Exploring Animation as a Presentation Technique for Dynamic Information Sources

D. Scott McCrickard John T. Stasko Q. Alex Zhao
Graphics, Visualization, and Usability Center
and College of Computing
Georgia Institute of Technology
Atlanta GA 30332-0280
{mccricks,stasko,azhao}@cc.gatech.edu

Abstract

The constantly growing and changing nature of certain information sources creates new problems in presenting it to the user. While it may be desirable to maintain awareness of changes to this information, it is typically not a person's primary task. This article describes how animation can be used to communicate dynamic information in a limited space and with limited disruption to the user. We focus on a study on the preferences and reactions of twenty-five participants to tkscore, an application that presents NCAA Tournament game scores using a variety of different animated displays. Results from the study are provided along with future research directions.

Keywords: Animation, dynamic information, visualization, small screen displays, awareness, peripheral motion, user study

1 Introduction

The Internet and the World Wide Web can bring a plethora of information to people on their computer desktops. Current computer display tools can communicate information about a great variety of topics, yet they can also distract people from other daily tasks. Consider working at a computer while worrying about the traffic or weather on the drive home, or constantly checking on a breaking news story while trying to meet an important work-related deadline, or keeping track of a sports contest while working late. This research examines situations like these to determine methods for delivering important information in a constant but non-intrusive manner.

This information explosion is an interesting and paradoxical phenomenon. While many people feel overwhelmed by the sheer volume of information, it is still critical for individuals to have access to the information important to them. For instance, people do care when an important new software release occurs, when email arrives from their parents, when traffic is horrible on the interstate going home, when their file is caught behind five 20-megabyte jobs in the printer queue, and what the score is when their favorite team is playing a baseball game. Clearly, the availability of this type of information *can* be a good thing, as long as it is the information desired, and it is presented in an appropriate and non-intrusive manner.

The majority of related research in the field, however, has focused on the communication of *static* information. Relatively little research and much less progress has been made on visualizing and communicating *dynamic* information. This is particularly important since so much of the new information available electronically now is dynamic: stock prices fluctuate, news bulletins arrive, email queues grow, alarms sound and the weather changes. The communication of this type of information to people is made more challenging by the dynamics.

What do we mean by dynamic information? Dynamic information is structured, abstract data that changes or is updated either at regular but frequent times or at irregular and unpredictable intervals. Dynamic information requires not only that the information be communicated, but also that it is presented at an appropriate time and in an acceptable manner. For example, a stock quote changes far too frequently to interrupt the user upon each change, while a colleague's Web page might change infrequently but at unpredictable times when the user might not care to learn about it.

Often with static information, a person seeks to answer a question or make a decision. Consequently, they examine an interface, come to some conclusion, and move on. But with dynamic information, people's tasks more closely align to *awareness*, a constant knowledge about the state of and changes to a body of information.

The focus of our research is on maintaining awareness of the contents of dynamic information sources. For instance, information about weather, traffic, news, and process status all fit within this category. This type of information is useful to a person throughout their daily activities, but it often is complementary to other tasks such as document editing, coding, or correspondence. People want to maintain awareness of information, but they do not want this awareness to overwhelm their other work activities. How can this be done?

One solution is the use of animation as a visual tool in maintaining awareness. Tools such as news tickertapes use animation to convey dynamic information, but such tools often have been criticized as being too distracting. It is our expectation that much of the distraction stems from the nature of the animations and the tasks for which they have been used. We have been studying different forms of animations to better understand their capabilities and utility for presenting dynamic information.

Central to our understanding is a user study that examined the use of animated devices in monitoring sports scores during the opening days of the NCAA Basketball Tournament. This study has helped with the development of a programming toolkit for incorporating animation into user interfaces and has revealed guidelines for the proper use of animation in awareness situations. This article examines the role of animation in interfaces, focusing on lessons learned in developing the animation toolkit and observing how users made use of the animation.

2 Exploring animation as a solution

What is animation? Baecker and Small describe it as "sequences of static images changing rapidly enough to create the illusion of a continuously changing picture" [1]. It has been used to generate emotion, provide entertainment, and supply information.

A variety of animation techniques can be employed to communicate information, many of which come from motion pictures and animated films [1, 8]. For example, fading an

object in or out gradually adds or removes it from the field of view. Moving an object, particularly one too large to fit in the display area, can reveal parts of the object that were previously not seen. A movement can be enhanced to seem more realistic and less distracting by using augmentation techniques such as slow-in slow-out when starting and stopping a movement, motion trails to indicate speed and direction, and anticipation cues to show that a movement is about to start or stop. Zooming in toward an important object or away from an unimportant one can draw and hold the attention of a viewer.

Animation has been used in various information visualization situations. Baecker and Small list several uses for animation, including among others identification, transition, demonstration, history, guidance, and feedback. Some examples include the percent-done indicators for providing feedback [13] and animation of icons for demonstrating corresponding physical actions (a paintbrush with painting motions, a pencil with drawing motions) [2]. One use conspicuously absent from the list is the application of animation to better utilize screen space. For example, cone trees [16] use animation to show more information (in this case about hierarchies) than would otherwise be possible in a given space. We feel that this is a distinct advantage in secondary awareness tasks.

Animation has been used to show dynamic information as well. Algorithm animation systems demonstrate how the dynamic processes of algorithms work [19]. The Tickertape interface scrolls text messages from email and other resources across the screen [15]. Bartram explored the use of animation as a peripheral device that could attract attention to specific information [3]. However, the goal of these research efforts was to use animation to attract attention to changes. Instead, we wish to explore the use of smooth continuous animation as a way to blend new information into the display in a non-intrusive manner.

We are particularly interested in integrating animation into a user interface toolkit, thus making it more accessible to programmers and to facilitate uniform animation effects. Several user interface toolkits have been developed that allow the programmer to include animation in the interface. The Artkit toolkit allows programmers to create transition objects that describe how an object will move [7]. A reference to the transition object is then added to a graphical object to create the animation. Another toolkit, Amulet, was extended to include support for animation [14]. Animation can be attached to any value of any object, including position, color, or visibility.

These and similar toolkits provide a great deal of power to the programmer, yet they are limited in that they only enable single-time animations that cannot show the constant, repetitive effects that seem useful for awareness situations. To overcome this, we created Agentk, a set of widgets that are useful in supporting awareness with peripheral animation. The widgets in Agentk differ in that they do not universally integrate animation support for all objects, but rather support specific default behaviors that commonly occur in visualization applications. We focus on providing three widgets, each with a different animation that supports a different type of data: the *fade* widget cycles between items of textual or graphical data, the *ticker* widget scrolls text horizontally across the screen, the *roll* widget scrolls text vertically. While this choice may limit the power and generality of the tools, the benefit results from the ease with which information from common awareness situations can be communicated. For example, cycling between the contents of multiple variables (which could contain email headers, ball scores, or stock quotes) can be created by a single fade command. Prior toolkits seemed to focus on the availability of effects rather than their utility. The Agentk widgets, as well as many programs that use them, are available from

http://www.cc.gatech.edu/~mccricks/agentk/ and reports on their development and use can be found in [12, 10, 11].

Our philosophy is that a constant, repetitive animation can help maintain awareness of dynamic information by requiring little space and by integrating changes smoothly in the next iteration. We expect that users would be willing to give up space on their computer desktop for a display that cycles between items of interest, and as long as the animation is gradual, the distraction should be minimal. However, animation has been discounted in many situations as too intrusive. The constant motion on the screen may be too distracting for many users. Furthermore, it is unclear that the space tradeoff would prove to be worthwhile. However, computer users have long sacrificed desktop space for constantly changing displays like clocks, email biffs, and load monitors. Perhaps they would also be willing to sacrifice space for heightened information awareness. These issues led us to conduct the tkscore study.

3 The tkscore study

To test the utility of animation as an awareness device, we created tkscore, an application that monitored and communicated scores from the NCAA Basketball Tournament. We then deployed the application and surveyed users on their likes, dislikes, and desires for such a tool.

The NCAA Basketball Tournament is a single-elimination tournament consisting of 64 teams from across the United States. It generates much interest and is recognized as one of the most exciting sporting events in the nation. The large number of teams in the tournament necessitates that some of the early tournament games be played on weekdays. As a result, numerous people who are working have a desire to stay abreast of the scores of ongoing games, an ideal situation for an awareness tool.

The tkscore application shows the scores of basketball games using either a ticker, fade, or list display. The tkscore tool is started with a single command, which brings up a screen (see Figure 1). This control panel shows a list of all current games and the list of display types. The user can select and deselect the games that are monitored by clicking on the checkbox next to them. The user can toggle between the display types by clicking the radio buttons. The control panel can be dismissed by clicking the OK button and returned by pressing button 3 in one of the display windows.

The list display shows all of the scores at once (see Figure 2). but occupies a larger portion of the screen than the fade (Figure 3) and ticker (Figure 4) displays. Updates are obtained from the USA Today Scores Web Page, http://www.usatoday.com/sports/scores.htm. New scores appear immediately in the list display and on the next iteration for the ticker and fade displays.

For the study, all games for that day initially were selected and the participants had to choose a display type from a randomly ordered list of the three choices. The participants were encouraged to use several displays for an extended period of time. We monitored the informational and display selections of the users, though technical difficulties limited the amount of useful data we obtained.

After the study, the participants were asked a series of questions relating to their information desires and their display preferences. The remainder of this section discusses some

Figure 1: The main tkscore screen used to select display type and games. The display types are presented in random order upon startup to help avoid selection bias. If the fade or ticker display is selected, a speed selection bar appears. Initially all games are selected - a user can toggle the selection by clicking on the box next to the game.

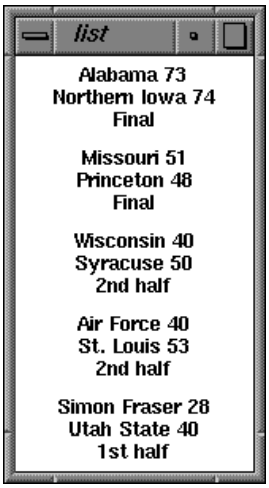

Figure 2: The tkscore list display. All selected scores are visible. When a score changes, the list display is immediately updated.

Figure 3: Five time-lapse snapshots in the operation of a fade display. This version of the interface displays the scores of baseball games. The first frame shows an initial block of text. The next two frames show how the text fades away into the background, and the final two frames show how the new text will appear in the same place.

Figure 4: A ticker display. This version displays a series of email senders and subjects. The headers ticker across the screen, and when new email arrives the new information is added to the ticker.

Info demand	Overall	Top preference			
		Fade	List	Ticker	No pref
Continual	8	3	3	1	1
Occasional	4	0	1	2	1
Casual	5	3	2	0	0
No real interest	4	1	0	2	1

Table 1: Number of responses to the question "How would you describe your interest in the NCAA Tournament?" from the 21 participants who returned the survey. The leftmost column of numbers shows the overall count for the participants while the other four columns show a breakdown based on the top preference from among the types of displays.

Response	Overall	Top preference			
		Fade	List	Ticker	No pref
More than needed	3	1	0	2	2
Right amount	10	5	3	2	0
Less than needed	7	1	3	1	2
No response	1	0	0	0	1

Table 2: Responses to the question "How did tkscore meet your needs for tournament information?"

of the key responses.

Twenty-five faculty and students used tkscore during the first four days of the tournament, and twenty-one of those answered the set of questions. Most used tkscore on several occasions, and most checked scores several times a day during the tournament. The usage monitoring logs (obtained for only eleven of the participants because of technical difficulties) showed that most of the eleven participants tried all of the animations, though only five users changed the animation speeds, and the speeds they settled on varied significantly. The cumulative time that a given participant used tkscore ranged from a few minutes to several hours.

Each display type had its proponents: seven people chose the fade display as their favorite, six chose list, and five chose ticker. The other three did not pick a favorite. Seventeen of the participants had at least a casual interest in the tournament, with eight expressing a desire to know about scores, game status, and more continually throughout the day. A breakdown of the participants' interest level is given in Table 1. Their evaluation of how well tkscore met their informational needs is shown in Table 2.

The reasons for selecting a display varied. The most common reason (given by 15 participants) was the ease with which information could be accessed and read. Ironically, this response was given equally by those who listed fade, list, and ticker as their favorite display. Table 3 shows a breakdown of the contributing factors to display selection.

When displaying information in a small space, certain choices must be made in constructing the display. The participants were asked to select the other features of the information that they would like to be displayed. Note that auditory cues, often looked upon as dis-

Response	Overall (max 21)	Top preference			
		Fade (max 7)	List (max 6)	Ticker (max 5)	No pref (max 3)
Ease with which information can be accessed and read	15	6	4	4	1
Amount of information visible at any given time	12	2	5	4	1
Level of distraction	9	5	1	2	1
Control over visible information	8	3	2	3	0
Control over rate of change	4	2	0	1	1
Other	4	3	0	1	0

Table 3: Responses to the question "What factors contributed to your choice of display?" Each participant could select multiple responses.

tracting, were the most desired mechanism for our users. Interestingly The top desire was to have auditory cues tied to important changes to the information, perhaps reflecting the desire to know more when and how changes occur. The second most desired mechanism was easier control over speed of updates, and the third was for more potential for user interaction. Both are related to the desire of users to feel in control of the interface, one of the golden rules of interface development. Improvements to the interface that deal with both of these issues are discussed in Section 6. A complete list of responses is given in Table 4.

Overall, responses to the application were positive. Users expressed desires for similar displays for weather information, news headlines, stock quotes, and activities of friends and colleagues. See Table 5 for a summary of the other informational desires.

4 Discussion

While animation in user interfaces is not new, information awareness provides a potential new domain for its use.

Would people be willing to sacrifice a small amount of space (or more) to potentially heighten their information awareness? Can animated displays in fact raise awareness to a suitable level? Or would the animations prove to be too distracting? This section will examine how our experiment shed some light on the answers to these questions.

Response	Overall (max 21)	Top preference			
		Fade (max 7)	List (max 6)	Ticker (max 5)	No pref (max 3)
Auditory cues tied to important changes to information	8	1	3	3	1
Easier to control speed of display updates	6	1	2	2	1
More potential for user interaction	4	0	2	1	1
Pictures and other graphics	3	1	2	0	0
Other	6	3	2	1	0

Table 4: Responses to the question "What additional display mechanisms do you desire in a program like tkscore?" ordered based on total number of responses. Each participant could select multiple responses.

Response	Overall (max 21)	Top preference			
		Fade (max 7)	List (max 6)	Ticker (max 5)	No pref (max 3)
Weather information	12	5	4	2	1
News headlines	11	3	4	3	1
Stock quotes	9	3	3	2	1
College announcements	8	3	2	3	0
Friend/colleague activity	8	4	3	1	0
Email/newsgroup summaries	6	3	2	0	1
MUD/MOO/Chat information	0	0	0	0	0
Other	5	2	1	2	1
Total	57	22	19	13	5
Average per person	2.71	3.14	3.17	2.6	1.67

Table 5: Responses to the question "With what other information sources would you use tkscore-like displays?" ordered based on total number of responses. Each participant could select multiple responses.

4.1 Understanding the role of animation in awareness

The first issue is whether people would be willing to sacrifice screen space for a potential gain in awareness. It is obvious from the extended use of tkscore that people were indeed willing to sacrifice a bit of screen space. Some people were even willing to have the entire list at once, though this was one of the reasons one participant gave for not using the list display. In the comments section of the questionnaire, nobody mentioned space concerns as a reason for not using the tkscore application.

Note that many users preferred the list display, which required significantly more space and did not animate changes. However, the sacrifice in screen space was still far less than for other options (such as checking the scores in a browser or starting many of the large Java monitoring applets), and the level of distraction was not listed as a major contributing factor in choosing a display for those who favored the list display (see Table 3). Those who were most concerned about being distracted by the display chose the small fade display that included perhaps the most gradual and least intrusive animated effect.

The second issue is whether these types of applications actually raise a user's awareness of the dynamic information. Over half of the tkscore users conveyed satisfaction with the information provided, and those that were not satisfied typically wanted more information to be displayed (the time remaining in the game or the players with the most points), a trivial addition to the application. While it is unclear whether users actually learned anything or whether they were able to accomplish other tasks, the users' satisfaction with their awareness levels is one important factor. Several of the most avid fans seemed to need more control over the rate at which new information was obtained: they repeatedly hit the reload button for a Web page, making the awareness of scores a primary rather than secondary activity.

Another concern is that a constantly changing display will be too distracting to the user. We attempted to evaluate this by asking users if the level of distraction was a factor in selecting a display. Five of the six users who preferred the list display also stated that level of distraction was a significant factor in selecting a display, which seems to indicate that some users prefer occasional sudden updates to the display over continuous animation. However, five of the seven fade proponents and two of the five ticker proponents also listed distraction as a significant factor, so there may be other factors in effect.

Maintaining user control over information flow is well-established as an important factor in designing visualizations and interfaces. None of our users listed it as a major motivating factor in selecting an interface, though some listed it as desirable in future versions of the tool. The main concern was the ease with which more information could be obtained. An action that allows the user to jump to a Web browser showing details of the game of interest may best solve this problem. It is important to recognize the bridge between maintaining awareness and obtaining information, and to allow separate tools to do each.

4.2 Matching animation types to awareness tasks

One goal of this research is to understand better the communication strengths and weaknesses of the types of animation introduced in this paper. Do the animations differ in their ability to communicate information, and if so, what types of animations are best suited for different situations? One indication of the relative qualities of the animations can come

from a comparison of the informational preferences of the participants who favored each device. The even division of top preferences (seven for fade, six for list, and five for ticker) suggests that no single animation type is best suited for every person and every situation.

Consider the question that asked for additional desired display mechanisms. One of the options was audio, generally considered to be highly intrusive. Interestingly, the data reveals that only one of the seven fade proponents wanted auditory cues, compared to three of five ticker proponents and three of six fade proponents (see Table 4). This suggests that perhaps the fade proponents are less willing to be disturbed by audio, suggesting that perhaps they chose the fade animation also because it was less intrusive. As such, perhaps fade is a better choice for communicating lower-priority information where the user does not want to be disturbed.

The list display was the only one that did not use smooth animation. It also takes up the most screen real estate. For these reasons, it is more like a standard application designed to command the attention of the user and not like an awareness device intended only to provide secondary information. We suspected that the participants who favored this display were extremely interested in the scores and were willing to sacrifice physically and mentally to stay up to date. The data bears this out. Table 2 shows that half of the list proponents found that the list, while their favorite, provided less than a desired amount of information. Compare this to fade (1/7) and ticker proponents (1/5). The comments of the list proponents seem to further support our hypothesis. One noted that "I wanted info besides just the score, like pertinent stats on key players". Another said "It was much easier to use CBS Sportsline", a Web page that provides a large display showing significant information.

5 Guidelines

In summary, the results of this study suggest key objectives to be met by visualizations for maintaining awareness of dynamic information:

- **Communicate state of and changes to information.** As with the visualization of any information, visualization of dynamic resources requires that the current state of the information be communicated to the user. However, dynamic situations often have the added requirement that users want to know when and in what ways the information has changed.
- **Minimize the space required by the information display.** To put it another way, a visualization should maximize the space that can be used for other tasks. Since all the tasks compete for the same computer desktop space, the awareness task, which is of secondary importance, should occupy a minimal amount of space.
- **Minimize required user interactions.** Since awareness is not the sole task of most users, it is undesirable to create highly interactive visualizations that require user manipulations to reveal needed information. Ideally, a visualization should communicate enough information to maintain a sense of awareness with little or no action from the user and with minimal interruption of other tasks.
- **Maintain user's sense of control.** A primary tenet of user interface design is to maintain the user's sense of control [17]. Inability to obtain desired information

and unexpected changes in the appearance of the interface can create anxiety and dissatisfaction in the user. This seems to conflict with the problem at hand: since the resources considered in this paper change frequently, it is necessary to update the display to reflect these changes.

6 Ongoing and future work

Thus far, many applications that use animation have been developed ad-hoc in response to a specific need or desire: a user will request an application or a situation will arise and a programmer will develop an application to meet the need. The next step is to enhance the programmer's ability to incorporate animation in a manner that is proven to be helpful and, when possible, to automate the communication of information so that the best possible method, animation or not, is used.

While this addresses the problem of displaying the current state of the information, people are often interested in prior states as well; that is, the ways in which the information has changed. Motion is often used to draw attention to new or changed information, such as with mail biffs and flashing Web text. Since we here are using motion to display the information, however, we must consider other methods for highlighting changes.

One method is to use *markups* to show information that has changed. If it is sufficient to note that a change has occurred, bold, italics, or colored type can be used to indicate the portion of text that changed. For more data about the change, overstriking can indicate deletions and replacements. This technique was used in Bell Labs' HtmlDiff program [6]. *History-based shadowing* can show both new and old versions of information in a space-efficient way. Rather than simply repeating the text, the shadow shows a prior state of the information (see Figure 5). These markups have been integrated into the Agentk toolkit (see [12] for details) and are currently being tested both empirically and in user studies.

Important in the understanding of the role of animation in the awareness process is its integration into applications. Based on the knowledge gained from the tkscore study, we expanded the interface to include more informational options and more control over the display options. The new interface, tkwatch, can display news headlines, stock quotes, weather information, and sports scores. The user can control the color, font, and size of the display as well as the presence of history-based shadowing and automatic highlighting described earlier. We are conducting a study to examine the correspondence between display choices and informational desires.

Another application, "What's Happening", delivers automatically generated news, event reminders, and other content, as well as user submitted postings and chat-room discussions to the local community. Its distinguishing attribute is a small screen-real-estate interface that uses animation to cycle through different pieces of information without demanding much attention from the user away from their primary tasks. We are beginning to deploy

Figure 5: An example of history-based shadowing for a series of baseball scores. A shadow could show the state a certain number of minutes previously, the state on the prior animation cycle, or the state of the information prior to the most recent update.

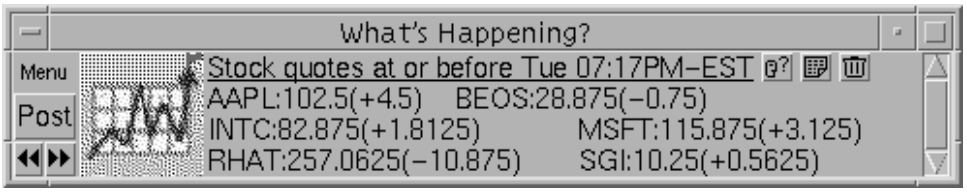

Figure 6: The "What's Happening" interface displaying stock quotes. The menu bar allows a user to select display topics, post or follow up to content, or page through existing content.

this application and to observe how people use it. Through "What's Happening", we will learn whether animation can help the application to stay in the peripheral and whether this type of application can enhance people's awareness of the current affairs in the community.

Our ultimate goal is to automate the awareness process in the spirit of prior work in the automation of the presentation of information. Mackinlay was one of the first to address the topic of automating the design of graphical presentations [9]. Casner [4] stressed the importance of understanding the task of the user in designing a visualization. Other projects have looked at large data sets, artifact design, and the resulting frameworks [5, 18]. However, much of the research to date has focused on characteristics of the information and characteristics of the task at hand. We wish to add to that the need to focus on multiple tasks, not just a single primary task. Specifically, we want to support easy creation of awareness mechanisms for an arbitrary dynamic resource.

The nature of the mechanisms would depend not only on the information in the resource, but on the level of importance the user gives the information. High-priority information (emergencies) can be presented in a more intrusive manner. Low-priority information (casual interests) may be best left in a repository where the user can check it at a leisure moment. Some of the information that falls between the extremes might be best suited for an animated display. We hope to make it easy for the user to specify an information resource and a delivery mechanism and have the information delivered in the desired manner.

7 Conclusions

By far, the main focus of research in communicating information has been on the display of large information sources using innovative, but often complex, visual displays. Sometimes overlooked, however, is the development of *appropriate* solutions for the particular tasks in which people are engaged. A communication mechanism need not be a rendered, 3-D encapsulation to be effective. In fact, in awareness situations such displays would be inappropriate.

In this work, we have examined the task of maintaining awareness of dynamic, usually textual, information sources. Our focus has been on small animated displays that use scrolling and fading techniques to convey the state of the dynamic information. We have presented a set of specifications that such tools should meet to be successful, described a simple widget set to provide the animation capabilities, and presented initial study on the effectiveness of such tools. We then provided example application domains in which these techniques can be useful.

The tkscore study examined the use of animated displays as a way to maintain informa-

tion awareness. The participants in the study seemed willing to sacrifice desktop space for heightened awareness. Most of the participants were happy with the amount of information provided (though some desired more), and nobody listed distraction from the animation as a reason for not using the program. The results described in this study are a stepping stone to a better understanding of the use of animation in maintaining awareness.

These types of animated visuals need not be stand-alone tools. We speculate that they could be integrated into larger information visualization systems to help communicate the status of dynamic components of the information. Because the tools utilize so little screen space, they would not rob valuable screen real estate from the primary visualization.

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