Multitouch Magic Fisheye : Precise interaction with dense data on tabletop

Fred Vernier

LIMSI-CNRS Labs. Univ. Paris-Sud BP 133, 91403 Orsay cedex, France Frederic.vernier@limsi.fr

ABSTRACT

Fisheye lens can be useful on multi-touch devices where dense usemap based applications need rich interaction to zoom, pan, rotate, select, annotate, etc. Direct input precision is often not critical to pan, rotate or zoom a map, but selection of items remains critical on dense maps. Surprisingly, only a very recent work on mouse based fisheye lens revealed how fisheye lens can dramatically improve precision. Unfortunately the disclosed techniques heavily rely on mouse pointer and cannot be transposed on tabletops. In this paper, we present a multi-touch interactive fisheye lens called MMF – Multitouch Magic Fisheye. MMF decouples the lens definition phase and the interaction phase on different fingers, enabling flexible input gestures with higher precision. We then present design issues (activation and lens offset) and discuss user strategies (choice of fingers and hand) to achieve a smooth integrated gesture with activation, lens adjustments and precise selection. We finally describe two concrete realizations of MMF through the implementation of a 1D Combobox menu and a 2D lens.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces. - Graphical user interfaces.

General terms: Design.**Keywords:** Multi-touch, fisheye lens, precision input.

INTRODUCTION

Fisheye lenses are now well known techniques but very few popular software use it. Attempts to explain it often refer inputs problems (poor input precision and overshooting). In fact, when fisheye lens is attached to the mouse cursor it does not magnify the motor space (see [6,8,1] for more details), resulting in the user overshooting magnified targets. Surprisingly, only very recent research work [1] suggested to improve fisheye efficiency by increasing the input precision in magnified areas. They achieve measured improvement by releasing the constraint of mapping lens and cursor's position to the same fluid movement of user's input device. The solutions proposed by [1] decouple fisheye movements and interaction with magnified content (like target acquisition) at the cost of an additional articulating task (modifier key, ring manipulation) or use cursors speed to introduce fast and precise modes [6,1]. Another lens-based touch-tabletop interaction technique that offers a solution for precise data selection is the focus+context technique of the iLoupe [9]. iLoupe was designed for tabletop and the focus area provides a precise access to data.

Chia Shen SDR Lab, SEAS, Harvard University 33 Oxford Street, Cambridge, MA 02138 USA Chia_shen@harvard.edu

The quest for precision has also taken place on direct touch systems (tabletops, touch screens, etc.) but for another reason: direct touch surfaces do not offer the same precision as its mouse counterpart and legacy applications barely work on touch screens. Benko et al [3] introduced five techniques based on Dual Finger: Offset, Midpoint, Stretch, X-Menu and Slider. These techniques all rely on a first gesture to gain precision and then on a SimPress click (harder press of the finger on the surface). Such pressurebased interaction is not supported by every touch surface. "Stretch" is the closest to a fisheye lens and outperform the other 4 techniques but suffers from occlusion.

Fluid DTMouse [4] is a multitouch mouse emulation to support legacy applications on the DiamondTouch table. It displays a mouse cursor in between two fingers (like Midpoint of [3]) but use a third finger to trigger mouse button avoiding SimPress. Fluid DTMouse alleviates occlusion and increases precision. Precision is in fact doubled when moving only one finger because the cursor moves precisely at half speed (see Midpoint discussion of [3]). The third finger (DTMouse) offers better precision than SimPress (Dual Finger Midpoint), yet neither technique benefits from a fisheye which potentially provides greater than a 2x gain in resolution and precision if appropriate mechanisms can be designed to enable motor space resolution increase.

The idea of fisheye lens on direct touch surface has been explored with DTLens [5] and a technique for "Rubbing the fisheye" [8]. DTlens uses two fingers to set both lens location and size. DTLens supports only limited interaction with the underlying content and the annotation task discussed in [5] does not require high precision. "Rubbing the fisheye" addresses the precision issue with a compound gesture (rubbing the finger on the surface to zoom-in or zoom-out the fisheye then a 1sec timer let the user release her finger and hit one of the zoomed target). The second half of the gesture introduces a timer which severely limits the efficiency of the technique, and focus location is barely predictable since the user may not accurately set the center of the magnification. One of the biggest problems of the technique is the lack of movement of the fisheye lens once it has been invoked.

This paper presents Multitouch Magic Fisheye (MMF), a fisheye technique efficiently mapping multitouch inputs to fisheye lenses in order to maximally improve their precisions. We present two implementations of the technique: a 1D Fast Fisheye Combobox (FFC) to show how it works

on the selection of a country among a list of 200 entries and a 2D map fisheye to show how it works on spatial data.

MULTITOUCH MAGIC FISHEYE PRINCIPLE

The Multitouch Magic Fisheye (MMF) starts with applying the Midpoint input technique to a fisheye output. By using the 2+1 fingers posture to manipulate the fisheye lens we first leverage the multitouch capabilities to avoid occlusion and improve precision and predictability of focus location. Unlike Fluid DTMouse where the third finger serves only as a trigger, MMF empowers the third finger to operate as a direct touch selector in the middle of the fisheye lens. As this finger remains independent of the first two finger ones (defining the lens) it can become a powerful input device. This precise (but still direct-touch) third finger can:

- Tap (select) magnified items
- drag local items (may be dropped later in non fisheye mode when first two finger have been released)
- drop items on local areas (may have been grabbed earlier in non fisheye mode)
- adjust fisheye properties with a related gesture (e.g., center offset or magnification factor)
- pan the fisheye (will add small offset between first 2 fingers and fisheye boundaries)

In essence, once the fisheye magnified motor space is defined by the first two-finger touch, MMF treats this space as a new separate and independent touch zone, allowing external touch input gestures to operate inside this movable secondary input zone. As with Fluid DT Mouse, this strategy of using 2+1 fingers remains independent from how single touches are managed (i.e. normal direct touch).

ACTIVATION AND DESIGN ISSUES

MMF can be triggered by detecting 2 simultaneous contacts (separated by a plausible distance) on full multitouch tabletops (e.g. optical tabletop systems) or by detecting plausible bounding box (on DiamondTouch like systems). This activation we call direct, can tolerate more than one finger touch area, e.g., the ring finger and/or pinky finger to touch the table. Such tolerance is important because user observation reveals that it is more comfortable to sometimes rest two or three fingers on the table surface (i.e., more fingers imply a hand's weight is divided among more contact points and reduce friction during movements). The pinky and the ring fingers can also be used to distinguish thumb from the middle finger, as they are closer together. These additional fingers also indicate which hand (left or right) is used as they are always on the same side of the thumb to middle finger axis. The other way to release the finger ambiguity is to wait for index finger to tap the surface one time before activating the fisheye lens. Lens is made more explicit and because the index finger always falls on the other side of the thumb-middle finger axis closer to the index finger it tells the system where the hand is resting on the surface. This activation strategy we call "lazy" as it waits for the third finger to appear. It is also very well suited to fight the overshoot problem. When only 2 fingers touch the table a temporary cursor can help the user to position the center of the lens before it appears.

MMF can then use the information on the hand location to best set and adjust the lens position. The fisheye's focus should be located with an offset from the two touch points of the hand to have the index finger comfortably ready over the focus area. In lazy activation, this offset can be set precisely under the 3rd finger tap.



Figure 1: Expected location of fisheye's focus according to relative position of the fingers involved in the Magic Multitouch Fisheve.

As in Fluid DTMouse user strategy to touch with thumb+middle fingers, leaving the index finger in the air, seems convenient while a bi-manual equivalent strategy was also reported being natural by users [3]. The goal of using a finger of the second hand as the third input finger is twofold:

- Improve stability (third finger is not connected to the same kinesthetic joints of the skeleton thus will involuntarily interfere)
- Increase reach among magnified items (moving index finger in between thumb and middle finger has a small comfortable area)

We highlight how the hand posture of Fluid DTMouse mimics hand posture over a traditional mouse (thumb and middle finger holding the mouse and index finger triggering the button). This comparison can be extended to MMF's similarity to the Apple Magic mouse [7] (thumb and middle finger holding the mouse while index sliding on the multitouch top surface of the mouse). This latter comparison explains the term "magic" used in the name of our technique as we expect magic mouse users to be easily become familiar with MMF.

MAGIC FISHEYE COMBOBOX

In this section, we present a concrete implementation of MMF to illustrate its utility and benefits. Magic Fisheye Combobox (MFC) is a Combobox widget displaying a Fisheye Menu [2] on demand using the Multitouch Magic Fisheye interaction described above. It is illustrated in

Figure 2. It is implemented as a QuartzComposer (QC) patch listening TUIO events, processing multitouch events in a JavaScript engine and displaying efficiently a list of textures generated with QC components. MFC allows title items to be inserted in the list (e.g., the Alphabetic letters in *Figure 2*) with different levels of magnification while not in focus. Title miniatures are limited to a readable level, text is aligned alternatively left and right and then shifted to appear slightly on the side of the regular items). Regular items are either right or left align according to where the hand is.

MFC operates in single finger mode to open/close the Combobox. Single finger can also roughly set the fisheye position and preselect the closest item under the finger. In the 2-finger mode MFC sets the fisheye position and the size at the same time, it then preselects the item exactly in the middle of the 2 fingers. If finger(s) is(are) released on top of the combo list in one of these two modes, the preselected item triggers a "selection" event. Finally, the user can also tap with the 3rd finger while in the 2-finger mode in order to select any visible item in focus (i.e. "Colombia" instead of "China" in Figure 1). When the first two lens defining fingers are released, the Combobox is immediately closed to avoid a possible conflicting event. The precision of MFC using 2+1 fingers is enabled by 3 factors:

- As the defining fingers do not occlude the pre-selected item and because the pre-selection occurs on a sliding motion (not on tap) the base precision depends on surface technology and not on fat finger effect. The precision of the focus area placement can be sub-pixels in many tabletop technologies.
- As discussed in [3] for Dual Finger Midpoint, by moving only one of the 2 fingers in the 2-finger mode, the pre-selected item changes along with fisheye's center at a doubled precision compared to the moving finger.
- As the third finger tap or slides on top of the magnified items (in magnified motor space), the precision is multiplied by the magnification factor of the fisheye lens.

Following MMF principles, MFC is an accurate technique to select items from a long list of items. This precision is achieved without sacrificing usability:

- Lens's size AND position are mapped directly to a human naturally integrated feature (location and gap between two fingers)
- Magnification factor can be automatically adjusted so items in focus are always large enough for the upcoming third finger (fisheye magnification strength can be automatically adjusted to magnify items at the size of thumb's contact that is usually bigger than index finger).
- The index finger can tap directly on visible items like anywhere else on the direct touch surface.

We decided to not display a cursor in between the first two defining fingers of MFC because the feedback of preselected item is sufficiently visible. However MMF and MFC are not incompatible with other fisheye usability improvements such as transparency [8,1] or speed coupling flattening [6]. A visible cursor could be useful in such cases.

MFC uses the direct activation strategy to speed up the selection. We also combine the first 2 touches with the



Figure 2: Fast Fisheye Combobox with the country "Cambodia" preselected in light blue among a list of 200 (end of the list omitted). The thumb and middle finger both define fisheye position and size while index finger moves down to select one magnified item

opening of the Combobox. If any one of the first 2 fingers touches the Combobox button, it opens the list and set the fisheye in between the 2 fingers. The list can also be open with a simple touch first. Two fingers are then put down to control the fisheye.

MAGIC 2D FISHEYE LENS

In the previous section, we applied the MMF principle to a 1D fisheye menu because it is similar to well understood widgets (menu or Combobox) and thus relatively easy to test and compare during the development process. FisheyeMenu [2] in the literature has undergone a challenging experiment showing fisheye is not the fastest technique. In our case, the top challenges for direct-touch surfaces are precision and screen footprint [3,4]. Handheld or laptop ouch screens are still limited in size and the touch surface is shared in tabletop conditions. Both contribute to the needs for better support for precise input and best utilization of screen space. In this section, we apply MMF lenses on 2D content as in all the other previous work we reviewed [1,5,6,8]. As illustrated in *Figure 3*, we faced a challenging trade-off between fisheye size, distance of the focus area to the index finger and occlusion

- The hand can occlude focus (in *Figure 3* the selection "Vert-Galant" is partially occluded)
- The index finger may be too far from focus (in *Figure 3* the index finger reaches the center but not the left of the focus)
- The lens should be large enough to leave undistorted objects in the focus (in *Figure 3*, the train station north of "Vert-Galant" has a label too long to fit in the fisheye).

Unlike 1D fisheye we couldn't find a satisfactory trade-off for single hand usage. Many users that we informally tested with reported problems with unexpected location at activation or with target being unreachable. Early users didn't report problems with bi-manual use of the technique and several users expressed the need to have large fisheye lenses. We finally chose a trade-off between the direct and the lazy activation. When the first two fingers hit the surface, the fisheye appears in the middle between the thumb and the middle finger. If any later third contact point is detected in the focus of the fisheye it is considered as a precise "click". If any later third contact point is detected outside of the fisheye lens, along the normal vector illustrated in Figure 1, the fisheye is re-centered to this point. The radius of the fisheye is then modified to have the first two contact points close to the edge of the lens. This new radius is computed proportionally to the distance between the first two fingers. As the focus is already under the index finger of the first hand, such action can only be triggered by a bimanual gesture.



Figure 3: 2D Fisheye on a subway map with train stations selectable ("Vert-Galant" station selected).

This transition to a bimanual mode of operation re-centers the fisheye to a very predictable location. The new radius of the fisheye allows the user to setup the size of fisheye as big as necessary and the proportional aspect means the first two fingers can still further modulate the size of the lens. Users who know they won't use the first fisheye can use their index finger to replace the middle finger as anchor on the edge of the lens.

CONCLUSION

We presented the Multitouch Magic Fisheye which leverages multitouch capabilities of direct touch surfaces to enhance fisheye input precision and flexibility. We applied this generic technique to an 1D fisheye menu and described how the Magic Fisheye Combobox can smoothly combine 1, 2, and 3-finger operation modes. We also applied this technique to a 2-D fisheye lens and found bimanual operations more appropriate. We explained why MMF dramatically improves precision despite it is implemented with a combination of an imprecise fisheye lens and an imprecise direct touch surface. However this paper also contributes by showing fine setup necessary to integrate the selection in a fluid gesture. A good setup depends on the task and the shape of fisheye so future works should be conduced to produce generic guidelines for designers.

ACKNOWLEDGMENTS

We want to thank the AVIZ and In-Situ teams of INRIA for their precious comments on this work in particular Jean-Daniel Fekete and Emmanuel Pietriga.

REFERENCES

- Appert C., Chapuis O. and Pietriga E., High-Precision Magnification Lenses. To appear in proceedings of CHI 2010 (Atlanta, GA, USA, April 10-15, 2010), ACM, NY
- Bederson B. Fisheye Menus, In Proceedings of UIST'00 (San Diego, CA, USA, November 5-8, 2000), ACM, NY, pp. 217–226.
- Benko, H., Wilson A. and Baudisch P., Precise Selection Techniques for Multi-Touch Screens. In Proceedings of CHI'06 Human Factors in Computing (Montréal, Québec, Canada, April 22 27, 2006), ACM, NY, pp. 1263–1272.
- Esenther A. and Ryall K., Fluid DTMouse: better mouse support for touch-based interactions. In *Proceedings of AVI'06 (Venezia, Italy, May 23-26, 2006)*, ACM, NY, pp. 112–115.
- Forlines C, and Shen C. DTLens: multi-user tabletop spatial data exploration. In *Proceedings of UIST'05 (Seattle, WA, USA, October 23-26, 2005)*, ACM, NY, pp. 119–122.
- Gutwin C. Improving Focus Targeting in Interactive Fisheye Views, In Proceedings of CHI'02 Human Factors in Computing (Minneapolis, USA, April 20 - 25, 2002), ACM, NY, pp. 267–274.
- 7. Magic Mouse. Apple Inc. October 2009 http://www.apple.com/magicmouse/
- Olwal, A. and Feiner S. Rubbing the fisheye: Precise touch-screen interaction with gestures and fisheye views. In *Proceedings of UIST'03 (Vancouver, Canada, November 2-5 2003)*, pp. 83–84
- Voida S., Tobiasz M., Stromer J., Isenberg P. and Carpendale S. Getting Practical with Interactive Tabletop Displays: Designing for Dense Data, "Fat Fingers," Diverse Interactions, and Face-to-Face Collaboration. *In Proceedings of ITS 2009*.