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Feature Article

DAY OF THE DOLPHINOID

An excerpt taken from a paper written by Douglas Moreman Ph.D, Dept. of Computer Science, Southern University,

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After the first reading of this paper, we sensed that the author had not been following the evolution of the AUV. But continuing to explore the paper's content produced a vision unspoiled by current thinking and concepts that were refreshing and somewhat poetic. It reminded us of the would be explorers who dreamed of sending unmanned vehicles to the stars... years before they did. (Editor's note)

Introduction

We propose to study methods of "higher level control" of the behavior of computer controlled robots, with autonomous research submarines being the first area of application. Let us think of methods of "lower level control" as sufficient to program an "automatic pilot" to follow a course, even one that has curves, in response to sensors of position and acceleration. Methods of "higher level control" would, by contrast, be used to compute the path, possibly through terrain with unknown features, making pit stops for refueling and re-calibration, deciding to visit site A before site B. It may be that site A appears to be "more interesting" due to interaction of parameters given by the end-user and measurements the robotic craft has made.

Our First Exercise in Ethorobotics:

A surface ship places and services several unmanned, seafloor-based submarine systems. Each system has one Home Base, immobile on the sea floor, and at least one microsub and an untethered submarine run by a microprocessor. Each microsub gathers data and reports that data to HomeBase while recharging its power supply.

We desire an adaptive system whose exploration will be guided by the discoveries of its past exploration and by changes, possibly accidental, in its own performance parameters. We will attempt to use lessons learned from the study of the behavior of animals. Conversely, questions raised in autonomous robotics may lead to new research in animal behavior.

To design an "intelligent being", we begin with drives and motivations. The popular idea in pseudo-science fiction of an "android" lacking "feelings" may be nonsense if feelings are reflections of motivations. Motivations form the basis of adaptive behavior. We represent motivation in a structure of interacting drives. Adaptive "instinctive" behavior will lie on the foundation provided by that

The long range goals of our world include creating a programming language to be used by mission planners to input their priorities into the brain of an autonomous vehicle. One of our special procedures for creating ideas of control is to use what we can of the findings of various schools of animal behavior (notably those Nobel Prize winners Von Frisch, Lorenz and Tinbergen), beginning not with "learning" but with "motivation". The behavior of our robot will be determined by "drives". For example, one drive may be analogous to "hunger". As the battery charge decreases towards the minimal amount computed, the drive to go to a recharging point increases. The timing of changes in behavior is flexible and is accomplished via "resolution of (conflicts of) drives". Though anthropomorphic in description, our approach leads to computer programs. "Drives" are simply numbers ranging from 0 to 1 based on measurements from sensors. The resulting behavior is highly adaptable to unpredictable conditions and can be robust, with the craft modifying its behavior in response not only to external conditions, but to changes in its own performance.

structure. Later, intelligence will grow as some of the instinctive behaviors become ever more flexible, as the stimulus space becomes more complex and variable, and as variable and complex habits are shaped by trial and reward.

Advantages of Autonomy

One surface ship can have several home bases and their microsubs operating simultaneously. A large number of subs can be operated by one team of humans. Microsubs, not needing to periodically surface for the relief of a human crew, can achieve more continuous productive time. Microsubs will not be subject to mistakes and inefficiency born of fatigue or boredom. We will try to insure that, as seems palpably likely, for middle resolution surveys of deep sea floors, microsubs will be so cost-effective that they open "a new frontier's' for science and industry. Looking further forward. we might see the first intelligent machine may rather than an android, be a *dolphinoid*.

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Die Umwelt Der Dolphinoid

Eibl-Eibesfeldt noted that each animal can perceive only a limited portion of the total environment with its sense organs. Its *personal* environment or *Umwelt*, is made up of the particular stimuli that the animal perceives, such as bees who can perceive ultraviolet light. He might well have pointed out the even more significant matter of *patterns* in the stimuli, and that those patterns that are obvious to one species may be effectively, invisible to another. Two distinct species live in distinct stimulus worlds due to the *filtering* of their different neural hardwares and the effective "world" of a

Microsub

Each Microsub is controlled by its own microprocessor (the brain), is battery powered, equipped with navigation and science sensors. Its density is that of sea water. Microsub can cruise for four hours at 5 ft/sec. Microsub recharges and downloads data to HomeBase. The sub's behavior is determined by its ethorobotics program's reactions to input from sensors.

MissionOne

The following is a description of MissionOne and its stages. The sub surveys vicinity of HomeBase (within "sight" of , or nearly, the lights of Home), species is its *Umwelt*. We, its programmers, will determine the *Umwelt* of a dolphinoid.

HomeBase

HomeBase rests on the sea floor. It is a recharging station, possibly a massive "box" of batteries, but it also houses a Brain, communications gear, a few sensors and navigational aids. It communicates, possibly at long intervals, with the "ServiceShip" and much more frequently with each of its microsubs. Upon appropriate signal from ServiceShip, HomeBase recalls and retrieves every microsub, then returns to the surface. HomeBase is a communications hub, linking Service Ship with other microsubs and also linking microsubs. Later, HomeBase will serve as a MotherShip that moves slowly with tightly controlled velocity, possibly drifting with the current.
HomeBase has various tools used in cooperation with the tools on the sub. HomeBeacon emits sounds whereby the sub can determine direction to Home. HomeRanger acoustically gives information by which the sub computes the distance Home over long ranges.

measuring current and elevation and running tests of its own functioning. ServiceShip waits to see that the system is functioning and seems safe. HighSurveyOne (HSOne) is a high altitude survey within range of HomeBeacon. Let us assume that the search path is pre-programmed so that, viewed from above, it looks like a turbine fan (or a daisy missing every other petal). The path of the survey then consists largely of "blades" having straight edges (called "legs") running away from and then, after an offsetting turn, back towards HomeBase. The sub moves briskly along, perhaps varying its altitude in slow responsive changes in the elevation of the sea floor below. During non-stop travel, quantities are measured and recorded in maps. Possibly at high spots at far reaches, the sub will place markers and measure the current. Later stages can use maps and markers of first surveys for safer and more accurate blade-crossing and for more distant exploring. The search pattern of HSOne can be fixed as is the cocoon-spinning behavior of some caterpillars, or adaptive as the web-spinning of some spiders. We can allow adaptability in particularly interesting spots, eliciting immediate exploratory behavior. Other surveys include Feature Following, CloseStudy, and RandomSurvey.

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Maps

Much of the data gathered will be organized by the Brain into maps, its "mental image "of its world. Maps will be three dimensional computer models of topography overlaid with other data. During exploration, these maps will be used by the sub in further refining its mission and only later shown to humans. HSOne will detect interesting spots and compute blade-crossing features. FeatureFollowing will travel along deduced cross-blade structures, gathering yet more data and improving maps. CloseStudy will visit

The scientist may define "oddness" and plan for the sub to be interested in such. Some initially interesting values can become boring. The defining of parameters of the Interest Function can be altered through a weighted average of recent-most extreme measurements.

Calibrations and Play

Malfunctioning instruments can not only vitiate our scientific results, they can cause the loss of the Microsub. But, the necesinteresting spots along efficient paths and gather data at higher resolutions. A problem with maps will come from the inherent inaccuracy of measurements of the subs location. The sub will have behavior to reduce this inaccuracy and the maps will be corrected by experience. There is an interesting technology to mention then ignore for now. The sub could map its digitized photos, showing plants and animals, onto a 3D wire frame model. We will be able to "see" vistas that no man's eyes will ever directly see, illuminated by a "sun" that these vistas will never see. Could the sub use these internal (mental?) pictures?

Curiosity: Interests of a Microsub

The sub will be "born" (launched) with "innate" interests and will develop, by our rules, new interests through experience. The sub is curious about oddities.

sity to calibrate leads to the virtue of the abundance of diversity in behavior for us to create. We will find here one reason for the existence of "play" in animals. Substances and even animals may adhere to the surface of the microsub. For this and other reasons, various sensors will need calibration. Calibration is he re-setting of a sensor to make it give the same reading of a more accurate sensor or to match its own readings from earlier readings at some place where conditions are assumed to be constant. Measure-ments may show that some sensor is reading inaccurately, and this inaccuracy may influence later behavior. Calibration would include such things as circling to measure its turning radius (in both directions). Some of the self-testing and calibration behavior around HomeBase may appear to be "play".

Editor: *Rather than present conclusions or recom-mendations, just think about the possibilities of the world's oceans filled with dolphinoids.*

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End of Day of The Dolphinoids

The following is a table of contents of more Extensive notes from which the above article was excerpted. The full article (Part I of a larger work) is

Ethorobotics of Dolphinoids.

Deep Sea Exploration via Microsubs

Trekking the Pyrobenthic Canyons

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