MECHANIZATION OF THOUGHT PROCESSES

A SYMPOSIUM entitled "The Mechanization of Thought Processes" was held at the National Physical Laboratory during November 24–27. About two hundred invited delegates came from thirteen different countries to listen to, and discuss, papers on a wide range of topics related to 'artificial intelligence'. Associated with the symposium was an exhibition of devices and machines related to the general theme.

Dr. M. L. Minsky, of the Massachusetts Institute of Technology, gave the opening paper, which was concerned with "Heuristic Programming". Heuristic methods can be distinguished from the straightforward methods of solving a problem by the fact that they cannot be guaranteed to work. They are not 'algorithms'. The paper dealt with programmes for computers rather than with special machines, because any machine that can be fully specified can certainly be simulated on a digital computer, and trials by computer are less expensive.

The special features of heuristic methods discussed were 'pattern recognition', 'learning', 'planning ahead' and the use of analogies or models. These features were illustrated by a proposed programme for proving theorems in Euclidean geometry, where the model consists of actual constructions of points and lines. When tried out on the theorem that 'the base angles of an isosceles triangle are equal', it provided an unusual proof, using the congruence of the triangle to its mirror image.

There were two other papers on the general principles of intelligent machines, by Dr. D. M. MacKay, of King's College, London, and Dr. J. McCarthy, of the Massachusetts Institute of Technology. Dr. MacKay's paper examined the problems of obtaining intelligence in machines, and of evaluating it and distinguishing it from mere ability to calculate. He was led to the conclusion that one needed a hybrid system consisting of a digital decision process with an analogue process for evaluating 'weight' of information and proximity of a solution, etc. Several of the later papers concerned such devices.

Dr. McCarthy described a computer programme which he is developing, called the 'advice taker'. This programme, when given a set of statements about the world, is intended to deduce conclusions about action to be taken. In the discussion, some speakers felt that the proposed 'machine' would be too logical, and that practical decisions are not made in this way. It was agreed that the final answer would be given when the programme could be shown to work, or not, as the case may be.

It is not possible to describe here all the papers that were read and discussed. They can perhaps be divided into four groups, and some from each group will be mentioned. The groups are: (1) proposed mechanisms for intelligent machines, not necessarily related to neural mechanisms; (2) proposed mechanisms for intelligent machines which bear some relation to what is known of neural mechanisms; (3) the lessons to be learnt from the study of perception; (4) a number of related topics and applications.

Perhaps the most interesting mechanisms discussed at the symposium were those that attempted to reproduce some of the known constructional features of the brain. They were contained in papers by Dr. A. M. Uttley, of the National Physical Laboratory, Dr. F. Rosenblatt, of Cornell Aeronautical Laboratories, and Dr. W. S. McCulloch, of the Massachusetts Institute of Technology.

Dr. A. M. Uttley's 'conditional probability computer' embodies a classifying network, or 'tree', and a set of counters to record the number of instances of each possible state of the input channels. These counts are recorded in a logarithmic scale, so that their differences represent the logarithms of estimated conditional probabilities. The conditional probabilities are used to infer patterns at the input when only part of the pattern has actually been presented to the machine. In the paper presented to the symposium, this work was developed by considering how neural networks, with their connexions in some respects random, could perform in a way similar to the highly organized electronic model.

Dr. F. Rosenblatt described recent theoretical work on the behaviour of the 'perceptron'. This is a 'neural' network in which a large population of 'neurons' have random connexions to the inputs, and their connexions to the outputs are paralleled by feed-back connexions which modify the parameters of the 'neuron' so that frequent stimulation of an output will reinforce the neurons which feed this output. The hypothetical neurons assumed by Rosenblatt obey linear equations, for convenience; but computer simulation has shown that they would work with a wide range of characteristics.

Dr. W. S. McCulloch's paper was concerned with hypothetical neurons working with binary signals, and with a threshold—the well-known 'Pitts and McCulloch' neurons. It did not attempt to describe what happens in the brain, but explored switching circuit design using these particular switching elements. The problem considered was how to make switching circuits which are insensitive to variations of threshold.

Dr. O. G. Selfridge, of the Massachusetts Institute of Technology, described a process which was not related to neural mechanisms, but which would adapt and improve itself to handle recognition problems. The process, called a 'pandemonium', was described in rather anthropomorphic terms, but this was perhaps less obscure than an abstract description would have been. The pandemonium contains an assortment of 'demons' each responsible for looking out for a particular feature in the input. Some demons may look for features in the output of lower demons. At the highest level in the system, the strongest output of any demon is detected by a decision demon. Processes were described for inventing demons, making them more or less powerful according to experience, and so forth. A practical example is under development; this is a pandemonium for the translation of manually keyed morse.

A very interesting paper by Dr. Ross Ashby, of Barnwood House Hospital, Gloucester, showed that habituation can be demonstrated in a mechanism without any detailed assumptions about its construction. The only assumptions made were of a behavioural kind. By habituation is meant the decrease of response to a stimulus when it is regularly repeated. An indication was given of the circumstances in which extraneous disturbances could cause de-habituation.

Among the several papers giving the point of view of biologists was one by Dr. H. B. Barlow, of the

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University of Cambridge, which treated the coding of signals in sensory mechanisms. There is evidence of mechanisms operating at low levels in sensory pathways to reduce the amount of redundancy in the vast number of parallel information channels. Unlike the recoding proposed by Shannon for communication channels, the aim is not to remove all redundancy, but to reduce the number of pulses on any given channel, and to reduce correlation between channels. For two binary channels, the specification of such a coding device is very simple, and a model of this device was shown in the exhibition.

Among the specialized topics discussed was automatic programming, to which a morning's session was devoted. Dr. Grace Hopper, of Remington Rand, Ltd., gave the opening paper, and the session was rounded off by a paper from Dr. A. P. Ershov, of the Academy of Sciences of the U.S.S.R.

An afternoon's session was devoted to mechanical language translation, and Dr. Ershov, at short notice, said something about the groups working on this subject in the U.S.S.R.

Unusual fields for mechanization formed the subject of several papers. Dr. L. Mehl, of the École Nationale d'Administration, Paris, spoke on automation in the legal world. He described a machine for retrieving legal information and a machine for legal argument. The limitations of such machines are that they are incapable of evaluating data, or of developing the principle of law, so they cannot be a substitute for the jurist.

Dr. F. Paycha, of Paris, spoke about the logical structure of medical diagnosis, emphasizing the vast volume of facts on which it is based, and the need for mechanization to reduce the chance of an error. In the discussion which followed, the question was raised of how far probability considerations should be allowed to influence diagnosis.

Speech recognition was the subject of two papers. Prof. D. B. Fry and Mr. P. Denes, both of University College, London, described how linguistic information has been brought into the problem of speech recognition. A machine capable of handling 13 English phonemes and using digram frequencies to make a decision was shown in the exhibition. A paper by Mr. P. Ladefoged, of the University of Edinburgh, reviewed the whole field of speech perception, making the particular point that speech is not, in any sense, a sequence of small discrete elements.

In the analogous field of visual pattern recognition, a paper was read by Dr. W. K. Taylor, of University College, London.

Other papers dealt with literature searching, the mechanization of administration, and learning in animals, in addition to the subjects mentioned above.

The general impression given by the symposium was that in none of the fields of study is there any finality as to the basic approach to the problem. In the field of intelligent machines, there was a wealth of suggestions, but none of these has yet reached the stage of a successful test. It was also evident that many suggestions that can be made for machines to solve problems or perceive patterns may fail because the number of individual units in the machine is too large and that any practical machine must include some trick to achieve economy of equipment.

The modern theory of automata began with A. M. Turing's proof that universal computing machines were possible. Dr. Turing's ideas, and those of J. von Neumann, led to the construction of electronic computers, which are the working tools of the experimental approach to artificial intelligence. It seems possible that a further great advance in the development of intelligent machines will soon be made.

The *Proceedings* of the symposium, including the papers read, together with the discussion, will be published by H.M. Stationery Office in due course.

D. W. Davies

DEVELOPMENT OF ELECTRIC CABLES

Mr. S. E. Goodall delivered his presidential address before the Institution of Electrical Engineers on October 9. His subject was electric cables, and a substantial part of his address was devoted to reviewing the history of their development.

It was in the year 1812 that the first experiments were made in applying a soluble material, said to be india rubber, to the insulation of copper wires. The great initial development of the electric telegraph took place as a means of inland communication and the circuits employed were almost wholly composed of overhead, open-wire, lines. It was the timely discovery of the excellent properties of gutta percha as an insulant and its practical application to electric cables by Werner Siemens that initiated the development of submarine telegraph cables and indeed of cables generally. The year 1851 saw the first cross-Channel cable in operation, and fifteen years later the first successful telegraph cable spanned the Atlantic Ocean. The pioneer of the electric power cable was Sebastian de Ferranti. The transmission of power by alternating current at 10,000 volts from the Central Station at Deptford to the West End of London was effected by concentric cables of entirely novel design. Oil-impregnated paper was the dielectric, and the type of construction devised by Ferranti remained the basis of high-voltage power cable design for half a century. By 1900 single-core and three-core impregnated paper lead-sheathed cables were in regular manufacture in Britain.

The manufacture of telephone cables developed rapidly from about 1890. Multi-circuit lead-covered cables when first introduced were filled with insulating material such as paraffin wax, but their electrical characteristics were soon greatly improved by the adoption of the dry-core technique, in which advantage is taken of the air interstices to obtain lower electrostatic capacitance. The first cables used for long-distance telephony were simply adaptations of telegraph cables and used gutta percha as a dielectric. For gutta percha, balata was later substituted and this held the field for submarine purposes until comparatively recently.

Two very important developments in high-voltage power cables occurred during the 1920's. The major factor tending to initiate breakdown in high-voltage cables had been traced to ionization in voids

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