Electronics and Health Care Revisited: Thirty-Eight Years Later

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Predictive Paper

I. Introduction

In 1962, V. K. Zworykin published a futurist paper entitled "Electronics and Health Care." He imagines visiting a family physician in 2012, 50 years into the future. He describes what the initial visit would be like and what subsequent followup visits might entail.

We have just reached the year 2000, a new millennium. Our health care system is quite different than it was in 1962. It is undergoing revolutionary change, not unlike the industrial revolution of 100 years ago. In 1962, medicine was generally practiced by stand-alone, single practitioners. Health care was largely a "mom and pop" industry. Now, 38 years later, health care has become industrialized. A majority of Americans are members of, and get their health care from, a health maintenance organization (HMO) or independent practice organization (IPO). Most specialists, although appearing as independent, are members of one or more IPO's or insurance company-based organizations and operate under some form of capitation. The practitioner is being paid less and is expected to produce more. The classic Dr. Welby of the 1960's is a very rare commodity.

II. Medical Informatics

Dr. Zworykin looked into his crystal ball to see how electronics would influence the practice of health care. As engineers, the first thing we notice is that an entirely new discipline has developed since 1962, one that Dr. Zworykin included within the realm of electronics. That discipline is computer science, or, more precisely within the current context, information technology in general and medical informatics in particular. His vision was clear, and the electronic device technology that he envisioned is in fact becoming a reality. But what he did not see was the impact that health industry politics and the application of information technology would have on the health care system.

At the center of Dr. Zworykin's vision is the central diagnostic computer and the lifelong electronic medical record. Indeed, the holy grail of modern medicine is the quest to achieve such an all-inclusive lifelong health record. There has been long discussion as to what belongs in such a record. Advances in data storage devices have made such discussion irrelevant. The answer is: "store everything." The more timely and difficult question is the efficient and specific retrieval of the needed information from the stored data. This leads to questions of indexing schemes at storage time or natural language processing at retrieval time. One must remember that the lifelong record is not made up of just text. It is a multimedia record containing pictures (x-rays, MRI, pathology), signals (EEG, EKG), sounds (heart, bowels), and videos (echo cardiogram, angiogram). Bulk storage may no longer be a problem, but efficient, specific retrieval certainly is.

III. Medical Data Security

Almost every day, there is a news story concerning the security of the Internet itself or the data banks accessible via the Internet. Unlike the world of 1962, the world in the year 2000 includes the "hacker," and so the security of the data bank containing the lifelong record or the distributed data bank containing the parts of the lifelong record is also an issue. As engineers, we would argue that these problems are solvable. What seems to be unsolvable are the politics that must be taken into account when proposing an engineering solution [1].

IV. Diagnostic Assistants

There have been several attempts at the development of medical diagnostic computers or at least programs designed for medical diagnosis. DxPlain [2], Iliad [3], and QMR [4]

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are well-known examples. Dr. Zworykin predicts that it is the diagnostic computer that gives the physician the time to regain the position of the classic family doctor, concerned with the holistic well-being of the patient instead of just managing disease. But the politics of the medical community has placed these computer programs in the category of diagnostic assistants, for only the physician can make a diagnosis. Unfortunately, most physicians find that they barely have enough time to make a considered diagnosis, let alone deal with their patient's total well-being. The recent study by the National Research Council, "To Err Is Human" [5], points to the need for automated systems to provide the oversight to help reduce medical mistakes.

V. Imaging Technology

Dr. Zworykin's vision of the future surgeon's use of "new tools of observation" bears a striking resemblance to our modern reality. Imaging technology is playing an increasingly important role, first in diagnosis and more recently during surgery. Diagnostic X-ray and fluoroscopic imaging techniques were available for many years before 1962. Since then, there has been a tremendous increase in the types of imaging modalities available to the health care practitioner. Most known to the layman are the three-dimensional (3-D) techniques of the MRI and CT scan, and the motion capturing techniques of the echo cardiogram or the fetal sonogram. More recently, techniques that visualize metabolic functions have been added, including functional MRI and the PET scan.

Advances in imaging techniques have greatly advanced the surgeon's ability to perform minimally invasive surgery. The development of the arthroscope [6] for knee surgery has been extended to the endoscope for chest and abdominal surgery. Further refinements have allowed noninvasive (a medical euphemism) diagnostic techniques such as endoscopy and colonoscopy. The use of MRI or CT images in a virtual reality environment has recently led to the development of truly noninvasive virtual colonoscopy [7] and virtual endoscopy [8] techniques. More recently, the open MRI machine is allowing image-guided surgery [9] to be performed for the placement of vascular stents or the removal of brain tumors.

VI. Robotics

The surgeon is not only being aided by imaging techniques but also by robotics, a technology that did not appear in Dr. Zworykin's crystal ball. Holes, to anchor replacement joints, are created in bone by robotic drills, resulting in fewer post-surgical complications [10]. Surgeon-controlled robotics are also used in laser eye surgery [11] and open heart surgery, giving even the skilled surgeon a tremor-free hand capable of even finer hand–eye coordination [12].

VII. Tissue Compatibility

Although progress is being made in more accurate and less invasive diagnostic and surgical techniques, very little progress is being made in the areas of artificial replacement organs or in the rejuvenation of our natural organs. The problems associated with the biocompatibility of materials used for producing artificial organs or the rejection problems associated with transplanting natural organs are far from being completely solved.

VIII. Consumerism

Dr. Zworykin concludes by providing us with the guiding principle by which his crystal ball operates: the need for physicians to have immediate access to both health records and the universe of medical knowledge. His instincts are good. MEDLINE first became available in 1966 as an electronic gateway to the medical literature for the health care practitioner. But use of MEDLINE increased by an order of magnitude in 1998 when the PubMed version of MEDLINE became a free service available to patients via the Internet.[1] As we enter the twenty-first century, it appears that the consumer is taking a personal interest in health care and is being enabled by many of the same "electronics" that were designed to enable the health care professional during the last century.

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[1]See http://www.ncbi.nlm.nih.gov/PubMed/.