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Its Moral Implications

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The application of electronics to medicine in this century has been an outstanding contribution to medical science and education, and has enabled thereby a greater understanding not only of the function of many systems of the human body but also of the natural history of disease processes.

In this connection, the electrocardiograph and the electroencephalograph epitomize benefits of the application of biophysics in clinical medicine. In addition, other biophysical instruments have been developed to study a variety of physiological events at the bedside and in the laboratory. Therefore, it is not surprising that medical schools have chosen to use electronic instruments more and more in basic medical education, and that the understanding of physiological phenomena by medical students, for instance, has been significantly facilitated in laboratories of experimental physiology equipped with electronic devices that record simultaneously a number of different physiological events. [1, 2]

Although the impact of automation and use of electronic computers in industry is duly appreciated, their recent introduction in medicine introduces this question: Can moral problems arise from the widespread application of electronic computation? Therefore, at the dawn of an era of electronic computer usage in medicine, I should ask if either current or future applications of electronic data processing techniques and computers in medicine are exempt from moral consequence.

On January 14, 1959 the first Conference on Diagnostic Data Processing was held at the Medical Electronic Center, The Rockefeller Institute, in New York City. Since then the number of papers, hitherto scanty, dealing with electronic data processing techniques in medicine has increased rapidly.[3] Many of the publications have dealt with particular applications of computers to specific research problems; others, fewer in number, with the application of electronic data processing techniques or computers to general medical problems. Finally, some papers are merely a futuristic view of the vast potential use, as well as the role, of automation in medicine.

At this point, I should like to distinguish between electronic data processing techniques in general and electronic computers in particular. Electronic data processing instruments are capable of handling a large number of data — sorting, classifying, tabulating, plotting, and storing them according to pre-established routines and methods. Such tasks are accomplished at speeds unattainable by human and mechanical means. Electronic computers, however, do more. They not only perform multiple arithmetic and more complex calculations, but also make logical decisions pertaining to the data with which they work. Such efficiency and accuracy account for their increasing use to control automatically most of the operations of certain industrial plants and engineering systems.

ELECTRONIC COMPUTERS

The efficiency of electronic computers derives from their easy manipulation of all the items of information that have been previously converted into a code of electrical signals of absolute character; i.e., the presence or absence of an electrical charge. The conversion of alphabetic or numerical information into a simple code of electric charges has been the goal of years of multidisciplinary investigation. Most current electronic data processing instruments convert automatically into code any information with the form of digits or numbers. For example, a number comprising two digits such as "13" is immediately accepted by an instrument and coded into a set of charges. Likewise, a letter, for instance "A", can be converted into an intermediate code of one or two digits which in turn can be converted into a set of charges arranged, however, in such a way to characterize the letter "A" and only that letter.

Electronic data processing instruments and computers accepting information in digital form are called digital electronic data processing equipment or digital computers. Other computers manipulate information in the analog form; that is, a quantitative but not digital expression of an event. For example, the position of the needle of a car's speedometer is an analog expression of the speed of that car. The digital expression of the same speed would be given in numerical units of distance per unit of time (e.g. miles per hour). Analog computers perform calculations with analog information in a manner similar to digital computers.

Most current instruments detecting physiological events record them in analog form. Events like the electrical activity of the heart (ECG) or that of the brain (EEG) are phenomena that we have learned to recognize from their analog presentation. Analog computers that would analyze automatically the information contained in these analog records

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[1] Hoff, H. E., Geddes, L. A., and Spencer, W. A.: The Physiograph — An Instrument in Teaching Physiology. *J. Med. Educ.* 32:3, 181, 1957.

[2] Peiss, C. N., McCook, R.D., Rovick, A. A., and Randall, W. C.: Electronic Instrumentation in a Medical Physiology Laboratory — an Evaluation After 2 Years' Experience. *J. M. Educ.* 35:660, 1960.

[3] A complete bibliography is beyond the scope of this article. The reader is referred to Proceedings of Conference on Diagnostic Data Processing. Sponsored by The Medical Electronics Center of the Rockefeller Institute (IRE Transactions on Medical Electronics ME-7: 4, October, 1960), and to the Proceedings of the 1st and 2nd IBM Medical Symposia (IBM Education Center, Endicott, N. Y.).

will be of real usefulness in medicine. Digital computers, on the other hand, will be more suitable for comprehensive quantitative analysis of large volumes of clinical and laboratory data.

CURRENT MEDICAL USES OF ELECTRONIC DATA PROCESSING TECHNIQUES AND ELECTRONIC COMPUTERS

Electronic data processing techniques and electronic computers (analog or digital) have been applied to medicine for the following purposes: 1) large scale statistical analysis of clinical and research data; 2) collection and processing of medical information concerning the natural history of disease processes; 3) testing complex physical models of biological systems; 4) aiding the establishment of clinical diagnosis; and 5) automatic control of the activity of electromechanical substitutes of physiological systems (heart-lung machines, respirators, etc.).

A MORAL CONSIDERATION

Plausible as they may seem, the tasks assigned to computers in medicine may not be provided with moral impunity. Strangely, the moral vulnerability of computers derives not only from man who has invented and designed them, but also from their potential dangers beyond possible human control. Such a potentiality was emphasized recently by Dr. Norbert Wiener.[4] In pointing out the possible moral and technical consequences of automation, Wiener said: "Machines can and transcend some of the limitations of their designers, and that doing so they may be both effective and dangerous."

It must be understood at the danger lies in the computer's almost unlimited capacity store information, to manipulate it and originate thereby new control-information at a speed incomprehensible to human beings. To some, any thought of danger or threat resulting from the work of computers may sound preposterous, for whatever information is given to computer must be given by man. Indeed, to borrow the words of the Doctor of Aquinas, the computer *"est quam tabula rasa in quo nihil scriptum est."* But in contrast to the *"tabula rasa"* of the human soul, the computer can accept new information at a fantastic speed. Therefore, it is not difficult to conceive a computer of such extraordinary capacity so as to store all the information that man has ever known since his creation, and in addition deliver that information in a formidably small period of time. What, then, can we ask the computer to do with all this knowledge? And for what purpose?

Assume for a moment that current work in developing a suitable code for all medical information and knowledge has been finished, and further, that such information and knowledge has been transferred to the computer's electronic memory. Now the computer is ready to "work" this information. The question then arises "What can we ask the computer to do?" It may categorize for us the signs and symptoms of disease processes if we provide the computer with some indication of what a disease process is. It could also classify different diseases if we gave instruction on how to proceed to classify such diseases. Perhaps it would even establish cause-effect relationships if we previously had defined what constitutes a cause and what constitutes an effect of the cause. It might also establish the range of variation of function in health and what constituted significant departure from health.

Provided with such capabilities, the computer would then be ready to accept any medical information from a person and detect readily thereby an incipient disease. If allowed to do so, the computer could conceivably set up a whole series of therapeutic measures and to correct automatically the degree of departure from health which the computer established so accurately. The danger of such an Utopian plan lies in the speed at which the computer would perform the forenoted steps, thus reaching a point when efficient interference may become impossible. For Dr. Wiener also states[5]: "If we use to achieve our purposes a mechanical agency with whose operation we cannot efficiently interfere once we have started it, because the action is so fast and irrevocable that we have not the data to intervene before the action is complete, then we had better be quite sure that the purpose put into the machine is the purpose which we really desire and not merely a colorful imitation of it." In complete agreement with this idea, we may indicate that the moral danger of using this kind of automation in medicine lies in the human incapability of defining accurately the very purpose of the work of the computer itself. And were we even to assume a computer could serve best to correct physical disorders of man, can we assure it will best serve man's psyche also?

The forementioned description is, no doubt, far from becoming a reality. Indeed, it may never become a reality. Initial steps, however, have already been taken, and it is pertinent to analyze the possible morality of such steps and to discuss the moral aspects of certain applications of automation in medicine. For even at the risk of allowing unnecessary freedom to our projective thoughts "we must always exert the full strength of our imagination to examine where the full use of our new modalities may lead us."[6]

THE DIAGNOSTIC AUTOMAT

If and when the day comes that a computer will be capable of making an accurate diagnosis on a patient presenting an array of bizarre symptoms, enormous relief will be felt by those who consider clinical diagosis as the most important task of a physician. We shall not discuss the obstacles already encountered in programming the task of the computer to estab-

[4] Wiener, Norbert: "Some Moral and Technical Consequences of Automation", Science 131: 1355, 1960.

[5] *Ibid.*

[6] *Loc. Cit.*

lish accurate clinical diagnoses of certain disease processes. Instead, assume for a moment that all the difficulties have been superseded and that an infallible "automat" diagnostician already exists. Then, it would appear simple to ask the computer to identify a whole group of signs and symptoms and categorize them according to a specific disease. However fascinating, this would help to solve but few problems the modern physician is apt to encounter.

In instances of clinical emergency resulting from deranged body function, it is far more important to assess accurately the patient's *degree* and *quality* of deterioration; indeed, this may take precedence over the establishment of a clinical diagnosis of disease. Nor is the patient *himself* less concerned about whether he is healthy or ill, and if he is ill, what can be done to make him healthy. In fact, almost always this is the only concern of the patient, not what the name of his illness is. Many persons, of course, inquire about the diagnosis because they have acquired the habit of learning characteristics of specific disease processes, as well as their incidence, symptomatology, prognosis, and treatment. At times this serves to ease the physician's obligation, permitting the patient awareness of difficulties lying ahead. All too often, however, such situations tend to lead to increased anxiety, the patient considering himself doomed to the worst aspect of his disease. It is unquestionable that most patients are not instructed on the spectrum of individual variation of diseases as we conceive them today. The patient of the future perhaps will be more conscious of this variability and he, like Tolstoi's Ivan Ilyitch[7] will not feel any relief when confronted by either doctor or computer who can only say: "such and such a thing shows that you have such and such a thing in you, but if this is not confirmed according to the investigation of such and such a man, then you must suppose such and such a thing. Now if we suppose such and such a thing, then . . ."

In describing the foregoing situation, Tolstoi indicates that "for Ivan Ilyitch only one question was momentous: was his case dangerous, or not? But the doctor ignored this inconvenient question. From a doctor's point of view, this question was idle and deserved no consideration: the only thing to do was to weigh probabilities." May we ask if a computer capable of establishing a diagnosis would consider Ivan's question idle, also? Will the weighing of probabilities be the most important thing the computer would be capable of doing?

MORALITY OF AUTOMATIC THERAPY

Were a computer to diagnose with accuracy clinical syndrome, it also is likely that it could select the best treatment for that particular clinical situation, and the selection would be made correctly and with rapidity. Therapeutic experiences of countless professional persons who had treated similar cases over the years would have been collected in the computer's memory. Thus, it would be a simple, logical task for the computer to determine which one of the many already tried treatments would provide most beneficial results. Here again, one must consider the morality of the computer's electronic judgment; how to decide if treatment is good or bad, and how good or how bad is it?

For centuries, physicians have disagreed on the right or wrong of innumerable therapeutic measures. It is unlikely that computers would settle such disagreements since the computer's therapeutic decision would depend solely on the experience gained with various kinds of treatment with or without regard to their moral values. If such were the case, the computer's pronouncement of treatment obviously should never be taken as a dictum to which no moral test could be put. As an example, what if a computer upon consideration of a pregnancy complicated by serious disease were to recommend a therapeutic abortion as the best solution? Or, are we to anticipate the computer's strong recommendation to sterilize those with a dominant trait of a severely disabling condition? Could the computer eventually make an impersonal announcement simply by weighing probabilities, or would a moral judgment be made according to the patient's own scale of values, the physician's scale of values, or society's scale of values?

Even more dangerous from a moral standpoint could be the therapeutic decisions of computers when these were used as guides in the management of a patient by a series of automatic control devices. Preliminary experiments with such systems have proved successful to induce and control anesthesia. It is likely that similar systems will also be used in the future in order to manage automatically those patients with severely deteriorated pathophysiological situations. Since such situations continuously change, they will require swift readjustments of the control mechanisms. Thus, the assessments and decisions of the computer would have to be both accurate and fast. It is doubtful that the physician and the auxiliary personnel could even keep note of such decisions. Indeed, at times the physician might find himself completely defenseless either to prevent or correct a decision therapeutically sound but morally wrong.

Could we expect, for example, a computer to decide to terminate the life of a patient with pathophysiological situation deteriorated beyond hope of reversibility? Would this decision, however expedient and efficient to the computer, be tested in a proper moral perspective? Of course not. A plea for critical appraisals of the moral aspects of any method of automatic control as powerful as the one envisioned here may sound not only dramatic, but even fanatic to some. It might even appear out of perspective, for it would be just as simple to initiate

[7] Tolstoi, Lyof S.: *The Death of Ivan Ilyitch* (New York, Thomas Y. Crowell Co., 1899) *The Complete Works*, II, p. 31.

automatic correction of pathophysiological alterations immediately after they occur, as it would be to discontinue such automatic control at the precise point where a decision beyond the capabilities of the computer should be made. The plea may sound more justified, however, to those already aware of these latter situations being possible if — and only if — the stop at the crossroad of a moral decision has been anticipated by the physician programming step-by-step the evolution of the automatic control process before it had been allowed to start.

AUTOMATIC MEDICAL INFORMATION: RIGHT OF PRIVACY?

Full scale application of electronic data processing techniques in medicine would permit storing the records of all clinical situations arising in the course of a person's life. Multitudinous medical records collected according to these methods could be made available to any physician. It would doubtless be a blessing to both the patient and physician to have such complete information readily available. This kind of medical "historian" has been envisioned by Dr. Almy.[8] He has suggested the creation of a national library of past histories of all persons living in this c ntry. He illustrated an extreme van- tage of this system. An con- scious patient is brought the hospital emergency room thout identification data. Upon roper coding of the patient's fing rints a code number would be ans- mitted to the central lib y of medical histories. In a m. er of seconds, all medical info ation available on the patient w d be transmitted from there to t phy- sician treating that patient spite vast distances separating t phy- sician and the library. Ou de of the theoretical advantages f the forementioned system, wo d the documentation and coding f the patient's medical history t ough- out his life be an invasio f his privacy?

Indeed, a person realiz that all kinds of intimate info nation concerning himself is ava ble in seconds to innumerable ersons in the world may justifia y fear that without his having really much control, such info nation might be released not alw ys for his own good. The issue f life insurance policies, the sele ion of personnel for specific jo . per- haps even the mating of uples, could be seriously affecte by an automatized system of re ording medical information. If our society ever reaches this level of o ganiza- tion to what extent will d cisions be based on mathematic expres- sions of materialistic value while spiritual considerations wil be set aside because they are not quanti- fiable?

[8] Almy, Thomas P.: Some Comments on the Usefulness of Electronic Data Processing in Medical Practice. Proceedings of Conference on Diagnostic Data Processing. Sponsored by The Medical Electronics Center of the Rockefeller Institute. (IRE Transactions on Medical Electronics ME-7: 4, October, 1960.)

AUTOMATION AND PATIENT-PHYSICIAN RELATIONSHIPS

Patients themselves have followed with extraordinary interest progress made with the use of computers in medicine. Some are delighted over the prospect of a machine capable of infallibly tagging their ailments, assessing a prognosis, and selecting the best possible treatment. Some physicians look at such a possibility as a more tangible threat than that of socialized medicine. Full reassurance can, however, be given to both the over-optimistic patient and the overly concerned physician that such situation should never come about.

Since its initiation the use of electronic data processing techniques and computers in medicine has been carefully studied and evaluated. Those making pioneer efforts in this field are aware not only of the capabilities and limitations, but also the dangers in the use of powerful tools of automation in medicine.

Judging the initial trends we may envision with confidence that a full-scale application of computers in medicine will lead to an improvement of the relationships between the physician and his patients. This relationship may become warmer than ever before in the history of medicine, for computers may prove extremely useful to the physician in detecting and pointing out hidden signs of illness long before they become readily apparent to the patient himself. Correlations hitherto unsuspected between certain aspects of the psychological and p sio- logical behaviors of a patien may become apparent and permit the gearing of treatment in the right direction. By no means do we anticipate that computers will replace the physician's role in interpreting medical data. On the contrary, greater scope will be permitted by this interpretation and the physician's judgments will be more scientific than they have been at times.

Physicians have always been aware of technological achievements and have been ready to apply them to medicine when betterment of man's health can result from this. Computers and electronic data processing techniques have been one of the outstanding achievements of the last decade. They have entered the medical field at a fast pace. Physicians need not be wary of this intrusion. On the contrary, they must welcome it, for if properly used it will contribute immensely to the scientific progress of medicine. Whether we agree or disagree on some of the moral considerations we have presented is irrelevant at this point. Agreement must be reached, however, on the moral obligation of all physicians, for keeping abreast of current and future technological advances and for the progress made with the application of these achievements in medicine. May this plea reach especially those engaged in teaching activities, for in the education of today's medical students, computers and electronic data processing techniques will become tools of importance at least equal to the

meth s used by past generations of medical educators.

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