The MEDIGATE System for Direct Entry of Physical Findings by the Examiner User Interface Issues

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Abstract

The MEDIGATE System (Medical Examination Direct Iconic and Graphic Augmented Text Entry System) is a computer enhanced interactive graphic and textual record of the findings from physical examination designed to provide ease of user input and to support organization and processing of the data characterizing these findings. The system described here mimics a program implemented on PLATO graphical display system fifteen year ago and, in addition, utilizes some of the advanced graphic and interface design features that are provided by modern workstations; these include multiple re-sizeable windows, improved graphics, menus, color graphics, and icons, flexible input devices, higher resolution and object-oriented interfaces. This presentation will outline the design and performance off the system now implemented using SuperCard(tm) on the Macintosh platform, and will highlight some of the nuances involved in mixed initiative system design for this professional environment.

Introduction

The MEDIGATE System (Medical Examination Direct Iconic and Graphic Augmented Text Entry System) is a computer enhanced interactive graphic and textual record of the findings from physical examination designed to provide ease of user input and to support organization and processing of the data characterizing these findings. The system described here mimics a program implemented on PLATO [Williams et al, 1974, 1975, 1976; Williams, 1982] well over a decade ago and, in addition, utilizes some of the advanced graphic and interface design features that are provided by modern workstations [Williams et al, 1989; Pionkowski et al, 1989].

Discrete components of computerized medical record systems for several types of environments of clinical care have been successfully developed over the years. However, several critical domains of potentially worthwhile physician-computer interaction have not been addressed to the satisfaction of the practicing medical community; these include facile input of an account of the present illness, contextual displays of patterns of laboratory data, and the recording of observations from the physical examination [Williams et al, 1989]. In particular, the MEDIGATE System focuses on interactively debriefing the examiner, perhaps during the examination itself, and recording observations or findings from the physical examination at the level of detail defined or customized by the examiner-user.

The design of a health or medical record system and its components must contemplate (1) the environment of clinical care in which the system is to be used - wellness clinic, physician's office, emergency facility, outpatient facility, inpatient care of varying intensities and the like, (2) the area(s) of specialization involved, and, critically, (3) some features of the historical development, purposes, operating environment and current constraints of the medical record enterprise.

When medical science was less advanced and clinical care to several generations of a family was provided by individual practitioners, the front and back of a 5" x 8" card (and the memory of the practitioner) was adequate to record features, over a period of years, sufficient for effective and proper clinical care of the patient. With advances in the complexity of medical science and in the effectiveness and, hence, the hazard of intervention, with provision of care by groups of practitioners or even by serial groups of practitioners rather than by individual physicians, with

increasing concern over liability issues, with escalating emphasis on evaluation of the processes and outcomes of care, with continued idiosyncratic use of terminology, and with responsibility for payment for care now largely in the hands of third parties, the role of the medical record has undergone significant transformation - and indeed, more is often demanded of the medical record than it has been designed to or than it has been able to efficiently provide.

Exemplary of a common and important deficiency in current records is confusion about the meaning of shorthand observations such as "normal", "within normal limits" and similar terms of art. Such issues are important not only in the day to day provision of medical care but in the development of data bases that may ultimately foster better analyses of disease and the complexities of its management.

The main features of the MEDIGATE System are: a) intuitive and expedient input of simple or complex observations from the physical examination, b) improved clarity and accuracy of the record of findings through immediate feedback of narrative text and pictorial graphics representing the observations, and c) ease of retrieval of readily usable information. This computerized tool provides a flexible but structured format for relevant data. These features support an increase in the scope, organization and credibility of the information processing feasible within and among medical records in such a way so as to advance patient care and, ultimately, to enhance opportunities for clinical research of high credibility.

Goals and Evolution

Clinical data are often incomplete, highly subjective, qualitative, non-standardized and sometimes ambiguous and difficult to verbalize. Contemporary interface designs have often not afforded appropriate tools to encapsulate and organize data of these types; clinicians have thus been denied an important opportunity to interact with their data and to harness the power of computers for crucial areas of medical information processing. The primary goal of the MEDIGATE System is to provide a software tool that allows for direct graphic interaction with the computer to input and retrieve data regarding the observations secured during a physical examination. The objective of the MEDIGATE System, featuring flexible graphic communication, is thus to overcome some deficiencies of interface design in this major component of the individual record of health and illness.

An intermediate goal of the MEDIGATE System is to provide a user interface that may also be employed as a front-end for existing medical record and consultation systems. There are presently a number of tools available to the physician for direct acquisition of some parts of the medical record: portions of the medical history through direct protocol-based and/or branched program interaction with patients, and more or less comprehensive computer generated reports of laboratory data and imaging information. However, history has generally shown that if the physician can not use a computerized medical record system for all areas of practice, he will not use it for any. Most health records require some provision for information on physical observations; arrangements for handling this component of the record have rarely found clinician acceptance.

The MEDIGATE System focuses only (at this time) on aiding the practitioner in developing and maintaining the record; it may also be used in paramedical areas involving physicians assistants, nurses, paramedical and other ancillary personnel. Furthermore, medical procedures extend beyond physical examination. The principles of the initial PLATO and the current MEDIGATE System may be expanded to include many types of medical procedure, as has been suggested in the somewhat similar recent approaches described for recording the findings of gastrointestinal endoscopy [Kahane et al, 1987] and of cardiac surgical procedures [Wheeler and McConnell, 1987]. In addition, there are several computer-based diagnostic and management support systems, often using expert systems approaches, as well as teaching tools for medical students

and practitioners; these often lack a user interface appropriate to facile data input, especially for the collection of physical findings.

Initial concepts of the interactive medical record system with graphics were implemented on the unique PLATO (**P**rogrammed **L**ogic for **A**utomated **T**eaching **O**perations) system at the University of Illinois in 1974, using an approach for the input of data from physical findings that has been used in paper form in several contexts [Sager and Pugh, 1987] and that has since been termed "direct manipulation" in the vocabulary of interactive interface design [Schneiderman, 1987]. In the past few years some basic features of this work were transferred to the Macintosh platform in order to exploit its support for interactive approaches. This work has provided a user friendly interface that is easy to learn and to use, and also has the capability to deal with content of the type and scope needed in order to complete the recording of the physical examination [Williams et al, 1989; Pionkowski et al, 1989].

The current interface was developed with SuperCard(tm), a popular hypertext program for the Macintosh platform which offers a pre-defined object-oriented development system. In addition, we have found that the SuperCard(tm) system, capitalizing on its multiple resizable windows, improved graphics, menus, color, flexible input devices, higher resolution, and its object-oriented interface that, in addition, is an important support for data base design, provides a good environment for prototype development for the domain discussed here. Components of the SuperCard(tm) interface (windows, buttons, fields of text, graphics, menus) are complete objects characterized by message passing, internal values, and a well-defined hierarchy. This pre-defined object-oriented approach allows the physician to graphically and textually describe the findings during an examination by the placement of appropriate object-oriented graphics or icons representing the observations on a pictorial representation or caricature of an area of the body. Once an instance of a finding has been specified, the user can then indicate attributes of that finding by selecting the appropriate attributes and modifiers from a menu.

Graphical Input of the Physical Examination

On commencing the physical examination the examiner may follow a sequence of input frames tailored to his custom, or a sequence that he has altered for a specific patient, or a sequence determined by external but pre-defined programs such as those dependent on complaints, patient response forms, questionnaires, or followup protocols, but always with the option of overriding such pre-defined directional authority to call up any desired input frame on demand. Thus designated (as with the abdomen -- see Fig 1) the examiner-user interacts with a graphic caricature, in the active window, of the area of the body that is the subject of attention. The physician then may quickly enter the current findings (see Fig 2 for one example of organization) by: 1) duplicating, placing and copying pre-programmed graphics and/or icons on the topographic caricature, or, in exceptional circumstances by 2) drawing in the finding freehand as it is noted.

* Duplicating - Here, the physician clicks on the label or colored icon of the finding being recorded and then drags and clicks the mouse to indicate the location of the observation, leaving a direct copy of the icon on the anatomic caricature. The iconic figure may be resized and its axes reoriented at this point for deposit of a revised but regular figure at the appropriate anatomic site.

* Freehand Style - This is done by simply clicking on the existing icon, and then outlining the area to be filled with the iconic pattern within the regional (here, abdominal) caricature.

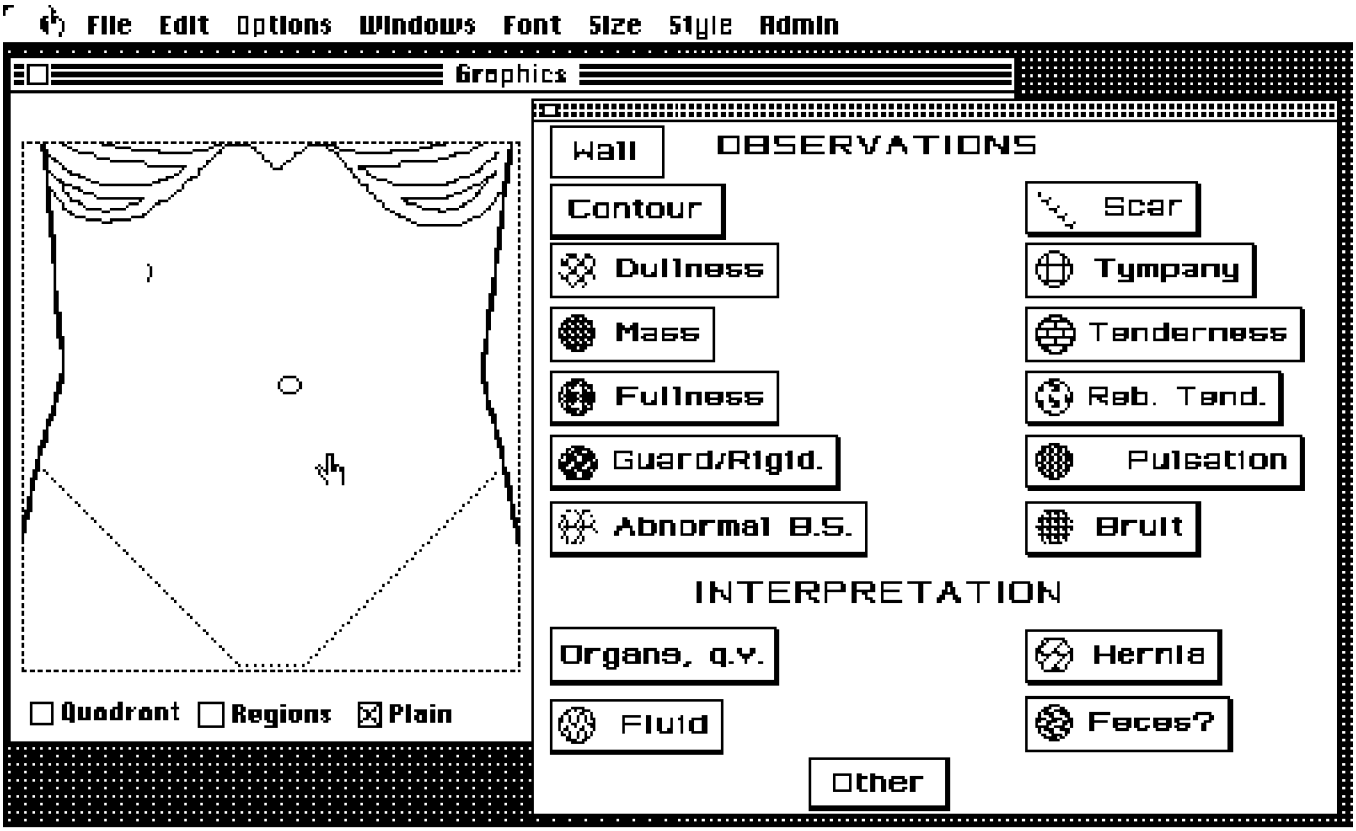

Figure 1

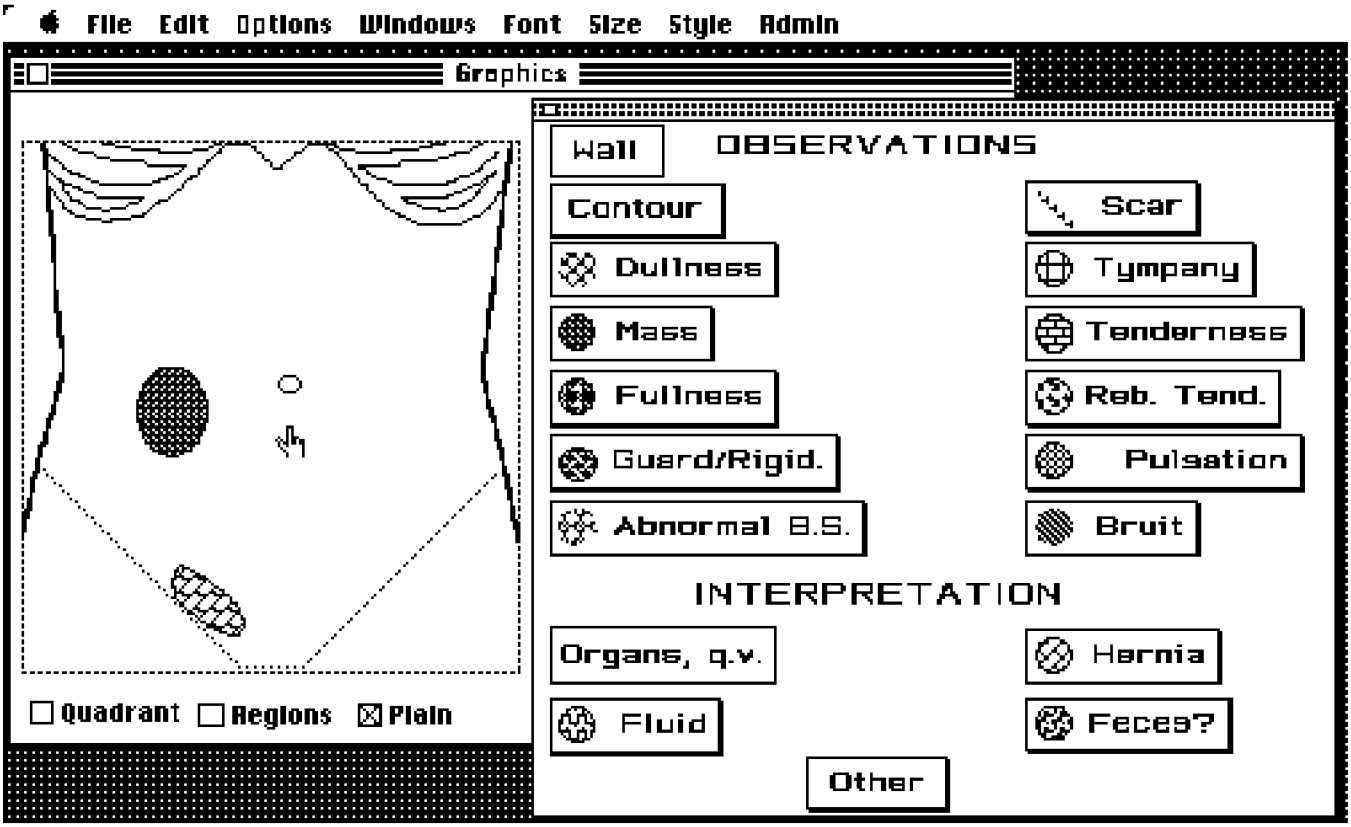

Figure 2

Thus, the examiner places a given instance of a finding (object) in the desired location. These objects are selected from a hierarchical listing of classes of objects. The specific instance of the finding (object) encapsulates the given frame of knowledge about itself - i.e. each finding "knows" the attributes that are important to its characterization. Hence, once a given instance of the object has been placed in the desired location, the examiner may select attributes about the object through the knowledge-base of information contained within the object specified. The attributes selected are displayed and are also used for generation of the narrative notes of the physical findings and then for passage to the data base. Some attributes may also generate iconic patterns as well, as when "tenderness" is superimposed on "mass", leading to superimposed patterns that are much more readily interpreted using the current color graphic capabilities of the displays. Another feature important to the generation of narrative notes of the findings is several grids overlying the anatomic caricatures that may be called up to indicate to the examiner the regional subdivision descriptors that will be used in generating the narrative translations (see "quadrants" vs. "regional" on the grid display options).

One issue of design and development involves the nature of the background figure in the active window on which the examiner-user "places" the icon indicating a finding. It is usually neither necessary nor desirable that this topographic mapping be to a detailed or photographic type of image - rather, the important issue is only the ease and clarity with which the examiner is able to record the findings through the relational landmarks caricatured. Furthermore, the choice of the optimal figure or caricature may depend on the input device to be used. In the PLATO implementation input was by touch using an infrared grid over the interactive graphic display panel - though convenient, resolution was limited and immediate proximity to the examiner, and hence, often, to the subject, was required. Current mouse and trackball input devices not only provide much higher resolution for input but also support greater flexibility in the placement of the input monitor, leading to far less intrusion on the attention and curiosity of the subject.

An important feature of tactical design is to minimize the number of explicit frame selections required of the examiner by embedding such selection in pre-determined sequences sensitive to the environment, the patient, and the practice and custom of the examiner. These factors should determine not only the sequence of examination and input but also the level of detail involved at each stage.

Thus, in order to maintain the integrity of the data base it is vital that the examiner not be prompted to respond to findings at a level of detail beyond that of his observations; it is only in this way that the system can "know" the level of detail implied by the examiner when he uses broad categories such as "within the normal range" or "normal to percussion and auscultation", as well as to be assured that the data base thus secured does not contain surplus and/or spurious findings. Similarly, the examiner must be able to defer or leave out portions of the examination without generating operational complexity or other user penalty, and to express uncertainty regarding any observation for which input is provided. Finally, although we have found that the vast majority of observations (somewhat over 95%)[Williams et al, 1976] can be anticipated and properly characterized through appropriate system design, provision must, of course, be made for ad hoc circumstances and input by free text.

The principle of reducing the explicit selection of input screens or windows required of the examiner extends also to the internal design of each window, mindful of the importance of minimizing for the examiner/user the number of menu and other selections required within each frame. Frame design involves trade-offs between the number of levels of a hierarchy of descriptors (each level requiring an explicit selection, or click, on alternatives) and the number of descriptors presented simultaneously on the frame that may contribute to an undesirable "busy-ness" of the frame - i.e. a trade-off between breadth and depth of descriptor selection at each level. Design conflicts and trade-offs are the rule; another example is the desire, for the mixed initiative dialog used here and for the maintenance of data base integrity, to encourage specific confirmation of

normality of some findings in the presence of abnormality in others, versus the ease of use of default assertion of normality only. Owing to the variety of environments and circumstances of care, customs and requirements of examiners, patient profiles and the like, it is sometimes not possible to offer universally satisfactory frame designs here; hence a premium is placed on ensembles of options and ease of customization and revision for individual users and circumstances of care. Thus, design for ease of customization itself becomes a major issue.

Since most observations from most portions of the physical examination are normal most of the time, the custom of physicians has been, on paper forms, to simply and rapidly check off "normal" when appropriate for each of the regional or physiologic systems into which the physical examination is divided. The difficulty here is that there is no way for an external observer to know, according to the individual training and custom of the examiner, the environment of care, the problem presented during that clinical encounter, and the like, what elements of the physical examination the particular user has explored, and hence, what he intends to imply by "normal" or other term of art. In the MEDIGATE System, an essential component of an initial customization is that the user specify at the outset those variables that the user-examiner customarily means to imply when using default indicators such as "normal". Hence, the resulting data base (and narrative report) has greater reliability and validity than when assumptions as to the meaning of default indicators must be made by external users of the data base.

For retrieval, the most attractive option is often simple retrieval of the graphic input screen derived from previous examination and input sessions. In addition, as observations are interactively entered via topographic caricatures on the screen, a primitive narrative statement is formed from the input of the findings, essentially a set of notes that is, at present, sensitive to the sequence of input of the findings and their modifiers. Though these notes are not literary prose, they are generally no more telegraphic than the shorthand notes now in common use in clinical practice. Rather, the present focus is on generation of the data base, the plan being to later improve the prose via translation from the data base thus captured, displacing concern at this time on directly cleaning up problems of sequence and the like during the input process itself. Currently, the narrative translation direct from the input serves primarily to highlight to the user any ambiguity that may appear during the input process. Though there is as yet no standardization of anatomic or descriptive terms to be used in recording data from the physical examination, the system is designed initially to support the terms of the draft metathesaurus now being released as a component of the UMLS (Unified Medical Language System) of the National Library of Medicine [Lindberg, 1989].

Current Status

Currently, the system has been developed in depth on the Macintosh for only a few areas beyond the abdominal and the pelvic examinations. Here we have explored tactical design issues for the Macintosh - SuperCard(tm) implementation going beyond those encountered in the initial PLATO design that was limited to one monochrome window or screen at a time. The appearance of color icons and graphics, multiple overlapping or tiled windows on large screen displays, object orientation, mouse/trackball and voice input devices and the like alter the tactical design of intuitive interfaces in quite fundamental ways. High level frames for other anatomic areas have been developed and the details are being filled in - the original PLATO implementation, for example, had over 500 frames available for detailed input, but these could only be accessed individually. We have found that the current multi-window capabilities of the Macintosh - SuperCard(tm) interface offer substantially greater flexibility in design options, with greater parsimony of explicit selections demanded of the user. In addition, perspicuity and a sense of place and context in the record are more readily communicated to the examiner in the present interactive multi-window environment.

Summary

After some years of off and on work, it has become apparent that physicians may profit from direct interaction with their data via direct data entry in a computerized medical record system, avoiding the necessity for an intervening human editor. Entry of the physical examination has been a stumbling block as present systems have tended to focus on content rather than the user interface.

When incorporated into ambulatory or inpatient electronic medical records the capture and analysis of most significant clinical information, through direct interaction with the professional user, may be significantly enhanced in the MEDIGATE System. These features contribute not only to patient care (including availability for routine input to expert diagnostic and management consultation systems) but to information management in clinical research [Institute of Medicine, 1988].

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