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Artificial Intelligence and Natural Perception

Kuenstliche Intelligenz und Natuerliche Wahrnehmung

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The research field of Artificial Intelligence (AI) has delivered many results, even if the achievements are different from the unrealistic promises and claims that have been made in the past. Many results have become invisible, because they are seamlessly integrated into current computer science and current practical applications: Search methods, planning, semantic modeling, Bayesian networks and even the XML-coding standard all have strong roots in AI. Furthermore, computer chess is no longer a main challenge. An extremely strong human chess master such as Kasparov constitutes a statistical outlier: Most humans will lose from the chess-playing algorithm since long. It now has become clear that the real challenge to AI research is in the confrontation with the real world, its complexities and uncertainties. This new challenge is centered around '*multiple agents & autonomous systems*': How do such systems need to perceive the world, how do control their movements and how they interact with eachother by means of a common language? In isolation, these research questions have been studied for a considerable time. However, it appears that the results of pattern recognition, computer vision, computer linguistics and autonomous-navigation research are not sufficiently advanced to make robot building an easy plug-and-play exercise today. For example, the results of computer-vision research appear too elaborate and too computationally demanding for applications in the real world. Specialized tasks may work nicely, such as face recognition but robust and general solutions for use in robotic systems are lacking. Similarly, within traditional logic-based AI, it was hoped that a rigorous pursuit of logic would yield real forms of intelligence in robotic systems. In reality, however, most applications consist of carefully handcrafted human designs, only yielding pre-programmed robot behaviors of limited complexity. Since the work of Brooks [1], however, a shift in paradigm has taken place. Today, we realize much more clearly that in the biological world, many – relatively simple – creatures will outperform existing autonomous systems when it comes to robustness. Still, to some researchers in engineering and AI, looking at biology is considered useless. Robustness in technical robotics is usually obtained by brute force, such as in the use of GPS for navigation. Other solutions involve technical additions to the environment, i.e., with bar codes, beacons etc.. A well-known argument within engineering and traditional AI goes like this: *"Initial airplane experiments were based on biologically inspired flapping wings. This did not work at all. Only when the technical solution of the fixed wing was introduced, flying machines became a success. Therefore, it is not necessary to mimick biological solutions"* . Indeed, the initial airplanes did not resemble birds very much. There were biplanes and triplanes, often with ingenious but strange solutions for control. However, anyone who looks more closely at modern airplanes will see that many of the deviant initial technical solutions have not survived. An F16 fighter plane has a clear bird-like appearance. Looking at the design of the wings in more detail, one will observe features such as the slotted high-lift wing, which the Boeing 737 has in common with the wing 'design' of the falcon, i.e., a mechanism to prevent stall at low speed and steep climbing angles (Figure 1). The reason for this apparent biomimesis is clear. Both the biological bird and its mechanical counterpart have to obey the laws of aerodynamics. In AI, similary, many believe today that there are fundamental principles of natural information processing which must be obeyed by both animals and animats. In this respect, the work of Pfeifer [2] has been very influential. The limitations of current robotics are most clearly revealed when it comes to perception. In the presentation, examples will be given of mechanisms in natural perception which may be very useful for robotics: foreground/background separation, color constancy and optic-flow computation. However, the single most important difference between natural vision and technical solutions is that the biological system saves a lot of computation through selective attention and an opportunistic sampling of visual patterns. Instead of a serial image-processing pipeline, most biological vision systems involve a tight feedback loop in which orienting and tuning of the visual sensor plays an essential role (Figure 2): Our eyes are, fortunately, no flat-bed scanners or high-resolution digital cameras. The research area which focuses on these aspects of machine perception is called the “Active Vision” paradigm. Results of this research will be applied in a camera-based text detection and reading system for use in autonomous robots. However, other applications are possible, which benefit from the computation-saving properties of Active Vision. One such application would be the design of VLSI CCD sensors which allow for a dynamic specification of regions of interest and pixel-resolution distributions, obviating the need for full-frame image analysis in real-time applications.

[1] R. A. Brooks, Intelligence without representation', AI Journal, Vol 47 (1991), S. 139-159.

[2] Pfeifer, R., and Scheier, C.. Embodied Cognitive Science: A novel approach to the study of intelligence in natural and artificial systems. In T. Gomi (ed.). Evolutionary Robotics, Vol. II: From intelligent robots to artificial life, ER'98. Ontario, Canada: Applied AI Books, (1998). S. 1-35.

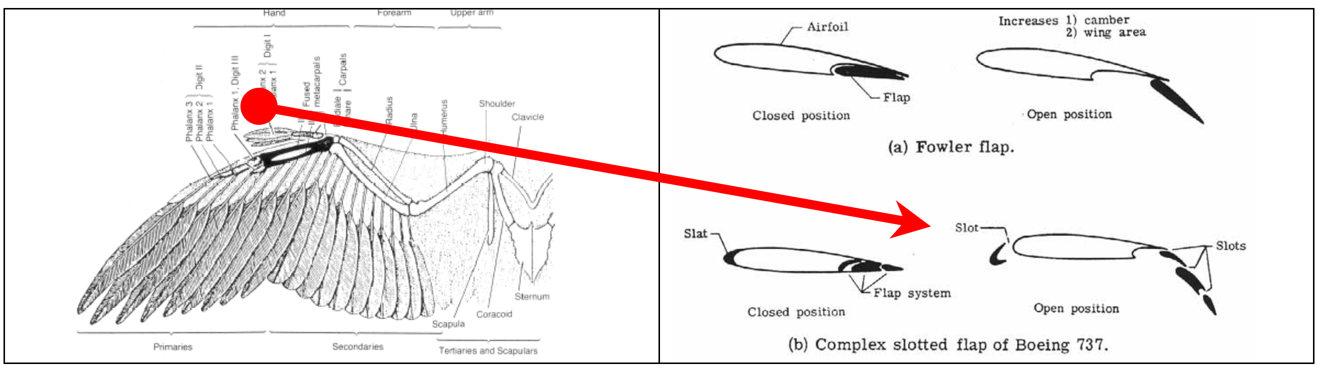

Figure 1. Solutions in biology and technology are guided by the fundamental principles of aerodynamics. The slotted wing allows birds and planes to achieve steeper flight. In Artificial Intelligence today, it is considered wise to look at biology, too.

Figure 2. The jumping spider uses Active Vision for object tracking and for planning a jump. Picture courtesy of Dr. D.E. Hill.