

CONCLUSIONS and FUTURE WORK

We have presented a variant of hierarchical marking menus that uses a series of simple inflection-free marks to make selections, instead of the traditional single compound mark. An experiment comparing the two techniques showed that using simple marks outperformed compound marks in both accuracy and selection speed for four different menu layouts and three difference input sizes. In particular, we showed that the simple mark technique can effectively select from a 512 item menu (*compass8-3*) without degradation in selection accuracy. This significantly increases the viable menu size for marking menus by a factor of five, from the previously established effective limit of 112 items (*compass4-4*) [6]. In addition, the data shows that performance with the simple mark technique remained fairly consistent as input or device size decreases, making it particularly suitable for small footprint devices.

While our work has explored many of the issues surrounding the simple mark technique, one issue that remains unanswered is whether users will find it easier or harder to remember a series of simple marks compared to a single compound mark. In order to make selections without displaying the menu, users have to memorize the marks required for each level of the menu. With compound marks, this task may be chunked [3, 10] as a single whole, whereas it is possible that simple marks will result in users thinking of the task as several subtasks, thus hindering their transition from novice (i.e., selecting with menu displayed) to expert (i.e., making marks without menu displayed) performance. Also, although our results do not indicate it, there is a small possibility that the simple mark technique's serial pen up/down events could lead to more mode errors [9] in practice than the compound mark technique where the single pen/up down event per mark essentially acts like a kinesthetically held mode while selecting from multiple levels. These issues along with a real world implementation of the simple mark technique should be explored further.

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Appendix A: Calculation of Unambiguous Leaf Nodes in Compound Mark Marking Menus

Let B be the branching factor of the menu (e.g., 4, 8)

Let D be the depth of the menu (i.e., number of levels)

Then, the total number of leaf nodes = B^D

Number of leaf nodes with unambiguous marks =
(number of marks with maximal number D-1 inflections) +
(number of marks with no inflections at all) =
 $B * (B-1)^{(D-1)} + B$

Example calculations:

compass8-2 layout = $8 * (7^1) + 8 = 64$ (i.e., all leaves)

compass4-4 layout = $4 * (3^3) + 4 = 112$ (43% of all leaves)

compass8-3 layout = $8 * (7^2) + 8 = 400$ (78% of all leaves)

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