Hand-held device evaluation in gesture interfaces

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Hand-held devices are a pragmatic approach for direct control of large displays by means of gestures. We evaluated the performance and intuitiveness of these devices in a consistent and reliable way. An evaluation that is based on task difficulty, completion times and error rates is defined in ISO 9241-9 [1]. The contribution of this paper is an ISO 9241-9 evaluation of the performance and intuitiveness of three gesture interaction techniques for controlling a large display. Two distinct devices and a one-hand versus two-hand case are evaluated.

Evaluation of point and select tasks

Soukoreff and MacKenzie [2] found inconsistent and contradictory results when comparing 24 evaluations of mouse performance, and thus showed that standardized evaluations are needed. MacKenzie [3] shows that ISO 9241-9 is suited for such evaluations because it reduces common HCI interface tasks to point, select, trace and drag. Intuitiveness as perceived by users is evaluated through rating scales in a standardized questionnaire [1, Annex C].

This study compares two representative, wireless devices. The Nintendo WiiRemote uses an absolute pointing solution while the Logitech AirMouse uses accelerometers for pointing. We define three cases: an AirMouse in one hand (AM), a WiiRemote in one hand (1W) and a WiiRemote in each hand (2W). The experiment was done on a 60" plasma TV at a distance of 2 meters.

In our evaluation an effective index of performance (IP_e) is calculated per device based on effective difficulty (ID_e) and task completion time (MT). We applied the recommendations on ISO 9241-9 by Soukoreff and MacKenzie for calculating ID_e and calculating error rates [2]. Also, we selected a task difficulty range from 2 to 6 bits; ID increases with distance and smaller target size. Tasks were horizontal and vertical tapping and dragging [1, Annex B.6.2].

Participants were allowed a brief training session to get used to devices and tasks. Three sessions were completed (AM, 1W, 2W), each consisting of two task sets (tapping and dragging). In a task set, the tasks were grouped per movement direction. The order of sessions, task sets and tasks were all randomized. Missing or hitting a target painted the target red or green for 15 ms.

Results

Our within-subjects test included 11 participants; one female, ten male. Ten participants were right-handed, one was left-handed. Users were proficient with computer use ($\bar{x} = 6.4/7.0$, $\sigma = 0.7$) while inexperienced with wireless hand-held devices ($\bar{x} = 3.0/7.0$, $\sigma = 1.7$). 2W was significantly ($p < .05$) faster in the tapping task than 1W or AM. Tapping performance was comparable for 1W and AM. For dragging, the results were comparable for 1W and 2W. AM tended to be slower for dragging. Especially for tapping, AM was less error-prone.

Table 1. Performance (IP_e), task completion time (MT) and error rates.

	one WiiRemote		two WiiRemotes		AirMouse	
	tapping	*dragging*	*tapping*	*dragging*	*tapping*	*dragging*
IP_e	1.87 (.49)	1.40 (.37)	3.28 (1.39)	1.34 (.42)	1.79 (.81)	1.15 (.37)
MT	1.26 (.47)	1.81 (.76)	0.79 (.29)	1.89 (.80)	1.41 (.56)	2.29 (1.06)
error rate	.89 (.22)	.80 (.23)	.55 (.17)	.98 (.24)	.44 (.12)	.88 (.29)

Values in bits/s for IP_e, ms for MT. σ between parentheses.

The intuitiveness of AM scored low compared to 1W and 2W. Participants attributed this to sensor drift in AM. Absolute pointing was preferred in 1W and 2W. However, AM provided jitter reduction that reduced pointing errors caused by minor trembling of the arm and hand. Our participants experienced this as the main drawback of 1W and 2W. 2W was experienced as only marginally faster than 1W or AM. Operating fatigue was mostly felt in the shoulder. Ten participants preferred 2W in both tasks for its novelty and intuitiveness.

Conclusion

Using two hands in a tapping task is faster, less error prone and more intuitive for beyond arms-length control of a large display with hand-held devices. However, it was perceived to be only slightly faster, suggesting that the task load is similar for one-hand and two-hand cases. The device itself does not influence the perceived intuitiveness nor performance of the interface, its sensor solution for pointing does. Both absolute pointing and jitter reduction improve performance.

References

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