DATAHAND*: DESIGN, POTENTIAL PERFORMANCE, AND IMPROVEMENTS IN THE COMPUTER KEYBOARD AND MOUSE

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ABSTRACT

This paper presents the design and preliminary evaluation of a new computer key and spatial entry system called Datahand. It is intended to improve human-to-computer data entry and control, as well as providing possible reduction of five major identifiable problems with conventional keyboards which subject operator to injury. The overall physical form of this product, its keys, and their organization, are unique in shape and function. Such a departure from traditional keyboards has presented an opportunity to consider new approaches to hand position, key design, spatial control and function. Preliminary empirical results from first users are covered in this paper.

CONCEPT

Introduction

The ideas that became the determinants which were to form the basis of the Datahand concept grew out of problems encountered while using conventional keyboards. These problems fall into two general categories, a need to rethink the tools of computer interfacing, as well as those functions that affect speed and accuracy. Electronic processing has significantly changed alpha numeric input as speed and accuracy have been affected by the addition of function keys and (ten) key pads to the keyboard. It is standard to have 101 keys, or more, in today's electronic keyboards. In addition, many entry devices use a mouse. These changes have denigrated the concept of home keys, and require the user to move the hands and fingers over a much larger area of control, thus adversely affecting speed and accuracy. In addition, the ergonomics associated with protracted use, such as word processing and repeated use of key entry pads, bring physical and mental stress and are potentially capable of physical damage to the user.

Fig. 1

System Concept

Datahand looks different, works differently and relates to the user in a different way from its predecessors. A series of demonstration models were developed. Each model was carefully studied and compared with previous designs until an overall configuration was defined that met the housing needs of the various components and the operational needs of the user, Fig.1. By splitting the keyboard into two separate components, a left and right unit, the user's hands are brought to the keys which are wrapped around the user's fingers, as opposed to a conventional two-dimensional keyboard. Each unit contains a mouse function thus eliminating the need for a separate component. Datahand is a plug-compatible replacement for both the conventional keyboard and mouse. Each unit (hand), Fig. 2, can be divided into five areas regarding the type of function to be addressed: (1) a thumb pocket that is recessed to hold the thumb and six switches, (2) four finger holes each containing a five-way-switch, (3) palm support, (4) a key

Fig. 2

assignment viewing screen, and (5) a mouse function, contained in each unit. The individual shapes that are brought together into a single hand unit are carefully developed to meet their particular area function, and work in concert with other shapes that make up a right or left hand unit. Each unit is free to move in an x and y motion for cursor control. The left and right units can be separated, while in use, to allow space for reference material.

The result is that the product system is more compatible with the human system, allowing for a more natural matching of human and machine. By providing a separate hand support and key function for each hand, individual differences in human hand, wrist, and forearm can be better accommodated. For example, arms do not have to be held at equal length to reach keys. As a totally new product system, each component of Datahand is specifically shaped, not only by its particular needs, but by other features that interact with it. The physical shape and organization of Datahand is unique in that it uses a three-axis approach to the entry function. Other designers, in attempting to improve on the keyboard, have used standard switches which in effect has limited function to two dimensions. The emphasis is on shaping the product to meet the needs of the user. This can only be done by considering the total needs of the system and being committed to making changes where necessary. Key assignments have been designed with a maximum overlap with standard QWERTY finger movements so that minimal relearning is required by the user.

HUMAN FACTORS IN DESIGN

It must optimumly perform all the intended requirements of utility. User function should be defined and enhanced by the effective use of human factors needs. The purpose and meaning of the product should be reflected by its appearance; that is to say, the organization and supporting features of a product should be shaped to visually convey their function (product semantics). A significant human factors concern is not just performance but the ease of learning.

The Hand Units

Each hand unit has a contoured palm and hand support making it more comfortable, and also graspable so that it can be easily moved for mouse control. Both units incorporate a mouse function (underside motion detection device). Mouse input is achieved by moving the entire right or left unit without removing the hands from the keys. Prototype units have been developed with a provision to allow palm support to be configured to the needs of the individual user hand size by the addition of shells to the palm support.

The actual prototype is shown in Fig. 3 and is a fully-functioning model.

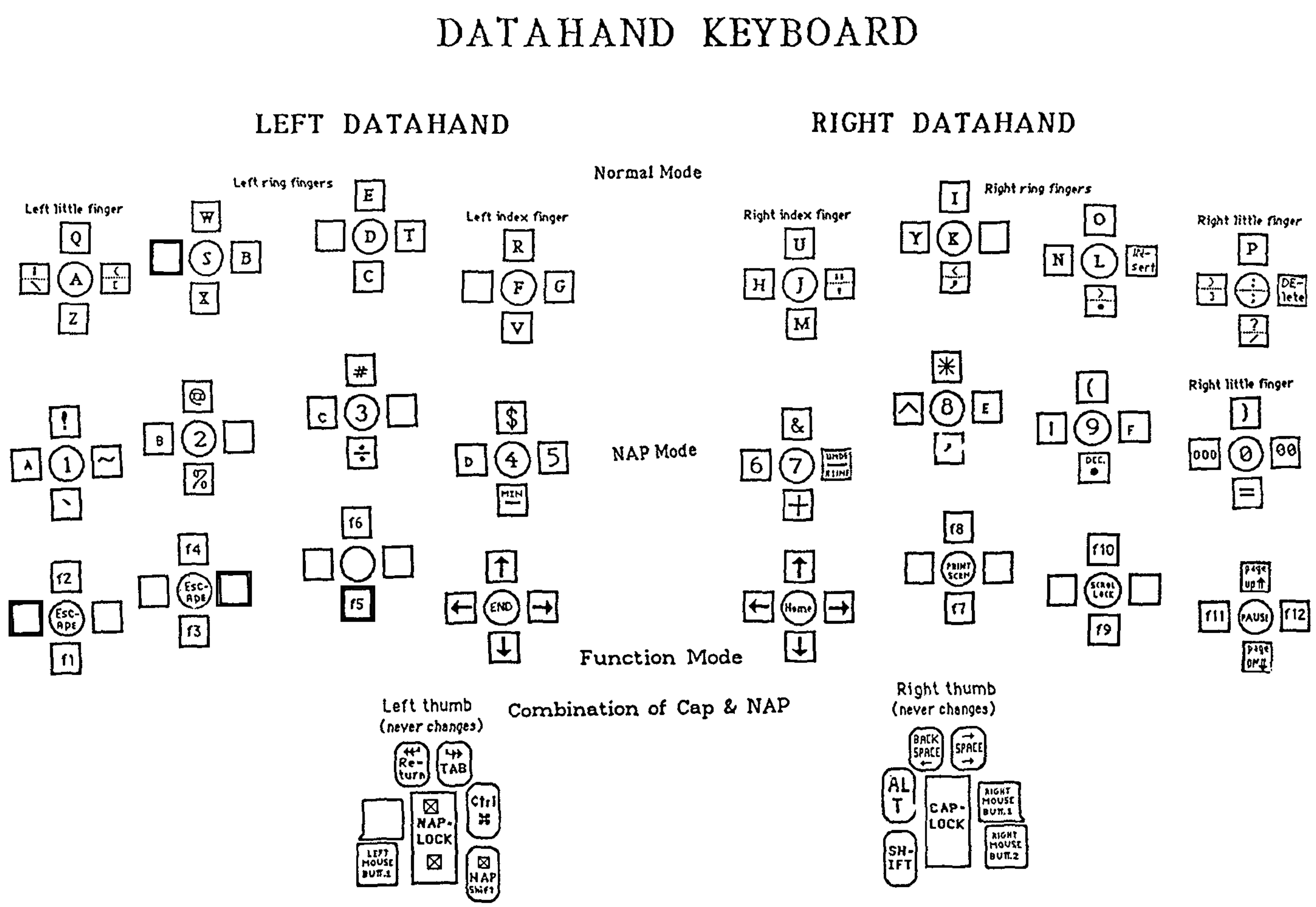


Fig. 3

Thumb and Finger Keys

Datahand electronically layers its keys in three modes: Normal, NAP, and Function. The standard keyboard's 4th row keys are in a new mode called the NAP (Numeric & Punctuation) Mode. In this mode, the numbers become the under-finger keys, and the keys above them become the punctuation keys, Fig. 3.

The circular key caps in Fig. 3 represent the keys at the bottom of the key wells. The square key caps clustered around each circular key cap indicates the keys which are accessed by forward, backward, left or right movement of that finger.

Datahand employs finger movements almost identical to a standard QWERTY keyboard, so that little relearning is required. The illustration, Fig. 4, indicates the close relationship of Datahand finger movement to the standard QWERTY finger movement.

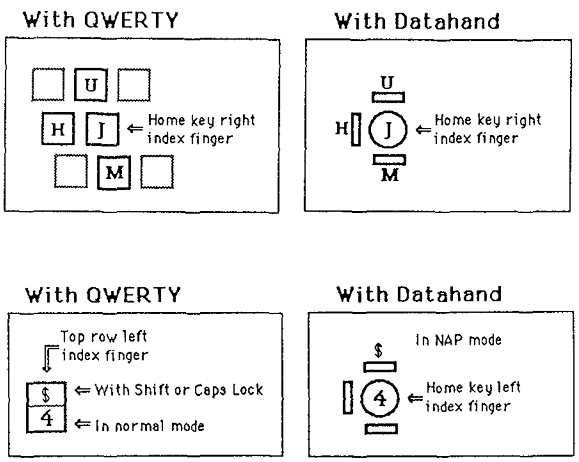


Fig. 4

The present design provides for a large illuminated color multiplexed display to be located above the fingers. Above each finger is a schematic depicting the keys that each finger can activate.

The thumb is mechanically and neurologically the most versatile and powerful digit on the human hand. With a conventional keyboard, both thumbs together share the space bar, providing no other routine inputs. With Datahand, keys are clustered about the thumb joints and tips such that seven keys may, by distinctly differing motions, be operated. Thus with Datahand, the thumbs control 14 data entry keys. This is an interestingly similar repetition of early human factors work wherein aircraft pilots' use of finger switches was significantly improved upon by transferring control functions from fingers to the thumbs.

Spatial (Mouse) Input

A. Vernier mouse control could be added to all applications (presently employing a mouse) with no software or hardware alteration. This is accomplished by making one hand's motion a *coarse* mouse control and the other a *fine* mouse control.

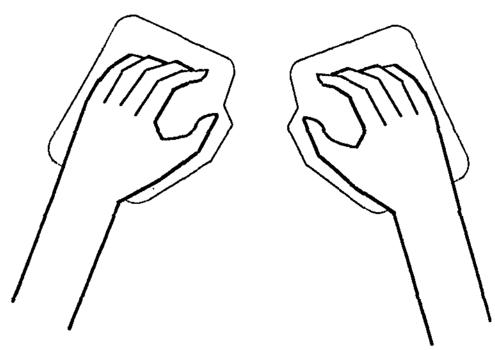
B. Simultaneous two point screen control is possible. For example, each of two diagonally opposite corners of a rectangle could be separately controlled by a left and right mouse device. This would give simultaneous control over both size and location in a graphics or CAD type application. This same selection method could enhance text selection in a word processor or field selection in a spreadsheet application.

C. Simultaneous three dimensional control for 3D, graphics, CAD and other applications. Use of the left hand to input a "Z" axis coordinate together with the right hand's existing "X and Y" axes input would make this easy and intuitive.

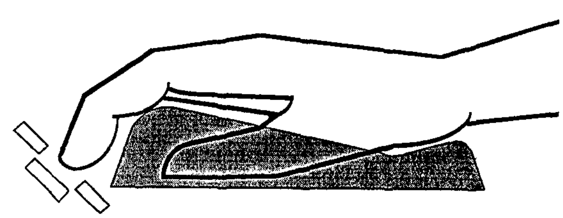
Keyboard Caused Injury

There are 5 major identifiable problems with conventional keyboard data entry systems which subject operators to injury as follows:

Problem #1: A conventional keyboard requires the wrist to be bent. This creates muscle stress, compresses the carpal tunnel and median nerve (through which finger-controlling tendons and median nerve pass), increases the friction on moving tendons by causing them to bend, and stretches the finger tendons. Datahand attempts to reduce these problems by allowing an operator's wrists to remain straight.



Problem #2: A conventional keyboard requires the operator's hand to maintain a flattened profile. This places constant tension on the finger muscles and tendons; it also requires a less-than-optimal angle of key actuation. Datahand allows the hands to remain in a natural relaxed position with the fingers comfortably curved. It was designed around a human hand in the most relaxed position.



Problem #3: A conventional keyboard requires the operator to constantly support the hands and arms floating above the keys. This creates constant muscle stress in the hands, arms, shoulders and neck. Datahand provides built-in palm rests which completely support the hands and arms.

Problem #4: A conventional keyboard demands that an operator maintain one single operating position for his or her hands and arms. This prevents variation in the muscle, joint and tendon loads. Datahand allows the operator's hands to move about independently.

Problem #5: A conventional keyboard requires considerable ergometric work to actuate the keys. Since a conventional keyboard's only operator support is achieved by partially resting the fingers on the keys, the keys must be stiff enough to prevent inadvertent operation. Also, since a conventional keyboard requires fingers to traverse long distances, the fingers must travel so quickly that fingertip impact is appreciable and requires a lengthy key travel to partially cushion the shock of impact. With Datahand, finger travel is only a few millimeters and because the hands are supported through the palms, the keys can be much more sensitive, have less travel, and therefore require less ergometric work.

EARLY SUMMARY AND EXTRAPOLATION ON FIRST CONVERSION LEARNING CURVES FOR TOUCH TYPISTS LEARNING DATAHAND

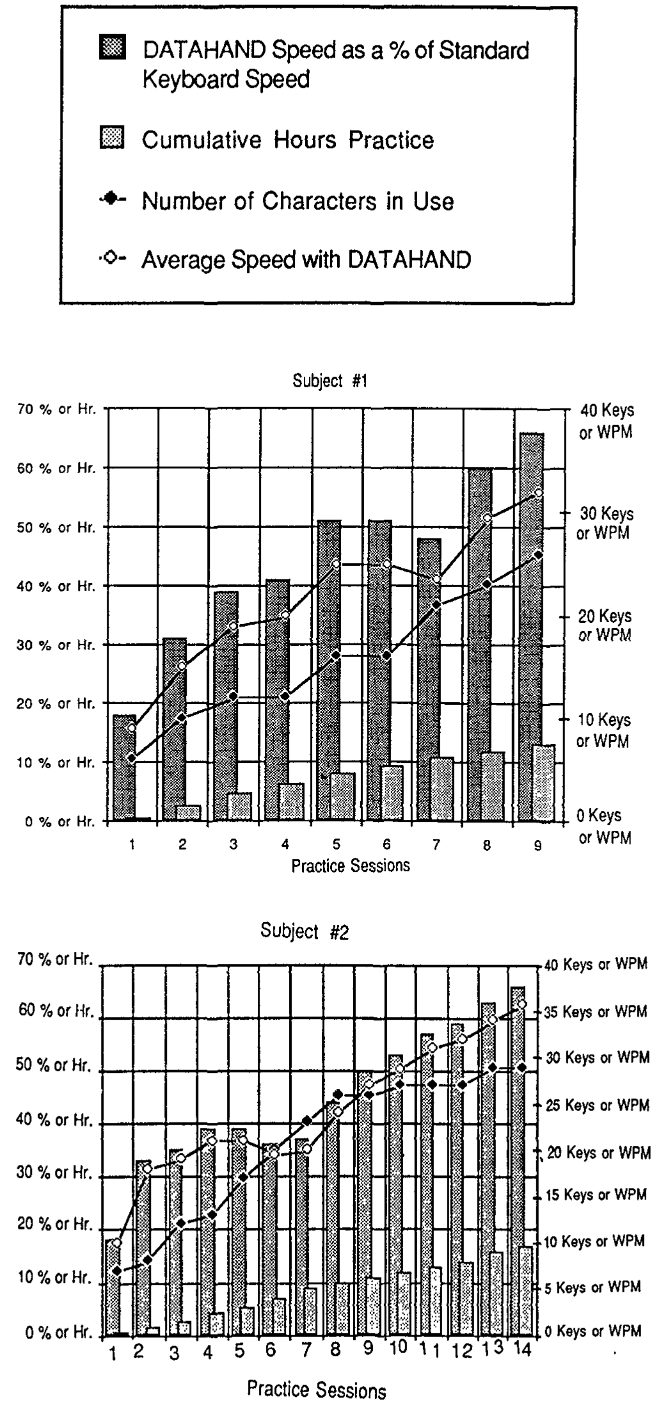
Findings

At this point only two controlled "conversions" (where experienced QWERTY typists learn to type utilizing Datahand) have been undertaken. These two operators are both thought to be above average in motivation, openness to change, learning speed and manual dexterity. This is based on their willingness to participate in this study out of enthusiasm for Datahand with no or minimal monetary payment. Subject #1 tests at 49 wpm on a conventional keyboard and subject #2 at 54 wpm. The prototype utilized for these preliminary tests operates significantly below the performance level expected for production models.

After 9 sessions totalling 13.2 hours, an average speed of 32 words per minute with an accuracy of 99.% utilizing 26 characters, was obtained by the first subject. The second operator after 14 sessions totalling 16.8 hours achieved an average speed of 35.7 words per minute with an accuracy of 98% utilizing 29 characters. Both operators' performances were very close to each other when adjusted for practice time.

Discussion

Although these are the first preliminary results from our first empirically quantified study, it appears that Datahand can be learned in a relatively few hours. How many practice hours will be required for operators speed to equal or exceed their standard key- board speed is not yet known. If Datahand will be faster and more accurate is not yet known. Likewise, it is not known if the potential medical advantages of Datahand will be realized in actual operation.



Respecting both graphs, the values for the columns read on the left axis. The darker bars represent Datahand typing speed as a percentage of the subject's average typing speed on a conventional keyboard. Speed measurement for both Datahand and conventional keyboards was made with Typing Tutor IV (Simon & Schuster Software by Kriya Systems, Inc., version I.2), a computer based software application which administers and computes typing speed. This application was used as the training program for typists learning Datahand.

The lighter lower columns represent the cumulative number of hours spent learning Datahand (time kept by the computer) and the values are read on the left axis in hours (Hr.)

The line connecting the dark data points represents the number of keys the typist is employing during each practice sessions and the value is read on the right axis. The line connecting the light data points represents the average speed in WPM achieved using Datahand, averaging all speed tests taken during each session. All speed tests averaged better than 98% accuracy.

Conclusion

It is hoped that this preliminary report will induce others within the human factors discipline to undertake more advanced comparative studies of the device.

*Datahand is a trademark of Industrial Innovations, Inc., Scottsdale, Arizona, U.S.A. Patents are pending.