VON NEUMANN'S CONTRIBUTIONS TO AUTOMATA THEORY

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The theory of automata is a relatively recent and by no means sharply defined area of research. It is an interdisciplinary science bordered mathematically by symbolic logic and Turing machine theory, bordered engineering-wise by the theory and the use, particularly for general non-numerical work, of large scale computing machines, and bordered biologically by neurophysiology, the theory of nerve-nets and the like. Problems range from Godel-type questions (relating to Turing machines and decision procedures), to questions of duplication, of various biological phenomena in a machine (e.g., adaptation, self-reproduction and self-repair).

Von Neumann spent a considerable part of the last few years of his life working in this area. It represented for him a synthesis of his early interest in logic and proof theory and his later work, during World War II and after, on large scale electronic computers. Involving a mixture of pure and applied mathematics as well as other sciences, automata theory was an ideal field for von Neumann's wide-ranging intellect. He brought to it many new insights and opened up at least two new directions of research. It is unfortunate that he was unable to complete the work he had in progress, some of which is in the form of rough notes or unedited lectures, and for some of which no record exists apart from his colleagues' memories of casual conversations.

We shall not here discuss his tremendously important contributions to computing machines and their use—his ideas on their logical organization, [1; 3] the use of flow diagrams for programming, [3; 4; 5] methods of programming various problems such as the inversion of matrices, [2] the Monte Carlo method, and so on,—but restrict ourselves to the automata area proper.

Reliable machines and unreliable components. One important part of von Neumann's work on automata relates to the problem of designing reliable machines using unreliable components [10]. Given a set of building blocks with some positive probability of malfunctioning, can one by suitable design construct arbitrarily large and complex automata for which the overall probability of incorrect output is kept under control? Is it possible to obtain a probability of

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