Fisheye Views are Good for Large Steering Tasks

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ABSTRACT
Fisheye views use distortion to provide both local detail and global context in a single continuous view. However, the distorted presentation can make it more difficult to interact with the data; it is therefore not clear whether fisheye views are good choices for interactive tasks. To investigate this question, we tested the effects of magnification and representation on user performance in a basic pointing activity called *steering* – where a user moves a pointer along a predefined path in the workspace. We looked specifically at *magnified* steering, where the entire path does not fit into one view. We tested three types of fisheye at several levels of distortion, and also compared the fisheyes with two non-distorting techniques. We found that increasing distortion did not reduce steering performance, and that the fisheyes were faster than the non-distorting techniques. Our results show that in situations where magnification is required, distortion-oriented views can be effective representations for interactive tasks.

Keywords
Focus+context, distortion-oriented representation, fisheye views, radar views, steering law

INTRODUCTION
Interactive fisheye views are focus+context techniques that use distortion to show both local detail and global context in the same view (e.g. [4,7,8,9]). Fisheyes are characterized by the in-place magnification of the focus area and the continuous transition to the demagnification of the surrounding context (see Figure 1).

Fisheyes support detailed inspection tasks and at the same time help users to maintain a sense of the entire dataset. However, although fisheyes have been shown to be useful for some tasks (e.g. [4]), they also have a reputation for being difficult to use. One reason for this reputation is that the distortion of a fisheye can hinder the user as they navigate the workspace. In particular, moving and positioning the pointer relative to the underlying data can be difficult, since the data appears to move in the opposite direction of the moving focus point. This effect has been shown to cause significant problems in targeting tasks [6].

It is not clear, therefore, whether fisheye views are a viable visualization technique for interactive applications– whether the difficulties of interacting with a dataset in distorted space will outweigh the benefits of having both focus and context in a single view.

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To evaluate the usability of fisheye views for interactive tasks, we carried out an experiment to assess how increasing distortion levels affect performance in basic pointing activities. We tested five representations: three types of fisheye view, and two non-distorting approaches as baseline comparators. The pointing tasks used in the study were *steering tasks* – where a user must move a pointer along a path that is defined by objects in a visual workspace (e.g [1,3,5]). In particular, we are interested in tasks where magnification is required in order to accurately determine the path (e.g. accurately tracing the edges of an object in a photograph requires considerable enlargement). In these cases, the magnification makes the path too large to fit completely into a single window.

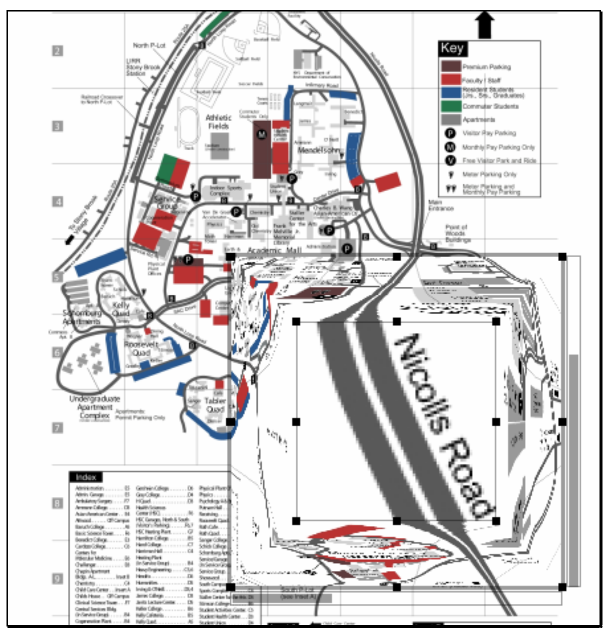


Figure 1. A fisheye lens on a map. © 2000 Idelix Inc. [7]

The experiment showed that fisheye views are a usable representation for large steering tasks. The focus+context approach was well suited to the task, and any disruptive effects of distortion did not reduce people's performance. As a result, steering with the fisheye views was significantly faster than with either of the undistorted techniques, and was more accurate in nearly all cases. In addition, most of the participants ranked one of the fisheyes as their top preference. These results help to put arguments about the efficacy of distortion-oriented views onto an empirical footing, and confirm that in situations where steering tasks occur frequently, designers can use fisheye representations without compromising usability.

STEERING TASKS

Steering, like targeting, is a basic component of many interactive tasks in 2D workspaces. Steering is integral to tracing, drawing, freehand selecting, gesturing, navigating menus, and pursuit tracking [2]. For example, digitizing the edges of a main road in the campus map of Figure 1 would involve steering along two narrow paths defined by the road boundaries.

The mechanics of 2D steering have been studied extensively by Accot and Zhai (e.g. [1,2,3]), who showed that performance can be predicted by an extension to Fitts' Law called the Steering Law [1]. The Steering Law relates completion time to two factors: the length and width of the path. The performance equation is:

$$T = a + b\,(A/W) \qquad (1)$$

where T is the completion time, a and b are constants, A is the length of the path, and W is its width. The constants allow consideration of the shape of the path (e.g. circular paths have higher constants than straight paths).

The steering law has been shown to accurately predict completion time over several path types, input devices, and task scales. However, one type of steering not considered in previous work is that where *magnification* is required to see the path in enough detail to steer correctly. For example, to accurately trace the edges of the road in Figure 1, the map must be considerably enlarged. Magnification of the source data implies that the path will often be made too large to fit within the visible workspace. In these situations, the need to scroll complicates the task and makes steering more difficult. Since fisheye views are always able to show the entire workspace, it is possible that they could be a good representation for large steering tasks. However, this benefit comes at a cost – the increased difficulty of interacting with data in distorted space.

FISHEYE VIEWS AND DISTORTED INTERACTION

Fisheye views use non-linear magnification to achieve a balance between expansion and compression of the data; depending on where the user's focus point is, different areas of the visualization will be magnified (or de-magnified) by different amounts (see Figure 1). In fisheyes where the focus point is tied to the mouse cursor[1], moving the focus thus involves interacting with the data through a distortion lens; this presents a particular problem called the *motion effect of magnification* [6].

When any type of magnifying lens is moved over a flat surface, the objects in the magnifier appear to move in the opposite direction to the motion of the lens. This means that objects move towards an approaching pointer, and away from a retreating one, making it more difficult to precisely position the focus point relative to the underlying data. The non-linear nature of the fisheye's magnification further complicates the problem, since objects move at different speeds depending on how close they are to the focus. Previous work has shown that this effect makes pointing tasks like targeting more time-consuming and more error-prone, with users tending to overshoot their targets as the amount of distortion in the fisheye lens increases [6]. In steering tasks, this problem can be easily noticed as a tendency for paths to "slip off" the side of the lens if the pointer moves too quickly near the boundary.

The magnification-motion problem in fisheye views may be related to a difference in the *apparent* and the *actual* control/display ratio of a fisheye. Control/display ratio (or C/D ratio) relates the amount of movement of the input device to the amount that the screen pointer moves across the data in the workspace [3]. An unmagnified and undistorted workspace has a C/D ratio of 1:1, and an undistorted workspace magnified to 2X has a ratio of 2:1, since twice as much mouse movement is needed to move the pointer the same distance in the workspace.

In a fisheye view where the distortion is non-zero, however, there is an apparent C/D ratio that is different from the actual ratio. In a fisheye's focus region, an object appears magnified (say at 2X), and this may cause the user to expect a C/D ratio of 2:1. However, the actual C/D ratio of the fisheye is always 1:1 – because of the way that fisheyes work, it always takes exactly the same amount of mouse movement to move the pointer across the object, regardless of the distortion level. If the user starts moving the mouse as if the ratio was 2:1 rather 1:1, they may move the mouse too far and too fast.

To assess whether the space advantages of the fisheye would outweigh these problems, we designed an experiment to see how different magnification levels and representation techniques affect steering performance.

EXPERIMENT METHODS

Participants

Twenty paid participants (11 male, 9 female) were recruited from a local university. All participants were right-handed, and were frequent users of mouse-and-windows systems (at least 12 hours/week). Nine participants of the 20 had some previous experience using an interactive fisheye system, and 10 of the 20 were regular players of computer games (at least 4 hours/week).

Apparatus

The experiment was conducted on a P4 Windows XP PC running a custom-built Java application. The display was a 21-inch monitor, set to 1280x1024 resolution. The study system presented a sequence of tasks that involved moving the mouse to steer through different paths drawn on the screen. Each unmagnified path was 40 pixels wide and 800 pixels long, but had different shapes (see Figure 2).

[1] Although there are different approaches to controlling the focus, focus-follows-mouse is the only reasonable approach for steering, since the user must be able to see the path under the cursor.

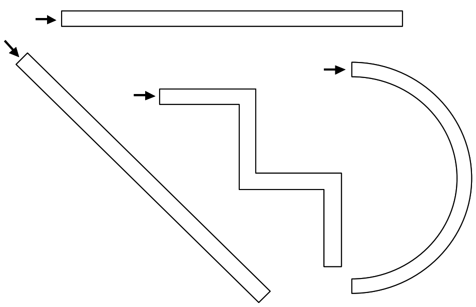


Figure 2: Paths used for steering tasks. Arrows indicate the start point of the task. At top is the horizontal path; at bottom are the diagonal, step, and curve paths.

Representation techniques

Participants performed the steering tasks with five different representations (see Figure 3). There were three fisheye techniques (S&B, round lens, and flat lens), and two non-distorting techniques (panning and radar view). These two non-distorting techniques were chosen as baseline approaches that represent two common ways of handling magnification in 2D workspaces.

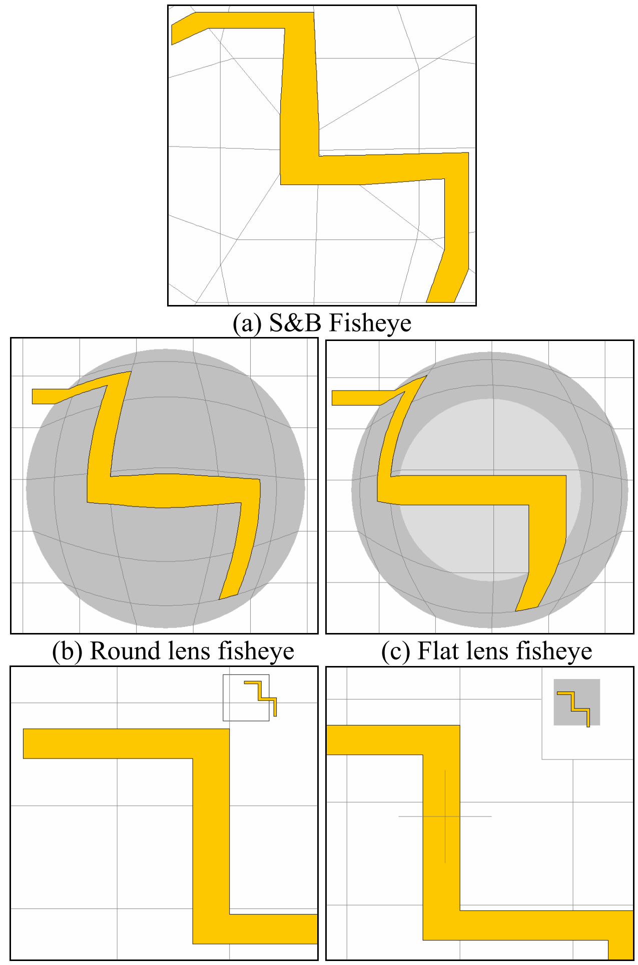
S&B fisheye. The S&B fisheye is based on Sarkar and Brown's 2D fisheye algorithm [9] using the polar transformation. In a rectangular window this results in a pyramid-shaped lens; lines were added to define the edges of the pyramid and help the subjects understand how the representation was distorting the space. The point of maximum magnification is the apex of the pyramid.

Round lens fisheye. The round lens fisheye uses a constrained hemispherical distortion lens also based on [9]. The area affected by the distortion was shown in a darker gray to help the subjects understand how the representation was distorting the space. The point of maximum magnification is the apex of the hemisphere.

Flat lens fisheye. The flat lens was created by truncating the hemisphere of the round lens. This resulted in a lens with constant magnification in the area immediately around the focus, and decreasing distortion in the remaining part of the hemispherical base.

Panning view. The panning view was a non-distorting view that showed the path in the main part of the screen at a particular level of magnification. To show participants where they were in the workspace, a small overview was shown in the upper right corner of the screen. A rectangle in the overview showed the position and extent of the main detail window. Subjects could pan the main view by dragging with the mouse; steering therefore involved both moving the mouse through the shape and then dragging the next part of the path into view.

Radar view. The final representation technique was an interactive radar view [11]. This system looked similar to the panning view, but in this case the miniature itself was the site for the interaction rather than the main view. In the radar, dragging the viewfinder can be used to move the data through the main view, and this is the way in which steering was carried out. The detail window contained a fixed set of crosshairs in the middle of the screen, and steering was accomplished by moving the viewfinder in the radar such that the path moved over the crosshairs (rather than moving the cursor through the path).



(a) S&B Fisheye

(b) Round lens fisheye

(c) Flat lens fisheye

(d) Panning view

(e) Radar view

Figure 3: Representation techniques used in the study. Grid lines have been added to illustrate any distortion effect. Note that the figures have been cropped and do not show the full experiment screen.

Magnification levels

Each steering task was carried out at three levels of magnification: 1X (normal size), 2X (twice normal size) and 4X (four times normal size)[2]. In the fisheye views, the full magnification level was only in effect near the focus point; in the non-distorted views, the entire path was magnified. Examples of the magnification levels using the round lens and panning view are shown in Figure 4.

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[2] In the S&B fisheye, actual magnification depends on the distance from the focus to the edge of the screen. We used a distortion value that would ensure a minimum of 4X magnification. Depending on focus location, actual magnification ranged from 4X – 6.5X.

The different magnification levels, in combination with the nature of each representation, led to a range of control/display ratios in the study. Table 1 shows the ratios for the conditions in the study. The largest amount of mouse movement is required by the panning view at 4X magnification, and the smallest amount by the radar view.

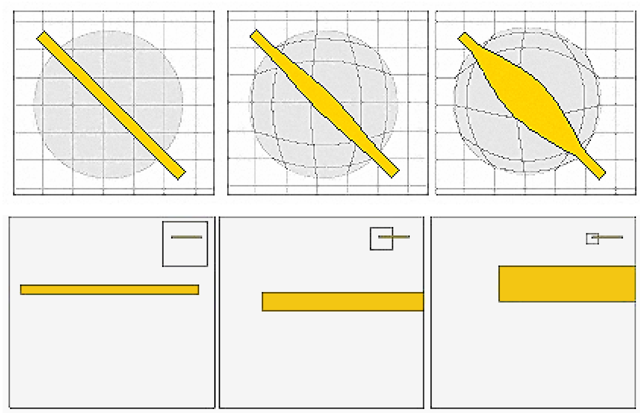

Figure 4: Magnification levels used in the study (1X, 2X 4X) for round lens fisheye (above) and panning view. Grid lines are added to illustrate the distortion; box in upper right of the panning view shows detail view extent.

Representation	Magnification	C/D ratio
Panning	1X	1:1
	2X	2:1
	4X	4:1
Fisheye (all types)	1X, 2X, 4X	1:1
Radar	1X	1:6
	2X	2:12 (=1:6)
	4X	4:24 (=1:6)

Table 1. Control/Display ratios for all representations and magnification levels (C:D indicates that moving C pixels with the mouse results in D pixels movement on the data).

Procedure

Participants performed steering tasks for each combination of track shape, representation and magnification. A typical experiment screen is shown in Figure 5. A single steering task involved entering one end of the path and following it through to the other. During a task, the system changed the colour of the path to indicate whether the participant was inside or outside the boundary, and to indicate when a trial had finished. Tasks were carried out in a back-and-forth fashion: after each 'outward' task, participants then carried out the 'return' path, returning them to their starting point. In each condition, participants carried out eight steering tasks (four in each direction).

To start a trial, participants clicked the 'Start' button (see Figure 5); the system then began recording data and counting the number of completed tasks. When the subject completed all eight tasks, the system would blank the screen, and the subject would press the 'Next' button to continue to the next condition. Participants were instructed to complete the tasks both quickly and accurately, and were asked to keep errors to a minimum.

A session contained the following stages: first, a short demographic questionnaire was given, followed by a practice session to provide some familiarity with both the representations and the tasks. Participants were then randomly assigned to an order group, and carried out the test tasks. Rests were allowed between conditions. After the session was finished, participants completed a second questionnaire asking about their preferences.

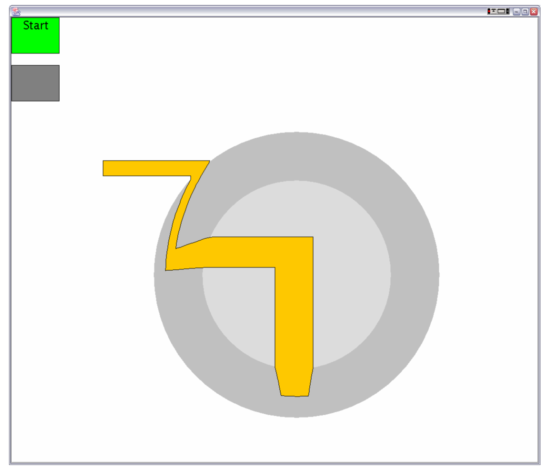

Figure 5: Typical experiment screen with flat fisheye lens.

Experiment design

The study used a 5 x 4 x 3 within-participants factorial design. Order was balanced using a Latin square method: each level of each factor occurred in every position in the sequence equally (e.g. all levels were first in the sequence an equal number of times). The factors were:

- Representation technique: S&B fisheye, round lens fisheye, flat lens fisheye, radar view, panning view;
- Path shape: Horizontal, Diagonal, Step, Curve;
- Magnification level: 1X, 2X, 4X.

With 20 participants and 8 steering tasks per trial, there were 9600 tasks recorded in total. The study system collected two types of data: completion times for each path traversal, and information about whether the mouse cursor was inside or outside the path at each point in its motion. In addition, participant answers to summary questions were recorded on a questionnaire.

RESULTS

We first present results that address the study's main research questions: how different representations affect steering performance, and whether increases in distortion affect steering performance in fisheye views.

We then report the results of additional analyses, including movement direction and path shape, demographic variables, and user preferences.

Effects of representation on performance

Completion time

Completion time was defined as the total amount of time required to traverse the path from start gate to end gate, and did not include any time spent outside the path at either end (although it did include any deviations outside the path during traversal). Note that this measure includes panning time for the panning view, because we are interested in the overall performance of the different representations.

There were clear differences between the three fisheye views and the non-distorting views (see Figure 6). With the fisheyes, users took between 3 and 4 seconds to complete a steering task. The panning view, although similar to the fisheyes at 1X magnification, quickly required more time at higher magnification. Participants performed least well with the radar at all magnification levels, needing between 6 and 7 seconds per task.

Analysis of variance showed a main effect of representation on completion time ($F_{4,76}$=66.1, p<0.001). Paired t-tests showed significant differences between all three fisheye views and both the radar and the panning views; there was also a significant difference between the panning and the radar.

In addition, there was an interaction between representation type and magnification level ($F_{8,152}$=47.5, p<0.001), reflecting the varying effect that magnification had on the panning view.

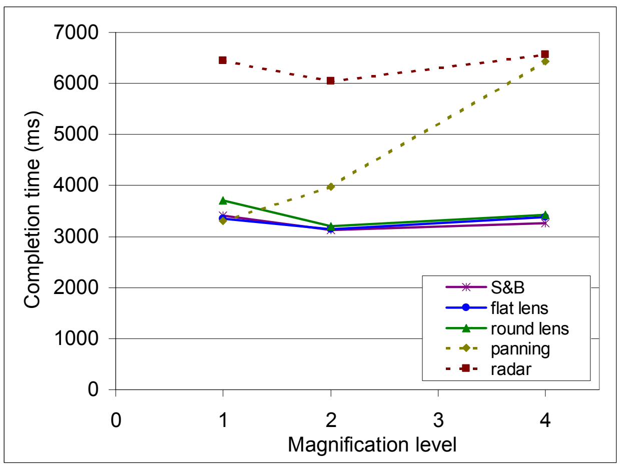

Figure 6. Mean completion time per trial for all representations, by magnification level. (Note that the fisheye data is show on its own in Figure 8).

Accuracy

An error was defined as any deviation outside the boundaries of the path during the traversal (after initial entry and before final exit). As discussed above, participants saw visual feedback when they were outside the path and were asked to keep errors to a minimum.

Error rates were fairly similar for four of the five representations (see Figure 7). The three fisheyes at all magnification levels had approximately one error per five trials, and the panning view ranged from about one error in five trials at 1X magnification to about one in 10 at 4X magnification. Considerably more errors were seen with the radar view – an average of nearly one per trial.

ANOVA showed a significant main effect of representation type on error rate ($F_{4,76}$=22.8, p<0.001), reflecting the radar view's higher rate. Followup t-tests showed that all four other views were significantly different from the radar. However, there were no significant differences found within the group of four, indicating that the error rates for the fisheye views are similar to that of the panning view.

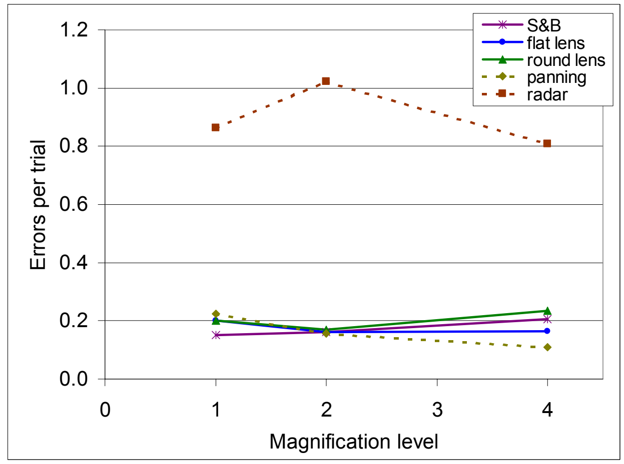

Figure 7. Mean errors per trial for all representations, by magnification level.

There was also a significant interaction between representation and magnification ($F_{8,152}$=3.54, p<0.001), showing that changing magnification affected different representations differently. Increasing magnification consistently reduced error rate in the panning view (as predicted by the increase in C/D ratio), but affected the fisheyes and the radar views in different ways. Errors were slightly less at 2X for the fisheye views, but higher with the radar at 2X magnification.

In sum, fisheye views were faster than the non-distorting techniques under magnification conditions, and their accuracy was no different from the most accurate of the non-distorting methods.

Effects of magnification on fisheye performance

To consider in more detail the specific effects of increasing magnification on the fisheye views, we repeated our analyses using only the fisheye data.

There was a significant main effect of magnification level on completion time in the fisheye data ($F_{2,38}$=10.6, p<0.001). However, rather than linearly increasing along with magnification, completion time actually went down slightly as magnification increased from 1X to 2X, and at 4X magnification was still lower than the 1X value for two of the three fisheye types (see Figure 8). Although the performance differences at magnification levels were small (from 1/10 to 1/2 second per trial), it is surprising to see that a small increase in distortion actually helped people to steer faster.

Analysis of accuracy data shows that the improved completion time at 2X did not occur at the cost of increased error rate. ANOVA showed no significant effect of magnification level on error rate when considering only the fisheye data (p=0.171).

These results clearly indicate that steering with fisheye views, at least in the situations studied here, is not adversely affected by distortion effects of the fisheye lens.

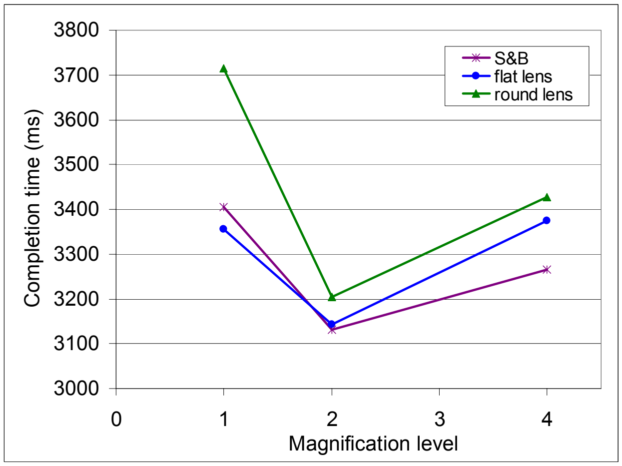

Figure 8. Mean completion time per trial, showing only the data for the three fisheye views.

Additional analyses: path type and movement direction

In addition to our primary hypotheses, we also analysed two additional variables: the direction that the user moved through the path, and the shape of the path.

Movement direction

Accot and Zhai [3] suggest that steering tasks are dependent on the direction of movement, due to differences in moving arms and hands in different directions. We tested whether movement direction had an effect on our representations. On the 'outward' path, directions were either down or right (except the curve, which involved both directions), and on the 'return' path, motion was up and left. We found a significant effect of direction ($F_{1,19}$=10.8, p<0.005) with left/up being significantly (although only slightly) faster than right/down (see Figure 9). There was no interaction with representation type, and re-testing of the main hypotheses with both the left-only and the right-only data gave very similar results. There was also no effect of direction on steering accuracy ($F_{1,19}$=2.5, p=0.13).

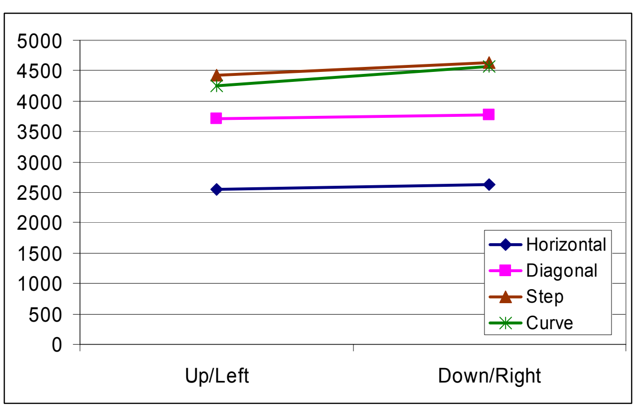

Figure 9. Mean completion time per trial by path type and movement direction.

Path shape

As found in other studies (e.g. [2]), there were significant main effects of path type on both completion time ($F_{3,57}$=85.4, p<0.001) and error rate ($F_{3,57}$=16.6, p<0.001). As can be seen in Figure 9, participants were fastest with the horizontal path; the most difficult paths were the step and curve path, and the diagonal path fell in between. Results for error rates are similar to these.

Demographic tests

We tested three demographic variables to see if sex, prior experience with fisheyes, or experience with computer games had an effect on steering performance. The only significant difference involved fisheye experience: those participants who had used an interactive fisheye before were significantly faster for all representation types ($F_{1,19}$=7.4, p<0.05) (see Figure 10).

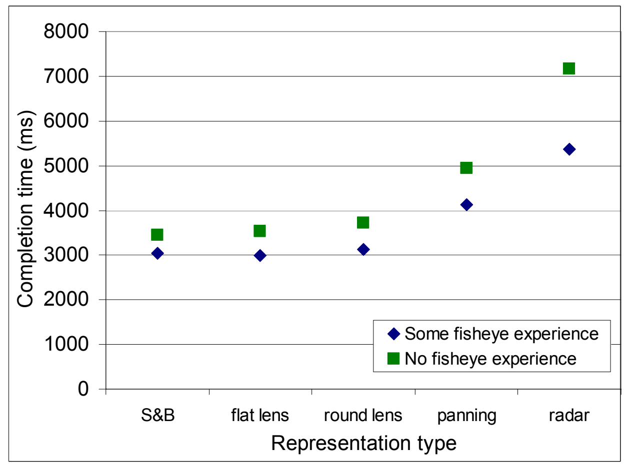

Figure 10. Mean completion time by representation type and amount of experience with fisheye.

User preferences

After the session, participants answered several questions about their preferences. We asked which representation the participant felt was fastest, which was most accurate, and which one they preferred overall. In general the fisheye views were well received; only in terms of accuracy was a non-distorting representation (the panning view) preferred.

Representation	Fastest	Most Accurate	Favourite
Flat lens	9	3	7
S&B	7	6	4
Round lens	3	4	5
Panning	1	7	3
Radar	0	0	1

Table 2. Participant preferences (cells show number of participants who chose the representation).

DISCUSSION

The experiment showed that steering performance with fisheye views was not adversely affected by increasing magnification up to 4X, and completion time actually improved slightly at 2X magnification. In comparison to the two non-distorting representations, the fisheye views were significantly faster than the panning view at 2X or 4X magnification, and faster than the radar at any magnification. Accuracy with the fisheye views was comparable to that with the panning view up to 2X, and was much better than with the radar. In this section, we consider explanations for these results, and discuss how practitioners can use the results in choosing representations for real-world visualization systems.

Explaining the results

Why did the fisheyes perform well?

The fisheye views performed well in comparison to two different baselines. The first baseline was performance on an unmagnified workspace, corresponding to the situation where no magnification is required to see details of the path. Compared to no magnification, the fisheyes performed well – in all but one case steering was faster with a magnified fisheye than with the normal workspace.

The second benchmark was the performance of two non-distorting representations with a range of C/D ratios. Although there are good reasons for the poor performance of the radar view (see below), it is still useful to see that the fisheye views were as good or better than two existing and competing techniques.

There are a number of factors that contribute to these results. First, the fact that fisheyes show the entire steering task in one window clearly benefited performance. This characteristic is the reason that fisheyes were faster at higher magnification levels than the panning view (which had to pan to move the path into view).

Second, fisheye views allow users to carry out the task in the same way that they would in an unmagnified workspace. No additional control actions (such as scrolling) are required, and no changes are made to the standard interaction paradigm where the mouse moves the control point rather than the workspace. In contrast, the radar view reversed the normal paradigm, and some participants did not adapt well to this change.

Third, a 1:1 C/D ratio was a good match to the task. That is, the amount of mouse movement required to steer at 1:1 was within a comfortable movement range – not too small for the size and sensitivity of the mouse, and not so large that awkward arm motion was needed [3]. In addition, a ratio of at least 1:1 ensures smoother motion on the screen; a lower ratio causes jumpy movement, a characteristic that participants disliked in the radar view.

It remains to be seen how fisheye views will compare against other non-distorting views (e.g. panning view with two-handed input, auto-panning, or a dragable magnifier [12]). Although we will make some of these comparisons in future work, our results suggest that fisheye views will at least be reasonable competitors against any non-distorting technique, primarily because seeing the entire path at once is so valuable in the task.

Finally, the fisheye views performed well in part because the difficulties of interacting through a distortion lens did not reduce performance; this issue is discussed next.

Why did magnification not reduce fisheye performance?

Increasing fisheye magnification did not lead to any reduction in steering performance. This stands in contrast to our previous work with targeting, where there was a marked effect of increasing magnification on targeting time and accuracy [6].

Although the data do not show any effect, the motion effects of magnification are clearly observable in the fisheye views we tested – particularly the ‘slipping off the lens’ behaviour described earlier. Why was the effect not quantified? One possible reason is the speed at which people carried out the steering tasks. Movement in steering tasks is much slower than movement in targeting (in our studies, people moved only about one-third as fast); at these speeds, the motion effect of magnification is much reduced. It is likely that although people experienced this effect, they were able to compensate for it without reducing performance. It remains for future study to determine if either increased magnification or task difficulty will cause an observable effect on performance to reappear.

The question of why performance improved at 2X is an interesting one that does not have an immediately obvious answer. We suggest one possibility that is based on the idea (introduced above) of apparent and actual C/D ratios. If participants believed that the 2X version of the path really was wider than the 1X version, they may have increased their speed accordingly. If it is the case that people were being overly cautious in the tasks (perhaps due to our instructions to minimize errors), this increase could have improved completion times without unduly affecting accuracy. Again, it remains to be seen whether this difference will be observable in other situations.

Why did the radar perform poorly?

There are two main reasons why the radar view performed poorly in this study. First, some participants had difficulty getting used to the interaction model where mouse movement corresponded to moving the viewport over a fixed control point rather than moving the control point over the workspace. This difficulty was particularly evident in the step path, where participants would regularly turn the wrong way at the corners of the path. This reversed interaction is very similar to the motion effect of magnification, but when globally applied in the radar, it appeared to have a much greater effect than in the fisheyes.

Second, the nature of the radar implies that movements in the view are scaled up considerably when they appear in the detail view. In the most extreme case (4X magnification), a one-pixel movement in the radar resulted in a 24-pixel movement of the shape in the detail view. Even though the increased size of the shape maintained the 1:6 C/D ratio, the large jumps caused considerable visual jitter that made the task more difficult. The jitter was most noticeable in the diagonal and curve paths; the other paths are rectilinear and in these the problem was not apparent.

However, the radar view could be changed to improve steering. In particular, a configuration that keeps the standard movement paradigm and reduces movement jitter (e.g. by using a two-handed approach with an additional input device to control a pointer in the detail view) will likely be much more accurate than the version tested here.

In addition, there are benefits of the radar representation that were not shown by our tasks. The main advantage of the radar view is that the magnification area is large (i.e. the entire detail view). Therefore, in steering tasks where it is only necessary to *see* the magnified path rather than to move the pointer along it (e.g. visual search), the radar allows users to be much less precise in steering than with the fisheye views (particularly the constrained variety).

Lessons for designers

Several lessons can be drawn from this research for the design of large visual workspaces. The most important of these is that fisheye representations should be considered as viable alternatives for interactive tasks. In particular, in situations where steering tasks are common and where magnification is needed – such as aerial map digitizing, editing and touchup of large photographs, or schematic chip design – users may well see performance gains with a fisheye representation.

The type of fisheye does not appear to affect performance, and so this choice could be made based on other factors in the task. For example, the two constrained lenses are valuable for helping users maintain a mental map of the workspace, since the distortion is restricted to the area around the focus. The flat lens is particularly useful when relative sizes and positions must be maintained, since the flat top provides constant magnification. The flat and round fisheyes, however, compress the data quite severely at the edges of the lens, and in cases where nearby objects have to be visible without too much distortion, the Sarkar & Brown system is more appropriate.

In situations where high magnification is required and where high accuracy is more important than task completion time, the panning view is still the best performer, since its higher C/D ratio helps to reduce errors.

Finally, experience with the radar view as configured in this study suggests both that reversing the standard mouse-motion paradigm and that using a small C/D ratio are problematic for steering. As discussed above, however, the radar representation itself is still of value; other versions of this system or different tasks would make it more effective.

CONCLUSION

In this paper we considered whether interactive fisheye views are good representations for carrying out large steering tasks in magnified 2D workspaces. Fisheyes present both advantages for steering (that the entire path can be shown in one view) and costs (that fisheyes cause motion effects in the data as the pointer moves). However, an experiment showed that the motion effects were not a factor in steering performance (at least at the mouse speeds used for our tasks), and so the space advantages of the fisheye allowed it to compare favourably against unmagnified steering and non-distorting representations.

Our results provide an empirical basis for arguing that fisheyes are good representations for real work. Fisheye views have been demonstrated many times, but their usability has not been considered in detail (exceptions include [4] and [10]). Although further study is needed to replicate and expand on our findings, we are beginning to understand and quantify the actual advantages of distortion-oriented representations in interactive task situations.

In future work, we plan to test our findings with additional task difficulties and higher magnification levels, and to compare fisheyes to other non-distorting representations. In addition, we plan to study the use of fisheye representations in real-world steering tasks. One practical extension to the present work is the issue of visual search along a magnified path. We are interested in whether fisheye views will work well for situations involving small displays and handheld computers, such as looking for a particular station along one train line on a PDA-sized subway map.

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