PRINCIPLES OF AUTOMATION

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WHAT A ROBOT CAN AND CANNOT DO

J. F. SCHUH

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*The eternal mystery of the world is
her comprehensibility.*

(Albert Einstein, J. Franklin Inst. **221**,
(1936), p. 351)

PREFACE

This book is meant for all those who are interested in the theoretical and philosophical problems connected with the robot and has a two-fold purpose. In the first place it is intended to help those whose work brings them into contact with automata to design, construct or use them intelligently and creatively. In the second place it will discuss problems like “*can an automaton really think?*”, “*how much further can we perfect automata?*”, “*can automata ever take over the world?*”, which appear to worry expert and layman alike to a certain extent.

It is a matter of common knowledge that since the end of the last world war we have succeeded — to name but two examples and with some exaggeration — in building huge factories (usually chemical) manned only by a couple of workmen and one engineer, and in building “**electronic brains**” which can perform calculations which were simply impossible before and can e.g. work out the pay packets for a big firm more cheaply and just as reliably as or even more reliably than an army of clerks.

The contemplation of these facts can give rise to a number of different reactions. In young (and not so young) men, it may arouse the desire to choose automation or computing as their profession. The author hopes that this book will help to give them the knowledge they need to realize this desire. Men who have already chosen this profession may wonder what are the practical limits of the automation, and what are the principles on which a better automaton can be constructed. The author hopes that this book will help to give them the insight needed to solve these problems. And all, specialist and layman alike, may find themselves asking with curiosity “*How much truth is there in the name of “electronic brain” which we give to these computers?*” and with a certain amount of trepidation “*Are we not, like the Sorcerer’s Apprentice, unleashing forces which we will be unable to control?*” Unfortunately, there is still only one simple answer to these questions: “*we’re not quite sure*”. Those (like the author) whose work brings them more or less directly into contact with automata tend to take an optimistic view, while those who stand a little further off often tend to think, in the words of the Psalmist: “*They have mouths, but they speak not; eyes have they, but they see not; they have ears, but they hear not; neither is there any breath in*

their mouths. They that make them shall become like them; yea, every one that trusteth in them" (Psalm 135, verses 16-18).

Let us take a closer look at the two examples of automata we have mentioned above. In the first, the chemical factory, we are no longer surprised to find machines to take the heavy work of lifting and pouring vast masses of chemicals off the workers' shoulders; but now we see machines which even relieve them of the task of measuring the temperature or the pressure, and turning the right knobs at the right moments. It is clear that if we were asked what the men in the old-fashioned factory were doing when carrying out these latter tasks, we might very well say that they were *thinking*, so that these machines which relieve them of the task of thinking have just as much right to be called "*thinking machines*" as the mechanized successor of the spinning wheel has the (unquestioned) right to be called a spinning machine. But while we see nothing wrong in saying that a spinning machine really spins, I think that most of us feel a certain resistance to saying that a "*thinking machine*" really *thinks*. This is because the thinking of these machines is so much more limited than our own that on second thoughts we doubt whether it really deserves the name — we may be fairly sure that a pressure stabilizer never thinks a pleasant or angry thought — or even less a thought about calculus. And on the other hand we feel that to equate what we know of the operation of a pressure stabilizer with thinking is to depreciate the value of our own thoughts, to insinuate that our own selves, which we feel to be so warm and living, are really just as cold and dead as that thing of metal and glass, if we could look deep enough.

If we turn to the electronic computer the situation becomes more puzzling and possibly more threatening. Not only does this machine perform a wider range of thought-like actions, including those which the human brain would find too time-consuming, although not too difficult, to perform in one lifetime — but its performances even resemble that of the human brain to a surprising and amazing extent when it is remembered that the electronic computer was designed as it is for reasons of convenience and not with the express purpose of resembling the brain. Here we feel an additional threat, though perhaps not so basic as the threat to our integrity mentioned above — which the electronic computer of course also provokes. We feel it quite possible that we could design computers of such complexity and power that they could free themselves of our yoke and dominate us. There is however no immediate danger of this happening at present; all automata so far made are quite docile.

In the introductory chapter we shall discuss the automaton in general terms, to introduce the reader to the subject matter of the later chapters,

and to show how the more speculative questions given above have arisen even if we cannot answer them.

A glance at the contents of this book will make it clear to the reader that it is not without diffidence that the author brings this book before the public: who, indeed, could consider himself an expert in the whole range of subjects covered here? The author is therefore very grateful to the many friends who have given him help and advise whenever necessary.

In particular MY FATHER, who despite his advanced age has read through various parts of the book and made valuable comments especially on **Appendix B**, which deals with *stochastics*, a subject which is near to his heart, has contributed to ameliorate the original text at many places.

I also owe much thanks to DRS. DOORMAN, who read through the whole of Chapter II and made many corrections and suggestions for clarification; if this chapter is a success (as the author naturally hopes), it is largely thanks to him. Messrs E. AAGAARD and J. T. KAGER contributed many useful improvements to chapter IV. Mr. G. J. VAN DER MARK made many suggestions which have led to a considerable improvement and clarification of the language of the original text and have led to the rewriting of many passages.

And last but not least, the author would like to thank Mr. R. H. BATHGATE, who took great pains to produce a faithful English translation in which he succeeded, in my opinion, extremely well and Mr. M. BREMMER who read through the English text and made many useful comments.

Eindhoven, December 1964

J. F. SCHUH

TABLE OF CONTENTS

PREFACE	V
Chapter I: INTRODUCTION	1
1.1. What is an automaton?	1
1.2. What is thinking?	2
1.3. Automata and nerve nets	5
1.4. Functions taking place in an automaton	6
1.5. Signals and information	7
1.6. The concept "signal content"	9
1.7. Types of signalling	12
1.8. Something about nerve nets	13
1.9. The neuron regarded as a switching element	19
1.10. More about automata and nerve nets	23
1.11. Chance, noise and interference	25
1.12. Something about memories	29
1.13. Circuits and logic	30
1.14. Example of a logical circuit. The binary adder	32
1.15. The signal transformer	38
1.16. The scientist as a "signal transformer"	40
1.17. What a robot can and cannot do	44
1.18. Something about the chess-playing machine	46
1.19. Conclusion	48
Chapter II: ELEMENTS OF LOGIC	49
2.1. Introductory remarks	49
2.2. Propositional logic	52
2.21. Negation	53
2.22. Disjunction	54
2.23. Conjunction	55
2.24. Implication	56
2.25. Equivalency	58
2.26. Some theorems of propositional logic	60

2.3. The algebra of classes	65
2.4. BOOLEAN algebra	73
2.41. Application of BOOLEAN algebra to switching networks	77
2.5. Further development and rounding-off of the foregoing theory	80
2.6. Semantic entailment according to E. W. BETH	86
2.61. Some definitions	86
2.62. The fundamental task of logic	88
2.63. Some examples of semantic proofs	90
2.631. <i>First example. The syllogism BARBARA</i>	91
2.632. <i>Second example. The syllogism DARAPTI</i>	92
2.633. <i>Third example. A very simple geometry</i>	93
2.64. Some final remarks	98
Chapter III: CODES AND LANGUAGES	101
3.1. General remarks	101
3.2. Codes and languages in general	102
3.3. Examples of some codes	105
3.31. The binary number system considered as a code	105
3.32. The "excess-three" code	107
3.33. The m -out-of- n -code	107
3.331. <i>The 1-out-of-n code or linear code</i>	107
3.332. <i>The 2-out-of-5 code</i>	107
3.333. <i>The 3-out-of-7 code</i>	108
3.34. The international telegraph code No. 2	108
3.4. Self-checking and self-correcting codes	110
3.5. Example of a language and its analysis	116
3.51. Introductory remarks	116
3.52. The structure of Carnap $n\pi$,	117
3.53. Example of a Carnap $n\pi$,	120
3.54. The concept of semantic information	122
3.541. <i>Some introductory remarks</i>	122
3.542. <i>CARNAP'S definitions of information</i>	124
Chapter IV: COMPONENT PARTS OF LOGICAL NETWORKS	131
4.1. Some introductory remarks	131
4.2. The most important circuit elements	133
4.21. The diode	134
4.22. The transistor	135
4.23. The magnetic core	141
4.231. <i>Some general remarks</i>	141

4.232. <i>Magnetic memory cores</i>	144
4.233. <i>Parasitic pulses</i>	147
4.234. <i>Some mathematical considerations</i>	149
4.3. <i>Some important basic circuits</i>	154
4.31. <i>The single-shot</i>	154
4.32. <i>The flip-flop</i>	158
4.33. <i>The AND-gate and the OR-gate</i>	161
4.34. <i>The NOT-gate or inverter</i>	162
4.35. <i>Basic circuits using single-shots</i>	163
4.351. <i>Shifting a pulse</i>	163
4.352. <i>Pulse gate which only passes pulses of phase t_1</i>	164
4.353. <i>The NOT-gate</i>	164
4.354. <i>AND-gates and OR-gates</i>	165
4.4. <i>Some important larger units</i>	165
4.41. <i>Shift registers and counting circuits</i>	165
4.42. <i>Selection circuits</i>	172
4.421. <i>The contact pyramid</i>	172
4.422. <i>The coordinate selector</i>	173
4.43. <i>Memories</i>	176
4.431. <i>Introductory remarks</i>	176
4.432. <i>Example of a permanent memory</i>	179
4.433. <i>Examples of non-permanent memories</i>	183
4.434. <i>Some further particulars concerning magnetic cores</i>	186
4.44. <i>The signal transformer</i>	189
4.45. <i>The self-adapting signal transformer</i>	191
4.451. <i>Some introductory remarks</i>	191
4.452. <i>WIDROW and ANGELL's solution</i>	193
4.453. <i>Some mathematical considerations</i>	195
4.454. <i>Another solution</i>	200
4.46. <i>The arithmetic unit of a digital electronic computer</i>	203
4.461. <i>Some preliminary remarks</i>	203
4.462. <i>Principle of the construction of a binary adder</i>	206
4.463. <i>The HEYN adder</i>	210
4.47. <i>Control circuit for a conditional program</i>	215
4.471. <i>Some general considerations</i>	215
4.472. <i>SCHITZ-MOL circuit</i>	220
Chapter V: <i>MECHANISMS IN GENERAL</i>	225
5.1. <i>Survey of the theory of linear differential equations</i>	225
5.11. <i>Some general remarks</i>	225

5.12. The homogeneous linear differential equation	228
5.13. The case of constant coefficients	231
5.131. <i>The homogeneous linear differential equation with constant coefficients</i>	231
5.132. <i>Particular integral of the complete equation</i>	234
5.2. The LAPLACE transform	236
5.21. Definition of the LAPLACE transform	236
5.22. Some general properties of the LAPLACE transform	240
5.23. Examples of LAPLACE transforms	243
5.231. <i>The unit step function</i>	243
5.232. <i>The unit pulse function</i>	246
5.24. The inversion problem for rational functions	250
5.3. Application of the transformation of LAPLACE to linear differen- tial equations with constant coefficients	255
5.31. General integral of the reduced equation	256
5.32. Particular integral of the complete equation	257
5.33. Behaviour of the integrals for very large values of x	261
5.34. Formulae for the particular integral of a linear differential equation	264
5.4. Basic principles of electric network theory	268
5.41. Networks in general	268
5.411. <i>Introductory remarks</i>	268
5.412. <i>Equations governing the behaviour of a network</i>	271
5.413. <i>The electromagnetic energy excited by the currents and voltages in a network</i>	273
5.42. The dipole	276
5.421. <i>Solution of the equations governing the behaviour of a dipole</i>	276
5.422. <i>The reactive dipole</i>	278
5.423. <i>The RC-circuit and the RL-circuit</i>	283
5.424. <i>The response of a dipole to a voltage</i>	286
5.43. The passive quadrupole	289
5.5. Principles of feedback theory	299
5.51. Introductory remarks	299
5.52. Feedback systems in general	309
5.53. Some considerations based on function theory	311
5.6. Separation of message and noise	317
5.61. Digital signalling	317
5.62. Analogue signalling and the theory of KOLMOGOROFF and WIENER	319

5.63. A few critical final remarks	324
5.7. Something about the digital computer	325
5.71. The block diagram of the digital computer	326
5.72. Example of a simple arithmetic program	332
5.73. Example of a puzzle program	335
5.731. <i>The puzzle and its analysis</i>	335
5.732. <i>Checking whether a symbol $(x_\xi, y_\eta, z_\zeta, \dots)$ represents a solution or not</i>	339
5.733. <i>Determination of the successor of a symbol of the form $(x_\xi, y_\eta, z_\zeta, u_\phi, v_\chi, w_\psi, t_\tau)$</i>	344
5.74. Example of a learning program	345
5.741. <i>A few introductory remarks</i>	345
5.742. <i>OETTINGER's problem</i>	346
5.743. <i>Arithmetization of the problem</i>	346
 APPENDIX A: HARMONIC FUNCTIONS AND THEIR COM- PLEX REPRESENTATION	 349
 APPENDIX B: STOCHASTIC PROCESSES	 353
1. Introduction	353
2. A few concepts	354
3. The statistical parameters	355
4. The stationary stochastic process	359
5. Remarks about the definitions	361
6. Ensemble of equivalent processes	362
7. The ergodic hypothesis	362
8. The intercorrelation function of two stochastic series	364
9. Stochastic independence	365
 APPENDIX C: FOURIER INTEGRALS AND SERIES	 367
1. An important integral	367
2. DIRICHLET's theorem	369
3. FOURIER's integral	370
4. BESSEL's theorem relating to trigonometric series	372
5. Uniqueness of the expansion in a trigonometric series	373
6. DIRICHLET's proof for the expandability in a trigonometric series	373
 ALPHABETICAL INDEX	 375

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BLAISE PASCAL

Not the very first, but certainly one of the most brilliant and famous designers of a computing machine (in fact only an adder and subtractor) was BLAISE PASCAL (1623-1662). In 1642 (or 1641, both dates are mentioned in the literature) he hit on the idea of constructing a computing machine to help his father (then in charge of the collection of taxes in ROUEN) in his work. Because of the backward state of engineering in PASCAL's days, it was, however, impossible to construct from his drawings a machine which worked without error for a reasonable length of time. However, PASCAL does not owe his fame to this invention, but to his activity as a mathematician (PASCAL's theorem about conics, PASCAL's triangle, foundation of probability theory), physicist (foundation of hydrodynamics, PASCAL's law) and philosopher (*Lettres Provinciales*, *Pensées de M. Pascal sur la religion*). In particular his *Pensées* have had a lasting influence on French intellectual thought.