V. Braitenberg, *Vehicles: Experiments in Synthetic Psychology* **(MIT, Cambridge, MA, 1984); 152 pages, $14.95.**

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This is a book that some readers will love and others will hate. It gives a cybernetics perspective of intelligence and intelligent machines. One reviewer, who apparently loved the book is quoted on the dust cover:

> "It is a delightful, quick read – a sort of cybernetic appetizer. . . . An even better analogy is that it is a cybernetic version of *Flatland* – a short, witty, informal, playful introduction to the world of feedback-controlled machines. . . . It has the same appeal to a reader's imagination and the same seductive simplicity and sense of enjoyment."

I agree with most of this. The book is witty and playful and generally fun to read. It has great pictures and is not likely to corrupt our youth or upset the horses. But it could have been much better.

The book has three parts: chapters on imaginary vehicles (read 'automata' or 'robots'), a gallery of entertaining sketches of landscapes populated by such vehicles, and some 'biological' notes on the vehicles.

The Vehicles

This part of the book is advertised as a sort of science fiction, a fantasy intended to let the reader enjoy some of the pleasures of understanding simple mechanisms. The first chapter is about a very simple vehicle. Subsequent chapters elaborate on it to introduce a range of concepts from automata theory, perception, and biology. The first vehicle has a sensor at one end and is propelled by a motor at the other. The speed of the motor is determined by the output of the temperature sensor. Braitenberg analyzes it as follows:

> In the long run it will be seen to move in a complicated trajectory, curving one way or the other without apparent good reason. . . . it is restless and does not like warm water. . . . Anyway, you would say, it is ALIVE, since you have never seen a particle of dead matter move around quite like that.

The second chapter introduces some vehicles made with two sensors and two motors connected in various ways. Braitenberg analyzes them as follows:

> Let vehicles 2a and 2b move around. . . Their characters are quite opposite. Both DISLIKE sources. But 2a becomes restless in their

vicinity and tends to avoid them. . . Vehicle 2a is a COWARD, you
would say . . . . Vehicle 2b . . . resolutely turns toward them and hits
them with high velocity . . . [it] is AGGRESSIVE, obviously.

In the next few analyses we are introduced to vehicles that are explorers,
have instincts, have knowledge, love sources, and ponder over their decisions.
In these analyses Braitenberg seems to be poking fun at some of his scientific
colleagues for seeing too much intelligence in simple behavior. There is little
danger that a reader will mistakenly take Braitenberg too seriously. He
capitalizes all of the loaded words. His vehicles are more engaging than those
one first encounters in books on finite state automata, probably because they
sense and respond to an environment.

As the vehicles became more complex, however, I became less comfortable
with Braitenberg's style. Good science writers are sometimes able to get across
a complicated idea by starting with a simplified sketch. Examples of this
abound in Feynman [1] or Greenstein [2]. In such cases, the author maintains
his credibility by unveiling important complications at the right time, and by
providing caveats when there is a danger that the reader will be misled.
Braitenberg, unfortunately, does none of this. In the next few chapters he
trivializes the process of learning (it's just association) and low-level perception
(it's just analog representations and lateral inhibition). With great enthusiasm
he presents an (apparently buggy) recognizer for bilateral symmetry and hails it
as providing important biological advantages. Somehow Braitenberg leaves out
communication and the development of language although I'm sure he could
have dispensed with that in a page or two.

Along the way Braitenberg lost my confidence. If this was intended in part as
a spoof on sloppy science, he made the joke too long. I came to suspect that he
believed too much in his own 'lies'. The casual reader is encouraged to believe
that building (or evolving) robots isn't so hard – you just mix up a little pleasure
principle, cross a few logic wires, and use multiple sensors and voila!

Drawings

Ten drawings by Maciek Albrecht are in the middle of the book. Anyone who
enjoys Escher or Rube Goldberg cartoons will take pleasure in these.

Biological Notes

In the last part of the book there is an abrupt shift to a drier style at the level
of *Scientific American*. In this section, Braitenberg considers various explana-
tions of the crossing of nerve bundles as well as microscopic neuroanatomy. He
discusses his own work on the principles of compound eyes of insects. He
provides a brief overview of early cybernetics, mostly the networks of McCul-
loch and Pitts. In contrast with the first part of the book, we read Braitenberg

here as a scientist presenting hypotheses, weighing evidence, and using competitive argumentation.

Unfortunately, even after his scientific discussions I found myself dissatisfied. I still could not understand what brain organizations would be sufficient for intelligence. Nor could I understand why the various feedback mechanisms would necessarily drive the neural network to converge to an appropriate state. It's not that Braitenberg should be expected to answer these questions. The answers are not known. What bothers me was that he didn't see the need as a cyberneticist to ask the questions. He was content to fiddle with simple if suggestive mechanisms with no concern for predicting the aggregate system behavior over time. If AI took the same attitude, it would be enough to demonstrate an IF-THEN rule and a working set, or perhaps a flip-flop and a combinational network and leave the details of intelligent machines for the reader.

Technologists may spot several places where Braitenberg is somewhat out of date. For example, his comments on available electronic technology don't reflect the capabilities of current integrated circuits. Recent work providing computational insights into human vision is also ignored.

Conclusions

I suppose I will recommend the book, but not enthusiastically and not for research background. Buy it, enjoy the pictures, and leave it around for the kids to find near the Fishertechnik set. If Braitenberg ever revises the book to more honestly consider the limits of both the ideas and of our understanding of intelligent systems, then I would recommend the book without reservations for tutorial purposes.

REFERENCES

1. Feynman, R.P., Leighton, R.B. and Sands, M., *Feynman Lectures on Physics* (Addison-Wesley, Reading, MA, 1963).
2. Greenberg, G., *Frozen Star: The Cosmology of Pulsars and Black Holes* (Freundlich Books, New York, 1983).

Erratum

The book review by Donna Auguste of Sleeman and Brown's *Intelligent Tutoring Systems* contained a misprint (see *Artificial Intelligence* 26(2)). The sentence starting on page 237, line 16,

Several books by Polya, including (but limited to) *How to Solve It*

should read

Several books by Polya, including (but *not* limited to) *How To Solve It*