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Nature builds other robots

Computer-simulated evolution as design philosophy

Wissenschafter at the laboratory for artificial intelligence at the University of Zurich let virtual natures, which specialize in the solution of a given task develop after the laws of the natural evolution in the computer. After their structural drawings material robots are to be built in the future.

On the screen of Josh Bongard tummeln itself strange natures. The spherical things, which remind of ants or tintenfische, try, to shift a large block. "block Pusher" calls it Josh Bongard, scientific coworker at the laboratory for artificial intelligence at the University of Zurich. The "block slidegate valves" is born in the computer and grows up in a virtual world to reproductionable organisms. In the course of a simulated evolution they developed to specialized natures.

Idea from the sixties

The "life" in the computer begins with a coincidental output population of different virtual organisms. The Wissenschafter places a task to these natures, evenly for example shifting a block. The computer evaluates the abilities of the individuals and assigns them different probabilities of reproduction: The further a "block Pusher" pushes the block, its chance is the larger on virtual reproduction. Thus - similarly as with the natural evolution - always posed the individuals best suitable for the task increase. The computer natures specialize in such a way in the course of one in the computer simulated evolution in the solution of their task.

The idea to concern complex problems after the model of the natural evolution had developed in the sixties. The American John Holland and Ingo computing mountain of the technical University of Berlin solved in such a way organization problems, whose direct computation would have been too complex. For approximately 15 years the procedure is used in the industry according to standard for optimization tasks, about if the form of a bearing area is to be designed for minimum air resistance. In the computer model the parameters of the form transfer the role of the "hereditary substance": With the reproduction these parameters change coincidentally, which "mutate" "genes" of the wing. Thus new form variants develop. The smaller their air resistance is, the more frequently reproduces themselves it. In the course of many computer generations the bearing area of their ideal form always approaches.

No new variants

With such standard techniques are however the morphology, i.e. the fundamental shape or structure of the wing, fixed. This form of the simulated evolution can bring therefore no new variants out, for example propeller instead of bearing areas. Nature however permits also surprising solutions in the course of the evolution. The Atlantic flight fish for example uses its brustflossen as wing and slides thereby over the water surface. On the other hand the Sugar Glider, uses an Australian marsupial mammal for the same task - the gliding flight - a stretchable skin between front and hind legs. Also Josh Bongards computer nature develop after the model of nature. The Wissenschafter does not code any more the morphology, but the growth process of its virtual natures in their "hereditary substance". Thus each simulation passage can bring its own, special solution out for the task posed.

The output stage of a block Pushers consists of a spherical unit, similarly a biological cell. Its "hereditary substance" is programmed into a so-called gene modulator network, which steers its growth process. The "genes" of the virtual nature produce thereby certain signals, which function after the model of chemical transmitters in the body. There they distribute themselves over the network in the origin and the neighbour "Zellen "and release procedures such as growth or division processes. The virtual cells separate not completely, but remain clinging together. Globular clusters with a kind member masses develop. The quantity of the individual computer signals - and/or the concentration of the simulated chemical materials - at the place of the division determines thereby the number of the "sensors" and "muscles" of the new "cell". Thus the virtual block Pusher developed a kind simple tastsinn: The balls at the ends of the extremities contain excluding sensors, which take up information about the environment. Other units are equipped neither with muscles nor with sensors. They serve exclusively structural purposes, for instance the extension of the member masses, besides they increase the weight of the organisms. Regarding its task is a meaningful change. To easy block Pusher slips away, if they push the heavy block.

As in the natural evolution the shape of the virtual natures depends strongly on the output population. Thus a simulation brought individuals out with a strong seitenarm. Another evolution procedure in the computer led to natures with two into one another arms. With this "ball" of member masses they push the block in front and stabilize at the same time. Common is all simulation passages however the mechanism, with which the block Pusher moves itself. The simulated evolution brought out for this - without defaults of the programmer - a surprisingly simple solution: At the end of its growth process the block Pusher is aroused by a signal impulse to their virtual life. Their "muscles" contract, the natures move. "cells", which are because of the soil, can be moved thereby upward. As soon as now a "cell" loses the contact to the soil, you send to "a signal at" muscles "the cell sensor" behind it. These react to with a movement impulse which pushes the nature jerkily forward.

Surprise for the researchers

The block Pusher needs no central intelligence in form of a brain for the controlling of its progressive movement thus. Rolf Pfeifer, the director/conductor of the laboratory for artificial intelligence, holds the opinion that a part of the intelligence of an organism lies in its

morphology (see box). It is therefore of crucial importance that shape and control developed at the same time, explains he. Thus the Wissenschafter contradicts traditional thinking samples in the engineer disciplines. According to conventional methods first the form of a robot is sketched, then its central control.

Pfeifer expects also that robots, which develop with the help of a simulated evolution will completely differently look, because they may develop quasi. The Wissenschafter gives only, has to solve which tasks of the robots. Then it delivers control and can by the computer simulation be surprised. The virtual evolution develops often amazing solutions, which would hardly have found humans, means Pfeifer. For the newness of the robots the interaction of redundancy and modularity, so the researcher is crucial. Systems, which were developed with traditional procedures, consist of visible functional units, to so-called modules. Each module fulfills a clearly defined function. A video camera for example contains an optical module to the picture recording and a microphone for the recording of noises. With a defect a module can be replaced simply. Safety-relevant functions are here usually redundantly implemented, i.e., in case of failure of a module another unit takes over its function. This can be reached at the simplest by a duplication of the appropriate modules. In the case of the video camera two microphones could be built. First precipitates, second takes over the recording of the noises.

Natural systems possess a more complex kind of redundancy, since the functions of the different modules overlap themselves. Spatial information for example can be taken up by the eyes, by the tastsinn or by the ears. A meaningful invention of nature: In the darkness a doubly implemented Sehsystem with four eyes would be senseless, while palpation and sense of hearing mediate also without lighting information about the spatial environment. This kind of redundancy produces stable and adaptive, in addition, complex systems. A hypothesis is now that with the help of the evolution simulated in the computer also with the robots this form of the redundancy develops. Such devices to understand, however, gives Pfeifer is then possible in principle might become very difficult to consider. Besides any longer simply the modules could not be exchanged with a repair.

Still the world simulated in the computer has few in common with the reality, is missing nevertheless a crucial step for the development of an intelligent individual: the intensive exchange with the environment. Pfeifer works however with its group already to extend the simulated growth process in the computer by interactions with the environment. The Wissenschafter expects first commercial applications of its research in approximately five years. Up to then a completely automated computer program is to be compiled, that the structural drawing of an overall system in co-operation with the industry, which develops laws of the evolution following.

Christa Rosatzin Strobel

Intelligence needs a body

C. r.-s. The secret of natural intelligence lies according to Rolf Pfeifer, which leads the laboratory for artificial intelligence at the University of Zurich, not only in the brain; also artificial intelligence cannot accordingly be reduced to a computer program. This basic idea coins/shapes the robot research at the University of Zurich and meanwhile also by other laboratories, like the Artificial Intelligence Laboratory of the American Massachusetts Institute of Technology (WITH), is pursued. Intelligen *** TRANSLATION ENDS HERE ***z braucht laut dieser These einen « K ö rper » , der einen Austausch mit der Umgebung erm ö glicht, wobei dessen Gestalt, also die Morphologie, und Materialeigenschaften eine wichtige Rolle spielen.In der nat ü rlichen Evolution haben sich Gehirn und K ö rper gemeinsam entwickelt. Ihre Funktionsweisen sind optimal aufeinander abgestimmt. Diese im Laufe von Jahrmillionen entstandene Einheit wirkt sich auch auf die Lernprozesse eines Individuums aus: Ein Baby ergreift einen Gegenstand reflexartig. Seine Hand wird automatisch ins Gesichtsfeld ger ü ckt; das Gehirn erh ä lt taktile und visuelle Informationen. Das Baby lernt. Der Lernprozess wird dabei von der M ö glichkeit, mit Hilfe des Arms Gegenst ä nde greifen und n ä her betrachten zu k ö nnen, wesentlich beeinflusst. Denn w ä re die Hand in ihrer nat ü rlichen Stellung hinter dem K ö rper, k ö nnte das Baby den Gegenstand, den es ergreift, nicht sehen. Ohne diese visuelle Stimulation w ü rde sein Lernprozess anders verlaufen. F ü r die Entwicklung des Babys sind also nicht nur seine kognitiven F ä higkeiten, sondern auch die Gestalt seines K ö rpers massgeblich. Nach diesem Verst ä ndnis liegt daher ein Teil der Intelligenz eines Organismus in dessen Morphologie. Intelligenz k ö nne, so der Wissenschafter, nur als Zusammenspiel der kognitiven F ä higkeiten mit der Gestalt des K ö rpers und seiner Interaktion mit der Umgebung verstanden werden. Die im Computer simulierte Evolution soll helfen, diese Zusammenh ä nge besser zu verstehen.

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