Testing Physicians’ Limits: Medical Informatics and Diagnostic Decision-Making

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Medical Informatics and Diagnostic Decision-Making

By Philip L. Frana

The idea that medical technologies have promoted physical, emotional, and intellectual “distingue” in the past, that is, a growing divide between caregiver and client, is well-known and popularly accepted. Yet this way of thinking about the introduction of technologies into medical spaces is of relatively recent origin and does not reflect the many other ways that powerful medical technologies, particularly medical-computer applications, have been evaluated in the past. Medical informatics, defined today as “the application of computers, communications, information science, engineering, and technology to medical care, medical education, and medical research,” is one useful and illustrative case in point. In the late 1950s and throughout most of the 1960s physicians, medical educators, and researchers embraced the movement toward the exploitation of computers to collect and organize burgeoning stores of medical knowledge and provide significant decision-support in their interactions with patients and students. Skepticism toward certain applications of medical informatics as agents of “distingue” did not emerge until the late 1960s.

Joel Howell in Technology in the Hospital (1995) notes that medical machines are today implicated as the source of all sorts of “evils,” including the devaluation of patient narratives of their own afflictions, the privileging of machine-generated medical data, and the transformation of the primary-care physician into a remote research scientist. Much less well understood is the role and evaluation of computers as medical instruments of change in the middle of the century. Here, the development of so-called “diagnostic-assistance programs” is considered as one particular area illustrating different views of medical technologies.

Although the term “medical informatics” does not appear in published sources until the mid-1970s, conscientious efforts to apply “computer medicine” in developing programs to aid in patient diagnosis began two decades earlier. The first diagnostic computer programs emerged from patient health questionnaires and tables of medical diagnoses. Around 1954 F.A. Nash, a London director of x-ray services, invented a slide rule-like device called a Group Symbol Associator which allowed physicians to line up a patient’s symptoms with major symptom-disease complexes and derive a diagnosis. Essentially, the device used propositional calculus to parse various combinations of symptoms. In the process, Nash reduced thousands of pages of traditional diagnostic tables to a machine slightly less than a yard in length.

At about the same time, Keene Brodman of the New York Hospital-Cornell Medical Center began applying the Cornell Medical Index-Health Questionnaire to the automation of medical diagnosis. The index collected data teased out of two hundred “yes/no” questions answered by three thousand undiagnosed patients. Brodman used an unspecified “conventional” digital computer to evaluate the data against the records of six thousand other patients whose symptoms and diagnoses were already known. This “Medical Data Screen,” Brodman reported, could correlate symptom complexes with the right diagnosis over forty percent of the time (the figure later rose to seventy percent).

Dr. Homer R. Warner at the University of Utah took a different approach to computerized medical diagnosis in 1960. Warner exploited his access to a Burroughs 205 computer to diagnose congenital heart diseases at Salt Lake’s Latter-Day Saints Hospital with Bayesian statistical estimation. Bayesian estimation calculates the probability of the validity of a proposition based on a prior estimate of its probability plus any new and relevant data. It is very close to what Alan Turing described as the factor in favor of the hypothesis provided by the evidence. The mathematical theorem was developed by the Reverend Thomas Bayes of England and published posthumously as “An Essay Towards Solving a Problem in the Doctrine of Chances” in 1763. Bayes’ theorem had already been “rediscovered” several times before it fell into Warner’s hands, eliciting commentary from such luminaries as Pierre-Simon Laplace, the Marquis de Condorcet, and George Boole.

Warner and his staff used the theorem to determine the probabilities with which an undiagnosed patient with definable
symptoms, signs, or laboratory results might fit into previously established disease categories. The computer program could be used over and over as new information presented itself, establishing or ranking diagnoses by serial observation. Warner found that by applying Bayesian conditional-probability algorithms to a symptom-disease matrix of thirty-five coronary conditions, the Burroughs machine could perform just as well as any cardiologist. Other enthusiastic early adopters of Bayesian estimation included John Overall and Clyde Williams for thyroid disorders, Charles Nugent for Cushing’s disease, Gwilym S. Lodwick for primary bone tumors, and Martin Lipkin for hematological diseases.

The celebration of computer-assisted diagnosis reached its highest pitch soon after the widespread application of Bayes’ work. Dr. Jordan Baruch of Massachusetts-based Bolt Beranek and Newman Inc., for instance, lauded the technology as “literally more intelligent and more capable than any group of humans.” Developers of programs incorporating Bayesian statistical methods in the 1960s celebrated computer diagnosticians as tools for making medicine cost effective. Many medical educators hoped that the programs would ease the burden of medical students memorizing a crushing load of arcane medical information. Computer-assisted tools also held out the possibility of diagnosis by technician. And everywhere in the early debates over the merits of digital diagnosis one could hear physicians heralding the dawn of truly “logical” medical diagnosis, medicine as the Ancients had intended.

Confirmation of Bayesian estimation as a worthwhile and valid technique for medical diagnosis came from an unusual Public Health Service-National Bureau of Standards collaboration. Homer Warner had been introduced to the possibilities of Bayes’ theorem by USPHS officer Lee B. Lusted who, with National Bureau of Standards (NBS) dentist and theoretical physicist Robert S. Ledley, quickly became a giant in the field of medical decision-making. Lusted and Ledley shared similar interests in digital diagnosis, and together hoped to realize the potential of the NBS’s general-purpose SEAC computer. Ledley’s first program automatically diagnosed diseases of the tongue, but more importantly, Ledley and Lusted began carefully scrutinizing the “reasoning foundations” of the “symptom-disease complex.” Out of this, both endorsed the validity of probabilistic diagnostic methods like Bayesian estimation, arguing that they captured the essential variability of disease better than printed tables. Ledley and Lusted also discovered that enormous computational power was necessary to really get at the total number of conceivable symptom-disease combinations they wanted to evaluate. For example, just one specialized branch of medicine with three hundred defined diagnoses and four hundred associated symptoms could generate $2^{300}$ possible combinations.

While the power and speed of computer grew rapidly to meet this challenge, by the late 1960s many medical researchers and commentators began issuing distressed assessments of the present and future for diagnostic assistance programs. Though computer diagnosis had always been controversial in some respects, especially in terms of the new demands it put on physicians to learn to use the new technology, by the late 1960s criticisms of diagnostic-assistance programs began to mount. Critics disparaged digital diagnosis programs as cost-containment measures. Moreover, as “logical” as computers seemed to be, even “imperfect” humans could out think them.

For example, INTERNIST-1/CADECEUS, one of the most promising digital diagnostic programs of the late 1970s and 1980s, got most of its diagnoses right. But it was maddeningly wrong just often enough to make it
Archivists Meeting...

Continued from page 1

discussed aspects of Intel's Internet and email management program including selection criteria for disposition of email, automated implementation of retention schedules, and the ongoing education and outreach components of the program.

Participants also discussed models for long term preservation of digital photographs. This is an especially pressing concern for corporate archivists: corporations have in the past relied heavily on the photograph holdings of their archives for a variety of uses including publicity, advertising, and internal publications. As use of digital photography becomes increasingly the norm, archivists are seeking solutions to a widening "digital gap" in visual documentation of company history that will likely result in a dearth of images for future corporate use.

Kaplan described CBI's current NSF-sponsored software history project. Effective searching of the online historical dictionary will to a large degree be dependent on an authority file (standardized set of names and subject headings) specific to the field of information processing. Meeting participants discussed currently available resources, outlined the process by which they have created internal authority files at their respective companies, and expressed interest in collaborating with CBI to establish a shared set of authority files for information processing resources.

After the meeting, attendees enjoyed tours of the Intel Museum and the Tech Museum in San Jose.

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swallowed up by its most dehumanizing aspects. From its expectant infancy as a solution to social and professional needs its awkward adolescence as a social and technological problem, diagnostic-assistance programs have charted an ambiguous and ultimately useful middle path between facilitation and consternation.

Medical Informatics

Continued from page 5

impractical for use in the "real world." Digital assistance also freed clinicians from few of the routine decisions it was supposed to. Physicians on rounds showed reluctance in applying programs like CADUCEUS simply because they absorbed precious moments with tedious data-entry. Finally, diagnostic-assistance programs tested physicians' limits by distancing them from their patient's afflictions, reducing them to a series of weighted variables.

Crucially, physicians limited expectations for diagnostic-assistance programs fueled their reconfiguration as limited applications. That is to say, physicians' restrained desires led to more constrained uses. In this way, ironically, medicine derived unparalleled benefits from the technology. Physicians embraced computers as virtual Solomon's houses of diagnostic information, if not as independent organizers of medical content. Pharmacists accepted narrowly conceived assistance programs as helpmates against antibiotic resistance and incompatible prescriptions. The computer's ability to discern patterns in telemetry data proved another successful targeted application of digital diagnostic-assistance (increasingly softened by use of the moniker "decision support"). No hospital cardiac care ward today is without sophisticated monitoring equipment descended from early electrocardiographic equipment which did "point recognition" and established "ventricular gradients." Yet these telemetry machines are still operated by human technicians.

Clinicians and medical researchers since the 1970s have found ways to make digital diagnosis useful without becoming