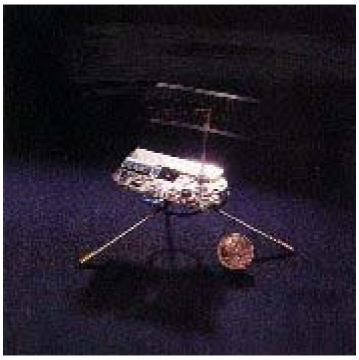
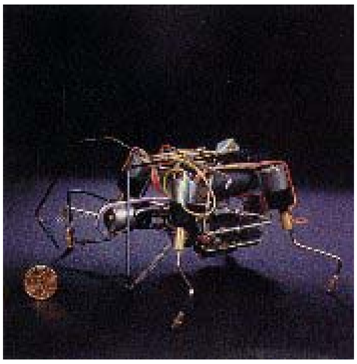
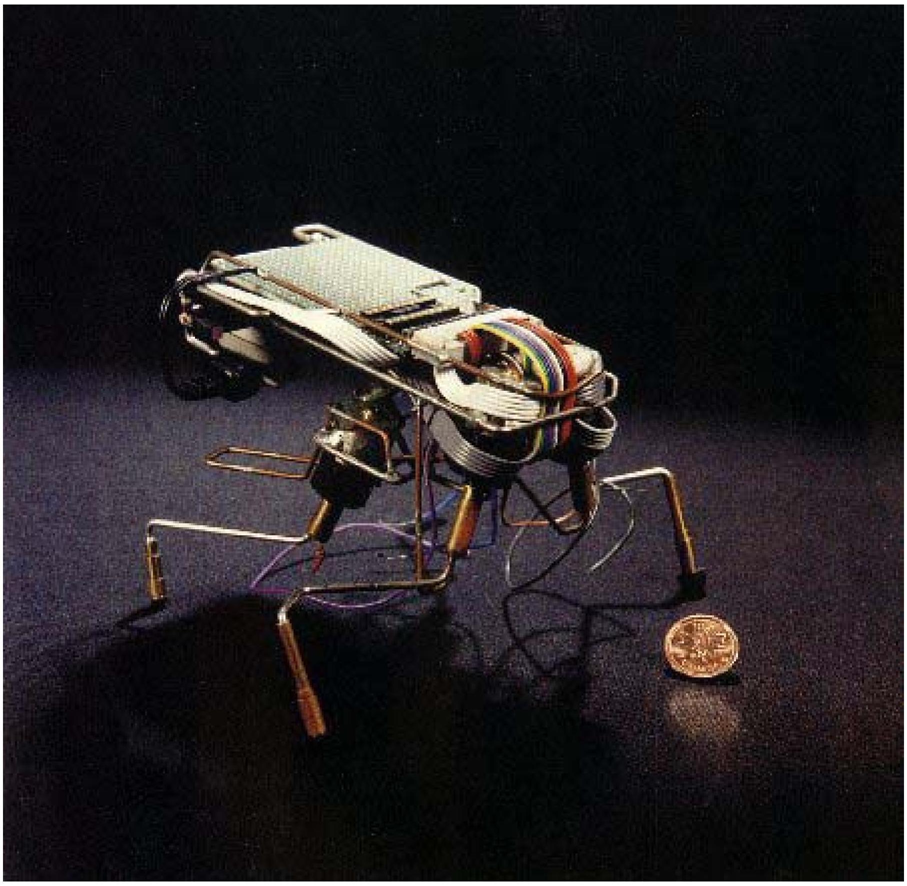
THE EVOLUTION OF FUNCTIONAL ROBO-ECOLOGIES

MARK W. TILDEN







Hollywood science fiction has always falsely portrayed the idea that robots just "happen" when motors, neon lights, silicon chips, and a little programming (usually shown as BASIC program listings) combine. Put in bucket, shake well, out pops R2D2. This has, alas, scared away more people from robotics than the "Terminator" because it just doesn't work, or when it does work, the damn thing doesn't even compare to a store-bought toy. Even worse is when enthusiasts are told that "The Real Money" is not in the robot mechanisms of their dreams but in industrial robotics, a field more concerned with statistics than imagination. Consequently, the robotic ideal still exists only on the silver screen and in the fertile imagination of its viewers.

Although current technology has made great strides in building artificial reasoning machines, there has yet to be any definitive way of interfacing such "brains" with robot bodies capable of surviving real-world complexity. Almost every attempt to make truly autonomous robots has resulted in failure. Exceptions have usually involved fantastic sums of money, thousands of man hours, usually both.

However, there is now evidence that there are simple, elegant solutions to making autonomous robotic devices, solutions which show adaptability and dependability even after undergoing significant damage. Some of the principles behind this work are being developed and expanded upon by Mark W. Tilden at the University of Waterloo in Ontario, Canada. Tilden's idea is not to study just one aspect of autonomous robot construction, but all of them, on a tight budget, short design time line, many biological precepts, and most importantly, outside of computer simulation or dependance. To date nearly forty functional robotic devices have been constructed, some of which have been running continually for over three years. Most are solar powered, smaller than a telephone, and so far have avoided the need for processor-based controllers.

Best of all, they are dead cheap.

This research is currently concentrating on four basic fields: Construction research, Vertebrate and Invertebrate design, and Cooperative behavior studies (abbreviated as CIVC, or "civ-ic" robotic studies). The main guiding principles are "Tilden's Laws of Robotics", which are:
1/ A robot must protect its existence at all costs.
2/ A robot must obtain and maintain access to a power source
3/ A robot must continually search for better power sources

otherwise known as:
l/ Protect thy ass.
2/ Feed thy ass.
3/ Look for better real-estate.

Notice these are vastly different from the classic Asimovian robot laws, which make for good fiction, but alas, lousy robots. These fields and principles are not studied independently but in parallel, introducing new types of robots into a simple "ecology" where they have to deal with the real world and each other. Some have been built to solve simple domestic needs (window cleaner, cat toy, floor cleaners), others were built just to test some principle, material, or unique electronic device.

The work has been going on only part time for three years as of this writing but in that short time there have been significant progress in all CIVC disciplines. It appears now that cooperative behavior amongst autonomous, goal seeking organisms may not only be possible but inevitable under low-stress circumstances. As well, it seems that the pervasive idea that robots must be fashioned upon some biological morphology (i.e., insects) may be inherently flawed. Robots are made from a different stuff and based upon very different principles, so it follows that optimal robotic forms might also vastly differ from what we might expect. As for function, CIVC robots have evolved from simple wheeled devices to some recent legged forms with astonishing adaptability (and more than just a passing biological similarity).

One of the interesting aspects of this work is that few of these robots are alike in style or function, and this has led to the conclusion that mobile robots alone are not sufficient for a balanced robot ecology. Robot "plants", as well as various other hybrids are vital to improve the "quality of life" in the robo-ecology. An interesting point is that although attempts have been made at building purposeless robots, it seems it cannot be done easily. Given sufficient time and environmental interaction, even the most inane self-contained mechanism will find a purposeful niche.

Future efforts will include documenting all aspects of CIVC robotic research in a book (or two) so that others can make their own devices, then concentrate on the building, observation and evolution of larger and more diverse robo-ecologies, placing them under various stresses, studying the reactions, and developing new generations of survivor automata.

But a single robot builder is too slow, so work is also progressing on the BEAM Robot Olympic Games, an international forum designed to get more people building artificial-life robots rather than writting computer simulations. BEAM, which stands for Biology, Electronics, Aesthetics, and Mechanics is designed as a method so that first time enthusiasts can get started easily. By building one or more simple self-contained creatures, anyone can gain the confidence and ability to assemble a wider range of robotic devices. The Olympics feature a decathlon of competitions ranging from the simplest two-transistor Solaroller race to flying robot contests. The competitions are all very open and adaptive, non-destructive cheating is encouraged, and winners and "Mad Scientists" are rewarded equally. The show emphasizes the light-hearted approach, events like the "Canadian-Rules-No-Holds-Barred Robot Sumo" detail adaptive evolution at its aggressive best.

The show is in fact an experiment in forced robo-genetic engineering where humans are used as the reproductive media. Like any good primordial genetic "soup", the more variations observed in the initial species, the better to boil a good stock from, metamorphically speaking. A 100 page Guideline is available to the interested, detailing everything from how to run such events to simple robot construction plans. The second such Olympics happened in April of 1993, along with 5 other Games scheduled internationally throughout the year.

Ideas will be nurtured and expanded on in CIVC robot designs, and once a sufficient database has been explored (and tested by the building of "herds" of devices), there will be more books written. Research can then confidently concentrate on developing robot mechanisms which do satisfy coveted Hollywood ideals, filling the vast variety of possible applications (bionics, medicine, space, construction, nanoscience, chaos engineering, defence, etc.). The result will not be HAL 9000's but likely a guide by which autonomous mechanisms can be made for the vast array of potential applications; everything from grass cutting hive organisms to robot goldfish.

What sort of functions are anticipated for these robots? Currently, it is difficult to tell. Proctoring an artificial life form is wrought with questions, but that's what fires the interest. Once there are sufficient answers, and concrete examples, to the questions of building "living" robots, then the science will only have just started. The motive is fascination, the results are hoped to do more than satisfy the demands of a tool based industry.

Of course, as the understanding of these primitives grows, so will the confidence to tackle bigger game. Eventually, mechanisms will be built at least as smart as the average simian, and possibly with similar attributes. After that there is bigger game still, but that's so far ahead that it's considered more science fiction than science.

But then, so was the telephone.

That's all.