Identifying Adverse Drug Interactions: a Unified Approach

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ABSTRACT

This paper describes a microprocessor-based implementation of a system which can identify potentially adverse drug interactions, for use by a physician prior to prescribing drugs. The system is intended for use in small-to-medium sized medical practices and groups, and also performs detailed patient medical record keeping, appointment scheduling, customer and third-party billing, and accounting. The system is specifically designed to be operated by personnel with no computer expertise.

The problem of adverse reactions due to combinations of drugs is mounting, and is receiving increasing attention. Each year, adverse drug reactions cause thousands of illnesses, and even deaths, and extended hospital stays estimated to cost more than $4.5 billion.

One way to solve this problem is by employing a computer system which can identify potentially adverse drug interactions prior to prescribing drugs. Computers already have a place in many physician's practices: computers are widely employed to help with billing and accounting; other uses, such as patient record-keeping and appointment scheduling, are gaining in popularity. A unified approach to automation in the physician's office is one which provides all of these features in one coherent, cohesive package.

This paper describes MEDSAFE™, a microprocessor-based implementation of such a unified approach. In MEDSAFE, drug interaction analysis is combined with an rapid-access, visit-by-visit patient medical record-keeping system. The system can automatically produce a list of currently-active prescriptions from the prescription records in the patient's visit-by-visit medical record. The drug interaction analysis (spanning over 30,000 drugs) is driven from this list. The visit-by-visit patient medical records also contain coded entries for procedures, which drive the billing function. MEDSAFE is currently undergoing final site-testing.

A unified medical office system must have certain attributes beyond the capability to perform all of the functions listed above. For example, the system must be operable by personnel who do not have a computer-operator background. There must also be a feasible growth path, which will allow for viable increases in both system capacities (number of users, amount of mass storage, etc.) and in system functionality (e.g., new functions).

These attributes evolve into specific hardware and software requirements, each of which is associated with specific technical challenges. The remainder of this paper discusses some of the prominent system requirements, and describes their implementation in MEDSAFE.

Integrated Functionality: Certain data within the system is needed by more than one of the major functions. For example: addresses, information about legal guardianship, and lists of specific medical procedures performed during any one visit are required for both patient medical records and accounting/billing purposes. Lists of currently-active prescriptions are required for patient medical records, and are also required to support the identification of potentially adverse drug interactions. This allows the user to perform drug interaction analysis by starting with a list of this patient's currently active prescriptions, and then adding in the proposed new prescription(s). Otherwise, the entire list of currently-prescribed drugs would have to be manually entered each time an interaction analysis is performed.

It is desirable that these data are entered only once, and that the relevant information is then automatically shared. This will result in fewer data inconsistencies, fewer operator errors, and less data entry work. This points up a major liability of constructing such a system by obtaining and integrating several existing software packages: such packages would not be able to share and properly control data in this fashion.

Consistent User Interface: Much research has shown that consistency is a key ingredient of those computer-to-human interfaces which are well-accepted by users, are easy to learn, and are easy to use. There are two aspects of implementing this: the computer-to-human interface and the human-to-computer interface.

In MEDSAFE, a major element of the computer-to-human interface in this system is the display screen. Comprehensibility is improved by dedicating certain areas of the screen to specific functions -- each specific type of information is always displayed in its own specified area. For example, the top line is used to display prompts and instructions to the user; the second line contains the name and address of the current active patient. Also, different categories of information are consistently displayed with different video attributes (white writing on a black background, black writing on a grey background, etc.) -- for example, the labels of a data field (which the computer provides, and the user cannot change) are always displayed as black-on-grey, while the contents of those fields (which can be changed by the user) are always displayed as white-on-black. The status line is bright inverse video; error messages displayed there blink. All of this serves to create a visual separation which makes it very easy for the eye to rapidly and reliably distinguish between the various types of displayed information. Similarly, when the system will allow the user to change the contents of a display (the system always initially displays data in a write-protected mode, wherein a data item cannot be changed without a specific action by the user), those data items which can be changed are underlined in white.

The lack of an underline always signifies that the displayed data cannot be changed at that time; its presence always signifies that the displayed data can be changed at that time. This practice is employed consistently in all portions of MEDSAFE. Figure 1 depicts an example MEDSAFE display screen format.

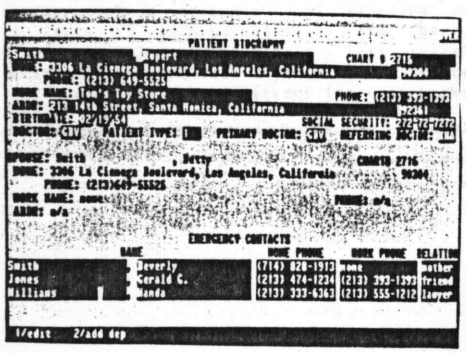

Figure 1. Example Screen Format.

The operational sequences, which form the human-to-computer interface, is also implemented with an eye to consistency. Related or similar operations are always performed through the use of similar operational sequences.

The user interactions are implemented through the use of special-purpose keys. There are sixteen of these 'function keys' in a row along the top edge of the keyboard, just below the display screen. The keyboard includes a type-ahead feature.

The MEDSAFE software uses the features of the hardware to create a user interface which is easy to learn and easy to use. Based on the video attribute services and using the function keys and dedicated screen areas, all major activities are activated by a single keystroke -- no keywords, computer jargon, or special syntax are required. All keys, including the function keys, are activated and deactivated so that at any instant only those keys which make sense to use at any given instant are activated. Those function keys which are used to activate the major activities are activated most of the time; hence, these keys have permanent labels. The remainder of the function keys can have their function dynamically changed as the user steps through an operation. Their labels also dynamically change (these labels are drawn on the bottom line of the display screen). In this manner, the user is not forced to confront a ungainly array of over 100 function keys, as he would if every system activity had its own dedicated function key; yet he retains the decisive advantage of being able to activate all activities by a single keystroke.

Figure 2 depicts all of the possible operational sequences which can be activated by depressing the 'patient' key. In the figure, rectangular boxes are employed to represent the action of depressing a function key; other actions by the user, such as typing a last name, are indicated within parenthesis. Time is increasing in the downwards direction, from the top of the page to the bottom as one flows downwards. At each 'branch', the user can choose exactly one of the indicated possible actions.

As an example, figure 3 depicts the sequence of screen displays corresponding to one of these operational sequences.

The top box of figure 3 depicts the contents of the display screen after the patient key is depressed. Note that although the main work area is blank, the contents of this area are not changed or erased by pressing this key. The only change on the screen is in the top and bottom lines. Our hypothetical user has also typed the last name 'Smith', which is displayed in the top line. He has not yet depressed the 'return' key.

The middle box depicts the content of the display screen after the return key has been depressed. The user now employs the 'arrowhead' cursor-control keys to move the flashing cursor down next to the patient he is interested in -- in this case, Beverly Smith. He now has seven possible actions: to depress exactly one of the 'patient', 'biography', 'coversheet', 'history', 'correlation', 'abort', or 'print' keys.

The bottom box depicts the contents of the display screen after the 'coversheet' key was then depressed. This complete sequence requires only four actions (depress 'patient', type 'Smith', move the flashing cursor, and depress 'coversheet'), and requires less than three seconds.

All operational sequences within the MEDSAFE system operate according to this general plan of activating major functions using a labeled function key, receiving prompts and instructions on the top line of the display screen, and activating a detailed operational sequence using the dynamically-changable function keys. This consistency of operation, in combination with the consistency of display, contributes to the unique ease-of-use of the MEDSAFE system.

The system also provides sophisticated "helping" functions for filling in drug names, drug codes, diagnoses, and procedures in a rapid, error-free manner. For example, if a drug code (the standard NDC system is employed) is provided by the user, the system will supply the complete corresponding drug name. Conversely, if the drug name is supplied, the system will supply the drug code. If only a <u>portion</u> (such as the first three letters) of a drug name is supplied, but that portion is sufficient so as to be unambiguous, the system will supply the drug code and the remaining portion of the drug name. If only a portion of a drug name is supplied, and there are multiple possibilities as to the complete drug name, the system will display a list of these possibilities, and the user simply designates the intended name from the list (using the flashing cursor), and the system will fill in the complete drug name and code. The "helping" functions for procedures and diagnoses are similar.

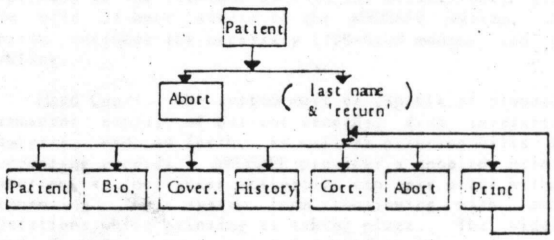

Figure 2. Example Operational Sequences.