Split Key

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Abstract

The present innovation concerns the development of a removable laptop keyboard that can be further separated between those keys normally operated by the right and left hands. Such an improvement allows for an increase in user comfort and aversion of the onset of musculoskeletal diseases. Wired and wireless conceptions are presented and the potential market discussed.

Introduction

Incredible advances in computing power and speed have enabled the integration of computing devices, services, applications, and benefits into every aspect of modern life. Productivity has greatly increased through these advances and the world's knowledge is increasingly accessible to every person. Unsurprisingly, this influx of technology has led to more people using computers for a greater number of tasks each day, averaging 2.5 hours of continuous use per day in 2007.[14, 15]

The computer interface has not kept pace with advances in computing technology and the standard keyboard layout is a prime example. The QWERTY keyboard was first patented in 1878 as a method to slow typists down while the mechanical typewriter printed each letter. It remains the universal default on all manner of input devices over more efficient layouts and has crossed over to devices where ten digit touch typing is impossible, cellular telephones are a prime example.[16] Similarly, the traditional rectangular keyboard shape has persisted despite numerous studies that detail the benefits of 'ergonomic' keyboards.[3-16] This conflict is especially important given the observed link between extensive keyboard use and the onset of musculoskeletal disorders (MSDs).[4, 9, 10]

If a computer user wishes to reduce their risk for MSDs they will be primarily interested in peripherals that position the wrist in a more natural position (the position it assumes when held loose beside the body). Adopting this position is believed to reduce the forces between the carpal bones and tendons that can otherwise lead to short-term inflammation of the tendons and sheaths , increasing the risk for MSDs later in life.[10] A keyboard can be optimized, as in figure 1, to reduce this risk by dividing a standard keyboard in half and prescribing the slant (Θ), gable (α), slope (β), and width (D) of each half so that the extension, ulnar deviation, and pronation of the user's wrists is minimized.[7,10]

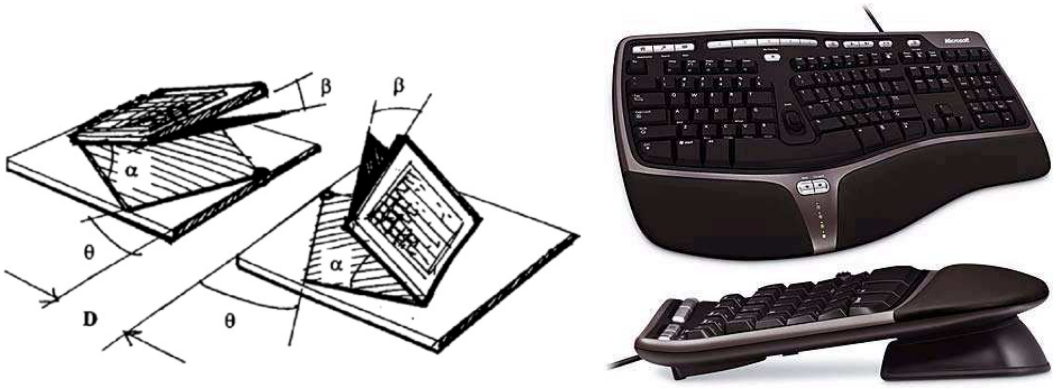

Figure 1. Left: Rotational axis definition; courtesy Marklin and Simoneau.[11] Right: Microsoft Natural Keyboard Elite 4000, exhibiting slant, gable, and slope key rotations.

Computers are used in an incredible variety of circumstances but can be broadly divided by form: desktop computers require peripherals (monitor, keyboard, mouse, etc.) for operation while laptops are self-contained units. Desktops reside at a single location and any component can be interchanged with ease due to external connectors and a vibrant accessory market. To improve comfort and reduce the potential for MSDs, a desktop user need only invest in ergonomic peripherals.

Laptop computers are designed for portability and have all essential elements integrated into a single unit. The ability to compute wherever a person chooses necessitates certain usability compromises, most notably in the screen and keyboard sizes and locations. Laptop keyboards are traditionally condensed in size and function and are almost exclusively sold in the rectangular, QWERTY layout. Laptop users could invest in ergonomic peripherals like desktop users but would sacrifice their comfort when mobility is necessary. Therefore, an integrated ergonomic interface system is desired.

A few laptops have been designed for enhanced user comfort and numerous patents exist with this same objective. Of those designs that have been commercially developed and sold, the accommodation has focused on a single parameter, the keyboard. The IBM ThinkPad 701C (figure 2) preserved full size keys and key spacing through the use of a sliding, extensible keyboard that grows beyond the laptop's frame. This extension did not allow any adjustment to the slant, slope, gable, or width of the keyboard. A more recent example is that of the Acer TravelMate 2482 which featured a gently curved keyboard that would conceivably reduce ulnar deviation in the wrist, as shown in figure 2. Neither of these attempts enjoyed significant and continued market success, possibly due to the small increase in user comfort and the inability to provide a full, adjustable ergonomic experience.

Figure 2. Left: The IBM ThinkPad 701C featured an expanding keyboard to provide full size keys. Right: Acer TravelMate 2482 with a gently curved keyboard.

Split Key Conception

Drawing from an understanding of laptop construction, usability considerations, and personal experience, two simple improvements on laptop keyboard and case design are proposed. Firstly, a laptop's keyboard will be improved to be separable into two independent halves that can, secondly, be separately removed from the laptop body. These halves will maintain normal function through either a wired or wireless communication link and, once removed from the laptop body, can be positioned in any location that is comfortable to the user. A sensible division of the keyboard is between those keys normally operated by the left and right hands, drawing a line between the 6, T, G, B and 7, Y, H, N keys in the standard QWERTY layout. The spacebar should consist of two, independent halves to permit spacing by either thumb. This improvement to laptop computers requires minor modifications to current laptop designs: the case must accommodate the addition of a short (approx. 15") cable or a wireless transmitter and battery to the keyboard housing and the keyboard attachment method be modified to be easily and quickly operable.

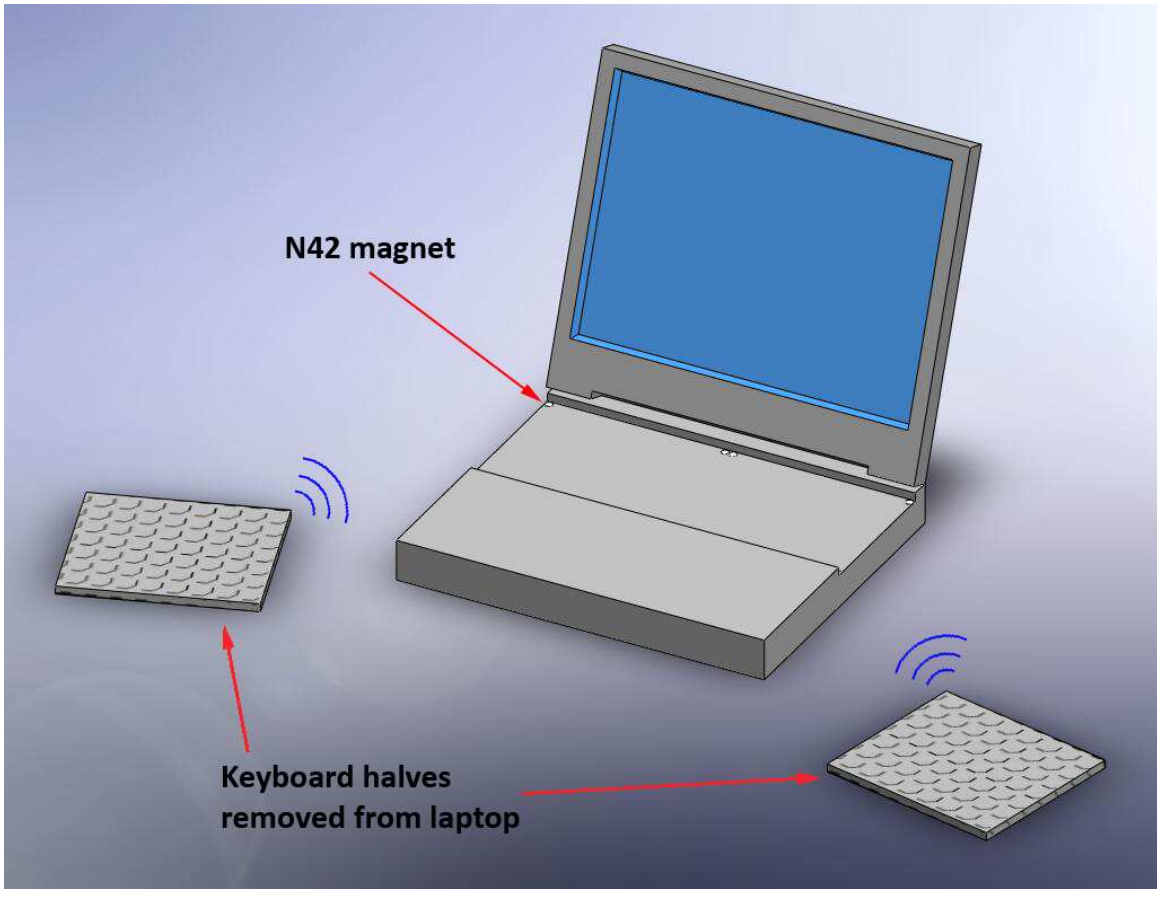

Figure 3. Initial wireless conception with keyboard halves removed from the computer. In the preferred conception, eight magnets embedded in the perimeter of the keyboard depression align with similar magnets mounted on the undersides of the keyboard halves. These magnets are oriented so that they are attracted to each other in order to effectively secure the keyboard while permitting easy, intentional removal.

Laptop keyboards are traditionally secured to the computer case through a number of screws, notches, and latches that permit keyboard removal for outright replacement or access to upgradeable components. This system is acceptable for occasional use but would be cumbersome if used daily. A number of latch, rail, screw, and non-traditional methods (hook and loop, etc.) have been considered to replace the standard attachment method. The preferred conception, figure 3, places magnets at each of the four corners of each keyboard half such that when the keyboard is positioned in the keyboard depression a magnet attached to the keyboard backing will be attracted to a corresponding magnet mounted in the keyboard depression. The attractive force between the magnets affixed to the keyboard backing and keyboard case with the physical interaction of the keyboard and the keyboard depression walls would prevent motion when the keyboard is docked to the case. These magnets would likely be of the rare-earth variety due to their superior strength and availability in small sizes (for example, Neodymium-42 disc magnets 1/8" dia. x 1/32" thick experience a .9 lbs attractive force when in close proximity). Such a magnetic attachment could be easily severed by pushing the keyboard halves outward, off the case.

This innovation is not restricted to the QWERTY layout and could be adapted to any layout useful to ten digit touch typists. The easily removable nature of the proposed keyboard will allow for the interchanging of keyboard layouts and enable those wishing to try different layouts within or between languages to simply purchase the alternate keyboard and connect it to the laptop. These aftermarket keyboards could exist in different colors to allow personal customization. Standardization of the overall keyboard dimensions and connectors or wireless protocol would facilitate this accessory market and allow any keyboard to be used with laptops from a variety of manufacturers.

Specifically claimed is:

1. A personal computer comprising a foldable enclosure having a display, electronic circuitry, and a keyboard assembly wherein said keyboard assembly is removable from said enclosure and having a division of said keyboard assembly between those keys normally operated by a user's left and right hands and allowing independent movement of said keyboard halves.
2. A personal computer according to claim 1 wherein said removable keyboard is operable once removed from said enclosure.
3. A personal computer according to claim 2 wherein said removable keyboard halves maintain communication with said personal computer through wired means and said keyboard halves are separable to at least a user's shoulder width.
4. A personal computer according to claim 2 wherein said removable keyboard halves maintain communication with said personal computer through wireless means.
5. A personal computer according to claim 4 wherein said wireless communication system of said removable keyboard can be recharged when said removable keyboard is not removed from said enclosure.
6. A personal computer according to claim 1 wherein a plurality of levers are rotatably connected to the undersurface of said enclosure whereby said display can be positioned at a height comfortable to the user while remaining functional due to removal of said keyboard halves.

7. A personal computer comprising a foldable enclosure having a display, electronic circuitry, and a keyboard assembly wherein said keyboard assembly is secured to said enclosure by non-permanent means.
8. A personal computer according to claim 7 wherein said non-permanent attachment is accomplished by magnetic means.
9. A personal computer according to claim 7 wherein said non-permanent attachment is accomplished by a mechanical latch, rail, or fastener system.
10. A personal computer according to claim 7 wherein said non-permanent attachment is accomplished by any combination of claims 8 and 9.
11. A personal computer according to claims 1 and 7 wherein said removable keyboard is operable while secured to said enclosure.
12. A device for key input to an electronic system comprising a sheet to which a multitude of keys are attached and a number of adjustable supports attached to the underside of said sheet allowing the variable positioning of said key input device in any manner comfortable to a user.
13. A device for key input according to claim 12 wherein said supports are collapsible to a flat profile.
14. A device for key input according to claim 12 wherein a deformable substance is attached to the surface of said support that contacts a work surface for the purpose of preventing the motion of said key input device.

Ergonomic Benefits

A removable laptop keyboard will extend many of the benefits of preexisting ergonomic keyboards to laptop users without compromising the laptop's portability. A split ergonomic keyboard, having slant, gable, and slope angles of approximately 12.5°, 14°, 0 to -7.5°, respectively, and a separation width such that the F7 and F8 keys are adjacent, is commonly recommended over the standard, rectangular keyboard arrangement in the literature.[7-12,19] This ergonomic arrangement can be partially attained under the current conception as the keyboard halves can be positioned with a 12.5° slant angle, 0° slope, and at a comfortable width. The gable adjustment and negative slope angles could be accomplished by building small wire or plastic supports into the backing of the keyboard. These would need to be able to fold flat for reinsertion to the laptop but would provide full keyboard orientation customization.

Marklin and Simoneau showed that separating the keyboard halves to shoulder distance provided the same benefit as one would experience from using a flat keyboard with a slant angle of 12.5°.[19] The independence of the keyboard halves allows the user to assume any comfortable position and permits multiple, ergonomically-sound positions to be used during long periods of use. This is a significant usability improvement.

Removing the keyboard from the laptop has the additional benefit of allowing the monitor to be positioned at a more comfortable height. Laptop users commonly position the unit for keyboard comfort, necessitating head tilting to see the screen.[1,6] This compromise can be eliminated if fold out supports are built into the underside of the laptop computer to position it upright and the keyboard is

removed from the inclined computer surface, as shown in figure 4. These supports allow the screen to be positioned at the user's eye level while retaining the ergonomic benefits of the removable keyboard.

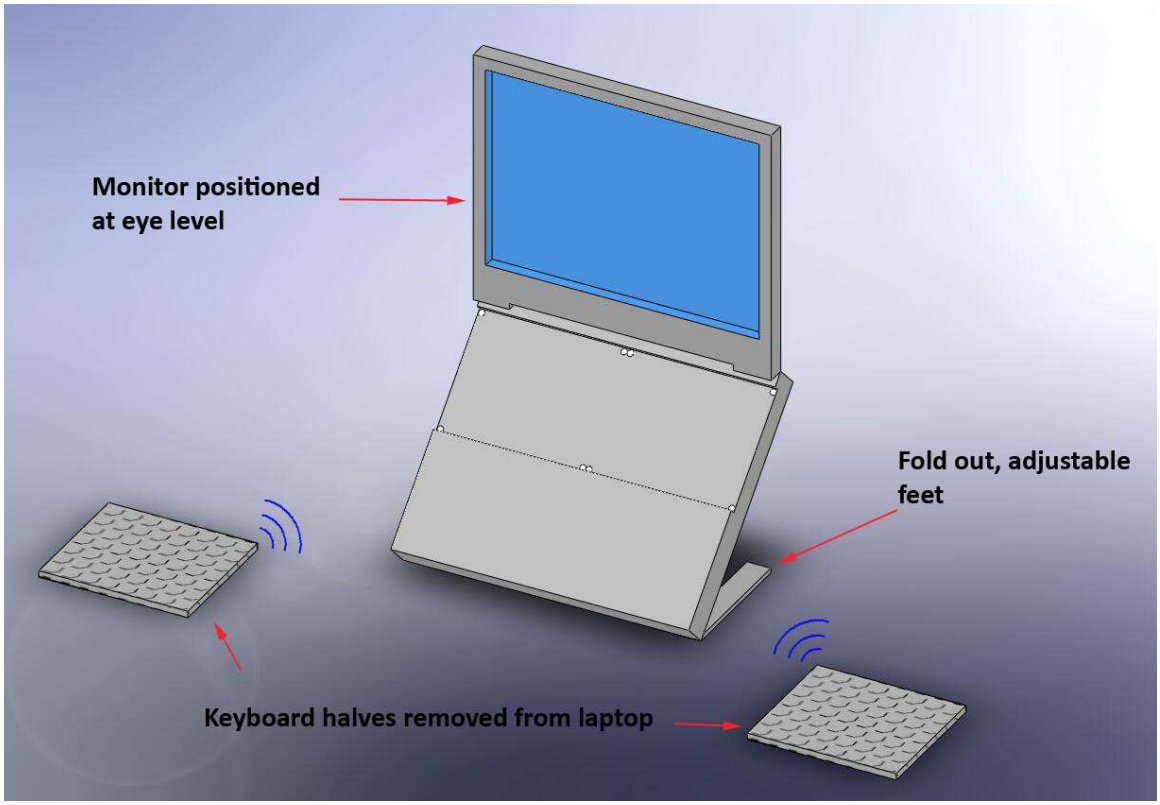

Figure 4. Removing the keyboard halves from the laptop and the addition of fold out braces allows the laptop to be positioned at the user's eye level for enhanced head and neck comfort in addition to the ergonomic benefits gained by separating and removing the keyboard halves.

Market Analysis

The computer market is dominated by international brands that subcontract computer manufacture to a few, mostly Asian, companies. The exact component prices and retail markups on a typical laptop are not discussed in publicly-accessible literature. A number of market research firms have studied the computer hardware industry but have not released their results, nor published in the literature. Due to this scarcity of information, the following estimates are based on the retail price of replacement laptop keyboards, the projected keyboard cost for the $100 laptop being developed by the One Laptop Per Child project, and current retail trends.

Replacement laptop keyboards are available for many past and current laptops at an average price of US $26.66 ($2.51 standard deviation) across all manufacturers. A second price point is provided in the specification for the $100 laptop which lists the sealed membrane keyboard cost at $3.00.[18] In comparison to common laptop keyboards, the OLPC keyboard is simpler to manufacture and compromises keyboard feel for liquid resistance and lower production cost. It also contains a 5-10%

markup to entice manufacturers to sign onto the project (Sunrex, Inc. won the first contract); this markup is taken to be slightly above the industry norm for keyboard manufacturers. This markup estimation in line with Sunrex's 2008 third quarter gross profit margin of 10.07% and is slightly lower than Sunrex's 2007 gross profit margin of 15.90%.[20] Assuming this 10% manufacturer markup and a 30% reseller markup on laptop replacement keyboards leads to an original component and labor cost of $16.72. The reseller markup contains all operating and inventory costs and is judged reasonable with respect to the margins on high end computer parts (which typically have margins of 40-50%).

With the individual laptop keyboard price approximated to $16.72, the expense of the additional materials required for the implementation of the Split Key concept can be considered. The following estimations are based on retail prices of components from K&J Magnetics, Inc. and Digi-Key, Inc. Contract manufacturers could likely negotiate for lower component costs, so these projections are considered conservative. Each full keyboard will require eight of the aforementioned N42 magnets and the case will require eight as well, totaling $0.80 per keyboard. The choice of wired or wireless communication is of greater importance. Multiconductor wire approximately fifteen inches in length is used to connect each keyboard half with the computer, coming to $2.45 for 30" and resulting in a total wired laptop keyboard cost of $19.97. The wireless version uses two wireless modules (the Bluetooth standard is chosen for estimation purposes) which are sold for $3.19 each and lead to a total wireless laptop keyboard cost of $23.90.

The foregoing keyboard estimates consider the primary component of each design and neglect additional hardware like wire connectors in the wired version while the wireless conception omits the transmitter power source and assumes the laptop has an integrated receiver (Bluetooth is common to most laptops of new manufacture). Also avoided are any retooling costs as it is anticipated that new laptops would be engineered specifically with the Split Key capability in mind.

Comparing standard and ergonomic aftermarket keyboards provides a good estimation of the acceptable cost increase when switching to an ergonomic keyboard. For the current purpose keyboards from Newegg, Inc. will give a consumer price comparison and those from CDW, Inc. are more representative of small and medium business purchases. In reference to table 1, surveying 242 keyboards on Newegg showed that ergonomic keyboards buyers are willing to accept a 352% price increase to go wireless and a 475% increase for a standard to ergonomic keyboard upgrade. The CDW survey also indicates an appreciation for wireless keyboard upgrades but does not when it comes to ergonomic alternatives. The CDW numbers may be biased due to the extensive selection of standard (27.21:1) and wired (7.71:1) keyboards over the ergonomic and wireless versions, respectively.

	Newegg, Inc. (242 samples)				CDW, Inc. (395 samples)			
	wired		wireless		wired		wireless	
	standard	ergonomic	standard	ergonomic	standard	ergonomic	standard	ergonomic
ergonomic/standard	151%		135%		94%		104%	
std: wireless/wired	352%				128%			
ergo: wireless/wired		316%				137%		
std wired/ergo wireless	**475%**				**133%**			

Table 1. Comparative price analysis between keyboards from Newegg, Inc. and CDW, Inc. Percentages represent the ratio between the average cost of one keyboard to an enhanced version.

Applying the trends of table 1 to the Split Key evaluation, consumers would be willing to accept an $8.53 increase for a wired, ergonomic version and an extra $62.72 to go wireless. CDW users are less willing, allowing only a $5.52 increase for the wireless laptop keyboard while the wired version would need to be a dollar cheaper for CDW users.

Considering the $2.45 and $6.38 price increases for the wired and wireless split key keyboards, Newegg customers would readily buy both the wired and wireless versions but CDW customers would be a tougher sell. This very basic analysis ignores the complexities in computer hardware and peripheral purchasing but allows for the general conclusion that the keyboard enhancements of the split key idea would be acceptable to technology consumers.

Turning to the larger technology market, some 38.6 million laptop computers were sold in 2008 and notebooks eclipsed desktop sales for the first time in the third quarter.[17] This growth is expected to continue as the number of computer users increases and as desktop users migrate to laptops for their next, primary computer (growth projections for fiscal year 2009 have been scaled back, but sector growth is expected to remain positive). As described previously, the computer manufacturing market is dominated by international companies leaving little room for a startup making new keyboards. Such a startup would also need to design laptop cases to accommodate the keyboard attachment mechanism and assemble the rest of the computer in-house or ship it to a separate assembler. Given these formidable barriers to entry, protection through international patents and licensing to computer manufacturers is the preferred strategy.

Projecting a market adoption of 1% would demand 385,000 split keyboards per year and a licensing fee of 1% per keyboard sold would total $77,091.90 for the wired concept and $92,271.35 for the wireless (assuming only the wired or the wireless version was in production). Seeking patent protection in the top ten computer-using countries is expected to cost approximately $100,000.00 and would likely be accomplished by filing with US Patent and Trademark Office and secondly in accord with the Patent Cooperation Treaty. Table 2 gives two, five, and ten year projections assuming the stated adoption, licensing, and patenting expenses:

	2 Year	5 Year	10 Year
Wired	$54,183.80	$285,459.51	$670,919.02
Wireless	$84,542.70	$361,356.76	$822,713.52

Table 2: The first year absorbs the one-time patenting cost, achieving profitability in the second year.

In addition to the previously-made assumptions, additional benefits could be derived from accessory sales of alternate keyboard layouts and languages. Market adoption would likely increase with time, especially if the potential for health care savings is investigated and promoted. It is also hoped that an academic study into the specific health benefits allowed by the Split Key concept would be conducted and establish the ergonomic similarity between a Split Key laptop and ergonomic keyboards.

Conclusion

The increasing capability and ubiquity of computing devices has led to substantial gains in individual productivity and information accessibility, but the longer term health risks associated with these capabilities must be considered. The improvements to laptop keyboards described herein are one attempt at enabling a more healthy human-computer interaction. Continued research into and adoption of interface enhancing peripherals will help to make the increase of technology a tolerable and hopefully comfortable one.

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