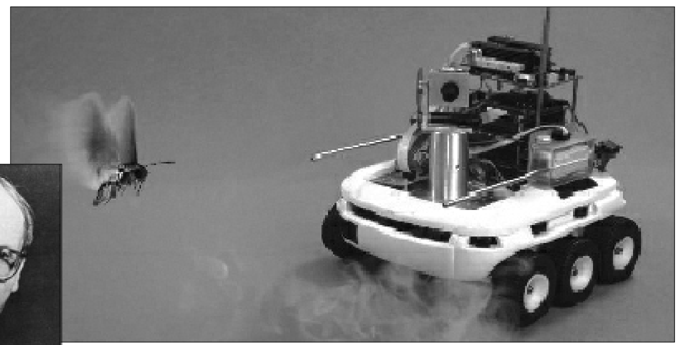
Leading by the nose

Twin strategies to locate where the smell of food is coming from ensure that fish do not go hungry, writes **S Ananthanarayanan**



Insect behaviour inspires search algorithm for robots

OVER the past two weeks, the journals *Nature* and *Current Biology* have carried separate reports on search strategies used in the natural world. One is of a "random walk" approach to improve the quality of scent information from a faraway source and the other is of the wide placement of nostrils of the hammerhead shark, to help get a clear fix on the origin of the odour.

Smell, as it radiates from a source, gets fainter and fainter. Sensing the direction of the fastest fall in strength would then indicate where the smell is coming from. This method can work so long as the smell is fairly strong and the fall in strength is discernable. But in real conditions, the smells are from a distance and are quite faint. Add to this the turbulence in the air or sea water, and determining a rate of fall in intensity, in some direction, is not practical.

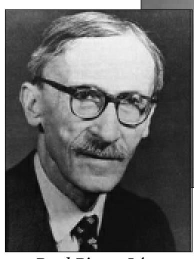
Natural systems, like fish that forage in the sea, or insects — like moths and butterflies — that find others of their kind with the help of smell have developed methods of polling the neighbourhood and then applying statistical methods to work out where the smell is coming from.

In January 2007, MassimoVergassola, Emmanuel Villermaux and Boris I Shraiman reported in *Nature* a method of rapidly polling the neighbourhood for signs of a strong or weak or no signal. The zig-zag motion soon yields a direction of "increasing information", which itself directs the manner of polling. This then leads to a direction of "increasing" the signal which can then be directly followed in a straight line. The zig-zag action, to collect information, is called *infotaxis* and the direct dash along the line of the strongest signal is called *chemotaxis*.

Lévy flight

The behaviour of foraging animals has been studied mathematically, important work being by French mathematician Paul Pierre Lévy (1886-1971). The Lévy flight consists of a number of short random movements interspersed with an occasional dash of greater length. The other kind of random movement is the *Brownian* motion, named after the Scottish botanist who detected the motion of molecules from the way tiny particles in suspension were knocked about. In the Brownian motion, the displacement from the starting point does not increase as fast as time passes because many movements would be in the return direction. The Brownian motion is, thus, more localised than the Lévy flight.

Random motion can take different forms depending on the kind of behaviour of the organism, through long steps or through frequent steps — be it in the case of the colliding molecules of a gas, the movement of prices of stocks and shares, the fortunes of a gambler or the gait of a drunkard. There are different mathematical representations that reduce to similar results in the very long run but show a short term behaviour characteristic of conditions that appear as parameters in the mathematical formulae.

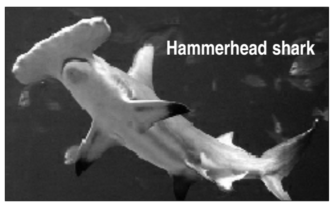


Paul Pierre Lévy

In the case of foraging animals, the Lévy flight foraging hypothesis holds that such flights are effective where prey is sparse and distributed unpredictably, but that the Brownian movement is good enough when prey is abundant.

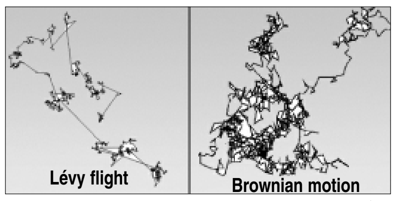
Verifying the hypothesis

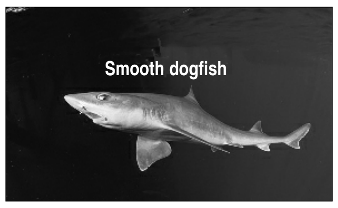
While studies had overwhelmingly shown that the hypothesis is true, recent reviews have questioned the validity of the statistical methods used in verification. Whether Lévy flights are found in real conditions has, thus, not been clear, nor have there been reliable studies in natural conditions that have different resource distributions.



The work of the multinational team, whose report is carried in *Nature*, has addressed this need for a rigorous study. They employed statistical methods known for robustness and accuracy on a vast animal movement data set assembled over 5,700 days. The time stamped depth data was collected using electronic tags attached to 55 individuals of 14 species of shark, tuna, bill fish and ocean sunfish, which prey in the open sea.

The Lévy search pattern was found to be prevalent, with some individuals switching to the Brownian motion pattern as they transited from sparse-prey waters to abundant-prey waters. The hypothesis, hence, looks like a good one — that foraging by exploiting optimum Lévy flight patterns has been selected in species through evolution because this leads to survival.

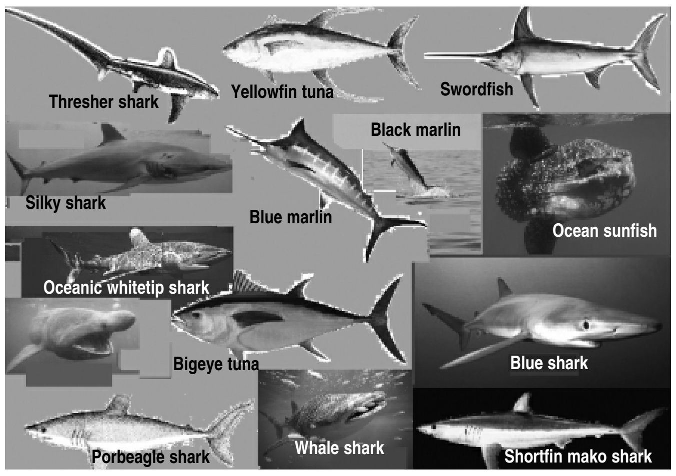




Pair of nostrils

Fish also smell, not through the organ for breathing, like mammals, but through a pair of openings just above the mouth called *nares*. These openings course samples of water, either by a pumping action or because the fish is in motion, to sensory organs that detect odours.

The journal *Current Biology* carries a report by JM Gardiner, Florida, and Jelle Atema, Massachusetts, where they find that the pair of nares of fish can act like our own pair of ears, which helps us locate a source of sound. Except when the sound is exactly in front or behind, the sound strikes one ear a split second before it strikes the other. This slight time lag helps us learn to identify the source of sound. In the case of sound, where there are continuous sound waves, it is actually the slight difference in the progress of the wave, called its *phase*, that carries the information, but the difference remains because of one ear being slightly further away.



Gardiner and Atema felt that as water was usually in motion, the concentration of odours was generally uneven and the direction of higher concentration alone could not be a reliable indicator of the source. They tried, instead, the feature that an odour spreading out would usually strike one side of the fish earlier than the second. They designed an experiment where a variety of shark, the *Mustelius canis* or the smooth dogfish, was exposed to bursts of odour to each nare, one after the other. The dimensions of the selected fish and its swimming speed match the speed of the dispersal of odours in water.

They found that the fish turned towards the odour burst that came first, for time gaps up to half a second, even if the second burst was of higher concentration. This is the first confirmation that the side-to-side time difference can be more important than the difference in concentration.

Animals with wider-spaced nares would thus be able to better resolve the source of odours, even at narrow angles and at higher swimming speeds. This may explain the evolution of the hammerhead shark, which has widely separated nasal openings on either side of its wide head.

"In addition to giving insights into the evolution and behaviour of sharks, the findings might also lead to underwater robots that are better equipped to find the source of chemical leaks, like the oil spill that is now plaguing the Gulf Coast," the researchers s

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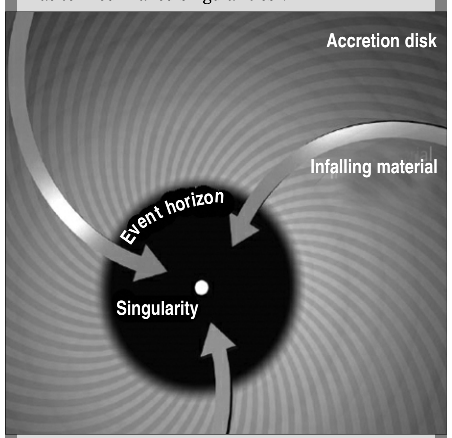
Stellar rebirth

Astrophysicist Pankaj S Joshi has shown that dying stars can be reborn, says **Sarthak Gangopadhyay**

PANKAJ S Joshi, an astrophysicist with the Tata Institute of Fundamental Research in Mumbai, has propounded a new principle on "naked singularities" — that dying stars can be reborn — which has taken space researchers across the world aback. Based on Albert Einstein's theory that the collapse of massive stars creates "singularities", he has shown that visible ultra-dense regions (billions of times more than the sun's density) develop as a result of collapsing stars.

The Scientific American, an international magazine, published Joshi's article, which is said to have been translated into 15 languages. It explains that when collapsing stars explode and their matter disperses in the universe, the layers that result give birth to new stars through condensation elsewhere.

What is so unique about this simple theory that has great implications for fundamental physics and cosmology? For the first time, it proposes an alternative to the traditional assumption that a big star, after collapsing, turns into a black hole. When a singularity is hidden behind an event horizon, it is called a black hole. The visible regions of infinite density are actually what Joshi has termed "naked singularities".



The astrophysicist believes that his new theory takes Einstein's contention a step further, allowing for greater insight. A star may collapse or shrink at any given moment after living for million of years, an issue that excites Joshi. His theory cannot be held to have solved the mystery, but it gives some clues regarding cosmic gamma ray bursts and helps unravel some high energy phenomena that occurs when viewed via a satellite.

The response to Joshi's new theory has been overwhelming. It will help cosmologists conduct more space research.

Sure way to pure

The prevention of poisoning as well as diseases consists in the observance of sanitary and hygienic measures in preparing food products, writes **Tapan Kumar Maitra**

FOOD is tested in the following cases: a) as a planned measure to control the observance of the sanitary and hygienic regimen in preparation, storage and realisation, particularly of stuff not subjected to treatment at a high temperature; b) when there is doubt concerning quality; and c) when toxicosis or other diseases occur due to intake.

The main task of microbiological testing of a food product is the determination of the total content of microbes and the model sanitary microbes. The model sanitary microbe for most foodstuff and water is E. coli.

Testing is also often done to detect the presence of *Proteus vulgaris*, Salmonella and aerobic and anaerobic organisms and for the toxins of these microbes.

The technique of collecting the samples and sanitary and bacteriological examination are fixed strictly by instructions in the corresponding State Standard. GOST 9225-68, for instance, specifies the methods for collecting samples and all the subsequent stages in testing milk, cream, ice cream, butter, koumiss (fermented mare's milk), yogurt, sour clotted milk, sour cream, acidophilin (sour fermented milk), cottage cheese and food prepared from it, dried dairy products, condensed milk and cold beverages prepared from milk. For testing, liquid foodstuff is diluted with sterile isotonic solution 1: 10. Compact products are melted or ground in the mortar and diluted in sterile water 1: 10.

Bacteriological tests of milk and dairy products are done to determine the total microbial content.

Sanitary and bacteriological tests of milk and dairy products consist in the determination of the total microbial content — microbial count — and the coli titre. In sour dairy products (yogurt, cottage cheese etc) the microbial count is not determined. The microbial count in milk is determined by a direct count and by inoculating nutrient media with 1 ml of different dilutions of the product tested. Dairy products should only contain specific micro-organisms or the given food, eg lactic streptococci and lactobacilli in sour clotted milk and lactobacilli and yeasts in koumiss.

The permissible microbial count in various dairy products ranges between 500 — children's mixtures subjected to pasteurisation and cooking — and 300,000 — cow's milk in cans and cisterns. The microbial count for pasteurised milk kept in bottles and packets is 75,000, for ice-cream 250,000, for condensed milk 50,000 and for dried cow's milk 50,000 per one millilitre.

The coli titre of dairy products is determined by a three-stage fermentation method and for most of them ranges from 0.3 to 3; only for children's milk mixtures, both pasteurised and cooked, it is above 11.1. Since milk and dairy products may be vehicles of the causative agents of certain infectious diseases (typhoid fever, paratyphoid fevers, brucellosis, tuberculosis, Q fever etc) these agents are identified by special methods. If pathogenic micro-organisms are detected in dairy products it is unquestionable that these products are not fit to be eaten.

The sanitary and bacteriological testing of meat and meat products comprises determination of the total amount of microbes per 1 gram of the product and the presence of E. coli, *Proteus vulgaris*, Salmonella organisms and anaerobes.

No stable norms have been fixed to date for the sanitary and bacteriological assessment of meat and meat products. According to the accepted provisional norms, the permissible microbial count for roast meat should be less than 500, for boiled sausage and meat jelly less than 1,000. The coli titre for roast meat should be above 1 gram and for boiled sausage and meat jelly more than 10. The presence of pathogenic and putrefactive microbes indicates that these products are not suitable for use.

Meat is tested to determine the total amount of microbes per gram plus the presence of E.coli

Canned foodstuffs such as meat, lard, beans, fish, vegetables and juices are also subjected to sanitary and bacteriological testing.

Canned food is tested microbiologically for aerobic and anaerobic micro-organisms and for the botulinum toxin. When there are epidemiological indications, canned food is tested for Salmonella organisms, pathogenic staphylococci and *Proteus vulgari*, the presence of these microbes shows that canned food is spoiled and cannot be eaten. It is permissible for canned food to contain non-pathogenic sporulating microbes, provided there is no bulging of the can and the organoleptic properties of the food are normal.

Fish, vegetables and egg are tested microbiologically, usually in cases of food poisoning or diseases. Tests are performed for detecting pathogenic and conditionally pathogenic microbes or their toxins by some commonly accepted methods.

Remnants of foodstuffs, vomit, lavage waters, faeces, blood, mucus, washings and scrapings and autopsy material may be subjected to bacteriological testing according to the epidemiological indications or on instruction of a health officer.

The prevention of poisoning and other diseases consists in the observance of sanitary and hygienic measures in preparing food products, their storage, transportation and realisation. It is also necessary to observe the rules for processing foodstuffs, especially for canning them.

Since food may get infected by the service staff among whom there may be sick persons or carriers of pathogenic micro-organisms, all personnel of food-supplying establishments must be examined regularly. Control of the vectors of the causative agents of intestinal infections is of utmost importance.

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