

[Poster] The Posture Angle Threshold between Airplane and Window Frame Metaphors

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ABSTRACT

Integrating different mental models and the corresponding interaction techniques for navigation and object manipulation tasks is a topic of concern for providing user interfaces for the wide variety of potential users. With a user controlled, egocentric hand-held device we aim at integrating the so far identified three major interaction techniques based on the metaphors of a steering wheel, a toy airplane and a window frame. Here, specifically the toy airplane and the window frame contradict each other, leaving the issue at which postural angle of the hand-held device the mental model of the users changes.

Index Terms: H.5.m [Information interfaces and presentation]: Miscellaneous

1 INTRODUCTION

Different people have different understandings how the position and orientation of a hand-held device can be used for navigation tasks in virtual environments or for the placement of exocentric cameras or objects [5] in Augmented Reality. As we strive for an easy-to-understand and clearly separated control, we provide a rate control that maps translation parameters of the device to viewpoint translation of the virtual camera and rotations accordingly to rotations [3]. The control interface is active as long as a button is pressed on the hand-held device, a tablet in our case where the button covers the whole touch surface of the screen. The pose of the hand-held device at the moment when the button is pressed serves as the initial pose against which the relative translational and directional control parameters are calculated.

While translations are easily mapped to the corresponding axes of the virtual camera, things are different for rotations. First, having a roll might not appear necessary, so we spare out this DOF for viewpoint control, thus gaining one open DOF for the input side. Second, two fundamental metaphors are apparent: using the hand-held device as a steering wheel (*steering wheel metaphor*) and using it as if playing with a toy airplane (*airplane metaphor*).

Mapping rotations for the steering wheel metaphor is straight forward: the hand-held device resembles a steering wheel. The intended axis of rotation is the normal vector of the display screen. However the device is held, upright as in a conventional car or flat as in a truck, the rotation can be mapped to the heading rotation of the viewpoint.

For the airplane metaphor this concept does not hold. Here, as Fig. 1 shows, the input axis of concern is the up-down axis of the display itself. The tablet device embodies the toy airplane. The metaphor is clearly transported when the device is held flat (Fig.

1(a) – pushing, e.g., the left side downwards and lifting the right side, states a left curve – similar to the wings of a plane. However, when the device is held upright (Fig. 1(b)), a user’s cognitive understanding of the usage, and thus the metaphor, changes. Following the above example, the airplane input technique would induce a left curve when the left side of the hand-held device is pushed away while the right side is pulled nearer to the user. We noticed that this behavior is counter-intuitive to the users – they expect a viewpoint rotation in the opposite direction. As this technique can be compared to a looking glass or an empty picture frame through which a user looks, we coined another name for a corresponding metaphor, calling it a *window frame*.

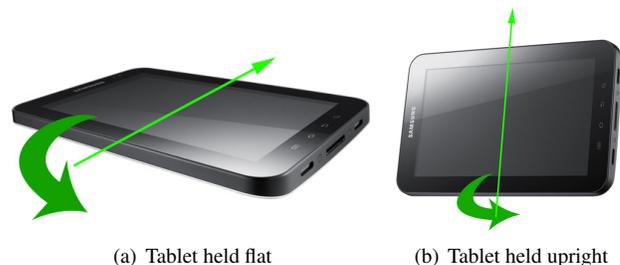


Figure 1: Major Variants to hold and use a Tablet Device for Navigation Control

The central question under investigation is, at which angle the switch of the metaphors occurs.

2 RELATED WORK

A fundamental basis for our metaphor-based techniques is derived from the work of Hinckley et al. [3] who put together design concepts to improve user abilities in virtual spaces. They recommend spatial references (in our case user’s own body and physical tablet as input device), relative gestures (our rate controls) and reduction of DOF (sparing out camera roll).

Yelistratov et al. [6] developed two navigation interfaces, one facilitating a balancing platform for feet control and a hand movement sensor with electrostatic field sensors.

Doulis et al. [2] also developed two navigation interfaces, yet hand-held devices acting as extensions of the human body intended to lead to so called extended body schema. The physical shapes of the two devices resemble a magic wand and a two hand-grips called NaviStick which, depending on the held posture define metaphors such as motor cycle grips or airplane wings.

Benzina et al. [1] essentially implemented metaphors similar to ours here but kept them as separate techniques.

3 EXPERIMENT

We conducted an experiment in a virtual environment to avoid any impact due to potential AR registration and calibration issues. The virtual world was a large scale and high resolution data set of the

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US state of Utah. The scenery was shown on the FRAVE [4], a visualization system consisting of six 65" displays aligned in a 3x2 matrix. The tablet was tracked with an ART tracking system and calibrated so that the local coordinate system resided in the center of the touch screen which was held in landscape orientation.

Test participants had a familiarization phase with a path visualized in mid air providing several curves and ascends and descends. No instructions about the user interface, except for how to activate, were given to not establish a mental model of any metaphor.

In the test, each participant had to execute three test runs with different initial holding angles of the tablet. The controls only would activate when the device was either held in an angle between 0 to 30 degrees (flat), 31 to 60 degree (tilted) or 61 to 90 degree (upright). The order of these intervals was permuted over all test subjects. In each of the three test runs, the participants had to navigate through 10 curves, each time starting over freshly from a given starting point. Curves were either having a small or large radius, and either were horizontally flat or going up or down besides their general left or right property. The order of the curves was also permuted over all test participants. The whole procedure took about 30 minutes.

There were 12 probands in total. The test users were aged between 17 and 27 years with an average of 22.08. Three of them were female. 11 had a driving license and most had experience with 3D computer graphics and videogames. 9 had experienced 6DOF input devices before.

4 RESULTS

The logged data was analyzed for notable turns in the wrong direction. A notable turn in the wrong direction indicates that the mental model of the metaphor changed. Fig. 2 shows the aggregated results. We calculated the percentage of the usage of the airplane metaphor (to specifically contrast against the steering wheel metaphor) and plotted this value over the holding angle of the device in radians. A holding angle of 0 means that the device has held flat while an angle of $\pi/2$ indicates an upright device pose.

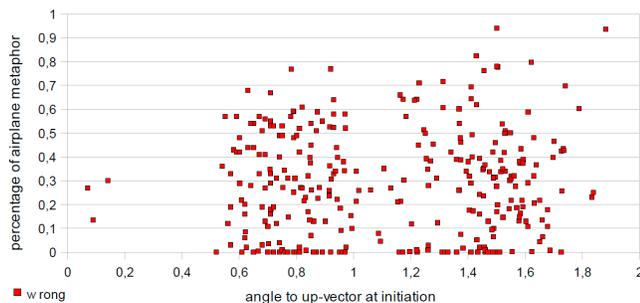


Figure 2: Incorrect Usage of Airplane Metaphor over Starting Angle

Starting from an angle of 0.5 (approx. 29 degree) unwanted influences of airplane rotations appear in extensive amounts.

For the reason of a clearer overview we had a look on the single probands. Looking at the data, the conclusion can be drawn that the conception of where the airplane metaphor ends differs with the users. For proband 1 the line seems to be at the angle of 0.5 (29 degree). Proband 3 and 10 seem to switch metaphors in a range of 0.6 to 0.7 (34 - 40 degree). User 5 and 7 are closer to 0.8 (46 degree), proband 6 starts at 1.2 (69 degree) and 2, 8 and 12 no sooner than an angle of 1.4 (80 degree). Test person 4, 9 and 11 avoid the use of the airplane metaphor in its divergent form altogether. They stick with the steering wheel metaphor.

Up to which point is the airplane metaphor used in a beneficial way? Does this question conclude to sharp lines of division with no real converging point over all users?

In this respect the cases of proband 2, 8 and 12 with whom the failure of the airplane metaphor occurs at a comparably large angle are now examined. If their data shows to use the airplane model with success over the range of angles where the metaphor starts failing for other users then the plan of devising a threshold for the flip of metaphors has failed.

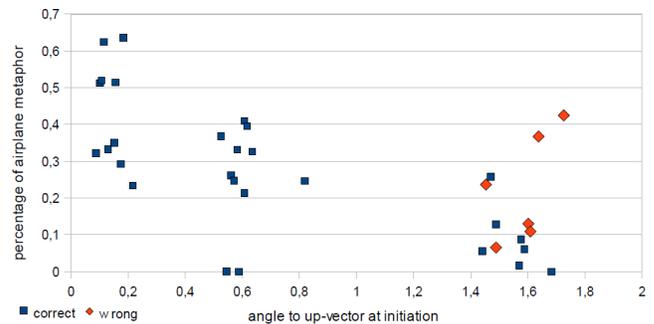


Figure 3: Usage of Airplane Metaphor over Starting Angle (proband 12)

All three users seem to use airplane mode with effectiveness up to an angle of 0.8 to 0.9 radians followed by a gap of airplane usage. Fig. 3 illustrates this gap on the example of test participant 12. The parallel occurrence of both positive and negative employment of the metaphor can be safely interpreted as the user realizing the unexpected inversion of the metaphor and executing a counter-rotation in order to compensate. This has been observed for almost every user in the study and phases in which the user intentionally used the inverted airplane steering to perform the correct turn because he learned to work with it. Such turns were excluded here.

Placing the parting line between airplane metaphor and a new window frame metaphor at an angle around 0.8 radians should improve the experience of navigating for most of the users.

5 CONCLUSIONS

While integrating the steering wheel and the airplane metaphor works out easily, the airplane metaphor generates issues. We discovered the window frame metaphor and tried to determine a unique threshold for metaphor switch. Our study showed that a value of around 0.8 radians might yield this demand.

Future work has to prove this hypothesis or might show that an actual calibration per user is required.

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