waits for incoming elementary signals, be they acoustic, light, or electromagnetic radiation. As each individual generally often also sends such signals, there is a relatively constant stream of signals coming in.
- Of these signals, it collects those it finds interesting, based on its own set of preferences (which can be personal or species-based, or both)
- The signals it keeps in short term memory are arranged into longer strings of signals, based on local context (i.e. an already assembled partial message in working memory).
- When it deems a word complete, that word is expressed in some form: as a sound pattern, as light hues flashing over the animal's skin, as a rhythmic motion pattern, as electromagnetic radiation patterns, or as combinations of several modalities.

This produces a characteristic distribution of activity: When one observes an individual being, it will seem largely inactive most of the time; however, an observer sees and hears light and sound patterns by other animals nearby. When the observed animal becomes active, its sound and light patterns will be both individualized (it chooses its own preferred style of self-expression) and shared: some properties, like distance patterns in what could be called expressive parameters, and especially relationships in time patterns ("rhythms") will reveal themselves to the attentive observer.

Sending signals and full messages costs energy; receiving them generates energy within each animal. When its energy sinks very low, it goes into a hibernation-like mode where it does little until it reaches high energy again; at high energy, it becomes hyperactive until its energy is near its average again. Within the group interaction, this leads to overlapping cycles of activity that create remarkable variety in the overall sound/light-scape of activity.

Note that for this modeled behavior, the precise nature of the individual atomic signals and their assemblages, as well as their meanings, are irrelevant: to observe communication behavior in a general sense, it is not necessary be able to understand the details. Thus, for practical reasons of simplifying understanding, we chose alphabetical letters as the individual signals, and strings of letters as full messages ("words").

We further posit that there is second level of "objects of interest": Each animal is assumed to have a background of several "magic words" it finds particularly attractive; incoming "word"-messages are compared to these magic words, and when they are similar enough, lead to heightened activity - this mode has been affectionately nicknamed "song and dance", or "party mode".

Preliminary conclusions

The behavioral richness of a modeled submarine communication ecosystem is quite rewarding for the careful observer: One can switch perspectives between activity at different distances. Here, the similarity of the location the piece has been developed for (Grosser Wasserspeicher Berlin) to the deep sea has been inspirational: it is very dark, very quiet, and has very long reverb decay. This preserves sound energy so well that one can still hear sounds from 100m away in the silent phases of the nearer creatures.

Maybe the most interesting insight is that even with large species-based and individual differences in expression of the discourse of messages, a careful observer can develop a fine ear for the shared vocabulary of elements.

Future work

Many aspects of the models have only been touched, and warrant further consideration:

Some individuals have only been sketched roughly, and fleshing out more details will make the overall ensemble behavior richer.

The animal's reactions to environmental influences are quite simple at the current state of development – in essence, most of them find intrusive observers a source of irritation. Here, a mix of curiosity and reluctance could produce intriguing interactions, not just with their known habitat neighbours, but outside influences too.

Introducing long-term memory is quite likely to produce interesting longer cycles of behavioral evolution; logging long runs of ensemble activity will create very rewarding material for analysis, generating further ideas for next directions to experiment with.