Hierarchical Marking Menu: menu breadth and axis shifting

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ABSTRACT

In this paper literature on hierarchical marking menus is analyzed. The conclusion is that authors relate menu breadth in hierarchical marking menus to straight marks only (menu mode, designed for novice users) and that no study had be done on the maximum depth when marks can have **four** directions.

Breadth in marking mode, the mode for experts, is defined.

Using axis-shift, four basic directions and this new definition of menu-breadth, a circular hierarchical marking menu (Odyschrift) is developed. Herein the user writes in a continuous movement (cursive handwriting). This makes Odyschrift feasible for text-entry. Some questions about the use of Odyschrift for text-entry are discussed.

In Odyschrift, commands have a spatial relation to eachother, comparable to a chess-board structure. Labels are indicating the places of the commands in this chessboard-structure. This structure and these labels are a new phenomenon in Human Computer Interaction, which has impact on subjects as menu organization and accelerator keys.

ACM Classification: H.5.2 [Information Interfaces and Presentation]: User Interfaces – input devices and strategies (e.g., mouse, touchscreen)

General Terms:

Keywords: Hierarchical marking menus, axis-shifting, menu breadth, text-entry, command structure

INTRODUCTION

Kurtenbach [7] analyzed "*a style of human computer interaction in which a user "writes" on the display surface*" (p.3). This 'writing' results in marks. Such a "*mark can signal a command*" [7] (p. 6). The commands are presented in menus ("*A marking menu is an interaction style that allows a user to select from a menu of items*" [7] (p. 23). Marking menu uses a pie-menu. An item is selected when the 'mark' enters the representation of a command in this pie-menu. In a **hierarchical** marking menu (HMM) menus can activate submenus.

In the next paragraph we point out that the maximum depth of an HMM with four basic directions is still unknown and that breadth is defined from the view of a novice.

MENU BREADTH AND DEPTH

Depth

Kurtenbach and Buxton [6] studied expert performance with HMM in speed and accuracy and the limitations in depth and breadth of HMM's.

Kurtenbach and Buxton [6] explored menus from one to four levels deep, the broadest consisting of twelve items. Their conclusion was that menus with a breadth of four and a dept less than five and with a breadth of eight less than three were not error-prone. ("*For menus of four items, even up to four levels deep, the error was less then 10%. This is also true for menus of eight items, up to a depth of two*" [6] p.486, Q2). (underlining by the author,avm).

Zhao and Balakrishnan [14] stated that the results of Kurtenbach and Buxton [6] "*indicate that in order to maintain high selection speed and an acceptable error rate of under 10% a menu with breadth of four-items per level can be at most four levels deep.* ([14] p.1 underlining by the author, avm).

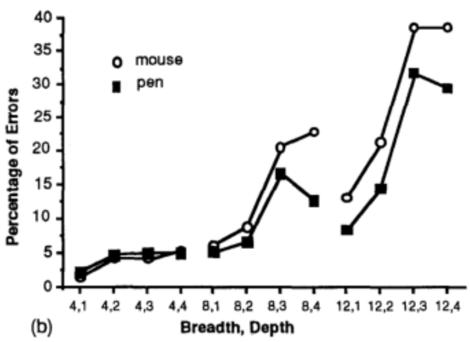

Figure 1: Kurtenbach and Buxton [6] p. 485

Kurtenbach and Buxton [6] concluded: **up to** four levels. Zhao and Balakrishnan [14] interpreted : **at most** four levels. In fact the experiment of Kurtenbach and Buxton [6] showed an error rate of 5% for a menu with breadth four and depth four. The graphic that represents the results (see Figure 1) gives no indication on which level the error rate of an HMM with four items per level will surpass 10%. Studies to the maximum depth for an HMM with four-items per level were not found.

Zhao and Balakrishnan [14]'s interpretation of Kurtenbach and Buxton [6] prevail in the literature. Examples are:

Ahlström *et al.* [1] wrote that Kurtenbach and Buxton [6] *"showed that users can achieve better then 90% accuracy using compound gestural strokes to navigate through two-level hierarchies of 64 items.* [1]

Ren and O'Neill [11] wrote that Kurtenbach and Buxton [6] "*found that selection performance with hierarchical marking menus reduces when breadth increases to eight or more, or depth increases to two or more*." [11]

These authors do not mention that Kurtenbach and Buxton [6] also found that the error rate by navigation through a four-level menu with four items per level is 5% and that the fourth level was the highest level investigated.

In this state of affairs we conclude that when breadth is four-items the level whereon the error rate surpasses 10% is unkown.

Breadth

HMM's have menu mode and marking mode. In marking mode no menu is displayed. The rationale is that users who know a menu by heart, do not need the assistance of that menu anymore. The relation between a menu-item and its sub-menu-items weakens for a knowledgeable user. This relation has no relevance for the expert, because he reaches the item in the sub-menu without the assistance of the menu. With the disappearance of menu-presentations for an expert, the number of levels in a menu-hierarchy is also diminishing for that expert.

Kurtenbach [7] introduced one marking mode, but it depends on the experience of a user on which hierarchical level he can change to marking mode. Therefore, we investigate grades in marking mode.

Menu-breadth is defined as the number of menu-items per level (see e.g. citations from [6] and [14] above). A hierarchy with less levels (depth) has more breadth, the number of commands unchanged. To express the influence of expertise – less levels needed – on menu-breadth, we define the breadth of an HMM menu as the number of items per level **that are selectable with a mark as such, including angles**. In this definition a mark can be compound.

In our definition of breadth, breadth is the result of a calculation. The number of directions for a mark, powered by the number of times the marking changes direction (the number of parts a mark has). In a formula: x^y, where x is the number of directions for a mark, y is the number of parts of a mark. The formula for an HMM-menustructure is x^y: z, where z is the depth of the menu-structure. The number of directions for a mark is set as constant in the menu structure.

Kurtenbach [7] designed and evaluated HMM x^1: z.

Bailly *et al.* [2] explored the extention of breadth of HHM, following Zhao *et al.* [14] in their interpretation of Kurtenbach and Buxton [6]. Bailly *et al.* [2] started with HMM 8^1:1. Bailly *et al.* [2] gave each mark in each of the eight directions seven different forms resulting in a breadth of 56 items. In our notation: Bailly *et al.* [2] introduced HMM $(8*7)^1$:z.

In our definition of breadth there is not only a transition to the next level of the hierarchical menu (z + 1), but also a transition between parts of the compound stroke (y + 1).

We visualize the transition in marking mode in Figure 2. Visualized is HMM 4^3:1. The circle in the centre is the starting point for marking. A user can choose one of four directions.

Before starting:	y = 0, z = 0
the first transition:	y = 1 , z = 0
the second transition:	y = 2 , z = 0
the third transition:	y = 3 , z = 1

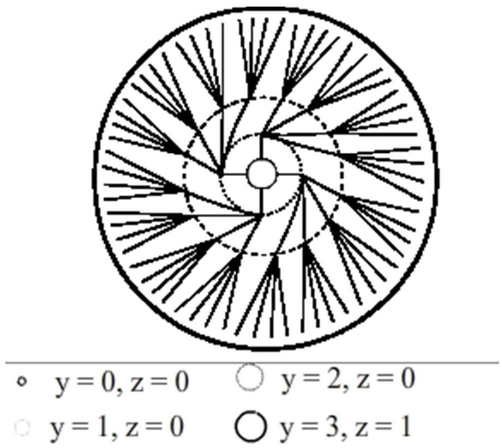

Figure 2: menu in marking mode

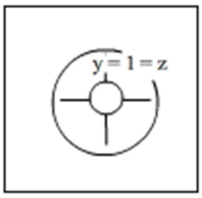

Figure 3: menu in menu mode

In Figure 3 the transition in menu mode is visualized.

Before starting:	y = 0, z = 0
the first transition:	y = 1, z = 1

In this paper we focus on HMM 4^3:1. We use in this paper a less technical name for HMM 4^3: Odyschrift.

In the next paragraph we analyze the transition from y to y + 1.

THE NEXT PART OF THE MARK

Zhao *et al.* [15] wrote: *"The advantage of treating strokes as line segments is that the exact internal shape of the stroke does not matter...".* and *"To handle curved strokes we must also consider curvature, an attribute that may differ at each point of the stroke.* (accent in original) ([15] p. 1078).

The solution of Zhao *et al.* [15] leads to print (pen up after every stroke). A neutral margin on the left and right of the stroke is a more elegant solution of the problem Zhao *et al.* [15] mentioned. Inside this neutral margin "*the exact internal shape of the stroke does not matter*". The curvature is considered. Van Meeteren [9] chose this solution. (see Figure 5)

We explain this figure. In Figure 5 line 7 represents a mark. The mark has two parts: the first in direction 2a and the second in direction 3a. 9 is the angle between the two parts. 8 is a margin: "*Figure 2 schematically shows a margin 8 within which a deviation from a straight line is not interpreted as a direction selection yet*." [9] p.8/9)

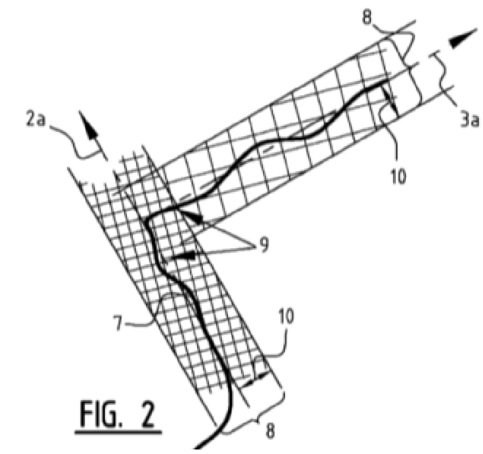

Figure 5: step y + 1 van Meeteren [9]

Delaye *et al.* [4] did also include a margin in their design of a continuous HMM: "*Contrarily to traditional pie menus, the active areas are not contigious (there is an inactive blank space between two neighbouring branches), in order to guide the user to make selections in a more trajectory-like way."p.2).*

A crucial difference between Van Meeteren [9] and Delaye *et al.* [4] is that the user selects a direction in [9]. In [4] he is selecting a menu-item, along a traject to the menu-item ("*a more trajectory-like way")* [9] focused on transition y +1, [4] on transition z +1.

For transition y +1 the user confirms the direction of his mark when the mark crosses the border of the neutral margin. Inside the neutral margin for transition y +1, the user chooses the direction for y + 2. He leaves the neutral margin for y +1 in the direction needed for y +2. For transition y + 2 the user has to change the direction of his marking, otherwise the mark will not cross the border of the neutral margin.

In the next paragraph we discuss axis-shift. Axis-shift is a method to force a change of direction, independent of menu-structure.

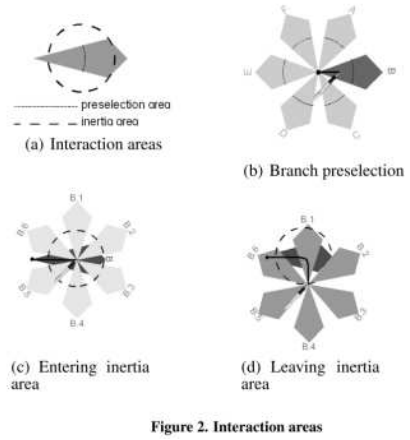

Figure 4: Interaction areas (from Delaye *et al.* [4]

Axis-shifting

Kurtenbach [7] decided to use boundary crossing for confirmation of transition z + 1. However, boundary crossing makes the interpretation of marks ambigious or unscalable. A figure and its caption in Kurtenbach [7] illustrated this problem (Figure 6). The caption:

"Possible interpretations of mark when selecting from hierarchies greater that two levels deep. The straight line sections of the mark have no artifacts to indicate whether the selection at that point is being made from the parent or from the child."(caption of figure 2.7 p.53)

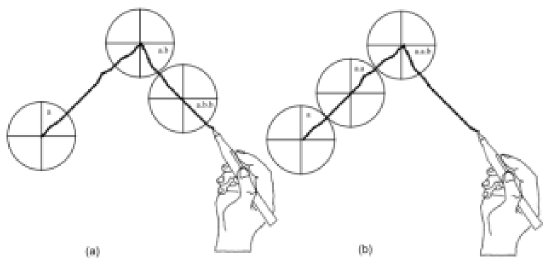

Figure 6: figure 2.7 Kurtenbach [7]

Scalability is an important feature of marks, therefore the best strategy is to disambiguate the mark.

Kurtenbach [7] chosed in his thesis for 'no category selection' to disambiguate the mark. 'No category selection' is "*based on the observation that items which have subitems are generally categories of commands, not commands themselves, and selecting a category is not a meaningful operation*." [7] Therefore every straight line selects an item from a submenu. ("*Thus, we can consider any straight line to be a selection into a submenu*" p. 51) [7].

But, this solution is restricted to two-levels menu. "*If menus require many menu items, and are more than two levels deep, axis-shifting must be used. In practice, we used no category selection in many situations*." (p. 60/61) [7].

In figure 2.8 (p. 54) (see Figure 7) in Kurtenbach [7] axis-shifting is showed. The caption of this figure says: "*Axis shifting rotates a child menu such that child menu items do not appear on the same angle as the parent menu item. This results in a mark language where selection confirmations are indicated by changes in angle. With this scheme marks can be drawn at any size*." (caption of figure 2.8 Kurtenbach [7] p.54).

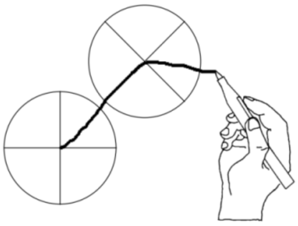

Figure 7: figure 2.8 Kurtenbach 7, p. 54

We found three publications, wherein axis-shift is used [9], [4] and [3] .

Delaye *et al.* [4] used axis-shift *"in order to avoid ambiguity problems by forcing a change of direction whenever a sub-menu is developed. ",(p. 2).* (Figure 8)

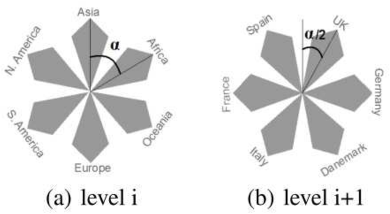

Figure 8: axis-shift in Delaye *et al.* [4]

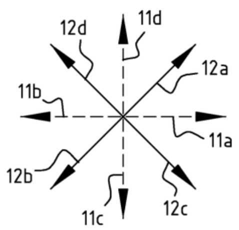

FIG. 3

Figure 9: axis-shift in Van Meeteren [9]

Van Meeteren [9 described axis-shift as: "*the starting directions are … perpendicular to each other, and the continuation directions are .. turned 45° relative to the starting directions. In this way an input cycle consists of a horizontal or vertical starting direction,…, and a continuation direction deviating therefrom, .. being turned 45° relative to the starting directions*. " (see Figure 9)

Buxton and Kurtenbach [3] used axis-shift to avoid ambigue straight lines. The menu-items are postioned in the central circle (level 1). The items a, b, c and d are not menu-items on their own, but are specifications for the menu-items 1, 2, 3 and 4 in the inner circle. The menu-items 1, 2, 3 and 4 can be chosen without specifications, by straight marks. *No category selection* is not available in this situation, because menu-items 1, 2, 3 and 4 are already *no categories*. Axis-shift is their solution: but item selection has still to end with a pen up event.

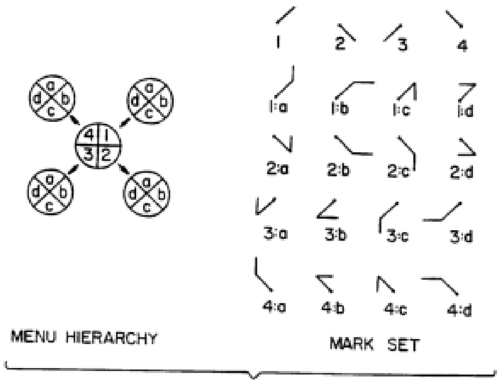

FIG. 12

Figure 10: figure 12 Buxton and Kurtenbach [3]

Comparition of axis-shift with no category selection

In Figure 11 a part of Odyschrift is presented. In four of the presented marks *axis-shift* is used. *No category selection* is used for the other four marks.

In Figure 11 the direction of a mark is indicated with a letter at the end of each part of the mark. In *no category selection* there are four directions: D(or d), R(or r), M(or m) and F(or f). In *axis-shift* there are eight directions: D, R, M and F for the starting directions, *o*, *e*, *i* and *a* for the continuation directions.

Two of the presented *no category selection* marks are inflection-free, namely the horizontal lines R*r* and R*f*. R*r* and R*f* differs in length. In R*r* the second part has the same direction as the first part, in R*f* the second part is in the reverse direction of the first part. To disambiguate them comparison is needed. The longest mark is R*r*. The shortest mark is R*f*.

Disambiguation is the purpose of *axis-shift*. The direction after the first part of the mark is nor continued, nor reversed. For example, the mark DO is the mark which goes to the upperleft corner and twist 45º to the top.

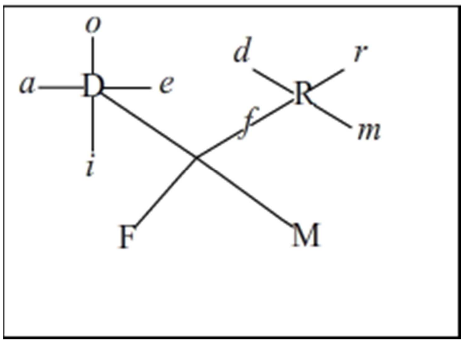

Figure 11: Comparition of No category selection and Axis-shift in HMM 42:1

Input-cycles

HMM 4[1]:2 in Buxton and Kurtenbach [3] has 20 selectable ‘menu-items’ (see Figure 10). Four marks signal a menu-item with a straight line, 16 marks have one inflection. The partial Odyschrift in Figure 11 has 16 menu-items, but all the marks are build in the same way (see Figure 12). Buxton and Kurtenbach [3] needs a *pen up* to terminate the signaling. In Odyschrift the user can continue his writing immediately after completion of a marking cycle.

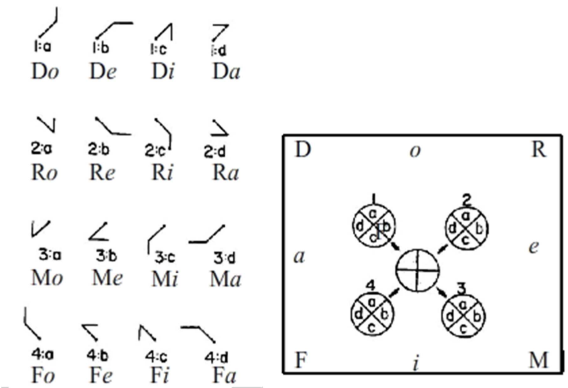

Figure 12: figure 12 Buxton and Kurtenbach [9] , adapted for HMM 4^2:1

Figure 13 shows three marking cycles. The marks in Figure 13 are starting in empty circles. The three menu-items 2:a, 3:b and 4:c are selected in three marks where the end of one mark is the beginning of the next mark (cursive handwriting) [1].

The method to terminate menu-item selection in Odyschrift is *Completion of a mark.* This method is available, due to the fact that every mark has the same number of parts.

Guimbretière and Winograd [9] also designed cursive writing with an HMM, by combining HMM with Quickwriting. Quickwriting and Guimbretière and Winograd [9] uses a neutral zone in the center. A mark is finished if the stylus returns to this centre. From there a next mark can start. A pen up event is not necessary.

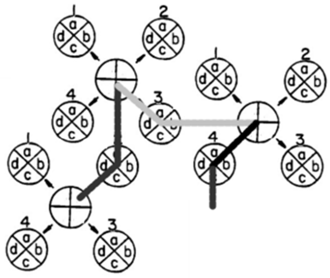

Figure 13: Three marks in HMM

The objective of Delaye *et al.* [9] was to *“facilitate continuous and fluent movements for selecting commands”p.2).* The marks end with the selection of a command. These ends are not the beginning point for a secondary selection.

In Figure 12 the marks have two labels: one indicating the content of the menu-item, one that informs about the directions of the mark. In the next paragraph we discuss this labeling.

LABELING WITH DIRECTIONS

In Figure 10 the labels of the marks are a compilation of the labels of the traversed menu-items. These labels are supposed to reveal the content of the menu-items. In Figure 12 an additional labeling strategy is used: the menu-items are labeled with the composite of the names of the directions made during the inputcycle.

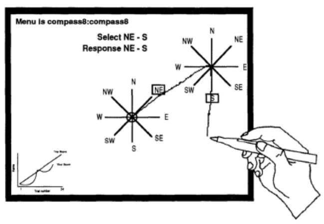

Figure 15: Figure from Kurtenbach and Buxton [6] p. 484

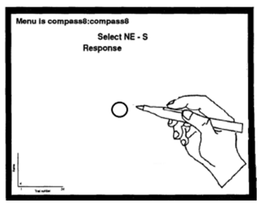

Figure 14: start of a trial

In a figure (p. 484) Kurtenbach and Buxton [6] showed their experiment screen at the end of a trial. (see Figure 15). The system displayed *“the menus along the marking to indicate to the subject the accuracy of their* (sic!*) marking” (p. 484)* after the marking was completed. Figure 14 is a reconstruction of the start, following the description of Kurtenbach and Buxton [9].

[1] A user can interrupt his writing with a pen up event if needed (e.g. to close to the border) and continue elsewhere or on another time.

To simulate expert behavior, *"the system would …display instructions describing the target at the top center of the screen.*" (Kurtenbach and Buxton [6] p. 484, underlining by the author, avm). "*The system would ask the subject to select a certain item using a marking"* (Kurtenbach and Buxton [6] p.484) (underlining by the author, avm). The instruction describes the route to the target. In our opinion the task to select a certain item is reduced to following the instruction given.

Figure 15 and Figure 14 contain the words **select NE – S.** NE and S are compass directions, but are used as menu-items (targets) in the experiment. Subjects could too easily interpret NE and S as directions. In that case they understood the words **select NE – S** as the *instruction* **draw** a mark first to the upper left corner of the screen and then down to the bottom side, and not as the *task* to **select** menu-item S from the category NE. In that case the dexterity of the subject is studied, but not expert behavior.

Kurtenbach and Buxton [6] simulated expert behavior by instructing the novice the route to commands on a two-dimensional surface. In this paper we use this method structurally.

Routes to commands

The hierarchy of piemenus in an HMM form a map; a map of the commands inside an application.

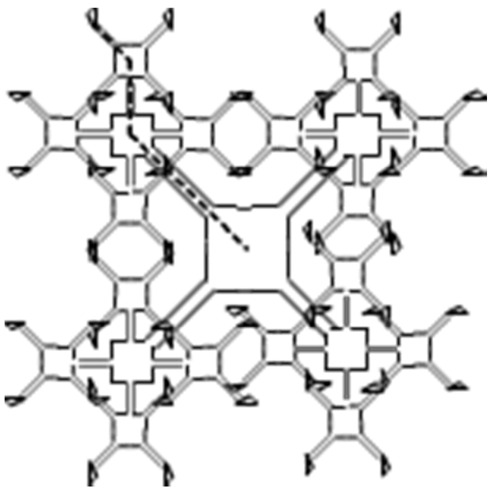

Figure 16: Map of commands in Odyschrift

The map of Odyschrift is shown in Figure 16. In menu mode, menus function as name-plates for the four 'streets' which lead to the next 'square'. The user reads these 'name-plates' and decides which 'street' leads to the command he needs. But, a description of the route will also do. In Odyschrift a user have to 'pass' three 'squares'. The menu-item that represents the command is labeled with the three instructions needed to choose the right 'streets'.

Delaye *et al.* [4] proposed "*to display directed branches that suggest a path to invoke a command*." [4] *p*.2.

Contrary to Delaye *et al.* [4] we see in their '*directed branches'* not suggestions for the route to a command, but feed-back to the user to inform him about the direction in which he is signaling to the system. In Odyschrift the function Delaye *et al.* [4] saw fulfilled by the '*directed branches'*, is fulfilled by labeling the commands with the route instruction.

Order of the commands

The commands have labels (derived from the successive directions of the mark). These labels are systematically describing the routes to commands. Every command has its own place in the set of commands.

A part of a mark is signaling a subcommand. The subcommand divides the collection of menu-items that is connected with the marking direction, in four parts and connect each of this parts with one of the next four marking directions.

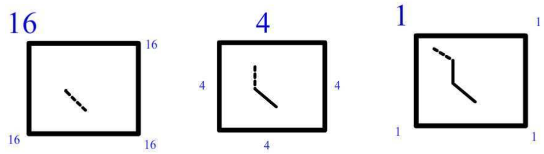

Figure 17: Subcommands

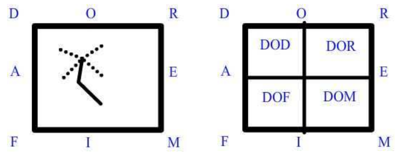

Figure 18: Circular

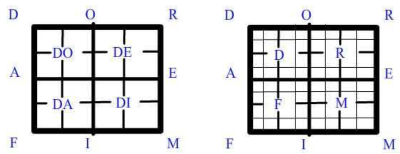

Figure 19: Chessboard organization

In Figure 17 the command 'DOD' is signaled. The first dashed D divides the sixteen commands that are placed in direction D, in four groups of four commands. The system places these groups in the directions O, E, I and A. The mark in direction O (Figure 17, middle) attributes the four DO-commands to the directions D, R, M and F. The last part of the mark signals the command DOD.

The commands 'DOR' , 'DOM' and 'DOF' are neighbours of 'DOD', sharing the same 'pie'(see Figure 18). We started reading upper left and read clockwise, following the convention in our culture[2].

In Odyschrift the circular movement is made thrice. The

[2] The Netherlands

set of 64 commands is divided three times in four parts. In Figure 18 and Figure 19 the Odyschrift commands are organized in a more abstract way than in Figure 16. This ‘chessboard’ is clearly structured.

In Figure 20 we present our idea for presentation of Odyschrift on a display or a keyboard, deduced from the ‘chessboard-structure. The chessboard-structure is stretched in its last winding. The hands and eyes of a user are placed next to eachother. This unwinding of the chessboard-structure is a tribute to this fact.

~~dod~~	dor	ded	der	rod	ror	red	~~rer~~	mod	mor	med	mer	fod	for	fed	fer
dof	dom	def	dem	rof	rom	ref	rem	mof	mom	mef	mem	fof	fom	fef	fem
dad	dar	did	dir	rad	rar	rid	rir	mad	mar	mid	mir	fad	far	fid	fir
daf	dam	dif	dim	raf	ram	rif	rim	maf	mam	mif	~~mim~~	~~faf~~	fam	fif	fim

Figure 20: Ody-ribbon and Ody-keyboard

Spatial organization

“The primary task for menu designers is to create a sensible, comprehensible, memorable and convenient <u>semantic</u> organization” (underlining by the author, avm), wrote Shneiderman 1986 p. 57 [13]. Shneiderman [13] wrote also: *“Menu items should fit logically into categories and have readily understood meanings”* [13].

The ‘chessboard-structure’ of Odyschrift is a two-dimensional menu. In this structure Odyschrift has the attributes a menu should have: a *“sensible, comprehensible, memorable and convenient”* organization [13]. The commands will fit *logically into ‘categories’*[13], be it that its ‘categories’ are spatial and not semantic.

However, hierarchical organization of a menu has a draw back: *“experts already know which commands they want and where those commands are, but a hierarchical selection widget requires additional navigation actions that take more time…*(Scarr *et al.* 2012, p. 1 [12]).

Scar *et al.* [12] pointed to *“alternative command-selection techniques.. that allow better performance for experts.”* HMM is one of them. *“When people become experienced with marking menus .. they begin to retrieve the correct command using muscle memory rather than visual search.”* In the opinion of Scar er al [14]) HMM does not fit well enough with traditional WIMP interfaces, because *“these systems are most often used with a mouse, which can make gesturing (as used with marking menus) more difficult.* [12]*”*

Odyschrift is an HMM, but has the characteristics of a WIMP. Odyschrift allows better performance for experts, but is also convenient for novices, and in accordance with WIMP.

Scar *et al.* [12]) studied the spatial memory of knowledgable users. They found that *“users can remember the spatial locations of controls without the need for hierarchy, implying that hierarchy traversal is inefficient for experienced users.* “ (p. 9).

Ahlström *et al.* [1] introduced “square menu”. Square menus arrange menu items in a square grid. Ahlström at al [1] concluded that *“Square Menus offer several pragmatic advantages (*above pie-menus) *– including their ability at any screen location,… their simple layout, and their support for broad structures.* ([1] *p. 1378)*

Odyschrift converses her hierarchy of pie menus in a ‘square menu’. As such Odyschrift claims the advantages Ahlström *et al.* [1] claim for ‘square menu’.

The designer can choose to omit a part of the ‘chessboard’ in the menu he designs. In that case he refers to the ‘chessboard’ by using the three-letter labels. In fact, he can omit 63 commands and present one command only with the three-letter label. In that case he uses Odyschrift as accelerator.

In the next paragraph we analyze Odyschrift as feasible technique for text-entry.

TEXT-ENTRY WITH ODYSCHRIFT

A *“case study of user behavior with marking menus in a real work situation”* ([8] p. 258) is reported. The authors concluded: 1. *“A marking menu was a very effective interaction technique in this setting”,* 2. *“A user’s skill with marking menu definitely increases with use”,* 3. *“The ability to switch back and forth between menus and marks is important.”* ([8] p. 263)

Ad 1: The setting has to be appropriate.
Text-entry differs from the application used in the study.
That application invoked *“a few commands that are used frequently, and require*(d) *a screen location as a command parameter.”* [8] Text-entry invokes many commands and does not require a screen location as a command parameter.

The last difference is not essential for the way the user marks.

The difference between ‘few’ and ‘many’ is gradual. In text-entry commands (to produce an alphanumerical character) are used very frequently. From this circumstances we defer that Kurtenbach and Buxton [8] itself does not falsify the hypothesis that its conclusion 1 hold for text-entry, as well.

Ad 2 and 3: increasing skill and switching between menu and marking mode.
Odyschrift, used for text-entry, will have a menu, presenting alphanumerical characters. A novice user will start with using this menu, but transition to expertise will be fluently.

Odyschrift is a cursive handwriting. The user chooses one of four directions (on-axis). On-axis selections are proved to be the least error-prone [6].

These characteristics of Odyschrift make Odyschrift a feasible technique for text-entry. For the time being there is no counter indication.

Breadth of Odyschrift for text-entry

The breadth of partial Odyschrift, introduced earlier, having sixteen marks, will be too small, because the Latin alphabet contains 26 characters. An Odyschrift extended with one step (y = 4) has a breadth of 64 x 4. That is too broad when the Latin alphabet is used.

The order of the alphanumerical characters

To write with Odyschrift each mark has to be appointed to a symbol. There are two decisions to make:

1. which order will be used: the order of the western culture from up to down and from left to right or the circulair order of Odyschrift and

2. are all Odyschrift characters available?

The answer on the second question is negative. Not all Odyschrift characters are available. Odyschrift can be used in other applications. It is wise to reserve a few characters for common tasks, such as navigation to the root of a hierarchical menu, or to quit the application. We decided to reserve the characters ‘DOD’, ‘RER’, ‘MIM’ and ‘FAF’, being the four characters related to four corners of the ‘chessboard’. Conclusion: 60 characters are available.

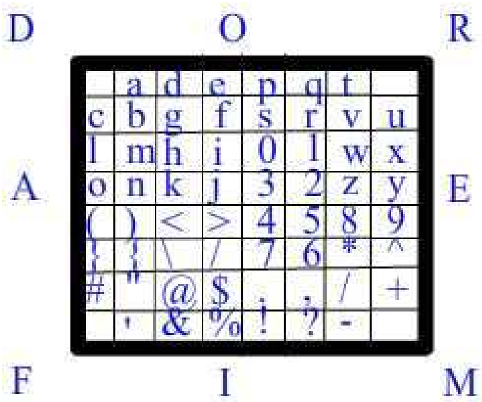

Figure 21: Odyschrift and the Latin alphabet

Figure 21 is our answer on the first question. We let the circular order of Odyschrift prevail. Our motive for this choise is that the circular order is natural in Odyschrift. If by chance symbols have another (conventional or natural) order, the Odyschrift order has the first priority, being the consequence of the Odyschrift-technique.

The qwerty-keyboard has a two-dimensional ordening, like Odyschrift. A possibility is to use the layout of the qwerty keyboard for Odyschrift. This ordening is familiar to many users. That is an advantage regionally and temporally. A more universal and eternal layout has our preference.

CONCLUSION

Analysis of the literature learns:

Kurtenbach and Buxton [6] reported a study. The study was done on dexterity of users, but not on the mental process needed in HMM.

A limit in menu depth for HMM based on four directions was not proven [6], contrary to the opinon of some writers [14], [1], [11].

Researchers defined the breadth of an HHM as the number of inflection free marks an HMM-structure has. (e.g. [14] and [6])

In our definition of breadth, the breadth of HMM is dependent on the number of parts a mark can have.

A change in direction during marking is seen as a subcommand to the system to distribute the active menu-items over the directions for the next part of the mark. At the end of this process the mark signals one menu-item. That item is executed.

An essential technique is axis-shift [7]. Axis-shift is known in the literature ([7] [3]), but only recently used in a design ([9], [4].

The result of the theoretical analysis is a method to signal commands in a continuous writing movement. Text-entry is therefore a feasible application of this method.

The commands to a system are organized in a two-dimensional space. Odyschrift gives descriptions of the routes to the commands.

FUTURE WORK

Figure 20 discloses our next concern. How is Odyschrift presented on the screen and what will be the relation between Odyschrift and keyboards?

Further questions that need answer are:

- Which functions deserve to hold the corners of the chess-board structure?
- Of course the user gets feedback from transition y +1. How?
- What are other applications for Odyschrift? The fact that the Odyschrift-characters can function outside the chessboard-structure, just like other names for objects, should be noted.

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