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Catching up in Technology: Case Studies from the Telecommunications Equipment Industry. Taylor Graham Publishing. 1994. ISBN 0-947568-63-8. £30. 203 pp. softbound.

In China, there are just 1.3 telephones per 100 inhabitants and in Bangladesh the density is even lower: 0.2 per 100. At present, these countries have a weak or absent indigenous capability to produce telecommunication equipment. Faced with the need to improve the telecommunication capability, the governments and international institutions have to decide as what to do: invest in the development of the telecommunication industry, buy production facilities or simply buy the needed products. Each of these scenarios has advantages and disadvantages and the right choice depends on many factors.

In the last years some developing countries have succeeded to some degree in developing their own innovative industries. However, this success has been limited to a few countries and to specific technologies. There are not many publications that deal with the reasons why some countries have been able to catch up in technology and other countries have not, and why it is easier to catch up in some technologies and not in others.

Answers to these questions are of direct importance for who are responsible for policy decisions with respect to initiation, coordination and management of the technological developments. Indirectly, the answers are also important for technical professionals, especially those involved in telecommunications, because they provide an insight into the nature of the activities and the technical development problems encountered in daily practice. The reviewed book is one of the few publications that deal with the above issues. It "compares and analyses the efforts of three developing countries, Brazil, India and the Republic of Korea, to build up an indigenous technological capability in the field of telecommunications".

The book is divided into six chapters. After the introduction in Chapter 1, Chapter 2 (27 pages) defines and analyses the problem and its context. The main theses of the book are stated, i.e. that (i) the necessary but not sufficient condition for building up a competitive industry is the ability to react to internal and external technological pressures, (ii) differences in the mix of policy measures account for much of the success in obtaining a technological capability, and (iii) the present change in techno-economic paradigm has given rise to new opportunities to developing countries.

In Chapter 3 (25 pages) the structure, technology and history of the telecommunication industry is briefly described and the impact of technological change (digitalization, increasing importance of software, introduction of new telecommunication services) on the structure of the industry, on international trade and on the possibilities for entering the telecommunications market as a producer are briefly described.

Chapter 4 (65 pages) contains the case studies. It describes in detail how Brazil, India and Korea have aproached the problem of developing the capability to design, manufacture and operate telecommunication equipment. For each country the national strategy and objectives with respect to (i) obtaining control over the telecommunications service sector, (ii) the research and development effort, and (iii) manufacturing sector are described. In Chapter 5 (43 pages) a systematic comparison of the policies and their effects is given. Chapter 6 contains conclusions.

The book is carefully written and very readable. It contains a wealth of facts, figures, references, conjectures and policy analyses that makes it useful to anybody involved in the telecommunication industry. The book's value is not particularly in the novelty of its conclusions—they are not truly unexpected—but in the facts and reasoning in support of these conclusions.

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JEAN KHALFA
What is Intelligence? Cambridge University Press. 1994. ISBN 0-521-43307-X. £19.95. 206 pp. hardbound.

INTRODUCTION

A compilation of eight lectures, this book is highly recommended for anyone who is fascinated by his (or her) own intelligence. For brevity, this review confines itself to discussing only concepts and issues, leaving out the wealth of factual information contained in the book.

WHAT *IS* INTELLIGENCE?

In his stage-setting introduction, editor Jean Khalfa (JK) discusses what intelligence really is: making and using tools (including language) and, importantly, the notion of responsible behaviour (including awareness of the consequences of one's own actions).

Roger Schank and Lawrence Birnbaum (RS&LB) look upon intelligence as the ability to solve problems. They stress functionality: "intellectual capacities cannot adequately be studied without considering the purposes to which they are put by the organism which possesses them". Performing an intelligent task is the most important criterion.

Richard Gregory (RG) claims that even passive interpretation of sensory information requires superior intelligence and illustrates this for human vision.

Simha Arom (SA) affirms that African tribal music has impressively complex rules which the musicians follow without even being aware of them. (This of course is true for all languages: the uneducated child or illiterate adult

uses complex rules of grammar with great facility in speech without any explicit knowledge of such rules).

INTELLIGENCE AND EVOLUTION

Darwin maintained that "there is no fundamental different between man and the higher mammals in their mental faculties". Nicholas Mackintosh (NM) contends that intelligence is not unitary but multi-dimensional; also, it does not increase monotonically along the phylogenetic scale."There are some sorts of problems of chimpanzee will solve and a pigeon will not (and vice versa)". In fact, NM would rather avoid the word intelligence altogether. JK also examines evolution: he wonders whether intelligence emerged when the living world reached a particular degree of complexity where instinct alone was not adequate for survival.

Daniel Dennet (DD) examines the role of language in the emergence of intelligence and wonders what types of thoughts would be possible without language. He sees three stages in evolution: (i) Darwinian blind evolution (survival of the fittest), (ii) acquisition of beneficial behavioural patterns by external conditioning and (iii) (intelligent) avoidance of unsafe behaviours, thanks to internalized models of the external world (based on direct knowledge as well as knowledge transmitted by other members of the species). (Without language of some sort, the last would not have been possible.) DD emphasizes that language permits thought transparence and visualization; by virtue of language, the human brain has access to a veritable treasure-house of thoughts of other members of the species. Language also provides the user of a mental space within which he can experiment with the world without danger.

Language capability has undoubtedly enabled intelligence enhancement. Dan Sperber (DS) points out that even its use demands high intelligence. Awareness of the speaker's intentions and motives is essential for understanding any utterance. This requires an internal model of the speaker's thought processes. Before speaking, the speaker would in turn need a model of the listener's thoughts, including the listener's model of the speaker (and so on).

RS&LB contend that a central aspect of intelligence is the ability to ask and answer questions. This requires language competence. DS remarks that language is itself generally considered to be proof of intelligence. Should one then concentrate on language abilities to understand the nature of intelligence? RS&LB differ. It is not our ability to create new sentences that needs explanation, they claim; it is our ability to create new thoughts. But they say themselves that the generative nature of language is necessitated by and is a reflection of the generative nature of thought.

INTELLIGENCE AND THE CHILD

Studying the child is a fascinating way of understanding the nature of intelligence. George Butterworth (GB) disputes the Piaget view that the child acquires knowledge primarily by motor interaction with it, that intelligence is expressed as programs of action and that action lends structure to perception, and even to thought and language. GB shows that the infant forms a mental picture of the external world, based primarily on visual and auditory perception. Perceptual functioning during infancy is a factor (though not the only one) involved in predicting IQ, particularly verbal IQ. Cross-sense integration and transference of perceptual understanding is an important prerequisite for the development of intelligence, concludes GB.

INTELLIGENCE AND EDUCATION

Understnading the nature of intelligence has important implications for educational policies. As RS&LB maintain, human intelligence is the product of evolution and enhanceable by training. They make the important point that education and AI should share the same concerns: what intelligence is, and how it can be acquired and improved. The 'consciousness' view of intelligence, they argue, implies that it is not augmentable: nothing can be done to make an entity more conscious and hence more intelligent than it is at birth; education is therefore totally pointless and unnecessary.

The Chomsky view (postulating special 'organs' in humans to account for cognitive abilities of various types) implies, argue RS&LB, that the end point and developmental path for the maturation of intelligence are both predetermined for all individuals, depending on the type and potential of the organ each individual is endowed with. One needs then to merely provide a very rich intellectual environment to all children (to facilitate adaptation of their organs at the highest possible level). No teaching would be necessary.

RS&LB assert that the human has an inherent predisposition to learn 'scripts' (memory structures that define behaviour in routine and mundane but complex situations involving several players) to associate one event with another and to rely on these for future processing. Acquisition of intelligence consists in the ability to learn scripts.

They propose teaching software of the following types:

1. Case-based learning involving interesting and complex (e.g. design) tasks for which skills are acquired as on the job;
2. Incidental learning of necessary but uninteresting information through interesting video games where good performance requires acquisition of such information;
3. Directed search of extensive video data bases which permit goal oriented exploration.
4. Simulation-based learning-by-doing (as in a flight simulator).

It is of course arguable as to how much of this is really inspired by AI concerns.

INTELLIGENCE AND MACHINES

Even intellectuals are generally reluctant to countenance the possibility of intelligence in non-humans—not in animals and least of all in machines. The philosophers insist that 'consciousness' is essential for intelligence; machines can never be intelligent since they can not have consciousness. The Chomskian view is that language capability (and, consequently, intelligence) in humans is due to their being endowed with a special 'language organ'.

DS feels that explanation of language must be grounded in the psychology of intelligence. He concedes that it develops in children and possibly in some animals; but can it be incorporated in machines, he asks. RS&LB argue on the other hand that the Darwinian position that "there is no fundamental difference between man and the higher mammals in their mental faculties" can be interpreted to permit intelligence to be attributed to computers as well.

Philosophical issues apart, one sees problems at the architectural level in visualizing intelligence in animals and machines. Even birds are able to do complex tasks. NM concedes that the complexities of behaviour involved in nest building, bird migration and homing pigeons are well known. DD points out however, that each interlocking part of the bird brain functions like a small computer program module which is given minimal information on a strict 'need to know' basis. This accomplishes the task, but such (decentralized) architectures cannot permit the type of global awareness (of the structure and contents of their thought processes) that humans have and exhibit in their every day life.

Roger Penrose (RP) echoes similar thoughts: humans solve mathematical problems in an insightful introspective manner which involves 'understanding' the issues involved; this is qualitatively different from the 'blind', mechanical, inference engine approach of AI systems. He draws a distinction between what he calls calculational and non-calculational brain action. An activity is calculational if it is potentially implementable in a Turing machine or a computer (or any other physical system). He asserts that the process of mathematical discovery of forming concepts, building up hypotheses and gaining insights into problems involves understanding; 'understanding...cannot be reduced to blind calculation".

He uses the Godel–Turing argument: there is a class of problems (predicting whether a computational process will go into an endless loop or terminate successfully) which cannot be implemented on a computer. Mathematicians, asserts RP, can solve such problems. The conscious brain is thus capable of non-calculational procedures. The operation of any physical system is computerizable. Physical systems cannot perform non-computerizable actions since physics does not permit non-calculational action. Any yet, the brain, a physical system, is able to perform non-calculational activity!

Like some others, RP does not take to the mystical view that the mind is beyond physics. Lacking a scientific explanation, he conveniently dumps this embarrassing paradox beyond the realm of mathematics, right in the lap of physicists! They better make a radical improvement in present day physics to explain non-calculational aspects of understanding. (But if the improved physics permits non-calculational action by the brain, why not in the case of computers as well?) One wishes this issue had been dealt with more exhaustively and more convincingly.

CONCLUSION

The RS&LB style is remarkable; an example: AI researchers face a treacherous Orwellian intellectual environment in which convenient alliances are formed between opposing camps to allow for better attacks by any two of the groups on the third.

RS&LB fault Chomsky for his "extreme views about the relative importance of innate rather than environmental factors in intelligence" and remark that it is his argument that the innate genetic endowment is universal, and his "immaculately correct political credentials" that saved him from harsh criticism. Needling Chomsky for his language organ explanation of language competence in humans, they tease, the human would have special purpose organs "devoted to mathematics, music, and who knows, the latest fad in the linguistic theory"! This tenor, though not typical of objective scientific discourse, drives the point well home and makes the chapter extremely interesting to read. It is unfortunate however that their chapter does not cite Chomsky source material for the interested reader.

On the whole, the book is highly informative, and will be extremely useful to the serious researcher, the beginning student as well as the casual reader. It has a wealth of experimental and factual material and extremely stimulating (even if controversial) views regarding the nature of intelligence.

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